ANNUAL ACCOMPLISHMENTS

JANUARY 2020

U.S. Department of Transportation

50 YEARS

Volpe National Transportation Systems Center

1970 – 2020

TRANSPORTATION INNOVATION FOR THE PUBLIC GOOD

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50 YEARS

MESSAGE FROM THE U.S. DOT VOLPE CENTER DIRECTOR

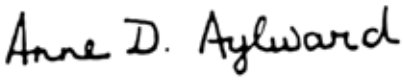
It's hard to believe we've turned the page to 2020—the start of a new decade and the beginning of U.S. Department of Transportation (DOT) Volpe National Transportation Systems Center's 50th anniversary year. The U.S. DOT established the Volpe Center in 1970 to serve as a federal resource positioned to provide world-renowned, multidisciplinary, multimodal transportation expertise on behalf of the Office of the Secretary, U.S. DOT's operating administrations, and other organizations.

I am pleased to present our Annual Accomplishments report. It highlights some of the Center's best work of the past year and provides illustrations of our ongoing efforts to impact the national and global transportation system.

Because it's our golden anniversary year, we've also included a few special notes that focus on our history of advancing transportation innovation for the public good. For more on our rich history, I refer you to *Five Decades,* a recently released Volpe Center publication that celebrates our cross-modal partnerships and sustained commitment to public service.

We recognize and appreciate all of our U.S. DOT partners and other dedicated colleagues across the transportation enterprise who have been part of this important journey.

We look forward to collaborating with you over the next half-century and beyond.



Anne D. Aylward

Director
Volpe National Transportation Systems Center
U.S. Department of Transportation

January 2020

50
YEARS

SAFETY

SAFETY IS THE NUMBER ONE PRIORITY FOR THE U.S. DOT, AND THE VOLPE CENTER IS COMMITTED TO REDUCING TRANSPORTATION-RELATED FATALITIES AND INJURIES ACROSS THE TRANSPORTATION SYSTEM.

AVIATION

Safety Assurance System Streamlines Aviation Safety Oversight

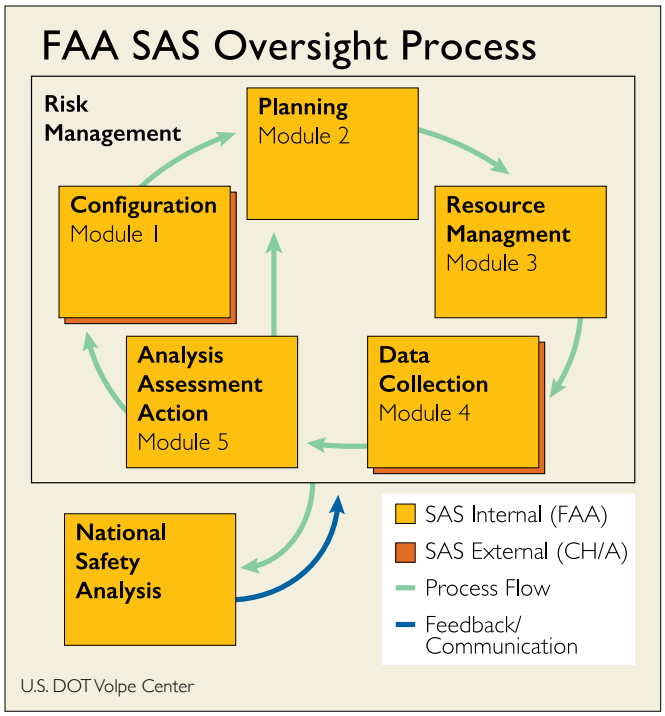
Aviation safety is among the U.S. DOT's highest-profile responsibilities, relying heavily on efficient, technological solutions. With more safety data available than ever before, the Federal Aviation Administration (FAA), through its Flight Standards Service (AFS) System Approach for Safety Oversight Program, has become proactive in using safety management principles to make smarter, risk-based decisions throughout the agency and with industry and global stakeholders.

In 2014, FAA introduced a single oversight system for field and regional aviation safety inspectors to perform safety assurance—the Safety Assurance System (SAS). Using risk-based decision making, safety management, and compliance oversight, SAS has transformed the AFS focus from regulatory oversight to a robust data-supported system. To accomplish this, inspectors now use SAS to review risk, as well as schedule, assign, and perform work. Most importantly, SAS is used to assess findings, take appropriate action, and reprioritize future work based on risk.

FAA turned to the Volpe Center's aviation safety experts to continue developing SAS. The Volpe Center has extensive experience in aviation operational safety and has worked closely with FAA in designing, developing, testing, and maintaining information systems used by aviation safety inspectors.

Volpe engineers, computer scientists, and analysts collaborated with FAA safety inspectors to form multidisciplinary Integrated Product Teams focused on improving the risk-based, decision-making process. Volpe Center staff used their knowledge of FAA safety data, standards, and business processes to develop safety

Opposite: U.S. DOT Volpe Center experts provide technical and risk analysis expertise to enhance aviation safety. Source: ©123RF.com



Above: The FAA SAS oversight process. Source: U.S. DOT Volpe Center

practices that aligned with FAA's compliance oversight philosophy and vision.

After business process reengineering was completed, the Volpe team designed and developed updated SAS software. Once a concept of operations was developed, the team met with subject matter experts to clarify procedures, and then wrote program level requirements. To date, over one million lines of code have been written. Volpe performed user acceptance testing of system requirements and validated functionality in October 2019.

Looking forward, SAS will expand to include Unmanned Aerial Systems oversight, add support for the FAA's integrated oversight philosophy, and allow inspectors to access SAS using mobile devices.

More than 4,000 FAA aviation safety inspectors and managers and over 2,000 industry professionals use SAS. This number is expected to increase with the expansion of SAS oversight to other Code of Federal Regulations parts. Volpe continues to work closely with FAA in applying its unique expertise to help design, develop, and deploy the future of air traffic management. **(Sponsored by FAA)**

1970 – 2020 TRANSPORTATION INNOVATION FOR THE PUBLIC GOOD

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HISTORICAL NOTE

Safety Performance Systems

In December 1985, a chartered plane crashed in Gander, Newfoundland, with more than 240 American soldiers aboard. A review of the crash concluded that the plane was overloaded, and that the chartered carrier had no safety protocol to ensure that the combined baggage, carry-on, and passenger weight was calculated prior to takeoff.

The Volpe Center, in response to a joint request from FAA and Department of Defense (DoD), carried out a technical review, created a centralized database, and developed a new aviation assessment tool to evaluate the safety record of carriers used by the military. The Volpe Center, in partnership with FAA, expanded the effort and created the Safety Performance Analysis System for scoring all air carriers.

Above: The crash in Gander, Newfoundland, of a chartered plane carrying American soldiers led to a series of landmark safety database projects. Source: U.S. DOT Volpe Center

Streamlining Real-Time Work Zone Data Improves Safety for All

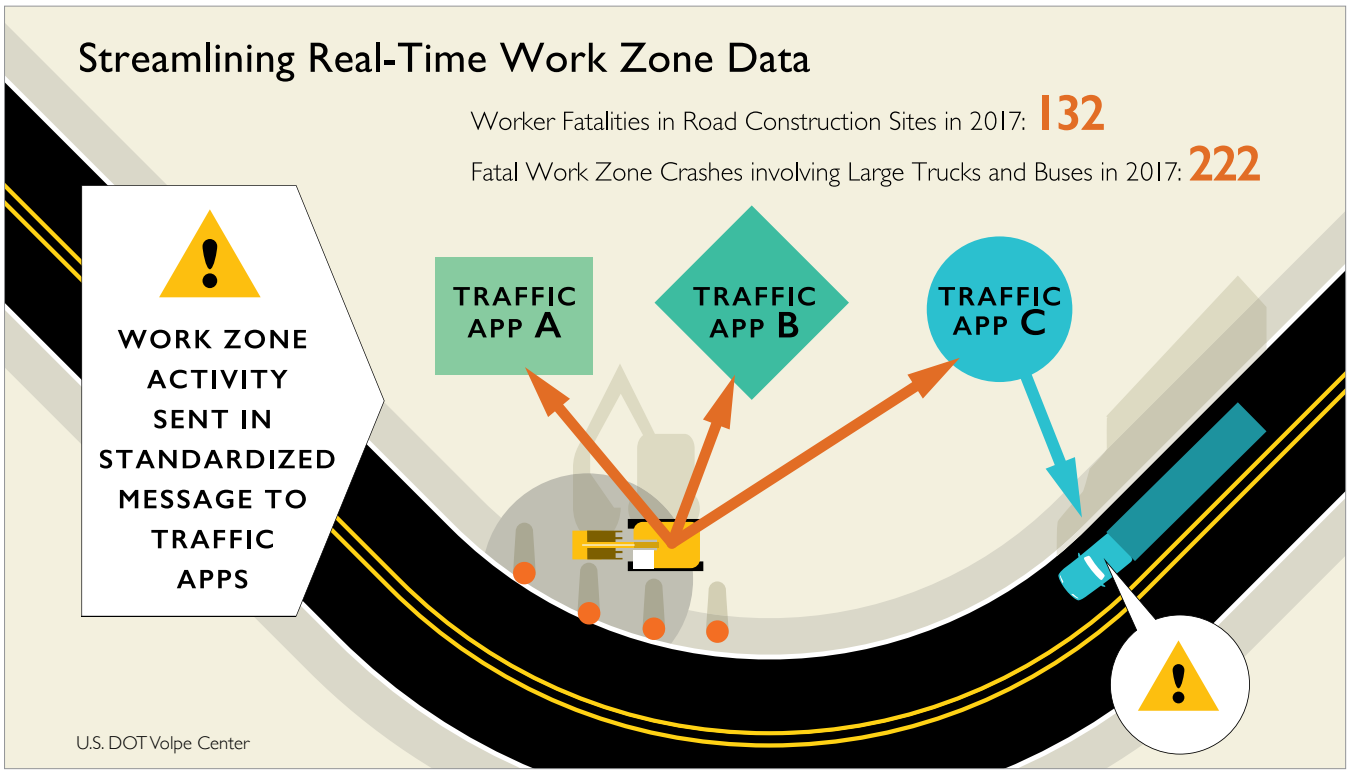
The nation's transportation system is increasingly data driven, dependent on reliable, standardized, and real-time information about roadside activities and work zones. The ability to access this data is critical—not only for keeping highway workers and drivers safe, but also for efficiently integrating automated vehicles (AVs) into the transportation network.

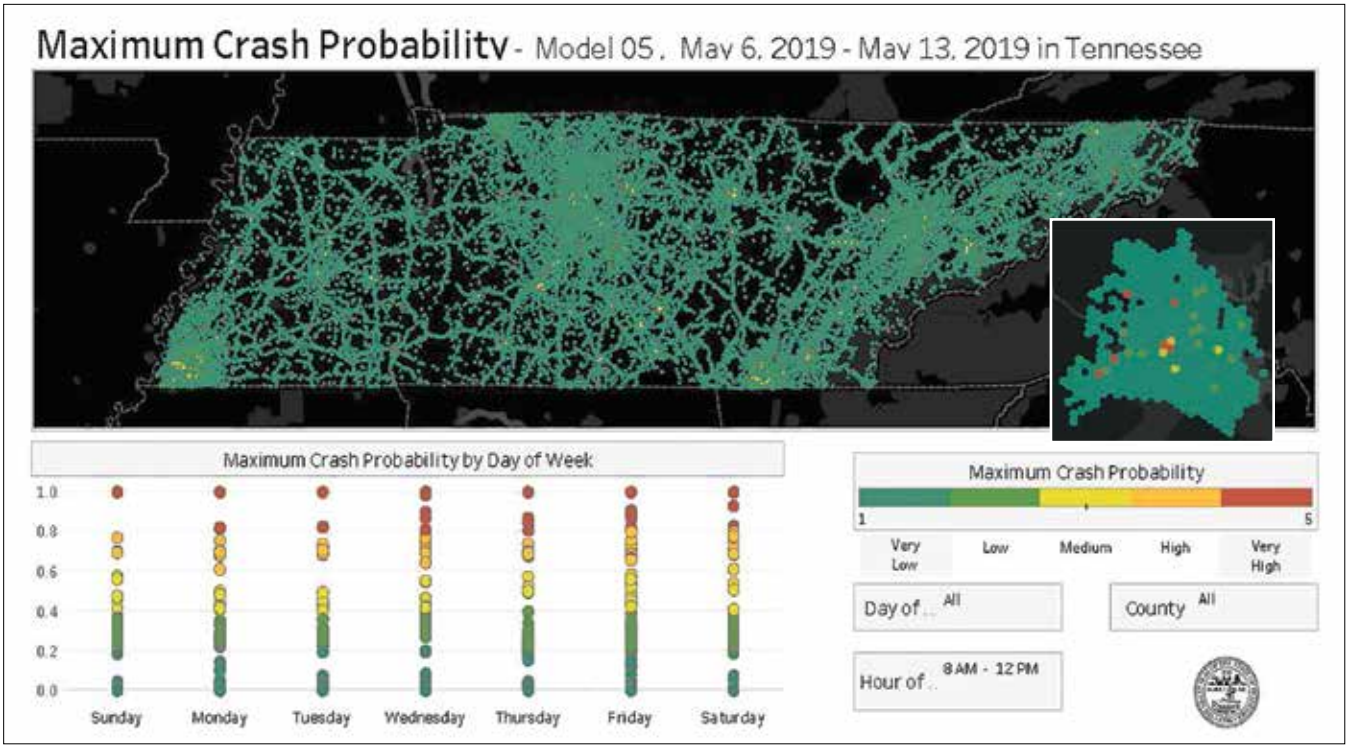
Road construction and associated work zone traffic controls are roadway activities that require dependable and consistent data for interested groups from state, county, and city DOTs—the infrastructure owners and operators (IOOs)—to the traveling public. Many IOOs maintain data on work zones, but the lack of common standards makes it difficult and costly for third parties to access and use this data effectively.

The Intelligent Transportation Systems Joint Program Office (ITS JPO) launched the Work Zone Data Exchange (WZDx) project in March 2018 to jumpstart adoption of a simple, open specification that will allow IOOs to provide consistent work zone activity data to third party users. The ITS JPO collaborated with the Volpe Center's innovation experts on the WZDx project based on the Center's longstanding commitment to providing high-quality strategic development, scope assessments, and exploratory research.

Above: The WZDx specification aims to send advance notice of work zone impacts to human drivers and AVs to improve safety in and around work zones. Source: ©123rf.com/Kenneth Sponsler

The Volpe Center co-leads the WZDx project with the Federal Highway Administration (FHWA) and the ITS JPO. Version 1.1 of the specification is now available for IOOs to initiate data feeds, allowing original equipment manufacturers, high-definition mapping and navigation applications, and





Above: Example dashboard summarizing the crash propensity model results for a week in May 2019 for each grid cell with sufficient data, by day of week, time of day, and county. Inset box shows Davidson County, including Nashville, TN. Source: U.S. DOT Volpe Center

others to use work zone activity data more effectively. Two IOOs recently activated standardized data feeds, and Maricopa County DOT demonstrated a real-time data exchange with in-vehicle electronic logging devices to alert a heavy truck operator of an impending work zone.

Standardizing data exchange on active work zones can improve highway safety and support the efficient integration of automated driving systems of the future. IOOs are quickly integrating the WZDx specification into roadway management and operations, sharing up-to-date information about roadside activities and work zones with other users. DOT staff and contractors working in and around the roadway in particular can benefit from data that highlights their location in work zones.

Using the WZDx specification to communicate to drivers that a work zone is active, workers can provide real-time, on-the-ground information to make work zone data more useful as a safety tool. Incorporating this information into navigation applications and maps will not only alert drivers to reduce speeds through work zones, it will also signal to AVs to transfer control to a human driver ahead of time.
(Sponsored by FHWA and ITS JPO)

Using Crowdsourced Data to Estimate High Crash Risk Locations

In 2018, 36,560 people died in highway crashes in the United States—marking the second consecutive year of reduced crash fatalities. In 2017, there were over 2.7 million people injured in motor vehicle crashes in the U.S. The U.S. DOT's Safety Data Initiative (SDI) aims to better understand and mitigate crash risk. The focus of the SDI is to:

1. Integrate public and private data sources to best characterize safety issues;
2. Deploy novel analytic tools, including machine learning, to tackle these challenges; and
3. Use advanced data visualizations to intuitively convey model results.

The SDI is an opportunity for public agency researchers to develop models that estimate the timing and location of crashes, which may help emergency responders, traffic management centers, and law enforcement proactively allocate resources to locations with the highest accident potential.

Crowdsourcing mobile applications are an emerging and rich source of real-time data about roadway conditions. The Waze navigation app provides an opportunity for users to actively report information about accidents, weather conditions, traffic jams, road closures, and road hazards. This

crowdsourced data can potentially support a wide range of safety research applications.

The Volpe Center, in support of the Office of the U.S. DOT's Under Secretary for Policy, is leading the SDI Waze Project, using this private-sector data source to better estimate where and when motor vehicle crashes are likely to occur. In the pilot, Volpe researchers began by integrating aggregated Waze user-reported crash information with crash and other traffic data from the state of Maryland and auxiliary data such as road and weather conditions. The team then used a machine learning approach to estimate where and when police-reportable accidents were likely to occur over a six-month period.

The Volpe model provides accurate estimates of crash risk within one-mile-area grid cells, and a one-hour time scale, across the state of Maryland. The Volpe Center team has since extended the Waze crash estimation models to a full year, and to three additional states: Virginia, Connecticut, and Utah. Building on statewide research models, the Volpe team initiated two case studies to develop real-world applications of the crash-estimation models.

The city of Bellevue, WA, collaborated with the Volpe Center to test if integrating Waze data can offer superior insights for Vision Zero, an effort to reduce traffic deaths and serious injury collisions to zero by 2030. The Volpe team integrated the Waze data with several local sources of traffic data to create interactive dashboards that provide city transportation officials with novel cross-referencing capabilities to explore traffic crash patterns.

To guide Bellevue's transportation safety investment decisions, the team also developed dashboards to identify conditions, times, and locations with high crash risk. The dashboards supported a city-wide assessment of safety concerns to determine where to allocate scarce resources for an intersection-level video analytics study of road user conflict scenarios, in partnership with Brisk Synergies, Together for Safer Roads, and the Pacific Northwest Transportation Consortium.

The Volpe team is also working with the Tennessee Highway Patrol to integrate Waze data into the state's existing crash prediction model, which currently estimates crash risk across 42 square-mile grids in four-hour time blocks. Using Waze data, Volpe data scientists have developed a model that can predict crash risk in one-square-mile grids, every hour. The improved model provides a high-resolution option to help Tennessee Highway Patrol optimize the allocation of troopers to the highest risk locations. Beyond Tennessee, the model's incorporation of crowdsourced data shows the potential for similar types of data-driven safety approaches elsewhere. **(Sponsored by U.S. DOT Office of the Under Secretary for Policy)**

Cybersecurity Framework Profile and Privacy Risk Assessment for the Connected Vehicle Environment

As the pace of innovation and connectivity increases, the vulnerability of transportation systems to cyber threats increases as well. While security and privacy are independent and separate disciplines, they are closely related.

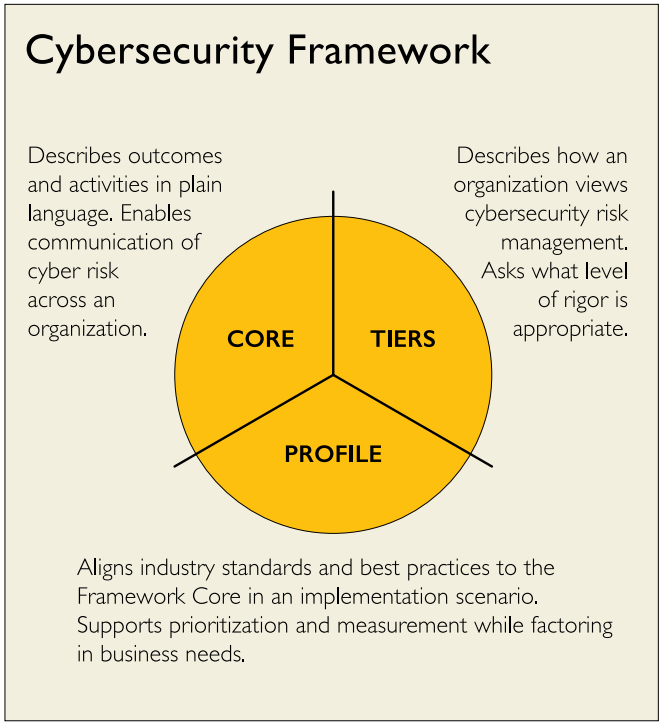
The ITS JPO coordinates research into and development of the technology evolution of each next generation of ITS, in partnership with modal administrations, the transportation industry, academia, technology innovators, and other interested parties. Connected vehicle (CV) technologies and their applications represent an emerging and vulnerable generation of innovative technology capabilities.

The ITS JPO initiated three CV pilot deployments in 2015 (across Wyoming; in New York City; and within the Tampa, Florida region), and one research site at the University of Michigan Transportation Research Institute (UMTRI). To ensure that cybersecurity would be integral to all CV solutions, the ITS JPO tasked each site with developing a security plan. As a result, the broader need for consistent cybersecurity and privacy guidance emerged.

The ITS JPO asked the National Institute of Standards and Technology's (NIST) National Cybersecurity Center of Excellence (NCCoE), under the project leadership of the Volpe Center, to develop a Cybersecurity Framework Profile[1] and tailor NIST's Privacy Risk Assessment Methodology (PRAM)[2] for the CV environment.

1 The NIST Cybersecurity Framework provides a common taxonomy for discussing cybersecurity activities within an organization and between organizations. It can be used by an organization to measure progress in its cybersecurity over time, and serves as a tool to communicate the organization's cybersecurity capabilities to auditors, regulators, and other types of assessors, as well as partners and vendors. Framework Profile development aligns the activities and outcomes in the Cybersecurity Framework Core with a given context: the cybersecurity areas of concern to a particular industry, organization, or functional area.

2 NIST's Privacy Risk Assessment Methodology (PRAM) provides a taxonomy for discussing privacy risk and a set of tools to assess privacy risk. The ITS JPO decided to use the PRAM because it differs distinctly from the privacy impact assessments (PIAs) typically employed to gauge privacy risk. In many ways it is better suited to support the engineering of complex sociotechnical systems, including those revolving around CV environments.



Above: The NIST Cybersecurity Framework consists of three main components: Core, Impementation Tiers, and Profiles. Source: The Framework for Improving Critical Infrastructure Cybersecurity, April 2018

The Volpe team served not only as project leads, but also as transportation technical experts, explaining the complex technologies and stakeholders involved in a connected vehicle deployment. MITRE, in support of NCCoE, provided the project's cybersecurity expertise. To collect the needed inputs to develop the Cybersecurity Framework Profile and PRAM, the Volpe and MITRE teams visited the four CV sites to facilitate structured workshops that focused on identifying and prioritizing mission objectives. The workshops generated additional information needed to address privacy risks, including each site's approach to privacy.

The Volpe Center and MITRE analyzed the accumulated real-word data in relation to the Cybersecurity Framework. For example, mission objectives were reviewed to determine the priority Cybersecurity Framework categories that supported them.

The result will be the publication of Cybersecurity Framework Profile and Privacy Risk Assessment for the Connected Vehicle Environment in early 2020. The report contains the Cybersecurity Framework Profile and PRAM, which can be used as templates by state and local project managers, system integrators, and planners to address cybersecurity and privacy risks of CV technologies in an organized and comprehensive way. **(Sponsored by ITS JPO)**

Mitigating Cybersecurity Vulnerabilities of Emerging Extreme Fast Charging Systems for Electric Cars and Trucks

The electric vehicle (EV) environment is a mix of multiple stakeholders, domains, hardware, and software. As communication, electricity, and transportation systems become more integrated, cybersecurity vulnerabilities that would normally be localized can now cause disruptions across multiple sectors. The initial development and deployment period for innovations within the EV environment is the ideal time to mitigate cybersecurity issues before they become widespread and ingrained, and thus difficult and expensive to remedy. This is equally true for new medium- and heavy-duty electric trucks (MD/HDEVs), which are in the testing stage of development, and for technological advances in extreme fast charging (XFC) of EVs and MD/HDEVs at public charging stations, also in development.

The Volpe Center has been consistently involved with federal and private-sector initiatives to identify and mitigate vehicular cybersecurity threats as advancing technologies have created new vulnerabilities. In 2016, Volpe Center cybersecurity experts developed a vehicle cybersecurity primer and guidance for government fleet managers on fleet risk assessment, cybersecurity vulnerabilities in telematics and fleet management systems, and effective solutions.

To determine what might be necessary to address cybersecurity threats to EV and electric vehicle supply equipment (EVSE), Volpe collaborated with the U.S. Departments of Energy and Homeland Security in a technical meeting held in November 2017, which drew a large group of interested parties across multiple industry sectors. Several significant needs emerged:

- Exploration of cross-agency coordination of governance and regulatory concerns regarding cybersecurity for EVSE.
- A practical baseline document to educate the disparate stakeholders and interested parties on each other's domains regarding XFC cybersecurity issues and concerns.
- A substantially better understanding of the heavy vehicle industry by the EVSE sector through mutual engagement. The heavy vehicle industry is different from the automotive electric vehicle industry in terms of XFC use cases—especially Class 7 and 8 MD/HDEVs.
- Exploration of current research and definition of future research goals, specific to electric trucks and XFCs,

to determine cybersecurity principles, risks/threats, and best practices.

In 2018, the National Motor Freight Traffic Association, Inc. asked the Volpe Center to identify threats and cybersecurity requirements for MD/HDEVs and XFC systems. To accomplish this, Volpe engaged a diverse set of contributors: federal agencies, cybersecurity professionals, electric trucking industry stakeholders, and international government agencies. Volpe prepared an overview of XFC systems, identified the cybersecurity objectives for XFC systems, and further broke down specific threats.

In July 2019, Volpe produced Extreme Fast Charging: Cybersecurity Threats, Use Cases and Requirements, which describes system requirements and provides a matrix of cybersecurity best practices for use by XFC equipment manufacturers, electric truck original equipment manufacturers, utilities, standards organizations, and other interested stakeholders. **(Sponsored by National Motor Freight Traffic Association and the U.S. Department of Energy)**

MOTOR CARRIERS

Commercial Driver's License Drug and Alcohol Clearinghouse Improves Roadway Safety

Since the early 1990s, the Federal Motor Carrier Safety Administration (FMCSA) has defined drug and alcohol testing regulations for commercial drivers and their employers. Motor carriers are required to contact the previous employers of potentially new drivers to confirm their drug and alcohol test records. However, some drivers have been able to side-step the discovery of their past drug and alcohol results and violations by excluding pertinent information on their job applications. To close this safety gap, Congress directed FMCSA to establish a Commercial Driver's License (CDL) Drug and Alcohol Clearinghouse and have it operational by January 6, 2020.

In April 2018, FMCSA partnered with the Volpe Center to achieve this congressional mandate. The Volpe team coordinated with OST CIO Office and FMCSA IT on designing new, innovative technology platforms and developing interfaces to meet this objective. In addition, Volpe experts have supported program implementation, communication and outreach, and education and training on the new program and system.

The Clearinghouse is a secure, web-based system that will provide FMCSA, employers, and state agencies with the tools to identify CDL drivers who are prohibited from operating commercial motor vehicles (CMVs) due to past DOT drug and alcohol program violations. The Clearinghouse will help ensure that such drivers receive the evaluation and treatment required by DOT regulation before being permitted to operate CMVs on public roads. The Clearinghouse will also identify drivers who move frequently and obtain CDLs in different states, providing a link to those CDLs in order to maintain complete and accurate information on drivers. The Clearinghouse meets all relevant federal privacy and security standards.

In March 2019, the Volpe team successfully launched the Clearinghouse website as part of a comprehensive communication strategy. The launch was also used to announce FMCSA Drug and Alcohol Clearinghouse program details and provide stakeholders with information on future

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HISTORICAL NOTE

Reducing Deaths and Injuries on Our Nation's Highways

In 1973, one-half of all traffic deaths involved a drunk driver.

In the early 1970s, NHTSA asked the Volpe Center to participate in a high-profile alcohol countermeasures program. Early research included evaluating police breath analyzers and related equipment for effectiveness and accuracy, as well as initiating the development of automatic breath alcohol testers and collaborating with over 200 forensic blood laboratories. The devices must not only be technically accurate but also easy to use. Before any testing device is used by police in the United States, it is tested at the Volpe Center for accuracy and usability.

Because of Volpe's national expertise in alcohol countermeasures, NHTSA and numerous judicial courts have called on the Center to give expert testimony—and continue to do so today.

program plans. To date, over 300,000 visitors have accessed the website to learn more about FMCSA's program.

In October 2019, the technical team expanded the Clearinghouse website to offer an online registration capability that enabled users to prepare for the January 6, 2020 compliance deadline. As a result, within the first two months more than 80,000 online accounts were established.

Recently, the team phased in website functionality that allows users to log into their Clearinghouse accounts to purchase query plans and pay required user fees. Since launching the Clearinghouse registration website, the site has been well received at industry trade shows and other public venues. **(Sponsored by FMCSA)**

Continuously Improving Data to Prioritize High-Risk Carriers for Intervention

Since implementing the Safety Measurement System (SMS) in 2010, FMCSA has used reportable crash events and safety performance data to assess motor carriers' crash histories and prioritize carriers for safety interventions. The crash data reported to FMCSA do not specify a motor carrier's role in the crash or whether the crash was preventable by the driver or carrier. An objective of FMCSA has been to evaluate whether considering a company's role in a crash would improve the agency's ability to prioritize interventions by better identifying the highest-risk companies.

With its successful history of supporting agency operations and initiatives, FMCSA asked the Volpe Center to support the 24-month Crash Preventability Demonstration Program. Volpe's role involved supporting the design and development of a business process for reviewing crashes submitted under the program; enhancing the existing FMCSA DataQs system to enable submission of crash type requests for data review (RDRs); updating the public SMS website to display results of the reviews; training external expert review teams on the crash review process; and developing outreach and communications materials to educate the motor carrier industry, the public, and enforcement personnel.

The Volpe Center's crash preventability reviews involved two stages. In stage one, the reviewer confirmed that all required crash-related documentation was submitted, and they gathered additional information available from FMCSA systems, including the crash report, driver history record, recent enforcement information for the motor carrier, and any media reports about the crash. If a fatal crash occurred, the reviewer requested the driver's post-crash drug and alcohol test results. In stage two, an experienced crash report reviewer evaluated all of the documents from stage one and made an evidence-based recommendation to FMCSA as to whether the crash was preventable or not. FMCSA reviewed the evidence collected by the stage two reviewer and the recommendation before making the appropriate determination.

The Volpe Center conducted evaluations of the program at 12 months, 18 months and 24 months after the program initiation. From August 2017 until the end of September 2019, over 14,000 RDRs were submitted to FMCSA; of these, some 57 percent were eligible for review. Approximately 93 percent of the eligible crashes were found to have been not preventable by the carrier or driver.

Because of the demonstration program's success and positive industry feedback, FMCSA announced its decision to operate a Crash Preventability Determination Program with an expanded number of crash types eligible for submission. As part of the new program, FMCSA has proposed to remove crashes determined to be not preventable from the SMS prioritization algorithm. The Volpe Center is now working with FMCSA to design and implement the permanent program in the coming months. **(Sponsored by FMCSA)**

Innovative Modeling and Analyses to Improve Safety-Based Decision Making

FMCSA currently uses the data-driven Safety Measurement System (SMS) to identify which of over half a million motor carriers to prioritize for interventions. FMCSA employs a limited number of safety investigators, so it is essential their activities are focused on motor carriers that pose the greatest risk to safety. An effective prioritization algorithm is critical to FMCSA's mission to reduce crashes, injuries, and fatalities involving large trucks and buses.

The Fixing America's Surface Transportation (FAST) Act of 2015 required the National Academy of Sciences, Engineering, and Medicine (NASEM) to conduct a study of SMS. In June 2017, the NASEM panel completed the study and issued a report, which recommended that FMCSA develop an Item Response Theory (IRT) model over the next two years to evaluate if IRT could offer a more robust statistical modelling approach for identifying and prioritizing carriers for intervention than the current SMS. IRT is a statistical model that is currently used widely in other fields, such as educational testing and human health services. Applying this technique to the transportation sector, however, would be

innovative and also presents some unique challenges. FMCSA asked the Volpe Center to support the design, development, and evaluation of the IRT model for use in the transportation context.

A multidisciplinary team from across the Volpe Center was assembled to design the IRT model, and to run and analyze the results, within the two-year timeframe. In the design phase, the team overcame several technical barriers due to the large data sets of over three million inspections annually and a large number of FMCSA violations. Volpe staff addressed the computing problems by designing an AWS Cloud platform to support the large data runs and optimizing the input data sets by paring down the number of violations through lengthy analysis to consolidate similar violation types and remove duplicate violations. As a result, run times for the model were reduced by about 20 percent on average.

Another challenge was to ensure the involved stakeholders—motor carrier industry, FMCSA Program Offices, and National Academy of Sciences Standing Committee—had the right information to make safety-based decisions moving forward. The stakeholder's interests and backgrounds were different, and each needed information on the IRT model and its results (e.g., the crash rates of the prioritized carrier population compared with carriers prioritized by SMS) to inform their decision making. Communications expertise on the Volpe team was instrumental in conveying the highly technical, robust modelling tool and technical results in an easy-to-understand way that related to the varying information needs of different stakeholder groups.

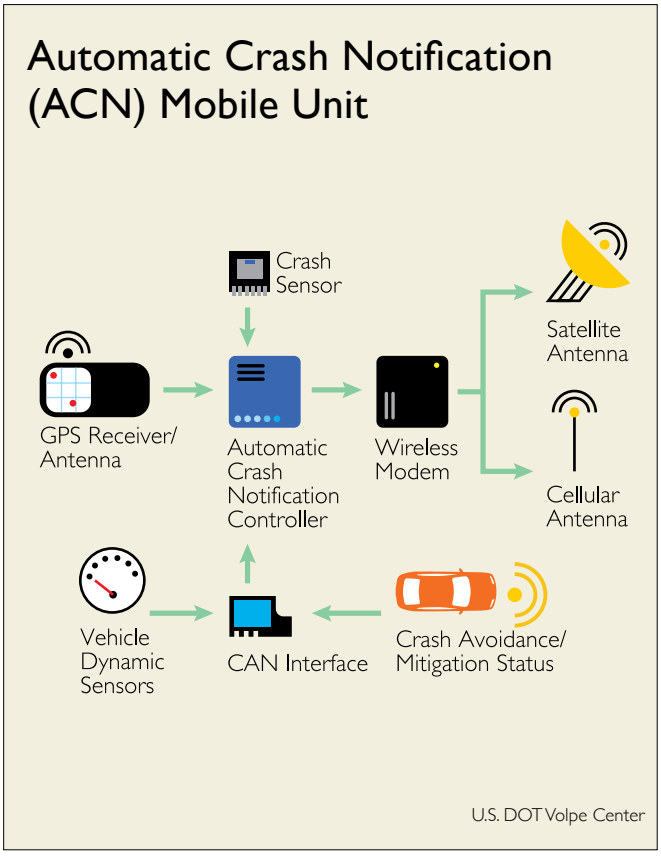
In September 2019, the Volpe team submitted the first draft of the technical report with a summary report for FMCSA review. The source code for the IRT model (version 1.0) was also delivered. FMCSA leadership will review the report and plans to make a decision on IRT in September 2020. Until then, Volpe will continue to help FMCSA by supporting the monthly runs of the SMS and providing needed analyses, visualization tools, or runs of the new IRT model. **(Sponsored by FMCSA)**

Assessment of Automatic Crash Notification for Commercial Vehicles Transporting Sensitive DoD Materials

The mission of the DoD's Defense Transportation Tracking System (DTTS) is to monitor the safe and secure movement of conventional arms, ammunition and explosives, and other sensitive material by commercial trucks and barges in North America. A key goal of this mission is to initiate rapid emergency response to in-transit crashes to minimize their impact and secure sensitive DoD property.

DTTS currently employs a fleet management system that maintains 24-hour monitoring, using satellite positioning and communications technology combined with digitized mapping. The Satellite Motor Surveillance Service (SNS) provides DTTS with in-transit security capability to monitor the visibility of sensitive DoD shipments. The SNS system relies upon the driver to notify the transportation service provider of a crash via a "panic button" emergency alert. A particular weakness in this system is that when a driver is incapacitated or unconscious, there is a lag before the system automatically detects that the vehicle is no longer moving and the driver fails to respond when contact is attempted.

DTTS is now exploring the best methods to meet their emergency awareness needs through automatic crash notification (ACN). ACN is an application provided by vehicle telematics systems that combine and integrate directly into the vehicle's electrical architecture, cellular communications technology, GPS satellite location capability,



Above: Architecture of an ACN Mobile Unit. Source: U.S. DOT Volpe Center

and sophisticated voice recognition. ACN technologies have been available for some time in automobiles, and are emergent as original and aftermarket equipment for commercial trucks. For DTTS, the Volpe Center recently conducted a technical and economic assessment of ACN systems and fleet tracking/management services that notify a tracking center of a crash involving a commercial truck.

First, the Volpe Center compiled the features of 52 fleet tracking companies in the existing market. They found that 68 percent of the companies offer critical event monitoring (e.g., detection of hard braking or excessive speed). However, only 8 of the 52 companies have a panic button for drivers in case of emergency. The Volpe team then assessed technologies that address crash sensing, safety systems installed as original equipment by large-truck manufacturers, aftermarket safety systems provided by third party suppliers, and associated communication technologies. Volpe experts also compiled statistics on the deployment rates of safety technologies in the current DTTS commercial fleet, based on a previous DTTS-sponsored study.

The Volpe team recommended three alternatives to DTTS for ACN implementation: (1) vehicle dynamic sensors for crash detection, (2) vehicle dynamic sensors integrated with crash avoidance/mitigation systems, and (3) crash sensors fully integrated with vehicle dynamic sensors. **(Sponsored by DoD)**

RAIL

Improving Safety at Highway-Rail Grade Crossings with Photo Enforcement

Fatalities and incidents at highway-rail grade crossings have been a long-standing problem for the Federal Railroad Administration (FRA). Each day, drivers make dangerous, reckless decisions to try and beat trains at crossings. Unlike vehicles, trains cannot swerve, stop quickly, or change direction to avoid collisions. Almost 54 percent of all public at-grade crossings are equipped with active warning devices (gates and/or flashing lights), alerting motorists to oncoming trains. Despite these alerts, of the 1,874 incidents that occurred at public grade crossings in 2018, approximately 73 percent (1,367) were at crossings equipped with active warning devices.

FRA has been engaged in an ongoing effort to increase public awareness around railroad crossings in order to reduce deaths and injuries. One approach is to improve motorists' compliance with grade crossing active warning devices. In 2016, the city of Orlando, Florida initiated a pilot driver education program at the East Princeton Street grade crossing, using Sensys America photo enforcement technology to send warning notices to drivers who violate grade crossing active warnings.

For over 40 years, the Volpe Center has collaborated with FRA to reduce highway-grade crossing and trespassing incidents. In addition to providing research capabilities, the Volpe Center has also evaluated FRA's engineering, education, and enforcement methods to improve the safety of rail operations.

A team of Volpe experts first determined whether Orlando's photo enforcement-based driver education pilot program successfully reduced the number of vehicles that violated grade-crossing active warning devices. Volpe engineers then evaluated the effectiveness of photo enforcement technologies to detect and deter highway-rail grade crossing violations along a mixed-use rail corridor. The team worked

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HISTORICAL NOTE

Keeping People Safe Around Trains

Every day, trains travel across more than 212,000 highway-rail grade crossings. Through the decades, the FRA has turned to the Volpe Center to help reduce highway grade crossing incidents. In 1976, there were 1,069 fatalities and 4,656 injuries at U.S. highway-rail grade crossings. Today, fatalities and injuries have decreased nearly 80 percent even while U.S. rail activity has significantly increased.

In 1971, in partnership with FRA, the Volpe Center published its first report on highway-rail grade crossing safety: Technological Innovation in Grade Crossing Protective Systems. Today, a multidisciplinary Volpe Center team continues to work in support of FRA's efforts to improve rail safety including highway-rail grade crossing safety and trespass prevention.

Above: Photo enforcement system installed at the East Princeton Street grade crossing in Orlando, Florida. Source: U.S. DOT Volpe Center

with the city of Orlando and FRA personnel to develop the warning notice and education materials sent to drivers who violated grade crossing warnings. Volpe then installed a video data collection system at the East Princeton Street crossing, collected violations of the grade crossing active warning devices before and after the implementation, and evaluated the results.

The photo enforcement-based driver education program significantly reduced the number of vehicles that violated grade crossing warning devices and reduced the possibility of vehicles getting struck by an oncoming train. Twenty months after implementation, the overall violation rate was reduced by 17.2 percent. These results were forwarded to other rail safety stakeholders nationwide to show the effectiveness of the program in changing driver behavior. In July 2019, FRA published a technical report on the East Princeton Street grade crossing pilot. **(Sponsored by FRA)**

50
YEARS

INNOVATION, AUTOMATION, AND TECHNOLOGY

TRANSPORTATION INNOVATION IS HAPPENING AT AN UNPRECEDENTED PACE. FROM DRIVERLESS CARS TO UNMANNED DELIVERIES, INNOVATION AND NEW TECHNOLOGIES ARE KEY TO THE FUTURE OF A SAFE, EFFICIENT, RELIABLE TRANSPORTATION SYSTEM.

Opposite: U.S. DOT Volpe Center experts are helping to develop a transportation system that safely includes automated vehicles across all modes. Source: ©123rf.com

National Dialogue on Highway Automation

No longer considered science fiction, automated vehicles (AVs) have the potential to significantly transform our nation's roadways and provide potential safety benefits.

To better understand the implications of automated vehicles for the transportation system and the agencies responsible for the planning, design, construction, operation, and maintenance of the roadway infrastructure, the Federal Highway Administration (FHWA) held a series of national workshops to engage stakeholders on the topic of automation. This National Dialogue on Highway Automation was a series of meetings held across the country to facilitate information sharing, identify key issues, and support the transportation community in safely and efficiently integrating automated vehicles into the road network. Input received during the National Dialogue will help inform FHWA research, policies, and programs.

FHWA called upon the Volpe Center's expertise in advanced vehicle technologies, technology innovation, and policy to support and facilitate these workshops. Much of this work was informed by the Volpe Center's ongoing

Above: National Dialogue meeting in Detroit, MI. Source: U.S. DOT Volpe Center

work in supporting modal agencies across the Department in the topic of automated vehicles.

FHWA held six National Dialogue on Highway Automation meetings to discuss the integration of automated vehicles in the nation's transportation system. Meetings were held in Detroit, Philadelphia, Seattle, Chicago, Phoenix, and Dallas, and each attracted nearly 200 participants. To ensure input from a broad cross section of the transportation community, stakeholders included original equipment manufacturers, technology suppliers, transportation network companies, state and local agencies, and public sector partners. Discussion topics included transportation policy and planning, digital infrastructure and data, freight, operations, infrastructure design, and safety. Volpe Center staff facilitated the discussions and provided subject matter expertise in highway automation.

By engaging a diverse group of key stakeholders across the country, the National Dialogue on Highway Automation meetings provided FHWA with useful input as they consider how to support state and local agencies and the broader transportation community to prepare for the safe and efficient integration of AVs. **(Sponsored by FHWA)**

Automated Driving Systems Demonstration Grants

In December 2018, the U.S. DOT announced a Notice of Funding Opportunity (NOFO) for Automated Driving System (ADS) Demonstration Grants. Up to $60 million in federal funding was made available to eligible entities to fund demonstration projects that test the safe integration of ADS into the nation's transportation system. The grants also aim to gather significant safety data to inform rulemaking and foster collaboration among state and local governments and private partners.

The goals of the ADS Demonstration Grants include:

- Safety: Test the safe integration of ADS into the nation's on-road transportation system.
- Data for Safety Analysis and Rulemaking: Ensure significant data gathering and sharing of project data with U.S. DOT and the public throughout the project in near real time.
- Collaboration: Work with innovative state and local governments and private partners to create collaborative environments that harness the collective expertise, ingenuity, and knowledge of multiple stakeholders.

The Volpe Center supported the Office of the Secretary–Policy (OST-P) in conducting the technical evaluation of the responses to the NOFO. This involved providing technical reviews of 73 proposals submitted from across the nation, including cities, states, universities, and other organizations. In addition to technical evaluation, Volpe Center staff provided grant proposal management expertise, including project management, technical meeting facilitation, and subject matter expertise in automation. The Volpe Center also provided significant data analysis to support senior leadership decision making in assessing the proposals.

In September 2019, U.S. Secretary of Transportation Elaine L. Chao announced nearly $60 million in federal grant funding to eight award recipients in seven states for the ADS Demonstration Grant. The awardees included Texas A&M Engineering Experiment Station, University of Iowa, Virginia Tech Transportation Institute (awarded two projects), Ohio Department of Transportation, Pennsylvania Department of Transportation, the city of Detroit, and Contra Costa Transportation Authority.

Volpe Center experts collaborated directly with colleagues at U.S. DOT on this innovative project. **(Sponsored by OST-P and FHWA)**

CARMA Testing and Evaluation of Research Mobility Applications

FHWA is focused on advancing strategies for how infrastructure can move traffic more efficiently using cooperative driving automation technologies.

Above: A three-car platoon of vehicles equipped with the CARMA2 platform at the Aberdeen Test Center. Source: U.S. DOT Volpe Center

FHWA developed the innovative, open source CARMA[SM] platform to encourage collaboration in improving transportation efficiency and safety. CARMA[SM] enables and facilitates the cooperative tactical maneuvers of automated driving systems with other vehicles and the roadway infrastructure through wireless communication. Using this platform, industry, academia, infrastructure owner-operators, and public agencies can collaborate on the research and development of cooperative driving automation capabilities.

The Volpe Center collaborated with FHWA's Turner-Fairbank Highway Research Center (TFHRC) to develop a comprehensive test framework that gradually expands the breadth of test scenarios and environments from the proof-of-concept stage to more advanced prototypes. TFHRC previously tested the cooperative adaptive cruise control (CACC) proof-of-concept application on the first-generation CARMA (CARMA1) platform.

In 2019, Volpe used the second-generation CARMA2 platform to evaluate the performance of three mobility applications in development: vehicle platooning, speed harmonization, and cooperative on ramp merging. Testing was conducted at the U.S. Army's Aberdeen Test Center (ATC) using a fleet of five 2013 Cadillac SRX passenger vehicles equipped with CARMA2.

Vehicle platooning is a promising solution for increasing highway capacity and alleviating traffic congestion. A platoon consists of a lead vehicle that uses wireless communication to provide information and cooperation rules with at least one follower. Successful platooning requires organized behavior and negotiations between the leader and following vehicles in order to support formation and a safe close-following distance with higher accuracy, faster response, and shorter gaps.

1970 – 2020
TRANSPORTATION INNOVATION
FOR THE PUBLIC GOOD

50 YEARS

HISTORICAL NOTE

The Future of the Automobile

In February 1979, the Volpe Center hosted a major conference on the future of the automobile. Then U.S. Secretary of Transportation Brock Adams delivered the opening keynote address and challenged the automobile industry, government, and others to work together to reinvent the automobile to be safer, cleaner and significantly more efficient.

The conference was attended by several hundred leaders from industry, academia, and independent research and consumer groups. Technological options for automobile manufacturers in the areas of engines, fuels and powertrains, and structures and materials were considered and debated and a new research agenda was developed for industry and government.

Using a new "All Predecessor Following" platooning algorithm, the tests demonstrated the successful platooning of five CARMA2-equipped vehicles traveling up to 60 mph with time gaps as low as 0.6 second. This is a significant advance over the CACC proof-of-concept tested on CARMA1, promising enhanced traffic flow stability, increased roadway capacity, and improved safety.

The speed harmonization application is designed to dynamically adjust vehicle speed recommendations in real time in order to reduce speed differentials and smooth traffic flow near areas of congestion, collisions, or special events. The CARMA2 test demonstrated the application's basic design intent. Absolute speeds and a fixed change to a commanded speed in use were successfully tested. However, signal availability on the ATC track, located in a remote area, was a significant challenge limiting the scope of the test and evaluation effort.

On-ramp entrance automation is a potential solution for congested traffic situations caused by traffic merging in urban environments. The cooperative on-ramp merge application is a special use case of the more encompassing cooperative lane-change application. Good progress was made; however, challenges to automatically stop and hold a vehicle at a specific waypoint and then accelerate to the correct speed of vehicles approaching in an adjacent lane from the rear were not reliably resolved.

The results of Volpe's test data analysis also revealed opportunities to improve the capability and performance of the three applications as their algorithms undergo further development and are implemented on the third-generation CARMA3 platform. **(Sponsored by FHWA)**

Improving Commercial Motor Vehicle Safety Through Information Sharing and Electronic Screening

As part of the Federal Motor Carrier Safety Administration's (FMCSA) mission of ensuring safety on the nation's roads, the Innovative Technology Deployment (ITD) program is utilizing electronic screening to target high-risk motor carriers to reduce crashes, injuries, and fatalities involving commercial motor vehicles (CMVs).

On October 1, 2016, the FAST Act established the ITD program to provide federal grants to states in order to improve overall safety and increase efficiency and effectiveness of CMV safety programs; improve data quality and sharing among states, and between states and FMCSA; reduce administrative costs; and implement high-priority FMCSA safety projects.

Above: FMCSA staff, Volpe ITD support team, and Texas ITD team visited Devine weigh station to learn how e-screening technology supports roadside inspection of large trucks. Source: Tom Kelly, Office of Analysis, Research, and Technology. Source: U.S. DOT Volpe Center

Electronic screening technology has made a difference in improving roadside inspection effectiveness. Information systems funded by ITD provide a way for safety and credential information to be accessed on the spot during an inspection. With such technology, law enforcement can make a decision to either let go of good carriers or stop bad carriers for inspection based on accurate data. This makes the process more efficient and less costly in the long run.

The Volpe Center provided support to the ITD program through grant application review, state technology deployment, compliance certification, core compliance monitoring, data quality evaluation, web site development, business requirement development, data analysis, production operation monitoring, and process improvement.

Recent work included: completing 31 state grant application reviews and summarizing a list of projects per state that requested funding and priorities; certifying Rhode Island as a new ITD deployment state—and re-certifying 10 existing states in order to maintain their ITD core compliance; conducting five state core compliance reviews; performing monthly data quality assessments on states' input data, and monitoring their performance; and developing enhancements to the online information portal, including the addition of a jurisdiction weight station map and complex query reports.

As a result of electronic screening, 189,962 inspections were conducted in 2019, and 56,001 vehicles and 6,792 drivers were put out of service. The ITD program ensures the safety of the nation's roads by making inspections more efficient and accurate, preventing high-risk CMVs from causing dangerous incidents on the roads. The Volpe Center's team of information technology experts and analysts will continue to support FMCSA and the ITD program in making the nation's roads and highways safer for everyone. **(Sponsored by FMCSA)**

Transferability of Automation Technologies to Transit Buses

Vehicle automation technologies enable systems in which at least one element of vehicle control (for example, steering or speed control) occurs without direct driver input. Although automation systems for light-duty and commercial trucks are increasingly available, these systems have yet to appear in transit buses. The Federal Transit Administration (FTA) asked the Volpe Center to examine the state of the industry and the feasibility of transferring currently available automated vehicle technologies being used in light-duty vehicles and commercial trucks to transit buses.

Automation systems are typically tailored to support important use cases of the vehicle in question; the use cases consider environmental infrastructure and operational elements. Based on the evaluation of over 50 use cases, Volpe concluded that transit buses would benefit from automation systems that improve safety, enhance the operation of the bus during passenger pick-up and drop-off, or facilitate handling of the bus in the bus yard/barn and maintenance facility. A set of 13 available automation systems was selected for detailed analysis of transferability. The table below provides additional information about the automation systems selected for analysis.

Volpe Center engineers considered the associated technical and safety challenges of implementing those systems and ways to overcome barriers to implementation. The transferability of each system was given a grade of Red, Yellow, or Green, with Green indicating most ready and/or easily transferred.

The Volpe Center concluded that transferring existing automation systems from other vehicle body types to transit buses is not straightforward and will generally require modification, replacement, or redesign of components and systems on transit buses.

Sensors are a relatively mature technology, and should be adaptable to buses without modification. But to enable automation systems, the transit bus industry will need to implement new foundational vehicle actuation systems for propelling, steering, and braking. The research found that modifying propulsion systems should be easier than adapting steering and braking systems. Heavy-duty vehicle steering solutions that enable automation on transit buses exist and may not require extensive changes. Implementation of electronic control of a transit bus brake system appears to be a major challenge; the pneumatic brakes found in buses are less conducive to automation, and therefore more extensive design changes may be needed.

Automated applications may also require a new databus communication system architecture with bandwidth to carry numerous complex signals reliably. Finally, buses will require new human-machine interfaces to control automation systems, although these should be relatively easy to design and implement. **(Sponsored by FTA)**

Relevant Automation Systems and Modification Classifications

GREEN

Minor Modifications

- Object Detection and Collision Avoidance

YELLOW

Major Modifications

- Lane Keeping/Lane Centering
- Steering Assist
- Docking
- Park Assist
- Park Out
- Yard Park

RED

New Technology Required

- Automatic Emergency Braking
- Reverse Brake Assist
- Full Park Assist
- Valet Parking (Bus Yard)
- Adaptive Cruise Control with/without Stop-and-Go
- Traffic Jam Assist with Lane Keeping/Lane Centering

Source: FTA, *Transit Bus Automation Project: Transferability of Automation Technologies (Final Report).* FTA Report No. 0215, Figure ES-1, p. 1 September 2018

Determining Requirements for Automated Transit Bus Test Facilities: Considerations for Practitioners

Automation technologies have advanced rapidly in recent years, and have the potential to deliver numerous benefits for the nation's transportation system. Applying these technologies to transit buses can lead to improved safety, better service, lower costs, and greater efficiency. Transit agencies and other stakeholders need further test results, demonstrations, and policy guidance in order to better assess implementation issues and make informed decisions before deploying these innovative technologies.

The Federal Transit Administration (FTA) partnered with the Volpe Center to develop the Strategic Transit Automation Research (STAR) Plan , which outlines FTA's five-year research agenda on automation technologies. This includes a range of possible demonstration projects that may be conducted by transit industry/stakeholder research teams.

The STAR plan underscores the importance of research and testing of automated transit vehicles, which is necessary to demonstrate the safety, effectiveness, feasibility, durability, and maintainability of these innovative systems. Research teams planning to conduct automated transit bus testing will need to identify test sites with appropriate attributes required to support their work. FTA asked the Volpe Center to develop an advisory reference document that would enable a research team to select a test site that meets the requirements of a given study.

The Volpe research team sought to understand testing needs for previous projects, ongoing work, and planned work through interviews with U.S. DOT stakeholders in FTA and other modal administrations and external stakeholders including bus manufacturers, suppliers, transit agencies, associations, and existing test facilities. The team also performed site visits to current test facilities to understand their features and identify important gaps relative to future testing needs.

The results of this work were published in a report titled Determining Requirements of Automated Transit Bus Test Facilities: Considerations for Practitioners, released by FTA in February 2019. The project yielded an advisory list of 91 test site requirements related to the infrastructure, equipment, and personnel needed for an automated transit bus research study. These fall into six categories:

- **Test Center Features:** Physical features of the facility needed to support testing.

Above: Pierce Transit Bus at Virginia Tech Transportation Institute (VTTI) Test Facility with Simulated Transit Stop and Pedestrian Target in Background. Source: U.S. DOT Volpe Center

- **Functionality and Performance:** Permanent or temporary equipment or mock-ups needed to verify and quantify functionality and/or performance.
- **Safety:** Protocols and resources needed to verify system safety during testing and deployment.
- **Environmental Resilience:** Ability to control or simulate environmental factors such as lighting, visibility, and precipitation.
- **Human Factors:** Resources needed to verify and quantify human factors issues for the system.
- **Data Collection and Management:** Resources needed to acquire, store, and analyze relevant test data.

In choosing to define the test program, FTA advises research teams to carefully evaluate whether each of the requirements should be considered applicable for the specific test program. **(Sponsored by FTA)**

Improving Airspace Management During Space Launch and Re-Entry Operations

The United States is entering a new era in space transportation. Companies such as SpaceX, Virgin Galactic, and Blue Origin are accelerating the pace of technological innovation of the commercial space industry through applications such as payload delivery and space tourism. While a boon to eco-

nomic growth and U.S. competitiveness globally, the increasing frequency and complexity of space vehicle missions presents unique challenges for the FAA to efficiently manage launch and re-entry (L/R) operations across the National Airspace System (NAS).

Currently, the Federal Aviation Administration (FAA) blocks off large portions of airspace during space vehicle missions, often for longer than may be needed to ensure public safety. Impacted air traffic must fly longer routes during these windows—in some cases, adding more than 150 nautical miles to a route and incurring in excess of 20 additional minutes of travel time. FAA traffic managers and air traffic controllers also experience increased workload from traffic that is rerouted to avoid the affected airspace. This practice of protracted airspace closures is necessary due to the lack of automated and integrated means for FAA to:

1. Track space vehicle positions in real-time, and
2. Quickly and efficiently release airspace once the L/R event no longer poses a hazard to other air traffic.

Above: A rocket launches from Cape Canaveral, FL.
Source: ©123rf.com/emel82

FAA is developing a Space Data Integrator (SDI) capability to enhance situational awareness for traffic managers during L/R operations and ultimately reduce the impact of these missions on the flying public. SDI will automate many manual methods currently used for processing space vehicle position and hazard data, and will enable more dynamic management of airspace and traffic flows. Critically, SDI will enable improved responsiveness by traffic managers during off-nominal events such as vehicle failures. SDI will also help realize operational efficiencies and cost savings through reductions in airborne delays, aircraft reroutes, and expenses to aircraft operators from additional fuel burn.

The Volpe Center is uniquely positioned to help FAA operationalize an SDI capability. With expertise in Traffic Flow Management (TFM) systems and operations, as well as in data exchange mechanisms and standards, a Volpe technical team is directly contributing to the development of this capability. Specifically, this team is leading the definition of requirements for SDI to interface with FAA TFM systems to automate the processing, display, and exchange of essential mission-related data. As part of this effort, the team is evaluating the feasibility of using existing FAA information services, such as the System Wide Information Management platform, to implement aspects of SDI functionality in the near term to begin realizing benefits of the FAA vision for SDI. **(Sponsored by FAA)**

Creating a Safer and More Efficient Oceanic Airspace Through Space-Based Surveillance

Surveillance technology that allows aircraft to determine their position automatically through satellite navigation can improve safety and efficiency through enhanced situational awareness. FAA is currently analyzing how to improve oceanic coverage with a highly accurate and reliable system for tracking aircraft, called Automatic Dependent Surveillance–Broadcast (ADS-B) using receivers on satellites.

The Volpe Center plays a critical role in the FAA program that is responsible for evaluating and implementing Space-Based ADS-B (SBA) service, the Advanced Surveillance

Enhanced Procedural Separation (ASEPS) program. Through this program, FAA is currently evaluating opportunities to upgrade infrastructure to use ADS-B in U.S. oceanic airspaces, and offshore airspace such as the Gulf of Mexico and the Caribbean. The Volpe Center currently provides management support for the ASEPS program—including overseeing program scope and execution, and managing more than 28 support staff and the program's budget—and provides engineering support.

The Volpe Center's work in support of FAA's ASEPS program includes completion of an Operational Evaluation in the Caribbean using SBA data on the en route automation system to expand ADS-B coverage. The goal is to use this operational evaluation to test the technology for future expansion and use.

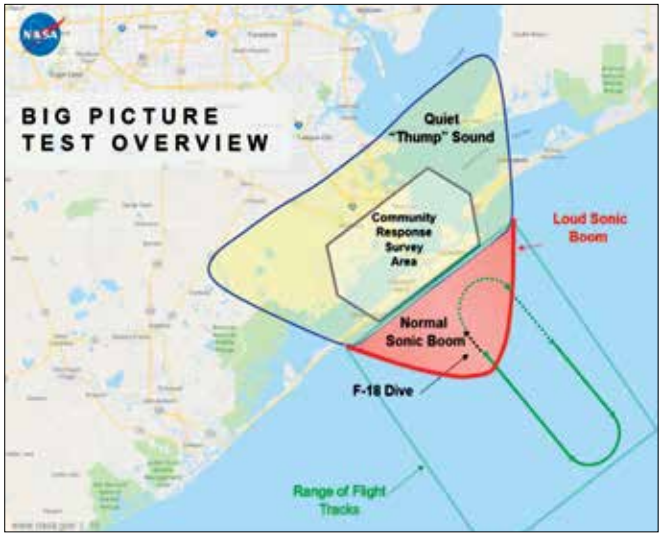
At the same time, Volpe Center technical staff continue to explore potential options to accelerate ADS-B service in the oceanic environment.

In the mid-term, a Volpe team will evaluate opportunities to improve contingency/disaster recovery operations using ADS-B service, and identify possible opportunities and solutions to improve air traffic service efficiencies.

Moving forward, the Volpe Center will support development of a future concept for oceanic operations leveraging a holistic approach that includes enhanced surveillance, enhanced communications, automation changes, expanded use of weather products, air navigation service provider coordination, and route structure changes. **(Sponsored by FAA)**

Technology Enabling Civil Supersonic Flight Including Community Response and Evaluation of Potential US Policy and Regulations

Supersonic travel became a reality 50 years ago when the Concorde airliner made its debut at the Paris Air Show in 1969, and was introduced commercially in 1976. The Concorde's problem was the sonic boom it generated at high speed. The noise was so disturbing to people and animals on the ground that federal regulations were passed to limit the aircraft's supersonic operation to over the oceans. Over land, it was restricted to subsonic speeds, which required higher, more expensive fuel consumption that made it difficult to sustain a profit. The aircraft was retired from commercial service in 2003.



Above: The QSF18 Test over Galveston, TX. Source: NASA

Recently, interest in supersonic commercial flight has been revived. The ideal scenario would be to make supersonic air travel available without generating sonic booms. New research has suggested the sonic boom footprint felt on the ground can be minimized to tolerable levels through aircraft design.

Because aircraft sound pollution is regulated today in the U.S. and internationally, establishing a standard for acceptable noise will be essential for the return of supersonic commercial flight. In support of the National Aeronautics and Space Administration (NASA) and FAA, a team of Volpe Center noise experts are helping to develop the science and gather data to support regulatory processes and potential changes to FAA's supersonic civil flight ban. The Volpe team is building confidence in low-boom flight technologies through sonic boom measurement, modeling, and minimization. NASA leads the design/build/execute mission, while FAA leads the regulatory initiative in the U.S. and participates in international rule making.

NASA's Low-Boom Flight Demonstrator (LBFD) project is a comprehensive effort to gather data needed to support new rules allowing commercial supersonic flight over land. The project has funded the development of the X-59 QueSST (Quiet Supersonic Technology), an American experimental supersonic aircraft. The QueSST's airframe is designed to substantially reduce the sonic boom felt on the ground. Its first test flight is scheduled in 2021.

To prepare NASA for future X-59 tests, the Volpe Center team has led the development of a detailed conceptual plan to scientifically gather people's perceptions about

sonic "thump" sounds. Volpe has assisted NASA throughout the research effort and is expected to continue this work, including supporting future flight tests of the X-59 QueSST demonstrator.

Over a two-week period in November 2018, NASA flew a supersonic F/A-18 jet 52 times in a unique diving maneuver over the Gulf of Mexico. This maneuver created quieter sonic thump shockwaves in a specific area or footprint. These footprints each covered approximately 60 square miles. NASA researchers matched community feedback from about 500 Galveston-area residents to the sound levels from each of the flights using an electronic public survey and microphone monitor stations on the ground. Extensive analysis of the data gathered during the QSF18 tests was conducted in 2019. These results will be used to inform researchers developing plans for future community testing with the X-59 demonstrator.

The Volpe Center is also supporting the FAA under the International Civil Aviation Organization's Committee on Aviation Environmental Protection (ICAO/CAEP). Volpe is providing expertise and participating in analysis that could aid in the development of potential en route sonic boom noise certification measurement procedures and analysis protocols. In parallel, Volpe experts will work with government agencies, industry, and academia to assess the potential environmental impact of a wide range of future supersonic aircraft demand scenarios. The ICAO/CAEP modeling activity will be conducted over the next two-plus years, with final results to be presented at the CAEP's 12th meeting in February 2022.
(Sponsored by NASA and FAA)

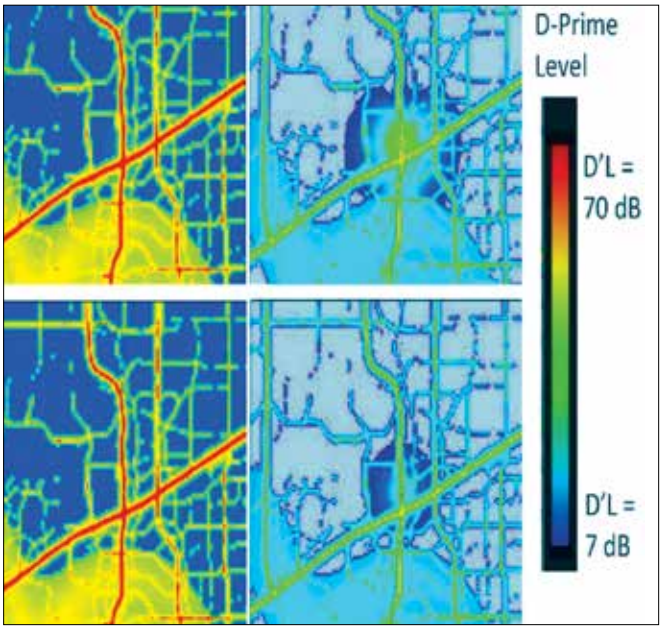
Can On-Demand Aviation Relieve Traffic Congestion?

Every day, in cities around the world, commuters spend millions of hours on the road traveling to and from work. According to U.S. Census Bureau data, the average commute for most Americans was just over 27 minutes one way in 2018.[1] The typical worker spent 225 hours commuting, or more than nine full days stuck in their car. Traffic congestion costs Americans $166 billion a year in lost wages and increased fuel.[2] On-demand aviation could be the answer to spending less time on the road and less money on the commute.

Commuters travel by various modes—car, bus, train—but typically not yet aircraft. To improve urban mobility and shorten commutes, Uber Elevate is fostering development of an aerial ridesharing network using vertical takeoff and landing (VTOL) aircraft. These aircraft would carry small groups of passengers between suburbs, cities, and within cities.

"Urban air mobility is joining autonomous vehicles, drones, and reusable rockets in a wave of transportation innovation that will change the way we live, work, and travel, and the Department is already playing an important role in enabling this change," said Elaine L. Chao, U.S. Secretary of Transportation at the Uber Elevate Summit in 2019. For such a system to work, however, Uber recognizes that communities must first accept the idea. VTOL noise levels must be quiet enough to not disturb the public and hinder acceptability. In 2016, Uber Elevate published noise objectives for its vehicles—VTOLs operating from vertiports and vertistops should approach noise levels half those of a truck traveling on a

Below: A comparison of audibility (D-prime metric) of a conventional helicopter and a notional eVTOL during the daytime and night is shown. The top two images are the conventional helicopter. The bottom two images are the notional eVTOL aircraft. The two graphics on the left side are during the morning rush hour and exhibit higher background noise levels. The two graphics on the right side are during the night and exhibit lower background noise levels. The noise from the eVTOL and conventional helicopter is masked during daytime operations. The noise from the eVTOL has significantly lower audibility levels than the conventional helicopter for nighttime operation. Source: U.S. DOT Volpe Center



1 "Average Travel Time to Work in the United States by Metro Area," U.S. Census Bureau, accessed November 4, 2019, https://www.census.gov/library/visualizations/interactive/work-travel-time.html.

2 David Schrank, Bill Eisele, and Tim Lomax, Urban Mobility Report 2019, (Texas A&M Transportation Institute, August 2019), https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2019.pdf.

residential road (approximately 62 dB LAmax at 500 ft. altitude), or about one-fourth as loud as the smallest four-seat helicopter on the market.

Existing tools and regulatory metrics were insufficient to determine the noise characteristics of VTOLs and assess community acceptability. That's where the Volpe Center's engineering design and software development capabilities came in handy.

Volpe Center experts developed a georeferenced noise modeling tool based on the Advanced Acoustic Model (AAM), and worked closely with Uber Elevate and acoustic experts from the University of Cambridge, United Kingdom and Josephson Engineering in California to implement a time-varying loudness capability, in order to facilitate acoustic research of VTOLs and understand community response. Recently, the Volpe Center developed and released AAM Version 2.4, which incorporates time-varying loudness with one-twelfth octave band spectral analysis and mixed fidelity analysis modes. Research found, just like that of a helicopter, VTOL noise is masked by existing background sounds during the day. During the night, VTOL audibility levels are significantly lower than those of helicopters.

Volpe's work in support of improving urban air mobility is informed by its work on other transportation innovation technologies including unmanned aircraft systems and automated vehicles. **(Sponsored by Uber Technologies, Inc.)**

Information Sharing Streamlines Airport Operations and Reduces Congestion

Much of the inefficiency that exists in today's air transportation system stems from a lack of information-sharing among the operators responsible for managing air traffic in busy terminals. NASA, FAA, and the aviation industry have developed technologies to improve handling of arrivals, departures, and airport surfaces, but to date, these capabilities have largely been developed and implemented independently.

The Volpe Center participated in a field demonstration of a system aimed at integrating information from each of these sources. Called the Airspace Technology Demonstration 2 (ATD-2), the demonstration brought together numerous federal agencies, private partners, and academic institutions for a field test at the Charlotte Douglas International Airport.

Engineers from the Volpe Center developed the system-wide information management (SWIM) data services and infrastructure that allowed airlines in the demonstration to share information with FAA and air traffic controllers. Building on this technology, the ATD-2 team fielded and tested a first-of-its-kind integrated arrival, departure, and surface (IADS) system. The IADS system integrates information from air traffic control and airlines to make decisions about departures, arrivals, and other air traffic functions. The SWIM technology developed by the Volpe team serves as the cornerstone of this system, making information transfer between the many operators possible. In addition, Volpe Center analysts conducted the safety risk assessment of the technology demonstration. A Safety Risk Management Document (SRMD) is required for any change to a system or new system in the NAS that is used by air traffic controllers.

Although the demonstration is ongoing, the ATD-2 is already showing improvements to the predictability and operational efficiency at Charlotte Douglas International Airport. Field demonstration results of departure metering from Phase 1 through Phase 2 thus far (September 29, 2017 through April 15, 2019) suggest that the ATD-2 IADS system saves fuel and emissions, reduces congestion on taxiways, and improves compliance with scheduled takeoff times for managing overhead stream insertion.

Benefit totals of the ATD-2 field demonstration at Charlotte Douglas International Airport through Phase 2 have saved 2,149,728 pounds of fuel, reduced 6,621,161 pounds of carbon dioxide emissions, saved 1,681 hours of engine run time, reduced delays by 248.8 hours, and saved passengers an estimated $1,194,080 in valuable time and operators an estimated $338,358 in flight crew costs.

The ATD-2 team received the NASA Aeronautics Administrator's Technology and Innovation Award, which recognizes work that has a profound positive impact on NASA's aeronautics research mission. The team has been demonstrating the system at the SWIFT (SWIM Industry Forum Team) workshops since the SWIFT workshop held at American Airlines in Dallas-Fort Worth in May 2019. **(Sponsored by FAA and NASA)**

Improving Vessel Traffic Forecasting for the St. Lawrence Seaway

The movement of cargo through the St. Lawrence Seaway currently supports more than 329,000 jobs and $46 billion in economic activity. More than 200 million tons of commercial cargo are transported on the waterway each year, providing low-cost and efficient transportation for the region's manu-

Above: Volpe Center staff join U.S. Secretary of Transportation Elaine L. Chao and SLSDC Deputy Administrator Craig Middlebrook in September 2019 as part of the St. Lawrence Seaway's 60th anniversary celebration. Source: SLSDC

facturing, mining, agriculture, and energy sectors.[3] However, the Seaway has reached a physical limit in terms of cargo per vessel. For example, the "Laker" fleet—vessels designed specifically to transit both the Seaway and the Great Lakes—have a maximum beam that leaves just two feet of total space between the vessel and the walls of the lock.

To sustain economic competitiveness—and to enable the Seaway to accommodate future growth in vessel traffic demand—innovative technologies and methods are needed to help optimize the movement of these vessels. A comprehensive Vessel Traffic Flow Management System will dynamically and automatically balance vessel capacity and demand throughout the Seaway to reduce system delays, lower fuel emissions, improve information exchange among operators and users of the Seaway, and enable more efficient use of operational personnel. The St. Lawrence Seaway Development Corporation (SLSDC) turned to the Volpe Center to achieve this vision.

Volpe experts are currently developing a prototype tool to forecast vessel traffic demand at locks and other critical infrastructure within the Great Lakes St. Lawrence Seaway System with greater accuracy and earlier notice than other available tools. The prototype aims to demonstrate potential improvements to the predictability of vessel transit times along the Seaway based on selected impact factors that could increase operational efficiencies and enhance situational awareness among both traffic controllers and Seaway users, such as vessel carriers and pilotage organizations.

This project is a quintessential example of how Volpe successfully leverages and blends expertise through collaboration across its technical centers to provide the most informed engineering solutions possible. Collectively, Volpe's data analysis capabilities are being applied to evaluate historical data from Seaway operations, including vessel positions and system delays. In parallel, prototype software is being developed that projects vessel demand on Seaway infrastructure assets such as locks and moveable bridges—drawing from similar capabilities previously developed by Volpe for use in air traffic flow management operations. Experience with human factors engineering is contributing to the development of notional interfaces and displays for exchanging data among Seaway users and operators.

In September 2019, the Volpe team presented a demonstration of its prototype demand forecast tool to U.S. Secretary of Transportation Elaine L. Chao, SLSDC Deputy Administrator Craig Middlebrook, and numerous stakeholders as part of the Seaway's 60th anniversary celebration **(Sponsored by the SLSDC and ITS-JPO)**

3 "The St. Lawrence Seaway: A Vital Waterway," Great Lakes St. Lawrence Seaway System, accessed November 5, 2019, http://www.greatlakes-seaway.com/en/seaway/seaway60/index.html.

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HISTORICAL NOTE

St. Lawrence Seaway: A Major Step Forward

The Volpe Center has been in the vanguard of developing and deploying state-of-the-art, easy-to-use, cost-effective vessel-tracking networks that enhance maritime situational awareness in waterways around the world.

In 2002, in collaboration with our partners at the St. Lawrence Seaway Development Corporation, a Volpe Center team designed and deployed an Automatic Identification System (AIS) based data network, dramatically improving navigation safety and traffic management on the Saint Lawrence Seaway.

The Saint Lawrence Seaway was the first waterway in the Western Hemisphere to operationally employ AIS technology.

Enhanced Maritime Domain Awareness Improves Safety on the World's Oceans

Safety and security on the world's waterways and oceans requires a willingness among nations to collaboratively address regional and global maritime domain awareness (MDA) issues. Safe maritime operations also lead to opportunities for economic stability by enhancing the secure global transfer of goods. Through enhanced MDA, countries can reduce smuggling, fishery violations, drug and human trafficking, terrorism, and environmental degradation.

The Volpe Center has developed the technology to enable improved MDA through data sharing between countries worldwide. In support of the U.S. Navy starting in 2006, Volpe Center engineers created the Maritime Safety & Security Information System (MSSIS). MSSIS is a freely shared, unclassified, data collection and distribution network that combines Automatic Identification System (AIS)[4] data from participating nations into a single data stream through secure Internet-based servers. Transview (TV32), a Volpe-developed Windows application, is the primary communications and chart display client for the MSSIS network. By contributing AIS data into MSSIS, a country becomes eligible to receive AIS data from over 70 nations participating in MSSIS. Technical assistance is available to any country willing to participate.

In developing countries in Africa and elsewhere, enhanced MDA offers numerous benefits. The U.S. Department of Defense (DoD) is encouraging these countries to build out the AIS infrastructure with U.S. assistance in the interest of increasing security cooperation.

The two critical utilities for AIS data transmission are electrical power and the Internet. In remote areas, either may be unavailable or unreliable, limiting a country's ability to meet AIS requirements and join the MSSIS network. In 2017, DoD's Defense Threat Reduction Agency (DTRA) asked the Volpe Center to help solve this problem and field test a solution in the Philippines.

Unlike Volpe's previous MDA contributions, the solution in this case is not software, but hardware. The completed kit comprises two small solar panels; antennas for AIS signal reception and Internet transmission; batteries, AIS receiver; an embedded computer; and a modem to send the AIS data to MSSIS for distribution. The kit is light enough to hand carry through rough terrain for installation.

In the Philippines, equipment is often positioned in remote areas that are hard to reach by foot or vehicle. To install the remote AIS equipment, a two-person Volpe technical assistance team is augmented with Philippines Coast Guard personnel. The combined group sometimes needs several modes of transportation to get to the final destination. This usually includes being ferried by a powered outrigger canoe to the island; trekking through dense jungle; and backpacking equipment to the site. Once installed, the integrity of the system components are monitored remotely by engineers at Volpe.

The solar-powered remote AIS units will vastly improve the MDA capabilities of the Philippine Navy, allowing the country to track vessel movements and maritime activity along the coastal waterways of its more than 7,000 islands. **(Sponsored by DoD/DTRA)**

Cutting-Edge Military Supply Chain Innovation System Streamlines United Kingdom Military Cargo Movements Worldwide

Like the U.S. Department of Defense, the United Kingdom Ministry of Defence (UK MOD) relies upon both military and commercial transportation to move its critical military equipment and supplies worldwide. Since 1993, the Volpe Center has worked closely with the UK MOD and, more specifically, its Customs Compliance entity, the WATERGUARD Programme, to help conceptualize, design, and develop a first-of-its-kind multimodal and multi-leg military supply chain logistics information system, also known as the Remote Access Movements Portal (RAMP). End-state RAMP was developed to support all Royal Air, Navy, Army, and Customs Compliance military supply chain logistics needs across the global theatre including land, sea, air, and rail.

RAMP combines data from multiple sources (industry, government, military) and enables the end user to not only move military assets and cargo from a point of origin to a desired destination, but also to research, request, assign, schedule, track, and analyze available multimodal transport options that reduce waste, comply with customs regulations, and support UK MOD business needs. The goal of RAMP is to standardize and streamline business needs across all branches of the UK military, in addition to better utilizing current and forthcoming military equipment, reduce wasteful

4 The Automatic Identification System (AIS) enables the automatic exchange of vessel identity data and real-time vessel movement data between ships, and between ships and shore stations. The International Maritime Organization mandates that all passenger ships, all cargo ships of 500 gross tonnes or more, and ships of 300 gross tonnes or more on international voyages, be equipped with AIS. Over 100,000 vessels now use AIS.

Above: The top screenshot shows near real-time military flight and ship movements with military station information using a prototype multimodal and multi-purpose military cargo visualization, reporting, and analytics tool. The bottom screenshot shows a mock-up of the end stage of the prototype tool and includes multimodal, multi-leg movements in addition to other cargo-specific information.
Source: U.S. DOT Volpe Center

UK MOD spending, reduce military equipment warehousing and storage, and better utilize existing military cargo space aboard all multimodal transport options.

The Volpe Center has proven expertise in military cargo movement operations worldwide. In 2010, Harvard University's Kennedy School of Government's Bright Ideas program selected Volpe's near real-time, web-based interface of UK MOD cargo operations as an exemplary model of government innovation.

As RAMP's creator, Volpe experts perform extensive on-site RAMP application development in Cambridge, Massachusetts, in addition to managing RAMP's future application innovation and direction alongside RAMP's UK MOD product owner and the UK MOD user fraternity. While many of RAMP's applications are currently under development, with many more applications in progress for 2020 and beyond, the system is no longer regarded as a prototype. It is being prepared for enterprise use as a UK MOD critical military system, with thousands of projected military supply chain users, operating as the premier military cargo movements system for the entirety of the Royal militaries. The latest RAMP applications showcase how the UK government is making ground-breaking strides in the standardization of its military supply chain activities and processes, unifying how the Royal militaries conduct movements, and streamlining not only equipment and support acquisition, but also receipt activities and standards.

RAMP's innovative transportation-related defense logistics capabilities fill a significant gap in multibranch and multimodal military supply chain operations, since no such system exists either domestically or internationally. The UK MOD's RAMP provides an advanced tracking and assignment tool for military cargo movements that is cutting-edge, innovative, and economical. For the U.S. DOT, RAMP illustrates that it is capable of collaborating with foreign governments to build in-house technical expertise and provide innovation in the military movement and cargo tracking arenas, paving the way for future multimodal and multibranch military movement needs around the world. (**Sponsored by UK MOD**)

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YEARS

INFRASTRUCTURE AND TRANSPORTATION SYSTEM RESILIENCE

THE VOLPE CENTER COLLABORATES WITH FEDERAL AGENCIES TO SUPPORT CIVILIAN AND DEFENSE INFRASTRUCTURE AND RESILIENCY EFFORTS THAT FURTHER U.S. ECONOMIC GROWTH AND ENABLE MORE EFFICIENT MOVEMENT OF PEOPLE AND GOODS.

Opposite: The transportation system depends on GPS. The Volpe Center is exploring complementary services in the event of a major GPS disruption. Source: ©123rf.com

Supporting PNT Resiliency in the Transportation Sector Through Demonstration of GPS Backup and Complementary PNT Technology

Accurate sources of Positioning, Navigation, and Timing (PNT) information support critical infrastructure in the transportation sector and are essential for national security. The primary and most recognizable service supporting critical infrastructure is the Global Positioning System (GPS). However, because GPS relies on signals broadcast from the constellation, its signals are low power at the receiver and thus open to vulnerabilities from intentional and unintentional disruption.

The Volpe Center is supporting the U.S. DOT Office of the Assistant Secretary for Research and Technology (OST-R) by conducting field demonstrations of candidate PNT technologies that could offer complementary service in the event of a major GPS disruption. The demonstration will focus on technologies at a high Technical Readiness Level (TRL) that can work in the absence of GPS. The effort stems from the 2018 National Defense Authorization Act (NDAA) Section 1606, which

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Vulnerability of the Global Positioning System

On September 10, 2001, the U. S. DOT, in consultation with the DoD, released a landmark report prepared by the Volpe Center that assessed the vulnerability of the national transportation infrastructure that relies on the Global Positioning System (GPS) to intentional or unintentional interference. A day later, on September 11, concern about the vulnerability of the nation's critical infrastructure became the driving force for national transportation policy.

"This report provides a roadmap for addressing possible vulnerabilities in GPS so that we can continue maintaining the highest standards of transportation safety," said then U.S. Transportation Secretary Norman Y. Mineta. The findings were initially used by DOT's operating administrations to strengthen safety-critical areas that have an impact on aviation, maritime, railroads, and intelligent transportation systems.

directed the Secretary of Defense, the Secretary of Transportation, and the Secretary of Homeland Security to jointly develop a plan for demonstrating non-GPS PNT capabilities.

With funding provided by the U.S. Air Force (USAF) and OST-R, the Volpe Center will stand up demonstration sites at NASA's Langley Research Center and at the Volpe Center's Aviation Weather Research Facility on Joint Base Cape Cod. The Volpe Center will prepare a field campaign, develop data collection, and PNT reference systems. In parallel, the Center has contracted with 11 technology vendors to support the demonstration and will be coordinating infrastructure installation(s) and user equipment to exercise PNT technologies in the demonstration.

The Volpe Center developed and executed an accelerated acquisition strategy to award purchase order contracts with the 11 technology vendors to support the demonstration. This strategy included input from a recently published U.S. DOT Request for Information to form awareness of vendors who wish to participate in the demonstration and provide information on their respective technologies. The field demonstrations are planned for March 2020, after which the Volpe Center will draft a PNT technology report to inform the National Space-Based PNT Executive Committee as to candidate technology, which will in turn provide input to Congress as called out in the 2018 NDAA legislation.
(Sponsored by USAF and OST-R)

Tools to Augment Transportation Infrastructure Resilience and Disaster Recovery

Fourteen natural disasters cost the United States $91 billion in 2018, according to a report from the National Oceanic and Atmospheric Administration (NOAA). Damage caused by droughts, wildfires, eight severe storms, and two winter storms impacted not only homes and businesses, but also the nation's vital transportation network—roads, bridges, tunnels, railroads, ports, and airports.

When natural disasters occur, how can communities overcome these events quickly and efficiently? Investing in transportation resilience—the ability of a transportation system to maintain or quickly return to functioning at an acceptable level in the face of one or more major obstacles—is one effective solution. The main concern in addressing transportation resilience is ensuring that infrastructure can withstand the next storm.

While the federal government often pays for immediate recovery after a natural disaster, non-federal cost-sharing requirements make both federal and non-federal partners (e.g., states, localities) responsible for funding mitigation efforts. These partners must be able to accurately assess the value of resilience in future infrastructure investments, which means understanding and incorporating the cost and benefits of resilience into project prioritization and the decision-making process.

Through its National Response and Recovery Program, the Office of the Secretary of Transportation (OST) has identified the need for a nationally replicable modeling tool to estimate the regional-scale impacts of natural or man-made disasters on the transportation system, reduce uncertainty, and improve pre-event planning and after-event recovery. The Federal Highway Administration (FHWA) is coordinating the tool's development with OST-R and OST's Office of Intelligence, Security and Emergency Response, and has asked the Volpe Center to be the lead tool developer.

Above: Washed out roadway in Jackson County, Mississippi after Hurricane Nate in October 2017. Source: The Mississippi National Guard

With a multidisciplinary technical team combined with highly developed modeling skills and geographic information system and software development capabilities, the Volpe Center is well positioned to support this important project.

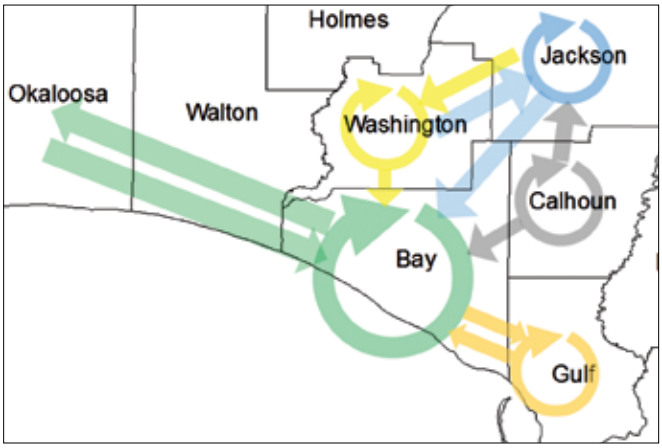
Development of the tool is in its early stages and will be completed over at least two phases. Ultimately, the tool will be able to estimate the regional-scale and societal impacts and associated costs of natural or man-made hazards on the transportation system. It will evaluate infrastructure resilience investments and their effect on associated costs and societal impacts under a given hazard condition, and it will enhance short-term disaster recovery project prioritization and decision making.

Natural and man-made disasters have been proven to be costly as well as dangerous. Hurricanes accounted for over a quarter trillion dollars in insured and uninsured losses in 2017, according to NOAA. This powerful modeling tool will help state DOTs, metropolitan planning organizations (MPOs), and federal agencies better understand the costs and benefits of investing in infrastructure resilience, and how to prioritize these investments so that the transportation sector is better prepared. **(Sponsored by FHWA)**

Understanding Transportation Needs in the Aftermath of Natural Disasters

Little is known about survivors' individual transportation needs in the aftermath of natural disasters—especially as disaster response shifts from life-saving operations to longer-term recovery activities.

Since Hurricane Katrina in 2005, the Volpe Center has worked with the Federal Emergency Management Agency (FEMA) to assess post-disaster conditions that impact survivor access to transportation, including transportation demand, constraints that transportation providers face, and the legal and administrative frameworks that affect how transportation services can be provided in disaster-affected areas. In the last year, the Volpe Center partnered with FEMA to apply an assessment methodology in the Florida Panhandle after Hurricane Michael, and in Northern California after the Camp Fire. The resulting transportation service plans address fundamental questions about post-disaster transportation supply and demand, taking into consideration that survivors' needs are immediate and dynamic.



Above: Top origin counties and destination counties among inter-county commuters in Bay County, Florida and vicinity. Source: Data provided by the Florida Department of Economic Opportunity. Visualization provided by U.S. DOT Volpe Center

The Camp Fire destroyed nearly 14,000 homes in Butte County, California. Soon after the disaster, FEMA and partners began working to identify and offer interim housing options to an estimated 980 households. As of May 7, 2019, 88 families were utilizing transportation shelter assistance and 298 households were placed in 18 leased commercial housing sites across 8 counties. Additionally, FEMA identified four temporary housing communities in Butte County that would provide housing for more than 550 households. Initially, FEMA had very little information about the transportation needs of these survivors.

In May 2019, the Volpe Center delivered the Transportation Service Plan for Disaster Survivors, Northern California: Camp Fire Recovery to FEMA. The plan establishes a framework for providing transportation support to survivors displaced to interim housing. The Volpe Center team interviewed officials at all levels of government to understand transportation constraints and opportunities in the affected regions. The team also used geographic information system tools to analyze transit service around temporary housing locations to suggest possible service modifications.

During disaster recovery, transportation service plans like the one developed for Northern California have helped government officials better understand the transportation needs of displaced individuals and families and viable options for meeting those needs. **(Sponsored by FEMA)**

Transportation Planning and Outreach in West Africa and Southeast Asia

Developing countries depend on efficient transportation systems to promote economic growth and provide access to markets, jobs, and key services. The Volpe Center has successfully supported the Millennium Challenge Corporation (MCC), an independent U.S. foreign aid agency that invests in developing countries around the world to foster economic development and alleviate poverty. Additionally, in support of the U.S. DOT's Office of the Assistant Secretary for Aviation and International Affairs (OST-X), the Volpe Center has been performing outreach on a range of international cooperation and facilitation issues for several countries in South and Southeast Asia.

Many countries continue to face challenges from a rapidly urbanizing population that is straining infrastructure. MCC-funded foreign aid projects are designed to support economic development and reduce poverty in partner countries, demonstrate a strong economic rate of return, and meet other environmental and societal impact goals. The Volpe Center's teams are made up of transportation experts representing many disciplines including transportation planners, economists, political scientists, policy analysts, data scientists, and civil engineers.

Above: William Lyons, Principal Technical Advisor for Transportation Planning at the Volpe Center (second from left) with MCC and Port Authority staff at the Port of Banjul, The Gambia. Source: U.S. DOT Volpe Center

Volpe has provided technical support to MCC teams in eight countries—Lesotho, Tunisia, Liberia, Nepal, the Philippines, Cote d'Ivoire, Sri Lanka, and The Gambia. Current projects include bus modernization and traffic management projects in Sri Lanka, and assessing priority cross-border corridors for infrastructure investment and related structural reforms on the first MCC Regional Compact in West Africa. In addition to due diligence support of proposed investments, Volpe technical staff are also overseeing implementation of a five-year road sector management project in Liberia.

The team is also working with OST-X to develop and conduct international outreach that aligns with the Administration's Indo-Pacific Strategy. A recent capacity-building workshop in Jakarta, Indonesia covered multimodal transportation planning and finance for major infrastructure projects, in partnership with the Indonesian government. Volpe technical experts also accompanied OST-X staff to participate in the Association of Southeast Asian Nations (ASEAN) Smart Cities Network Annual Meeting, where the U.S. team met with ASEAN city representatives to start planning a multi-year program looking at the planning, policy, and technology aspects of smart cities in the region. This work program will support the Indo-Pacific Strategy and Vice President Pence's announcement of the U.S.-ASEAN Smart Cities Partnership, established in November 2018.

MCC and OST-X are committed to infrastructure and capacity building investments supporting stability and prosperity in partner countries. Volpe's collaboration continues to enhance its proven expertise in innovative transportation planning and policy and institutional analysis in the international sector. **(Sponsored by MCC and OST-X)**

Creating Peer-to-Peer Learning Opportunities to Better Implement Performance-Based Transportation Planning

The signing of both the 2012 Moving Ahead for Progress in the 21st Century (MAP-21) and the 2015 Fixing America's Surface Transportation (FAST) Acts catalyzed a new approach to transportation planning. MAP-21 included provisions that transformed the federal surface transportation program into one driven by performance-based outcomes. The FAST Act continued this direction set by MAP-21 with minor changes. These provisions set by MAP-21 and the FAST Act relate to Transportation Performance Management (TPM) and Performance-based Planning and Programming (PBPP).

TPM is a strategic approach using data to support decisions that help achieve national performance goals set by Congress. PBPP is how state departments of transportation (state DOTs), metropolitan planning organizations (MPOs), and public transit providers implement TPM—by integrating performance-driven insights and strategies into their planning and programming processes. Together, TPM and PBPP can improve project and program delivery, inform decisions, focus staff on key objectives, and provide greater transparency and accountability of transportation projects.

Following the establishment of the national performance goals, the Federal Transit Administration (FTA) and the Federal Highway Administration (FHWA) set distinct performance measures pertaining to transit and highways respectively to help state DOTs, MPOs, and public transit providers in documenting and tracking performance. FTA and FHWA further published the final rule on Statewide and Nonmetropolitan Transportation Planning and Metropolitan Transportation Planning in May 2016, and FTA published the final rule on Transit Asset Management in July 2016. All 50 states (including Washington, DC and Puerto Rico) and all 400 MPOs (approximately) must implement key PBPP requirements that include the development of performance-based agreements (written provisions), integration of performance-based plans into the planning process (e.g., freight, safety, or asset management plans), target setting coordination, and the development of performance-based long-range plans and programs.

As a result of this rulemaking, there was a learning curve for state DOTs, MPOs, public transit providers, and FHWA and FTA staff now required to follow this new performance-based approach. FHWA and FTA asked Volpe Center transportation planning, performance management, and capacity building experts to coordinate and deliver a series of workshops to help FHWA and FTA stakeholders fully implement TPM and PBPP.

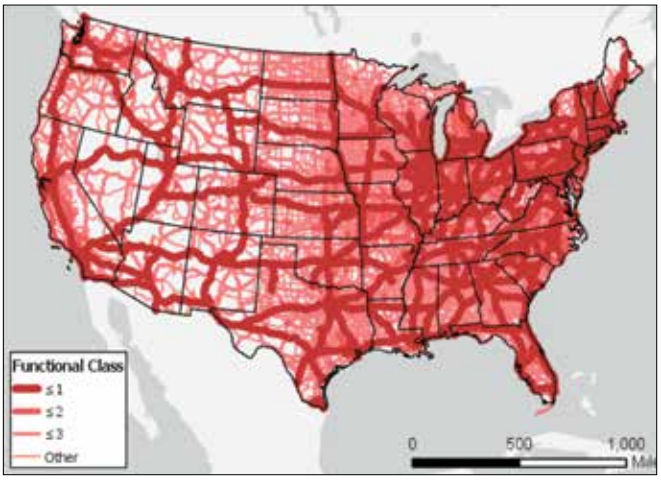
Volpe Center staff supported all aspects of the workshop series, including development of materials for and delivery of each of the workshops and close coordination with a large team of FHWA and FTA staff to organize the workshop sessions. Five workshops were held in 2019 across the country, from June through December 2019, tailored to participants in the Midwest, West, Mid-Atlantic, South, and Northeast. Through peer presentations and small group discussions, participants familiarized themselves with TPM and PBPP requirements, shared how their agencies were implementing the requirements, discussed what they had learned, and noted successes, challenges, and opportunities in implementing their efforts.

The result was a successful workshop series during which peers helped each other understand TPM and PBPP and how to better achieve goals using a performance-based and data-driven process. The five workshops involved approximately 400 participants, including 94 State DOT representatives, 102 MPO representatives, and 45 transit agency representatives. FHWA and FTA are currently assessing the results from the workshop series, with follow-on activities anticipated for 2020 to continue the momentum gained from the 2019 effort. **(Sponsored by FHWA and FTA)**

Development of a National Highway Planning Network Relies on Rich Data Sets

The U.S. DOT has maintained geographic information system (GIS)-based national road networks for over 25 years to support a wide variety of regional and national analyses. The nation's roads, and information about them, are very dynamic and it is hard to keep a GIS-based network representation of them current. Over the years, various U.S. DOT road networks have evolved for different purposes, and there are many challenges related to keeping multiple networks up-to-date and using them together.

A national road network, with a collection of core attributes that can be updated annually, can serve as a single foundation for mapping and analyzing our nation's infrastructure. This would enable the U.S. DOT and others to perform many analyses without having to go through complicated conflation processes to update and bring data together from different road networks. This effort fosters inter- and intra-agency collaboration with the resulting product helping agencies to more effectively work toward achieving their goals and missions.



Above: A view of the latest version of the National Highway Planning Network, complete with over 1.3 million road features.
Source: U.S. DOT Volpe Center

FHWA, along with the Bureau of Transportation Statistics (BTS), sponsored the development of a new National Highway Planning Network (NHPN). The objective of this project was to create a new network based entirely on Highway Performance Monitoring System (HPMS) data and All Road Network of Linear Referenced Data (ARNOLD), which is submitted to FHWA by states on an annual basis. The rich data provided by the states includes key attributes such as functional class, number of lanes, and annual average daily traffic, all of which can be used for local, regional, and national mapping, modeling, and analysis.

The Volpe Center's GIS expertise played an important role in the development of this new version of the NHPN. This project utilized ArcGIS to review state-submitted data and used Python to develop a highly automated process to develop the state networks from the raw HPMS and ARNOLD data and then bring them together into a single national network. Network disconnects within states, and network disconnects at state borders presented a significant challenge during this project. In answer to this, Volpe developed custom Python-based tools to identify and fix network breaks and to test the network to ensure that it is routable.

A unified U.S. DOT national roads network will make it easier for users to conduct analyses, reduce duplication of effort, and provide a foundation upon which to update as new user requirements arise. Additionally, this project provides an opportunity to showcase to the states how their data submissions are utilized at a national level as well as to identify areas for enhanced coordination to achieve a more consistent annual data submission. In December of 2019, the initial version was distributed to stakeholders across U.S. DOT for review. The resulting network will be freely available from the FHWA. **(Sponsored by FHWA and BTS)**

Improving Mobility by Expanding the Alternative Fuel Corridor Network

The demand for fuel-efficient vehicles by consumers and the need for a cleaner form of transportation are driving the growth of the alternative fuel vehicle market. More than a dozen alternative fuels are in production or being developed for use in alternative-fuel vehicles and advanced technology

Above: Designated electric vehicle (EV) charging corridors, fall 2019. Source: FHWA HEPGIS

vehicles.[1] Use of these fuels will help strengthen national energy security, support U.S. economic growth, enhance air quality, and offer consumers and businesses additional transportation choices. Section 1413 of the FAST Act requires the U.S. DOT to designate alternative fuel corridors (AFCs) in strategic locations along major highways for plug-in electric vehicle charging, and hydrogen, propane, and natural gas vehicle fueling.

FHWA is working with federal, state, and local officials, as well as private industry to help plan, develop, and promote a national network of alternative fueling and charging stations along National Highway System (NHS) corridors. These corridors will enable commercial and passenger vehicles powered by clean, domestically produced alternative fuels to travel reliably between cities, regions, and the entire nation. FHWA is expanding this national network by adding new corridor designations annually. To date, FHWA has solicited a total of 79 nomination proposal packages from state and local officials, resulting in AFC designations along portions/segments of 100 interstates and 76 U.S. highways/state roads, across 46 states and Washington, DC, covering more than 135,000 miles of the NHS.

1 "Alternative Fuels Data Center," U.S. Department of Energy, https://afdc.energy.gov/fuels/.

FHWA developed consistent national signage for AFCs in compliance with the Manual on Uniform Traffic Control Devices for Streets and Highways. Several states, including South Carolina, Minnesota, Louisiana, New Hampshire, and Rhode Island, are in the process of installing or have already installed AFC highway signage, which helps guide alternative

Above: Dedication of new AFC corridor signage in the state of Louisiana (from left to right: Louisiana Department of Natural Resources Secretary Tom Harris, Louisiana Department of Transportation and Development (DOTD) Secretary Shawn Wilson, Governor John Bel Edwards, and LDEQ Secretary Chuck Carr Brown). Source: LDEQ Communications

fuel vehicle drivers to available infrastructure, and creates general public awareness of alternative fuel availability.

The Volpe Center's energy analysis experts have provided FHWA with technical and programmatic support for the AFC initiative since its inception. Efforts include scoping and design of the initiative/program, development of the corridor designation process and framework, and analysis of nomination reviews and corridor highway mapping using GIS. In conjunction with the Department of Energy (DOE), FHWA has collaborated with a consortium of alternative fuel industry stakeholders to promote and advance AFC designations. Volpe team members familiar with DOE policies and programs have provided unique insight into alternative fuel vehicle technologies and build-out of associated infrastructure, in addition to key networking contacts from the public and private sectors.

In 2019, the Volpe team helped FHWA develop the Round 3 AFC designation Request for Nominations; provided general outreach and education for prospective applicants; participated in corridor nomination proposal evaluations/selections; and helped develop and maintain webinars, website content, and corridor network maps. Twenty-one Round 3 proposals were received and approved, adding 16 interstates and 32 U.S. highways/state roads to over 35,000 miles of the NHS.

FHWA has also implemented a series of AFC Convenings in various regions of the country. These meetings have facilitated regional partnership development, strengthened coordination among public and private stakeholders within and among neighboring states, evaluated priority corridors, and identified critical infrastructure gaps. This has helped foster regional strategies for advancing alternative fuel vehicle adoption, fueled infrastructure development, and encouraged corridor growth. In 2019, Volpe supported planning, development, and execution of three regional AFC Convenings in Texas, Rhode Island, and Utah. **(Sponsored by FHWA)**

Measuring Fuel Burn, Emissions, and Noise with the Aviation Environmental Design Tool

Since 2015, the Aviation Environmental Design Tool (AEDT) has been a critical element of the Federal Aviation Administration's (FAA) federally required environmental review process in response to increasing air traffic and modernization of the nation's aviation infrastructure. AEDT is a software

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Mitigating the Environmental Impacts of Transportation

The Volpe Center measures noise and emissions for all modes of transportation. In 1970, the Center created its Noise Measurement and Assessment Facility (now the Acoustics Facility) to help develop standards for transportation noise. The Volpe Center conducted acoustic research on the Concorde in the 1970s and today supports NASA research related to the next generation of supersonic aircraft, the X-59, including advancement of NASA's PCBoom and DoD's Advanced Acoustics Model, both related to supersonic flight technology.

In addition, Volpe Center engineers were the primary designers and developers of the Traffic Noise Model (TNM) for the FHWA and the Heliport Noise Model (HNM), the System for Assessing Aviation's Global Emissions (SAGE), and the Integrated Noise Model (INM) for FAA. The Center helped lead the development of the FAA's Aviation Environmental Design Tool (AEDT), a model that calculates noise, fuel burn, and emissions interdependencies during ground and flight operations at local, national, and global levels. Volpe's modeling tools are now used by over 785 users in 39 countries.

Above: The Concorde takes flight during an acoustic test.
Source: U.S. DOT Volpe Center

tool that provides data to the FAA and other agencies on the environmental effects associated with flight operations. The tool dynamically models aircraft performance in space and time to produce fuel burn, emissions, noise, and air quality data in order to assess the specific environmental impacts.

The Volpe Center, in support of FAA, leads the development and systems integration of AEDT. Volpe experts collaborate with the FAA and aviation manufacturers, as well as scientific and developer stakeholders from the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP), the European Organization for the Safety of Air Navigation (EUROCONTROL), the Georgia Institute of Technology, the Massachusetts Institute of Technology, ATAC Corporation, and many other universities and institutions. The Volpe team must maneuver a complex set of technical requirements and address a number of sometimes competing challenges, while simultaneously supporting a number of AEDT analysis efforts.

AEDT version 3b, completed in fiscal year 2019, is a transformative release of the software that significantly improves the fidelity of aircraft performance, fuel burn, and emissions modeling at low speed and altitude.

Licensed for use by more than 800 organizations in 37 countries, AEDT is the de facto global reference model for considering the interdependencies between aircraft-related fuel burn, noise, and emissions and their collective environmental effects. This sophisticated platform has positioned the United States as a leader in providing objective, data-driven policy input to ICAO/CAEP.

The positive impact of AEDT on the public within the U.S. and internationally is measurable. Relying on results generated with AEDT, the FAA is able to make environmentally responsible decisions on federal actions to improve the safety and efficiency of the National Airspace System, while being responsive to community concerns on aircraft noise. AEDT has also provided analytical capability to support policies and standards that have been developed for ICAO. **(Sponsored by FAA Office of Environment and Energy)**

Evaluating the Effects of Firefighting Chemicals in Aviation

Per- and polyfluoroalkyl substances (PFAS) are man-made chemicals that have been used in industry and consumer products worldwide since the 1950s. PFAS are highly toxic and can travel long distances, move through soil, seep into groundwater, and can be carried through air. Prolonged exposure to PFAS can lead to adverse human health effects.

Some airports in the United States extinguish fuel fires with a foam that can release PFAS into the environment. Aqueous film-forming foam (AFFF) is used by 524 commercial airports in the U.S. in compliance with 14 Code of Federal Regulations (CFR) Part 139, which defines aircraft rescue and firefighting capabilities, and mandates the use of AFFF. Because AFFF contains PFAS, CFR testing and training requirements—in addition to incident responses—may be responsible for the chemicals potentially impacting drinking water and other sensitive resources near these airports. Intense media attention in recent months has placed airports under increased scrutiny from regulators and the public.

To address PFAS concerns at FAA's most complex sites—including the FAA William J. Hughes Technical Center Superfund Site (FAA Technical Center) and the Mike Monroney Aeronautical Center—FAA's National Environmental Cleanup Program turned to the Volpe Center's environmental engineering experts for help.

The Volpe Center serves as FAA's national subject matter expert on PFAS, leveraging the latest scientific research on the chemicals' properties and behavior, site investigation methods, environmental forensic techniques, and treatment strategies. The Volpe team helped develop site investigation plans at the FAA Technical Center and the Mike Monroney Aeronautical Center, research proposals, and technical and regulatory guidance documents for government agencies and national organizations—such as the Interstate Technology and Regulatory Council (ITRC).

The Volpe team also identified best management practices for addressing legacy contamination and ongoing compliance challenges. They presented at major technical conferences on the occurrence, fate, and transport of airborne PFAS, and are currently developing a manuscript for publication in a peer-reviewed journal.

The Volpe Center's efforts have led to an increased awareness concerning the risks and impacts of PFAS at FAA facilities, as well as improvements in site investigation methods, including the identification of new sites and areas of concern. The public water supply for Atlantic City located at the FAA Technical Center, for example, has been adversely impacted by PFAS, and FAA is a potential target of future litigation. This underscores the critical need for Volpe's ongoing expertise to help ensure FAA's response actions continue to meet CFR requirements, but are also environmentally sound. **(Sponsored by FAA)**

Above: Bicyclists riding in Grand Canyon National Park. Source: NPS

Strategies to Enhance Active Transportation at National Parks

Every year, the National Park Service (NPS) welcomes more than 300 million visitors, and that number is expected to increase over the next decade. The parks and their neighboring communities face many significant challenges from increased traffic volume: vehicle congestion, noise and air pollution, and wildlife-vehicle collisions.

To address these issues, NPS is seeking new mobility solutions that allow visitors to explore the parks without a car. One increasingly attractive option is to encourage active transportation—such as biking and walking. These mobility alternatives will allow parks and communities to better manage vehicle congestion and pollution issues, while supporting local economic development and better protecting the unique natural and cultural resources of the national parks.

The NPS Active Transportation Guidebook aims to assist and inspire parks and their partners to identify and pursue opportunities that enhance active transportation to and within the national parks. The guidebook provides information about policies and regulations, and examples to improve safety, mobility, and the visitor experience through active transportation projects and programs. It covers a number of walking and bicycling topics, and applies them within the unique context and needs of national parks.

The guidebook covers:

- Implementing active transportation infrastructure, such as pedestrian paths, multiuse trails, pavement marking, signage and wayfinding, and bicycle-sharing systems and rental programs.
- Evaluating and improving safety for active transportation modes through infrastructure enhancements, education, and coordination with law enforcement.
- Incorporating innovative and emerging technologies, including existing and emerging count data sources, smartphone applications, electric and fat-tire bicycles, and automated vehicles.
- Offering activities and programs that provide visitors interpretive opportunities and the chance to walk or bicycle while enjoying parks in new ways, such as open-street events.

The Volpe Center provided technical support to NPS on the development of the guidebook, including research, writing, editing, and graphic design. Volpe planning staff also coordinated with subject matter experts on content development,

including bicycle and pedestrian professionals, NPS staff and partners, and FWHA staff. A Technical Advisory Committee with representatives from NPS, the Centers for Disease Control and Prevention, the city of Portland, Oregon, and the Adventure Cycling Association also provided feedback.

The NPS Active Transportation Guidebook was completed in July 2018, and Volpe and NPS staff held two webinars in fall 2018 to familiarize park staff and partners with the guidebook. **(Sponsored by NPS)**

Addressing Climate Impacts on U.S. Forest Service Transportation Assets

The climate poses many serious threats to the nearly 200 million acres of public forests and grasslands managed by the U.S. Forest Service. Roads, bridges, and other transportation infrastructure needed for access and travel within Forest Service lands are also at risk, due to heavy precipitation and flooding, landslides, and downed trees and debris from wildfires and tree mortality. When Forest Service roads are out of commission, it impedes not only visitation and critical operations, local economies are also impacted. Gateway communities rely on the roads for tourists to get to recreational sites and for residents to get to locations, such as timber harvest areas that they depend on for their livelihood.

A resilient Forest Service transportation network would ensure more consistent and continuous access, greater safety, and larger economic benefits, whereas the current system can become partially or entirely closed by extreme weather and other climate impacts. In 2016, the Forest Service asked the Volpe Center to develop a guidebook to provide its field staff with a process for increasing transportation network resiliency at the unit and regional levels.

Above: Extensive damage to Sevenmile Road after the 2014 floods in the Arapaho and Roosevelt National Forests.
Source: U.S. DOT Volpe Center

A working group of Volpe Center and Forest Service staff met monthly to shape the development of the guidebook, and reviewed each section as it was completed. The working group interviewed Forest Service field staff to understand their issues and needs and to collect ideas for implementation. With a draft in hand, Volpe Center and Forest Service staff met at the Francis Marion National Forest in South Carolina to apply its stepwise approach in the field. The resulting observations led to a few final modifications, and the guidebook was issued in September 2018. In 2019, the U.S. Forest Service began using the guidebook. For example, Plumas National Forest in California has been using the guidebook to inform post-fire resilience projects.

The U.S. Forest Service Transportation Resiliency Guidebook aims to strike a balance between being specific enough to be implementable and flexible enough to accommodate a variety of needs and challenges. The guidebook contains three main sections:

- **Identifying Climate-Related Vulnerabilities within the Forest Service Transportation Network** provides a framework for assessing vulnerabilities to climate change within Forest Service transportation systems using relevant examples of efforts and approaches from federal land management agencies and FHWA.
- **Reducing Transportation Vulnerability to Climate Impacts** provides a step-by-step guide for adaptation planning at the unit level to reduce the vulnerability of Forest Service transportation systems. A selection of "toolboxes" assist in step completion, and "resource-constrained approaches" provide opportunities for achieving step goals when resources are limited.
- **Implementation Opportunities—Linking to Forest Service Plans and Programs** discusses how to implement climate change vulnerability assessments, adaptation planning, and adaptation projects within existing Forest Service programs and planning processes and describes available funding programs.

Although quantitative information driving climate analysis evolves over time, the guidebook's analytic framework is likely to be helpful and robust for years to come. **(Sponsored by U.S. Forest Service)**

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YEARS

ACCOUNTABILITY

THE VOLPE CENTER ADVANCES TRANSPORTATION SYSTEM MANAGEMENT TO PROMOTE GREATER EFFICIENCIES AND INFORM BETTER DECISION MAKING.

Improving the Coordination and Efficiency of Transportation Research: The Research, Development, and Technology Strategic Plan

As priorities change, and the U.S. DOT looks to future development activities, federal transportation research must be streamlined and coordinated to maintain high levels of performance and cost-effectiveness. The Office of the Assistant Secretary for Research and Technology (OST-R) is committed to doing just that, and directed the preparation of the Research, Development, and Technology (RD&T) Strategic Plan. The RD&T Strategic Plan meets the statutory requirements of the Fixing America's Surface Transportation (FAST) Act, which requires the Secretary of Transportation to develop a five-year strategic plan to guide future transportation research and development activities.

The RD&T Strategic Plan improves coordination of U.S. DOT research by guiding the development of Annual Modal Research Plans of each operating administration and preventing redundancy. It also provides guidance on integrating technology transfer throughout the research and development process to facilitate the deployment and adoption of research results into the transportation system.

The RD&T Strategic Plan serves as a foundational document by aiding OST-R in support of U.S. DOT's operating administrations with tracking and evaluating the outputs, outcomes, and impacts of RD&T investments, and making adjustments and improvements as needed.

The Volpe Center assisted with updating and revising the RD&T Strategic Plan just as it has on the past three iterations. The Volpe Center staff brought an understanding of U.S. DOT's vast portfolio of research projects, strategic goals, and priorities to the table. Volpe staff also applied analytical and technical writing skills to review and summarize U.S. DOT's research portfolio under a coherent set of goals, objectives, and research strategies.

Opposite: One of U.S. DOT's critical RD&T planning areas relates to improving infrastructure including issues related to the condition, costs, funding, and delivery of the transportation infrastructure, as well as methods and technologies to increase its durability and resilience. Source: ©123rf.com/Pop Nukoonrat

U.S. DOT's Strategic Goals and Related Research Topic Areas

Safety

Automation:
Enable the safe integration of automated vehicles and unmanned aircraft systems into the transportation system.

Systemic Safety Approach:
Use systemic, performance-based approaches to ensuring transportation system safety.

Human Factors:
Ensure the integration of human factors into the design of the transportation system.

Infrastructure

State of Good Repair:
Maintain transportation assets in a state of good repair, ensure resilience to natural and manmade threats, and optimize material cost and durability.

Environmental Stewardship:
Preserve the environment, ensure the safety and cost-effectiveness of alternative transportation energy sources, and ensure the safe transportation of hazardous materials.

Economic Competitiveness:
Stimulate economic growth, productivity, and competitiveness through transportation infrastructure investments.

Innovation

Emerging/Enabling Technologies:
Advance the development of emerging/enabling practices and technologies.

Mobility Innovation:
Use innovative business models, partnerships, and private-sector solutions to expand mobility options for travelers, including underserved communities such as people with disabilities and rural residents.

Cybersecurity:
Develop approaches for maintaining the cybersecurity of the transportation system.

Accountability

Technology Transfer/ Deployment:
Facilitate the deployment and adoption of U.S. DOT research products into the transportation system.

Evaluation/Performance Measurement:
Monitor and evaluate the contribution of research, development, and technology activities toward the achievement of U.S. DOT strategic goals and objectives.

Data:
Ensure access to high-quality data to support data-driven technologies, operations, and decision making.

This ongoing project helps to promote U.S. DOT's strategic goals of safety, infrastructure, innovation, and accountability by defining research topic areas that relate to each, and establishing the research goals, principles, and priorities necessary to see those efforts through to completion.
(Sponsored by OST-R)

Leveraging Funds to Support Infrastructure Investments in Local Communities

Since 2009, Congress has provided $7.1 billion for 10 rounds of national infrastructure investments that have supported 554 projects in all 50 states. These funding opportunities were initially offered through the Transportation Investment Generating Economic Recovery (TIGER) Discretionary Grants Program, which was renamed the Better Utilizing Investments to Leverage Development (BUILD) Transportation Discretionary Grant program in fiscal year (FY) 2018. Continuing with the BUILD Program, Congress approved national infrastructure funding of $900 million for FY 2019.

BUILD grants support a wide variety of projects that make transportation safer and more efficient, including new and expanded roads, bridges, transit systems, freight hubs, and bicycle/pedestrian facilities. Many of the projects not only improve local mobility, but are also part of broader plans to improve local economic development and quality of life in communities.

BUILD is a very competitive program. In the 2018 round, 851 applications sought a total of $10.9 billion, but only 91 projects were selected to receive the $1.5 billion in available funding. This highlights the importance of a rigorous evaluation process.

While the Volpe Center has assisted the Office of the Secretary (OST) in the grant selection process since TIGER I, its role for the BUILD program was significantly expanded in 2018, requiring rigorous evaluation of the technical merit, cost-effectiveness, and readiness of the proposals. As a

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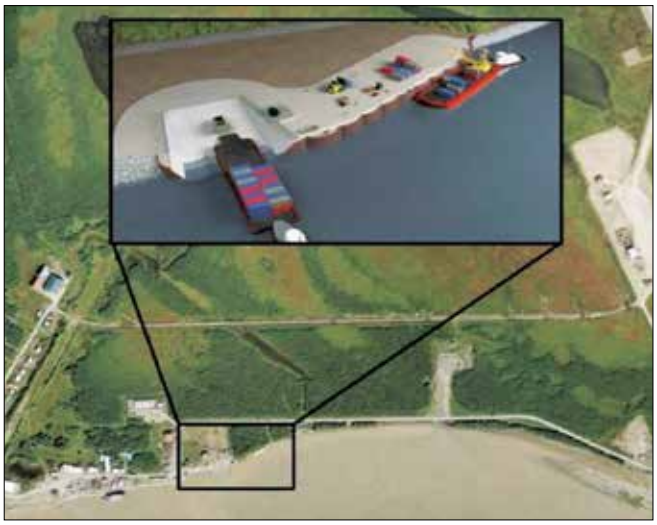
A Broader Perspective

In the 1980s the Volpe Center enhanced its strategic transportation planning capabilities to better prepare for the nation's future. The U.S. DOT, the White House, and others turned to the Volpe Center as a focal point for long-term strategic planning related to local, national, and global transportation issues. Following the 1993 establishment by the White House of the National Science and Technology Council (NSTC), the Volpe Center was continually called upon to support the Council and was a major contributor to the nation's first ever Transportation Science and Technology Strategy; Transportation Technology Plan; National Research and Development Plan for Aviation, Safety, Security, Efficiency and Environmental Compatibility; and National Research Agenda for Transportation and Sustainable Communities.

The Volpe Center's work as a leader in strategic planning and significantly related outreach activities continues to the present day.



Above: The Lower Yukon River Regional Port and Road Renovation Project in Alaska is one of over 90 projects across the nation to share in BUILD Grant Awards. Source: U.S. DOT

consequence, the size of the Volpe team tripled from 20–25 grant reviewers for TIGER to 75 for BUILD during FY 2018.

The first round of BUILD grant applications was evaluated from August to September 2018 and awarded in December of that year. Under a compressed four-week timeline, Volpe Center staff with surface transportation expertise worked on multidisciplinary teams to conduct technical reviews for all 851 projects, assessing applicants' alignment with BUILD program criteria. Environmental specialists at Volpe reviewed projects' readiness levels with respect to the environmental process, and Volpe Center economists reviewed applicants' cost-benefit analyses for 80 of the projects, verifying the information provided and correcting methodological errors.

Applications for the second round of BUILD funding closed on July 15, 2019, requiring the expertise of 60 Volpe staff to review grant proposals during the late summer and early fall. Those awards were announced on November 12, 2019. **(Sponsored by OST)**

Performance-Based Planning and Programming: An Efficient Approach to Transportation Decision Making

After passage of the Moving Ahead for Progress in the 21st Century Act (MAP-21), metropolitan planning organizations (MPOs) across the country faced a new challenge: how to implement performance-based planning and programming (PBPP).

PBPP is a system-level, data-driven process to better identify transportation planning strategies and investments. Long-range planning is the key; the goal is to clearly define objectives, evaluate and analyze strategies and investments to meet those objectives, and increase the transparency of transportation planning to inform stakeholders and the public and establish support for decisions. Although MPOs and their partners face challenges to meet the unique needs of each metropolitan area when implementing PBPP, each can learn best practices from peer MPOs.

To support the Federal Highway Administration (FHWA) in researching effective practices and innovation in implementing PBPP, the Volpe Center developed case studies of two MPOs: the Maricopa Association of Governments (MAG) in Phoenix, Arizona, and the San Diego Association of Governments (SANDAG) in San Diego, California.

SANDAG and MAG were excellent candidates for case studies because both MPOs had a head start in tracking performance due to state and local requirements. MAG began using PBPP after the passage of a local proposition that required it to produce a performance-based Regional Transportation Plan, which must be audited every five years. SANDAG began using PBPP in response to California's environmental mitigation mandates, local-option sales tax requirements, and an initiative to be more transparent to constituents.

The case studies demonstrate how MAG and SANDAG developed PBPP over time and give specific details of each MPO's approach, including successes, challenges, and plans for the future. For example, the study on MAG found that developing PBPP incrementally can be effective, and that agencies should be careful not to develop too many measures at once. The SANDAG case study found that a more holistic approach to PBPP, focusing on improving the environment, economy, and quality of life of the region, can help advance other sectoral goals in addition to transportation goals.

The case studies support the shift toward more transparency and performance-based decision making in transportation planning, across 50 states and over 400 metropolitan areas. This research will enable MPOs and states to streamline the transportation decision-making process and accomplish more public sector goals in the future. **(Sponsored by FHWA)**

Mitigating Cost Overruns with Better Planning Tools and Information

Federal and state transportation agencies are often faced with rising costs associated with road and highway infrastructure projects. Rising expenses can be directly linked to inaccurate cost estimation based on preliminary information during a project's early stages. According to the National Cooperative Highway Research Program, approximately 50 percent of large transportation projects in the U.S. have overrun their initial budgets.

Cost escalation of transportation projects can sometimes be attributed to right-of-way (ROW) costs. For certain projects, real property may have to be acquired in order to complete construction—that real property is referred to as ROW. Federal-aid highway programs, for example, could include highway alignments that require ROW. In the early stages of a project, transportation agencies must estimate potential ROW costs. It is imperative that ROW costs be determined and documented, and then tracked, managed, and updated throughout project development. Without the best possible preliminary information during the early stages of a project, this could lead to underestimating costs and overrunning budgets.

To remedy this problem, FHWA's Office of Real Estate Services sponsored a project to develop a method for capturing the data needed to make better estimations. First, Volpe Center experts interviewed state DOT geographic information system (GIS) and realty specialists to understand how ROW cost estimations could be improved by using geospatial applications. The Volpe team then developed a framework to demonstrate how GIS tools may be used for that purpose.

Currently, the Volpe Center is working to deliver the first version of a GIS-based demonstration for ROW cost estimation. The goal is for transportation agencies to use the guide to integrate elements of the GIS-based approach with their own data, in order to view impacts and estimate costs of proposed construction. This is expected to help transportation agencies refine how they plan preliminary ROW costs and, ultimately, minimize the changes of cost overruns.

This is an ongoing project, with the first version of the demonstration still under development. Plans for future improvement may be considered at a later date and could include compatibility with other state transportation agency mapping tools or ROW cost calculators.

In the near future, Volpe is planning a peer exchange with several different state DOT realty, IT, and GIS professionals to discuss the guide and their collective experiences using GIS for ROW estimation. The goal will be to inform the next version of the demonstration and identify best practices and user needs across all peers. **(Sponsored by FHWA)**

Updated Toolkit Improves Congestion Management in National Parks

Extremely long entrance lines, congested parking areas, crowded visitor centers, and backed-up traffic are familiar scenes at national parks. In 2018, more than 330 million visitors traveled on the 5,000 miles of paved roads managed by the National Park Service (NPS)—a 21 percent increase from 2006.

Vehicle congestion in national park units impacts safety—not only on NPS roads, but also on the public roadways that lead into the parks. In 2014, NPS developed a Congestion Management Program (CMP) to help national parks proactively cope with growing congestion by using innovative technology and planning tools. Five years later, the

Above: A parking lot fills at Narada Falls, Mount Rainier National Park, Washington. Source: NPS

two components of the CMP—the Congestion Management Toolkit and Congestion Assessments—required updating to reflect current NPS operations and data.

The Volpe Center's Public Lands Team has extensive experience working with federal lands management agencies analyzing complex site-specific safety and congestion issues, and helped develop the initial CMP. NPS asked the Volpe Center to support the CMP because of the team's understanding of existing issues and practices, and expertise in communicating technical material to non-technical audiences.

Volpe is supporting NPS in two areas: congestion assessments, which engage individual park units in defining their congestion problems, and updating the congestion management toolkit to help mitigate those issues. Congestion assessments are short-term technical assistance collaborations between park staff and transportation experts from Volpe, NPS, and Federal Lands Highway (FLH) that identify areas of congestion at individual parks. Recommendations are based on available tools in the toolkit and focus on park operations that can be implemented quickly. Potential solutions are tested for effectiveness and benefits on visitor experience, natural/cultural resources, and park operations. The Volpe team has supported many of the 15 congestion assessments delivered to date.

Additionally, new park examples were added to the Congestion Management Toolkit, and tools no longer relevant to NPS operations have been replaced with technologies like dockless bike share. The updated and streamlined document makes it easier for park staff to identify which tools efficiently

address specific problem areas within the park. The updated toolkit was posted on the NPS website in December 2019.

The updated CMP toolkit will help park units determine the most efficient methods for managing vehicle congestion on NPS roads, to better care for infrastructure and maintain a quality visitor experience. **(Sponsored by NPS and FLH)**

Performance Standards Assessment Tool Helps Evaluate Highway Safety Law Enforcement Grants

Each year, the National Highway Traffic Safety Administration (NHTSA) awards State Highway Safety Offices (SHSOs) approximately $640 million to finance priority highway safety countermeasures. Funds are provided through the National Cooperative Research and Evaluation Program (NCREP), jointly managed by NHTSA and the Governors Highway Safety Association. A significant percentage of these grants are given to state law enforcement partners for enforcement, training, community events, and other related activities.

Very few states have performance measures and/or goal setting built into their grant award processes, making it difficult for SHSOs and NHTSA to evaluate the effectiveness of these law enforcement grants.

The Volpe Center oversees and coordinates many of the innovative research program needs of the U.S. DOT, including the NCREP. Because of Volpe's strong track record overseeing NCREP contracts for a variety of highway safety countermeasures, NHTSA requested Volpe expertise to analyze best approaches to developing performance standards for traffic enforcement activities and to create a tool for implementing these approaches.

Volpe partnered with SHSOs, law enforcement agencies, and NHTSA to develop a performance tool to evaluate the efficacy of law enforcement grants. The tool can be used easily by law enforcement departments or agencies of any size. Resources include a user guide and webinar-based training. Volpe highway safety experts gathered qualitative feedback from participants during the program's pilot project in New Hampshire, Hawaii, and Guam and will follow up with the SHSOs and law enforcement partners about tool usability, opportunities for future rollouts, and ideas for improvement. The pilot ended in September 2019 and the Volpe Center team is in the process of performing the pilot evaluation. The plan is for a broader deployment of the tool.

SHSOs and their law enforcement partners now have a way to collaborate and help create performance measures for their transportation safety projects funded by NHTSA grants. Not only will the tool provide more accountability during the grant award process and generate relevant data without

Above: A Honolulu, Hawaii Police Department police officer pulls over a vehicle. Source: 123rf.com/Eric Brocer Van Dyke

creating an undue burden on the partners involved, it will also standardize data collected by SHSOs and law enforcement agencies without creating quotas. The performance measurement tool will also show that law enforcement is actively advancing safety in ways that go beyond writing traffic citations, by promoting training, community engagement, and media outreach. **(Sponsored by NHTSA)**

Education, Learning, and Training Initiative Improves FMCSA Safety Data

The Federal Motor Carrier Safety Administration (FMCSA) relies on state-reported crash and inspection data as critical input to its data-driven safety systems in order to reduce crashes, injuries, and fatalities involving large trucks and buses. FMCSA plays an active role in state data reporting through grants and the agency's Data Quality (DQ) Improvement Program, an initiative developed in response to a Government Accountability Office (GAO) report to ensure crash and inspection data are timely, accurate, and complete.

To be effective, FMCSA safety programs require high-quality data to objectively identify motor carriers that pose the greatest risk to safety for interventions. FMCSA's safety systems depend on data from 3.5 million roadside inspections and 180,000 crash reports received annually from states. After nearly 15 years, the DQ Improvement Program continues to monitor data quality and ensure states are continuously improving the data they submit—a key priority for FMCSA.

FMCSA implemented the DQ Improvement Program in 2005, and brought the Volpe Center's safety measurement and analysis experts on board to provide analysis, training, and outreach to improve the quality of data collected in the field. Volpe staff continue to play a key role in meeting FMCSA and states' data quality needs. The team's most recent initiative infuses education, learning, and training (ELT) into all aspects of the program.

The Volpe Center uses a diverse team to deliver impactful training with expertise in data reporting processes, analysis, FMCSA and state systems, design, communications, and education. Team members also support other FMCSA ELT activities and leverage knowledge learned to improve the DQ Improvement Program. Volpe is responsible for three key program components:

- **Consulting and on-demand training:** DQ specialists from Volpe work directly with states to continuously improve data quality.
- **Refreshing skills and knowledge for monitoring, researching, correcting, and uploading data:** Volpe develops and delivers hands-on refresher training on how to collect and process quality data and how to research and improve data before it is sent to FMCSA.
- **Online education and training:** the Volpe Center provides content for and maintains the DQ website, an educational resource for state partners with links to videos, job aids, and webinars.

The DQ Improvement Program strives to ensure states are continuously improving the data they submit to FMCSA. States are demonstrating not only an appreciation of the importance of data quality, but also a willingness to improve their data. Better data means better safety systems—and better safety systems means safer roads for the traveling public. **(Sponsored by FMCSA)**

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YEARS

SMALL BUSINESS INNOVATION RESEARCH PROGRAM

SMALL BUSINESSES THAT PARTICIPATE IN U.S. DOT'S SBIR PROGRAM HAVE DEVELOPED NUMEROUS NEW AND INNOVATIVE TECHNOLOGIES THAT HAVE BENEFITED THE DEPARTMENT AND THE PUBLIC, AND HELPED SMALL BUSINESSES GROW.

Supporting Small Business Technology Innovations

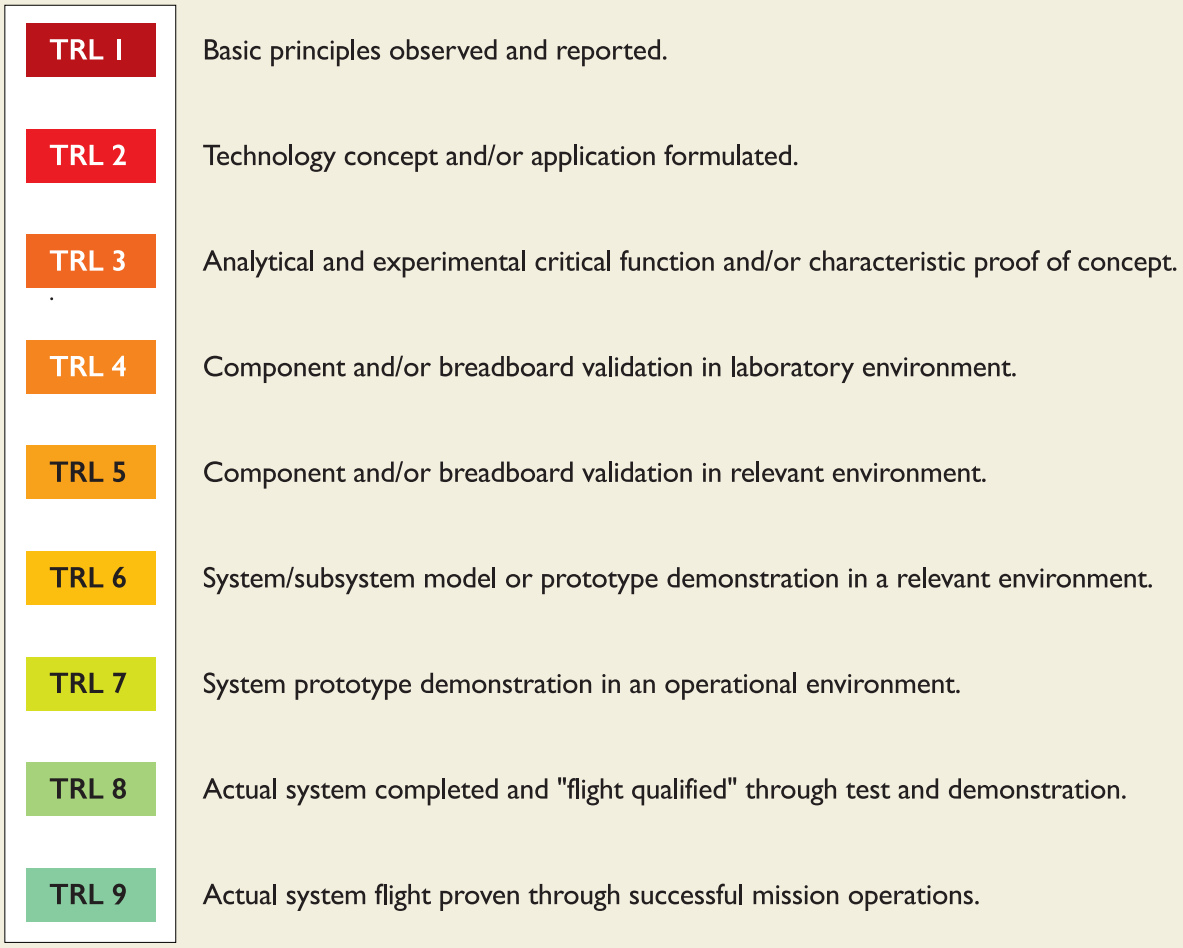
Innovation and innovators thrive in the entrepreneurial space. Yet, for many small businesses, the risk and expense of running major research and development programs to address modal priorities such as safety and efficiency are beyond their means. A potential solution is the U.S. DOT's competitive Small Business Innovation Research (SBIR) Program. Not only does the program award contracts to domestic small businesses to perform research and develop innovative solutions to the nation's most pressing transportation challenges, it also enables businesses to grow and compete on the same level as larger corporations.

On behalf of the eight participating operating administrations, Volpe has awarded more than $78 million in small business funding over the last 10 years. The SBIR Program uses a three-phase funding approach as projects move toward commercialization, starting with phase I projects focused on proof-of-concept. Phase II projects continue the research and development efforts initiated in phase I. When a phase II project nears completion, sponsoring operating administrations must decide whether or not to extend their respective phase II project onto a follow-on phase IIB, based on the project's commercial viability and potential for technology adoption. Phase IIB serves to continue the research as it matures closer to commercialization. This decision-point often requires U.S. DOT to consider the technology readiness of these expiring or recently completed phase II projects.

To solve this challenge, the Federal Highway Administration (FHWA) implemented an SBIR Technology Readiness Level (TRL) Assessment Pilot Program to evaluate the maturity of expiring phase II projects that may continue to be funded as phase IIB. FHWA turned to the Volpe Center to help manage the TRL Assessment

Opposite: The U.S. DOT's SBIR Program awards contracts to pursue innovative solutions to our nation's transportation challenges. Source: ©123rf.com/Andriy Sarymsakov

SBIR Technology Readiness Levels (TRL)



Pilot Program since Volpe personnel already had experience administering the SBIR Program and in facilitating the TRL process.

TRL assessments consist of a technology demonstration by the project's principal investigator to a panel of stakeholders, researchers, and/or subject matter experts. A TRL scale—originally developed by the National Aeronautics and Space Administration (NASA)—measures the maturity of a technology as it progresses toward technology adoption. TRL assessments help program managers and technical experts determine the next steps in the research process and compare levels of maturity between different technology concepts. The Volpe Center team supported FHWA in planning, facilitating, and documenting the SBIR TRLs and prepared the TRL assessment report and captured process improvements to support continuation of the program.

During the pilot program in fiscal year 2019, FHWA conducted five TRL assessments of phase II concepts developed by four small businesses. The average TRL of evaluated phase II concepts was level 5-6, which hovers between the "Applied Research" and "Development" phases in the research process.

This project will help the SBIR Program better identify which funded small business technologies have the greatest commercial feasibility, and their potential for adoption in the transportation sector. **(Sponsored by SBIR/U.S. DOT)**

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Stimulating Innovation and Economic Growth Through Investment in Small Businesses

The Small Business Innovation Research (SBIR) program is a highly competitive federal program mandated in the 1982 Small Business Innovation Research Act. The program targets the entrepreneurial sector where innovation and innovators thrive. Since the start of the program, the Volpe Center, in partnership with the U.S. DOT's operating administrations, has administered the program on behalf of the Office of the Secretary of Transportation. Through December 2019, over 1,000 research proposals have been funded and U.S. DOT has awarded $245 million in contracts to small businesses.

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YEARS

THOUGHT LEADERSHIP

AT THE U.S. DOT VOLPE CENTER, THOUGHT LEADERS FROM ACROSS THE GLOBAL TRANSPORTATION ENTERPRISE CONVENE TO DISCUSS FUTURE TRANSPORTATION CHALLENGES, GENERATE FRESH APPROACHES TO EMERGING ISSUES, ANTICIPATE TRENDS, AND INFORM DECISION MAKING.

Our New Mobility Future, held from May to September 2019, convened distinguished experts in transportation entrepreneurialism, design, policy, and data science who are transforming transportation modes to create a new mobility future—and to discuss how we're going to get there.

The themes these speakers discussed cut across each of the U.S. DOT's strategic priority areas: safety, infrastructure, innovation, and accountability.

Speakers brought their bold visions for the transportation systems of tomorrow, from autonomous cars that integrate an individual's tolerance for risk, to travel by rented bike or scooter, to flying taxis.

They challenged transportation professionals to think critically about the benefits of being able to pay a fee for speedier travel access; designing policy based on data while ensuring data privacy; road vehicle innovations to save time, fuel, and lives; making sure intelligent transportation benefits all users; and a trip using multiple public and private transportation services conveniently made with a single payment.

And, they presented the notion that even the nation's military benefits from commercial transportation services and innovations. This section recaps highlights of the thought leadership series. Video highlights are posted at **www.volpe.dot.gov**.

ADVANCING SAFETY IN OUR NEW MOBILITY FUTURE

"We are all interested in mobility. More trips are better. We want more travel for work, we want more travel for vacation, more travel for pleasure… We want this done in a faster, cheaper way. More trips mean that more people are better off."

DIANA FURCHTGOTT-ROTH
Deputy Assistant Secretary for Research and Technology,
U.S. Department of Transportation
May 22, 2019

AUTONOMOUS VEHICLES THAT INCLUDE RISK IN THEIR DECISION MAKING

"Two issues that have been central for us, which are being able to provide systems that are assisting you… and the issue of safety… often we end up making decisions which are a bit too risky. We need to make these systems to be safer… and we still want them to be simpler to work with."

BRIAN C. WILLIAMS, PHD
Bisplinghoff Professor of Aeronautics and Astronautics,
Massachusetts Institute of Technology
July 13, 2019

LAURA SCHEWEL
Founder and Chief Executive Officer,
StreetLight Data
June 25, 2019

BEYOND BIG DATA TO USEFUL DATA

"All of this data is out there, but that is not useful big data. You can't make a policy about that road based on that data… you have to turn that data into something useful."

AUTOMATED, CONNECTED, ELECTRIC, AND SHARED (ACES) VEHICLES AND THE FUTURE OF DRIVING

"What we're talking about here is about 4,000 movies worth of information being generated every day by an autonomous vehicle."

BRYAN MISTELE
Co-Founder, President, and CEO,
INRIX
July 9, 2019

AIRBORNE RIDE SHARING

"We know that urbanization is taking place all across the world, more people are moving to urban centers and choosing to live in urban environments; we know about the shared economy, we hear about folks taking shared rides... sharing cars; [and we know about] instant gratification... dial it up... and it can be at the house in two hours."

J. SCOTT DRENNAN
Vice President of Innovation,
Bell
July 23, 2019

SMALL SCOOTERS AND BIG DATA

"The public sector primarily has the responsibility for ensuring that these [micromobility] services are safe, that they're equitable, and that they're sustainable; [the public sector is] really the only entity that can hold private-sector mobility companies accountable."

REGINA CLEWLOW, PHD
CEO and Co-Founder,
Populus
July 30, 2019

GENERAL STEPHEN R. LYONS
Commander,
U.S. Transportation Command
September 17, 2019

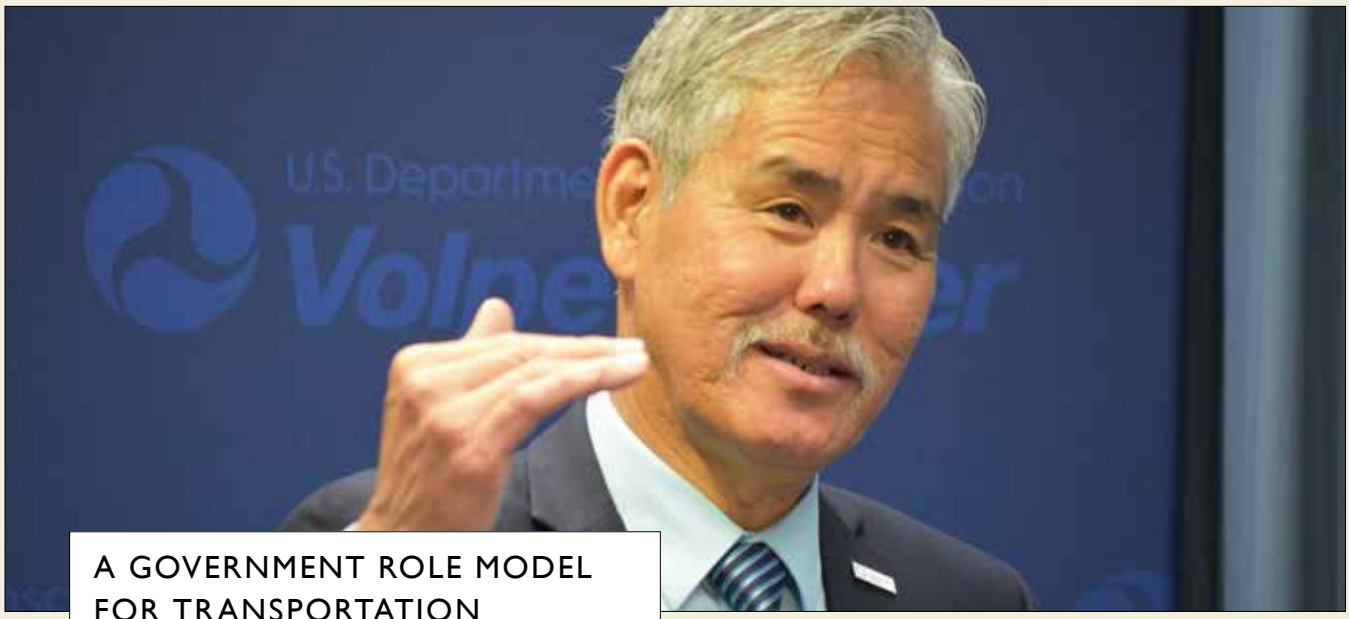
GLOBALLY INTEGRATED LOGISTICS AND THE CHANGING CHARACTER OF WAR

"Much of our mobility infrastructure today has been shaped by the need for national security and to move our forces. We recognize that the security environment is changing quite rapidly, [and] we're inextricably linked to… the viability of a commercial industry that we can rely on for national security needs in the future."

SARAH KAUFMAN
Associate Director,
New York University Rudin Center for
Transportation Policy and Management
September 19, 2019

MAKING SURE INTELLIGENT TRANSPORTATION GETS EVERYONE THERE

"Intelligent transportation [relies on] five key elements: reliability, data, safety, communications, and diversity, and—as we add intelligence to maximize our vehicle, driver, and passenger throughput—we have to keep in mind the experience. Are people safe, comfortable, and accommodated?"



A GOVERNMENT ROLE MODEL FOR TRANSPORTATION

"You want to get people into transit and then make the connections to modes. If you don't do that, you're going to drive. Once you get in your car, you're staying in your car—that's just the way it is."

RANDELL H. IWASAKI
Executive Director,
Contra Costa Transportation Authority
September 25, 2019

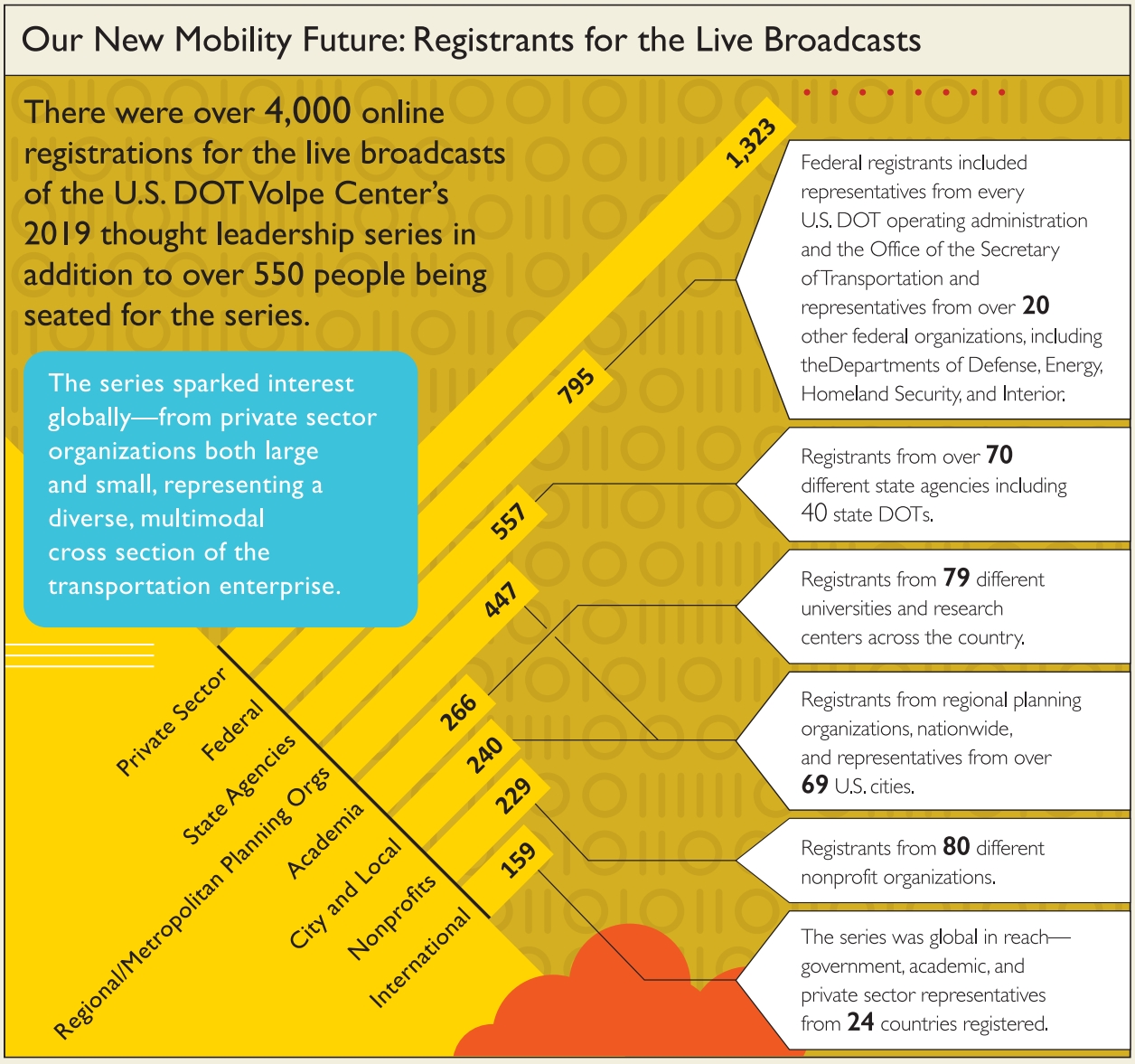
Above: Those attending Our New Mobility Future in person and those watching the live broadcasts had the opportunity to engage with experts during question and answer periods. Source: U.S. DOT Volpe Center

ENGAGING THE TRANSPORTATION ENTERPRISE

Through its thought leadership program, the U.S. DOT's Volpe Center is engaging a broad range of stakeholders in an important dialogue about emerging and future transportation issues. The Our New Mobility Future series continued to engage representatives from government, academia, nonprofit organizations, and the private sector in important conversations that inform decision making and help shape the future of transportation.

Those attending in person and those watching the live broadcasts had the opportunity to listen to a variety of perspectives and to engage with experts during question and answer periods. The chart below provides data related to stakeholder engagement in the series.

We hope you'll continue to JOIN THE CONVERSATION!



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50 YEARS

Volpe National Transportation Systems Center

1970 – 2020

TRANSPORTATION INNOVATION FOR THE PUBLIC GOOD

DOT-VNTSC-20-02

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The U.S. Department of Transportation's Volpe Center's Annual Accomplishments highlights our best work of 2019 and illustrates the sustained impact of the Volpe Center in supporting the U.S. DOT's top priorities and strategic goals: safety, infrastructure, innovation, and accountability. This year's publication highlights over forty projects carried out in support of and in collaboration with the U.S. DOT and other sponsors. This publication also features historical notes in recognition of the Volpe Center's 50th anniversary year. There is also a special section on the Volpe Center's 2019 thought leadership speaker series on *Our New Mobility Future.*

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