Annual Accomplishments

January 2019

U.S. Department of Transportation

Volpe Center

(Source: U.S. DOT Volpe Center)

Message from the U.S. DOT Volpe Center Director

The U.S. Department of Transportation (DOT) established the John A. Volpe National Transportation Systems Center (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, DOT's operating administrations, and other organizations.

Through the years, the Volpe Center's extensive cross-modal partnerships and sustained commitment to public service have led to innovative solutions that have advanced national and global transportation systems.

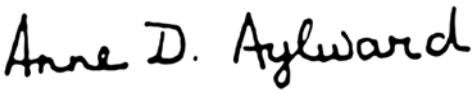
This document, our Annual Accomplishments, highlights some of our best work of 2018 and underscores our sustained support to the DOT and other key partners.

As a leader in transportation systems, analysis, and innovation, the Volpe Center is flexible and responsive to the needs and strategic goals of the U.S. DOT and the priorities of the Secretary of Transportation: *safety, infrastructure, innovation, and accountability.*

Through a vibrant culture of thought leadership and meaningful engagement in professional and technical organizations, the experts of the U.S. DOT Volpe Center anticipate and address emerging and future challenges.

The Volpe Center strives to maximize the linkages throughout DOT and the broader transportation community. By continuously seeking synergies among our projects, the Center works to transfer best practices, lessons learned, findings, and technologies across DOT and beyond.

We look forward to collaborating with you in the years ahead.



Anne D. Aylward, Director
Volpe National Transportation Systems Center
U.S. Department of Transportation

January 2019

(Source: ©123rf.com/Galina Peshkova)

Safety

The U.S. DOT Volpe Center works across all modes to support the Department's top strategic goal—transportation safety.

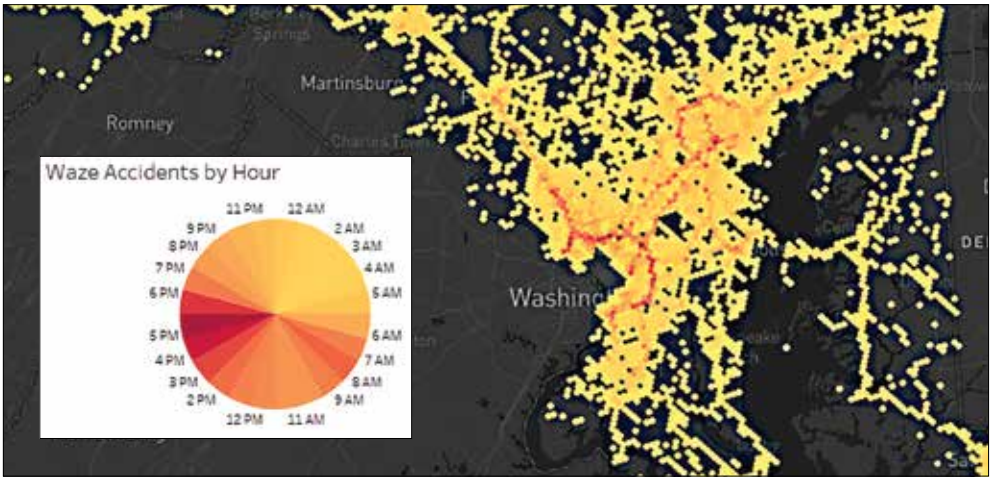
Road Safety

Integrating Safety Data with the Waze Pilot Project

In 2017, 37,133 people died in motor vehicle crashes, down following two consecutive years of large increases. In addition, over 3 million were injured in motor vehicle crashes in 2016. To better understand crash risk, the U.S. DOT Safety Data Initiative is using data analytics from private industry to identify factors that contribute to serious crashes.

Volpe Center data experts are leading the Waze Pilot Project in support of the Office of the Under Secretary for Policy, which is advancing U.S. DOT's vision of integrating government data with big data from private companies to estimate crash risk and indicate reportable traffic crashes in a reliable and timely way.

The crowd-sourced Waze application displays GPS-based road navigation on smartphones and tablets. Drivers who have the app open on their phone passively contribute traffic and other road data. Users can also take an active role by reporting accidents, the presence of police, and road hazards. Waze processes and combines individual reports to provide anonymous alerts screened to meet reliability and confidence thresholds. Cities and U.S. DOT can access the data through the Connected Citizens Program. U.S. DOT uses a secure, cloud-based, revocable-access archive, which can be used with analysis tools and shared-computing resources, for this complex and sensitive dataset.



The graphic illustrates the total number of Waze accident reports in Maryland from April to September 2017 in each one square-mile hexagonal grid cell, by hour of day. Most Waze accidents in Maryland are reported during commute hours (7 to 9 am and 3 to 6 pm), and in the Capital Beltway region (darker red indicates more accident reports in the chart and map). (Source: U.S. DOT Volpe Center)

In phase one of the Waze project, a Volpe Center team integrated traffic event data with police-reported traffic crash data and other variables, such as weather and roadway conditions. The team applied machine learning methods to estimate the number of police-reportable traffic crashes that occurred every hour in one-mile area grid cells across Maryland from April to September 2017. Models that estimate crashes in near real-time using Waze data can help emergency responders, traffic management centers, and law enforcement proactively allocate resources to locations that have the highest accident potential.

In phase two, the U.S. DOT Volpe Center will partner with state and local transportation agencies to develop specific applications of the Waze crash estimation models, and assess how they can inform traffic safety. One potential application is supporting risk-based operational decisions at traffic management centers.

The project has been highlighted by Secretary Elaine L. Chao and Under Secretary of Transportation for Policy Derek Kan at transportation conferences and U.S. DOT events. **(Sponsored by Office of the Under Secretary for Policy, U.S. DOT Bureau of Transportation Statistics)**

Improving Safety through Technology

The Federal Motor Carrier Safety Administration (FMCSA) aims to make highways safer for all drivers. One danger is fatigued driving, which leads to hundreds of crashes and deaths each year. Federal law requires that trucks have electronic logging devices (ELDs), which track on- and off-duty time for drivers. FMCSA estimates that nationwide ELDs can avoid 1,844 crashes, with 562 fewer injuries and 26 lives saved per year.

After December 16, 2019, all motor carriers and drivers subject to the ELD rule must use self-certified ELDs registered with FMCSA. To better enforce hours-of-service regulations, the ELD rule also required that FMCSA develop and implement technologies to allow enforcement personnel and carriers to securely transfer ELD data. FMCSA had 10 months to design, develop, and implement this technology solution and allow motor carriers and

FMCSA enforcement personnel perform a test of the new ELD technology during a roadside inspection. (Source: U.S. DOT Volpe Center)

Electronic Logging Devices: Implementation Timeline

Feb. 16, 2016 – Dec. 17, 2017

PHASE 1 (Completed)

Awareness and Transition Phase

During this time, carriers and drivers subject to the rule could prepare to comply and voluntarily use ELDs.

Carriers and drivers subject to the ELD rule could use any of the following for records of duty status (RODS):

- **Paper logs**
- **Logging software**
- **AOBRDs**
- **ELDs that are self-certified and registered with FMCSA**

Dec. 18, 2017 – Dec. 16, 2019

PHASE 2

Phased-In Compliance Phase

This two-year phase-in period extends from the Compliance Date to the Full Compliance Phase. Carriers and drivers subject to the ELD rule can use:

- **AOBRDs installed and in-use prior to December 18, 2017**
- **ELDs that are self-certified and registered with FMCSA**

After Dec. 16, 2019

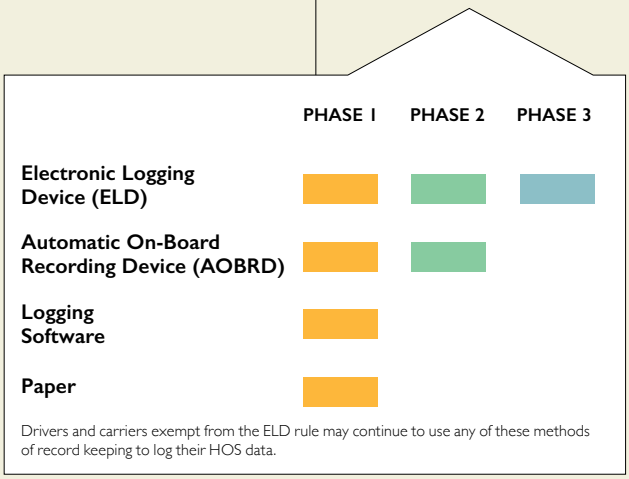
PHASE 3

Full Compliance Phase

All drivers and carriers subject to the ELD rule must use self-certified ELDs that are registered with FMCSA.

A Phased Approach

As the ELD rule is implemented, motor carriers will be allowed time to transition to full adoption of ELDs. This table illustrates which recording methods are acceptable during each phase of implementation.



Drivers and carriers exempt from the ELD rule may continue to use any of these methods of record keeping to log their HOS data.

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drivers to meet the compliance date. A multidisciplinary team of Volpe Center technical experts helped FMCSA meet this tight deadline.

Volpe assisted in the design and development of the technology for transmitting ELD data to safety officials, and a software application—Electronic Records of Duty Status, or eRODs—to assist safety officials in viewing and analyzing that data. Volpe experts also assisted in the design and delivery of communication and outreach materials, including a website that is the program's information centerpiece: https://eld.fmcsa.dot.gov. Finally, the Volpe team provides critical technical support and offers guidance to FMCSA as they work with ELD providers.

Recently, Volpe has expanded its support through education, training, and learning plans to ensure all stakeholders know how to comply with the ELD rule. Within the first six months of implementation, motor carriers successfully submitted more than 110,000 ELD files to FMCSA safety officials.

Since the implementation of the rule, FMCSA has been tracking the impact ELDs are having on industry compliance with hours-of-service (HOS) regulations. HOS violations have fallen steadily, concurrent with ELD rollout. These critical regulations ensure that commercial drivers get the breaks they need, improving safety for everyone on the road.

(Sponsored by FMCSA)

The ELD implementation timeline illustrates the phased approach to bring carriers and drivers into compliance with the December 16, 2019 rule for using self-certified ELDs that are registered with FMCSA. (Source: U.S. DOT Volpe Center)

Developing New Test Procedures for Vehicle Safety Applications

Vehicle safety applications are becoming standard issue on more and more vehicles in the U.S. Two emerging safety applications are intersection movement assist (IMA) and left turn assist (LTA), both of which identify and warn drivers of potential crossing-path collisions at intersections. More than 10,000 traffic fatalities happened at intersections in the U.S. in 2016, representing about 27 percent of all U.S. road deaths.

IMA and LTA detect vehicles approaching the intersection, determine if there is a collision risk, and present an audible and visual alert to the driver if needed. Ensuring that driver alert and automatic vehicle control systems are accurate and reliable can improve road safety, and can build driver confidence in vehicle safety applications and automated driving systems.

The National Highway Traffic Safety Administration (NHTSA) turned to the Volpe Center to improve its understanding of vehicle performance and driver behavior at intersections and to support the development and testing of effective IMA and LTA applications. Volpe identified metrics and provided statistics on how drivers navigate signalized and unsignalized intersections based on real-world driving data.

This effort consisted of two projects. In the first, Volpe experts identified the most critical parameters of driver behavior at intersections through a deep dive into previous research. That was followed by data mining of two naturalistic driving studies to identify scenarios that could be analyzed as samples of baseline driver intersection behavior. The analysis improved NHTSA's understanding of a typical intersection crossing, and the variables that affect or indicate a driver's decision to cross against approaching traffic.

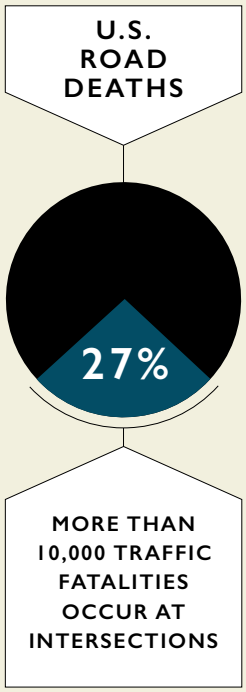
For the second project, the Volpe Center developed engineering test procedures for IMA and LTA that were carried out and validated at Joint Base Cape Cod and at the U.S. Army's Aberdeen Test Center. Test procedures included crash-imminent test scenarios, where applications warned a driver of a potential threat. There were also benign test scenarios, where applications suppressed a warning because even though the vehicles would cross paths, there was enough time and space for the vehicles to avoid a crash. Finally, there were false-alert test scenarios where no warnings were issued because the paths of the vehicles did not overlap. These test procedures can be used by vehicle and equipment manufacturers to demonstrate the effectiveness of their systems.

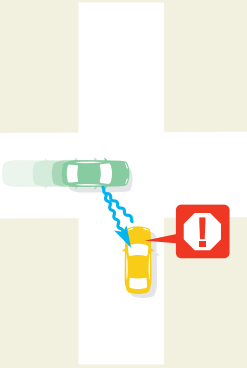
Based on these projects, the Volpe team concluded that gap size—the time between when a driver starts or is able to enter an intersection and when an oncoming vehicle crosses their trajectory—is a reliable, measurable constraint to use in determining whether a crash is imminent or not. Volpe experts analyzed crash data to find examples where insufficient gap size was a crash factor and an alert would have been useful.

The Volpe team recommends that IMA or LTA safety applications ideally be able to assess gap size to determine if a vehicle is able to safely clear the intersection in front of or behind crossing traffic. If the vehicle is unable to clear the intersection, the safety application would be expected to issue a warning to the driver, but limit unnecessary warnings when collisions are unlikely.

Volpe delivered two reports to NHTSA as part of this work:

Traffic Fatalities at Intersections





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- *Baseline Analysis of Driver Performance at Intersections for the LTA and IMA Applications*
- *Test Procedures with Countermeasure Timing Constraints for Intersection Movement and Left Turn Assist Safety Applications*

(Sponsored by NHTSA)

Developing Characteristics of Motorcycle Crashes to Inform Crash Avoidance Research

Motorcycles make up just 0.63 percent of all vehicle-miles traveled (VMT) in the U.S. and only 3.2 percent of all registered motor vehicles—but they account for more than 14 percent of annual traffic fatalities. Significantly reducing motorcycle crashes would greatly improve overall roadway safety.

Understanding the motorcycle crash problem is a critical first step in identifying potential strategies and mitigation techniques that can increase the safety of motorcycle operators and other road users. NHTSA turned to the Volpe Center to define the characteristics of motorcycle crashes in order to inform and guide motorcycle crash avoidance research and technology development. This is especially important as vehicle equipment manufacturers develop technology-based safety applications and automated driving systems that can avoid crashes or alert drivers to potential crashes.

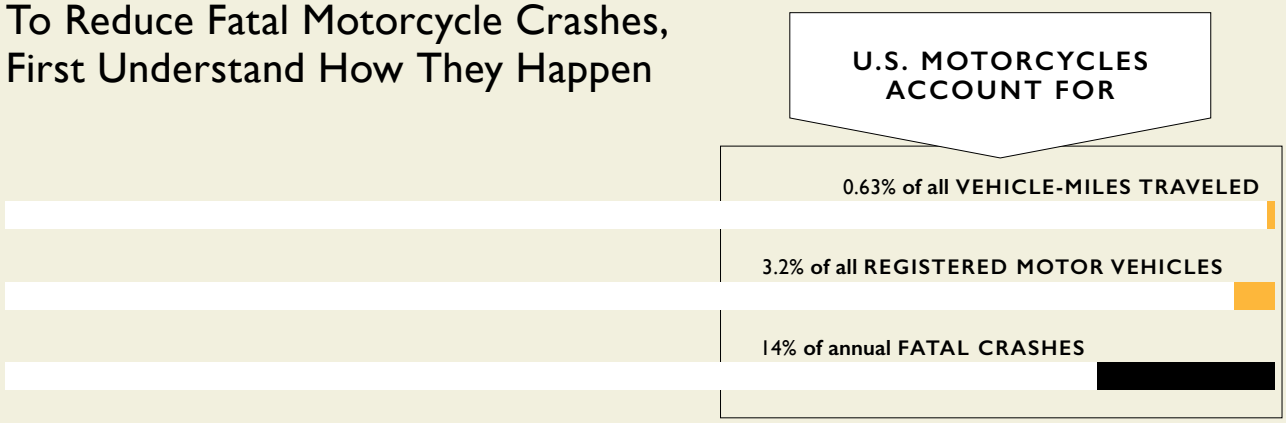
Volpe's team evaluated five years of crash data (2011 to 2015) from two NHTSA datasets: the Fatality Analysis Reporting System and the National Automotive Sampling System General Estimates System crash databases. Volpe identified over 507,000 motorcycle crashes, including 23,245 fatal crashes during the five-year period. These crashes were classified against a complex set of criteria, including 36 possible pre-crash scenarios, and crash-contributing factors such as obstructions, road conditions, and driver impairment. Volpe experts identified 11 common motorcycle pre-crash scenarios that account for 70 percent of motorcycle crashes and 81 percent of fatal motorcycle crashes.

One principal objective of this project was to identify the kinematics of common pre-crash scenarios, their measurable parameters, and predictive equations that can help determine the likelihood of a crash and crash avoidance needs. If an automobile and motorcycle are approaching one another at an intersection, what criteria can determine if risk of a crash exists and what actions are needed to prevent the crash? This is important as motorcycles and other road vehicles are increasingly equipped with sensors, driver alert systems, vehicle automation, and vehicle-to-vehicle communications systems.

For each of the multiple-vehicle pre-crash scenarios, the Volpe research team:

- Illustrated the configuration of each pre-crash scenario.
- Developed equations that describe the pre-crash scenario and identified the parameters that would determine when a collision will occur.
- Created plots to show the time history of speed and distance between the motorcycle and the other vehicle, illustrating the potential risk of collision over time.

To Reduce Fatal Motorcycle Crashes, First Understand How They Happen



The **U.S. DOT's National Highway Traffic Safety Administration** and the **Volpe Center** worked together to better understand the motorcycle crash problem, a critical first step toward improving the safety of motorcycle operators and other road users.

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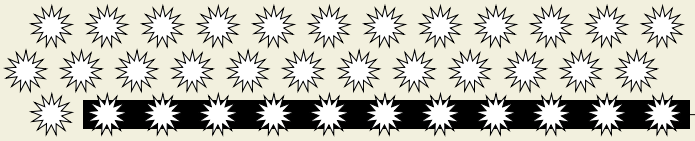
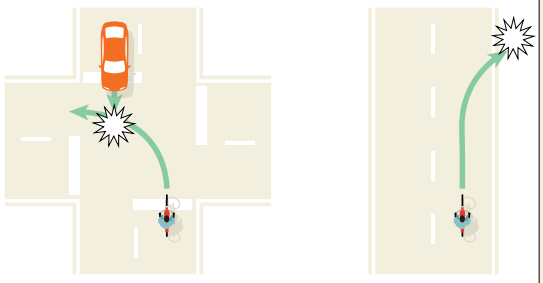




Volpe experts identified **11 motorcycle pre-crash scenarios** that account for **70 percent of motorcycle crashes** and

81 percent of fatal motorcycle crashes.

By identifying predominant pre-crash scenarios, researchers, technology developers, and vehicle manufacturers can focus on mitigation efforts and innovative technology applications to reduce fatal motorcycle crashes.

U.S. DOT Volpe Center

For single-vehicle crashes, Volpe identified sensor parameters that could determine whether the operator is likely to lose control or depart the road and countermeasure techniques to avoid these crashes. The Volpe research team identified mitigation measures that could reduce the likelihood of these events. By identifying the predominant pre-crash scenarios—and developing reliable metrics to predict vehicle paths and assess crash potential—researchers, technology developers, and vehicle manufacturers can focus on crash mitigation efforts and innovative technology applications.

The Volpe research team submitted a report—*Pre-Crash Scenario Characteristics of Motorcycle Crashes for Crash Avoidance Research*—expected to be published by NHTSA in 2019. **(Sponsored by NHTSA)**

Modernizing the Nation's Primary Vehicle Defects Database

To ensure safety on the nation's roads and to improve accountability to drivers, consumers, and manufacturers, data experts from NHTSA and the Volpe Center are modernizing the Artemis vehicle defects suite of applications to make it easier for investigators to flag potential risks to the driving public.

Artemis is the primary data system used by the NHTSA Office of Defects Investigation (ODI) to identify and address potential safety defects in motor vehicles. Defects may include issues with any part of a vehicle, from the engine, to air bags, to luggage racks. ODI is responsible for investigating potential safety defects and overseeing safety recall campaigns to assess recall effectiveness. Manufacturers may initiate recalls of their own, which are also tracked within ODI.

NHTSA investigators use Artemis to evaluate data submitted by manufacturers and consumers. These data may be used to inform recall action. In 2012, there were 15.6 million light passenger vehicles involved in recalls. This number rose to 46.8 million in 2016—a 199 percent increase.

Drawing on the Volpe Center's extensive experience in supporting the Artemis data program, Volpe experts are helping to build a one-stop-shop Artemis system, so that investigators do not have to seek out data connections from various sources. The new Artemis will be familiar to NHTSA vehicle safety investigators, and is being built to help ODI accomplish these overarching goals:

- Provide a unified, role-based workflow;
- Improve operational efficiencies, reduce costs, and reduce the risk of service interruptions;
- Improve the resiliency and reliability of the system;
- Ensure that all existing data is properly migrated to the new system without downtime; and
- Ensure ODI has access to Artemis data throughout modernization, and continue system operational support and development throughout the system's lifecycle.

Volpe has implemented several technical proofs-of-concept to validate the architecture and design of the modernized system in the Amazon Cloud. The modernized Artemis will consolidate several disparate data sources, which will let ODI investigators immediately see important safety-related information. In addition, the cloud implementation will significantly reduce the cost and effort associated with maintaining the legacy system.

The initial release of the modernized Artemis system is planned for early 2019 with a launch of the NHTSA Enterprise Portal and the internal early warning reporting functionality. The portal will provide a single point of entry for manufacturers that must provide data to NHTSA and can also be expanded to support applications from program offices that serve as data collection points for the organization. Volpe experts evaluate ODI's business processes, provide human factors analysis, design and develop software applications, and provide project management, infrastructure, and operational support to NHTSA for mission-critical information management systems like Artemis that help save lives, prevent injuries, and reduce traffic-related economic costs. **(Sponsored by NHTSA)**

Volpe staff produced a tool that can detect and map various features of work zones with over 90 percent accuracy across the SHRP2 NDS video data set.
(Source: ©123rf.com/Charles Wollertz)

Addressing Driver Behavior to Improve Safety

Driving behavior is a critical factor in nearly all traffic crashes. The Second Strategic Highway Research Program's (SHRP2) Naturalistic Driving Study (NDS) is a valuable resource for the transportation community, providing information on driving behavior and individual trip characteristics—including events like crashes and near crashes. The SHRP2 NDS allows transportation agencies to infer driver behavior, providing previously unavailable information to the highway community on how people drive in real-world conditions.

NDS research requires extensive access to supporting video data, recorded continuously while drivers operate vehicles. Traditional manual data reduction techniques are cumbersome, expensive, and sometimes impossible. With machine learning models, researchers can now quickly process large amounts of video data to find the data they need.

Volpe Center machine learning experts developed the methodology, example technology, and subject matter expertise needed to create a video processing tool. When completed, the SHRP2 NDS Video Analytics (SNVA) application will use machine learning to accurately identify and classify key driving conditions and roadway features from forward-facing video data. This information will be coded into the SHRP2 NDS time series metadata and the Roadway Information Database (RID). Public access to the database is by request.

Volpe Center analysts identified the SNVA application's processing requirements based on previous work with the Federal Highway Administration (FHWA), and proposed a possible solution. Volpe experts then developed that solution using agile workflow methods and continue to add new features to the application.

This project is now focused on detecting and mapping features related to work zones, traffic signals and signal state, and road weather conditions. Volpe produced a tool that can detect and map work zone features with over 90 percent accuracy across the SHRP2 NDS

video data set. Using machine learning techniques, analysts can process a one-hour NDS video in 30 seconds using commercial-grade computer processors, compared to three to four hours for manual coding. Reducing the time needed to perform NDS research also makes the SHRP2 data set more useful for research into validation of work zone models.

This project is building valuable machine learning expertise within the Volpe Center. The team is also working on natural language processing using machine learning, among the very first within DOT to do so.

Volpe delivered the first version of the work zone detection software in July 2018 to Virginia Tech Transportation Institute, which manages the SHRP2 NDS data portfolio for FHWA. The open-source software was made available to the public in September 2018 (https://github.com/VolpeUSDOT/SNVA). Future work may include analyzing roadway conditions, lane detection and counting, work zone structure mapping, and other features.

(Sponsored by FHWA)

Using Road Safety Audits to Enhance Visitor Safety in the National Park Service's Southeast Region

The National Park Service (NPS) doesn't just manage vast natural and cultural resources—it also manages a 5,000-mile system of paved roads. The NPS aims to provide safe transportation infrastructure and services to all visitors and NPS staff, and to reduce crash rates.

Surface transportation experts use road safety audits (RSAs) to identify potential safety issues and suggest countermeasures that can enhance safety. An RSA is a formal safety

Road safety audits conducted at national parks aim to improve the safety of all roadway users including motorists, bicyclists, and pedestrians. Pictured is the RSA team during the Natchez Trace Parkway 2017 RSA near Kosciusko, Mississippi. (Source: U.S. DOT Volpe Center)

examination of a future roadway plan or project or an in-service facility, conducted by an independent, experienced, and multidisciplinary team.

The NPS Southeast Region tasked the Volpe Center with leading teams to conduct RSAs at several regional parks. These RSA teams include staff from the NPS, FHWA, NHTSA, and state and local stakeholders. Teams take a 4Es approach to safety, recommending short- and long-term countermeasures that address issues related to engineering, enforcement, education, and emergency response.

For each RSA, the Volpe Center compiles and analyzes available crash data, facilitates meetings with stakeholders, manages site-visit logistics, and writes a report outlining the team's recommendations. In 2017, the Volpe Center conducted two RSAs each at the Blue Ridge Parkway in Virginia and North Carolina and the Natchez Trace Parkway in Mississippi. These sites are now implementing several of the recommended engineering and educational outreach initiatives for enhancing safety. For example, the Blue Ridge Parkway is installing signage to warn drivers about sharp curves, pedestrians, and wildlife. The Blue Ridge Parkway is also developing a more robust educational program, including new posters with traffic safety information in visitor centers.

In 2018, the Volpe Center completed three RSAs: two at the Blue Ridge Parkway—one near Lynchburg, Virginia and one at Pisgah National Forest in North Carolina—and another at the Natchez Trace Parkway. The Blue Ridge Parkway RSA post-implementation report was completed in 2018, and the Natchez Trace Parkway report will be finalized in early 2019.

RSAs are a valuable tool to evaluate road safety issues and look for opportunities for future safety improvements. The Volpe Center's efforts have helped the NPS identify ways to improve safety for all roadway users—motorists, pedestrians, and bicyclists—on two well-traveled NPS parkways in the Southeast region of the U.S. **(Sponsored by NPS)**

Transit Safety

New Tool Educates Transit Employees on Drug Abuse

The Federal Transit Administration (FTA) requires that transit employees whose jobs impact passenger safety receive at least one hour of training on the effects and consequences of prohibited drug use. These employees include vehicle operators, maintenance employees, dispatchers, and armed security personnel.

The Volpe Center's Drug & Alcohol team conducted field audits on behalf of FTA and found that transit employers frequently fail to meet the training requirement. Volpe staff created an engaging one-hour video on drug use and abuse to help increase compliance.

To create informative and engaging content, the Volpe Center team asked subject matter experts—including a public education officer, an emergency medical technician, and a drug treatment expert—to speak on camera about the effects of drug use. The experts provided information on how recreational use, abuse, addiction, withdrawal, and overdose can affect personal health, life, and job performance. They also discussed how to recognize the signs and symptoms of drug abuse in employees, including the potential for medical use of marijuana and opioids to develop dependency. Script development

FTA's new Drug Abuse Awareness video describes the effects and consequences of prohibited drug use on personal health, safety, and the transit work environment, as well as signs that may indicate prohibited drug use. (Source: ©123rf.com/macor)

was an intense and collaborative effort between Volpe's multimedia staff and the FTA Office of Public Affairs.

Volpe staff shot the video at subject matter experts' facilities, the Volpe Center, and locations around Cambridge, MA. The FTA National Drug and Alcohol Program Manager recorded an introduction to the video, and a Volpe employee provided the on-camera narration.

After a quality review by Volpe Center staff, the final video, *The Effects & Consequences of Prohibited Drug Use,* was published on August 29, 2018, on FTA's YouTube page. **(Sponsored by FTA)**

Rail Safety

Saving Lives at Highway-Rail Grade Crossings with Incursion Treatments

A vehicle stopped or traveling on a railroad right-of-way (ROW) can cause serious injury or even death. In Oxnard, CA, a pickup truck mistakenly entered the railroad ROW and turned onto the track on February 14, 2015, and was struck by a train. There were 27 injuries, 1 fatality, and 3 passenger train cars were overturned. Federal Railroad Administration (FRA) safety data shows that on average at least 15 vehicle-train crashes at highway-rail grade crossings per year are from vehicles mistakenly turning onto a railroad ROW.

The FRA Office of Research, Development and Technology initiated research on infrastructure solutions in response to incidents like the one in Oxnard. This research aims to study engineering treatments that can help prevent rail ROW incursions and provide FRA and stakeholders with data on how those treatments improve safety.

Volpe Center experts completed railroad ROW incursion treatments at the West Washington Street grade crossing in Orlando, Florida. (Source: Volpe Center/Marco daSilva)

As part of FRA's research program, the Volpe Center partnered with SunRail—the commuter rail system in the Orlando, FL area—and the city of Orlando to develop vehicle ROW incursion prevention engineering treatments, identify suitable grade crossings for implementation, collect before and after data, and evaluate the results. Volpe experts developed vehicle ROW incursion prevention engineering treatments specific to two crossings in Orlando.

The project successfully showed that low-cost engineering treatments, such as extending lane markings through crossings and adding reflective markers, can reduce vehicle incursions at grade crossings. Vehicle incursions decreased from 10 events in 2016 to 3 events in 2017—a 70 percent decline—at the two rail crossings in Orlando where treatments were evaluated.

The Volpe Center is helping disseminate the results of this study to rail safety stakeholders across the country. Volpe experts are also developing recommendations for agencies and municipalities thinking of using low-cost safety treatments at crossings where vehicle incursions are already a significant issue. **(Sponsored by FRA)**

Review of Fire Performance Standards Improves Rail Passenger Safety

Fires involving railroad equipment can lead to serious injuries and death for rail passengers and crews. FRA establishes, maintains, and updates regulations and standards that can prevent fires and lessen the consequences when fires happen.

The Volpe Center provides FRA with technical expertise to evaluate federal regulations and industry requirements on fire safety for passenger rail equipment. The Volpe Center recommends fire safety testing and analysis technology, and recommends potential ways for FRA to modify fire safety performance criteria for materials. Assessing fire safety test methods may also lead to more efficient testing approaches and cost savings for the rail industry.

As part of the FRA Passenger Rail Fire Safety Research Program, the Volpe Center, in conjunction with fire protection experts and industry fire testing professionals, have recently worked on three research topics:

- Developing heat-release-rate, performance-based testing requirements for interior railcar materials.
- Reviewing current passenger railcar wire and cable fire safety performance standards and recommending updates to improve safety.
- Evaluating modifications to the floor fire barrier test method and performance criteria.

Heat-release-rate-based performance requirements will better define and predict fire growth, and will provide a better understanding of the fire hazard threat of materials inside passenger railcars. The Volpe team evaluated the basis for establishing heat-release-rate-based performance requirements to assess and qualify railcar interior materials, furnishings, and assemblies. This effort included technical analyses, small- and large-scale tests of sample materials, and developing and validating simulation models.

Volpe Center and industry experts reviewed fire performance standards for electrical wire and cables in railcars, and reviewed criteria to determine whether recommendations for changes to the standard should be considered. The Volpe team reviewed the National Fire Protection Association (NFPA) 130 Standard for Fixed Guideway Transit and Passenger

Volpe Center engineers took heat measurements during a fire test of a passenger rail car seat at the SGS Govmark testing facility in Farmingdale, New York. (Source: Volpe Center/Mark Gentile)

Rail Systems, current FRA regulations, and rail industry best practices, as well as test methods, requirements, and standards for wire and cable fire performance in other modes of transportation and from the international community.

The Volpe Center team also addressed two issues related to fire testing research on railcar floor assemblies. The first issue involved assessing the potential use of a smaller representative floor assembly for fire resistance testing; the second was to determine if the current minimum prescribed fire exposure test time is sufficient to achieve best results. This research was conducted through an analysis of fire accidents and incidents in passenger railcars, technical analyses and fire tests of materials, and application and validation of fire prediction models.

The team recently finished the first phases of research and final reports for the heat-release-rate performance testing criteria and alternative floor assembly fire testing research topics, which FRA plans to publish. Volpe staff also recommended some changes to NFPA 130. The FRA-Volpe team attends annual committee meetings on NFPA 130, keeps NFPA members informed on government research, and welcomes feedback from industry representatives. **(Sponsored by FRA)**

Understanding How to Prevent Suicides on U.S. Railways

Rail suicide is the second leading cause of rail-related death in the U.S. Until recently, little was known about why these incidents occur, or what can be done to prevent them.

Prior to 2011, rail-related suicides were not reported to FRA. When FRA began collecting suicide data and actively participating in suicide prevention efforts and studies, it engaged the Volpe Center. Volpe's first step was to collect data and assess suicide prevalence to understand the extent of the problem. Initial research found the number of rail suicides in the U.S. was higher than many realized. Volpe next conducted a review of potential countermeasures, which uncovered possible mitigation models and research findings from other countries.

Volpe works with rail carriers, suicide prevention groups, and international rail suicide experts who have been studying such incidents for years, to improve the collective understanding of rail suicide. In 2014, FRA worked with the Volpe Center and the Association of American Railroads to convene the Global Railway Alliance for Suicide Prevention (GRASP), an international group of researchers, government regulators, and rail representatives who specialize in rail suicide and trespass prevention and mitigation strategies.

In the past year, Volpe took over as GRASP's host and manager. The Volpe Center shares knowledge and resources gained through GRASP with U.S. railways to help steer resources toward effective mitigation. Following successful models in other nations, several carriers have launched training for staff to identify behavioral warning signs of suicide and how to intervene.

Volpe also used GRASP member resources to educate the media and to engage with suicide prevention groups. One media-directed example discourages providing the details of when and where the event happened so as to avoid sensationalism and potential copycat suicides.

The Volpe Center partnered with the Samaritans, Massachusetts Bay Transportation Authority, and selected railroads to implement suicide prevention measures, such as signs and messaging at stations. (Photo courtesy of the Samaritans)

Another initiative encourages suicide prevention groups to promote stories of people overcoming suicidal thoughts or tendencies.

This broad, ongoing collaboration and research push by the Volpe Center and FRA will help rail carriers ensure they improve safety by considering how to address an issue that was once seen as unavoidable and difficult to solve. **(Sponsored by FRA)**

Aviation Safety

Smart Aircraft Wake Separations Make Flying More Efficient—Without Compromising Safety

An aircraft in flight leaves a swirling wake of air behind it, which may be hazardous to following aircraft if not accounted for operationally. To ensure safe aircraft operation in the national airspace system (NAS), either pilots accept visual separation responsibility and air traffic controllers provide pilots with advisory information about nearby wake turbulence, or controllers maintain safe aircraft spacing through wake vortex separation minima.

The Volpe Center supports the Federal Aviation Administration (FAA) in collecting and analyzing data to identify opportunities to safely revise wake separations of aircraft currently in service, and to set wake separation minima for new aircraft prior to entry into service (EIS). The NAS can be even more efficient if aircraft can safely fly closer together.

For aircraft in service, Volpe collects and maintains wake turbulence data, meteorological and surveillance data, and data on aircraft performance and physical characteristics. Volpe analyzes this data to determine safe wake separations between aircraft. In the past year, the Volpe Center enlarged and improved this critical database. The Volpe team

(Source: ©123rf.com/Artem Alexandrovich)

also developed and refined a suite of end-to-end processing and analysis tools to support FAA's needs for evolving concepts on wake separation optimization.

The Volpe Center's contributions have helped FAA evaluate and develop a number of improved concepts to reduce aircraft separation and improve efficiency, including the following:

- *Dynamic Separation Wake Mitigation* (DSW-M). Single-runway wake separations are static. They are set based on the longest-lasting wakes, for all weather conditions. DSW-M safely improves the efficiency of landing and departing aircraft under certain meteorological conditions that are linked to faster wake decay.
- *Wake Turbulence Mitigation for Arrivals – Rear Gate* (WTMA-RG). The WTMA-RG concept improves the efficiency of landing aircraft on closely spaced parallel runways by ensuring that a follower aircraft adjacent to a leader aircraft is positioned in a wake-safe zone. This procedure relies on the follower aircraft landing before the leader's wakes from the parallel runway transport to its approach path.

In addition, Volpe's wake analysis led to a new FAA order—JO 7110.308C—that allows for diagonal spacing down to 1 nautical mile between aircraft landing at certain types of runways, and with certain types of leader aircraft. This procedure is approved at eight airports, with San Francisco International Airport serving as a primary user.

For new aircraft prior to EIS, Volpe supports FAA in developing a generic and repeatable process to determine the wake turbulence spacing that can be integrated into an existing categorical system. Prior to EIS, FAA may assign new aircraft as no weight category (NOWGT) until FAA completes its formal wake separation assessment. To ensure safe separation, air traffic controllers assign a conservative 10 nautical mile spacing in front and behind NOWGT aircraft, which can cause delays with severe ripple effects.

Volpe supported FAA in developing a methodology that standardizes and streamlines the analysis needed to set wake separations for new aircraft. Volpe staff developed the method by identifying the analytical tools that are best applied to different aircraft sizes, performance characteristics, and design features.

Volpe experts submitted two drafts of the methodology to FAA in 2018. This methodology is continuously refined as new aircraft come into service. The Volpe team has used the new methodology to recommend safe wake separations for 44 new aircraft, which FAA will in turn recommend to the International Civil Aviation Organization. Volpe staff provided technical expertise in multiple areas to develop the methodology, including wake turbulence, aircraft flight characteristics, and aircraft design principles. **(Sponsored by FAA)**

Improving Airspace Safety and Efficiency with the Field Spares Inventory System

To sustain NAS infrastructure while maintaining aviation safety and efficiency, it is critical that FAA have an optimized, accurate inventory system of equipment and spare parts. Spare parts and equipment must be available for critical repairs and facility maintenance. For air traffic facilities and airports to achieve maximum efficiency, the NAS must have a balance of just-in-time spares and warehouse space for spare parts.

In 2012, FAA began to modernize its inventory system. A modern inventory system can prevent theft and fraud, and can help get flights back in the air after component failures and outages. Since 2016, the Volpe Center has played a major management support role in this effort.

The inventory system modernization project requires that every field spare have a unique barcode stored in FAA's Asset Marking System (AMS) database. When Volpe took on this project in 2016, the AMS had 4,225 records. Near the end of 2018, there were more than 73,000 records. FAA, Volpe Center, and contractor staff made over 100 visits to airports and facilities across the U.S. to help populate the database. FAA expects its inventoried asset database will significantly and steadily grow through 2019. **(Sponsored by FAA)**

(Source: U.S. DOT Volpe Center)

Innovation, Automation, and Technology

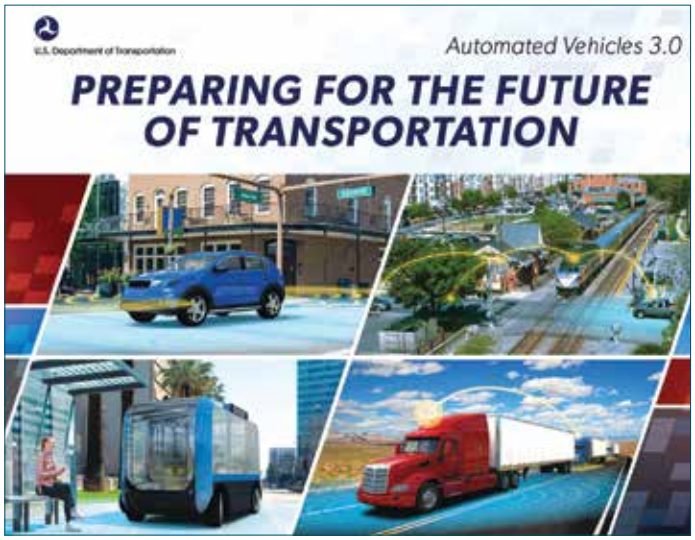
The Volpe Center supports U.S. DOT, DoD, NASA, and others by performing research and analysis that leads to new innovation and the safe and efficient integration of automation into the transportation system.

Automated Vehicles

Preparing for the Future of Transportation: Automated Vehicles 3.0

In recent years, the Volpe Center's automated vehicles team has developed strategy, research, and policy approaches for automated vehicles projects with many surface transportation modes. Because of this expertise, the Office of the Secretary of Transportation (OST) asked Volpe to lead development of *Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0),* the first federal automated vehicle guidance to take a multimodal approach.

In 2017, U.S. DOT published *Automated Driving Systems 2.0: A Vision for Safety.* U.S. DOT created this non-regulatory guidance document to support the automotive industry and other stakeholders as they consider and design best practices for the safe deployment of automated driving systems (ADS).



(Source: U.S. DOT)

In March 2018, U.S. DOT furthered the dialogue on ADS with its Public Listening Summit on Automated Vehicle Policy in Washington, D.C. The summit brought

Elaine L. Chao, U.S. Secretary of Transportation delivers the keynote address at the Public Listening Summit on Automated Vehicle Policy on March 1, 2018, in Washington, D.C. This summit helped guide and inform the *AV 3.0* final report. (Source: U.S. DOT)

together hundreds of transportation stakeholders to provide input and perspectives on how U.S. DOT can help safely integrate automated vehicles into the nation's transportation system. Volpe experts helped design the summit to identify federal and non-federal activities that can accelerate the safe rollout of automated vehicles.

And in October 2018, U.S. DOT released *AV 3.0,* which was informed by feedback from the summit and which expands the scope of the Department's vision on automation to all surface on-road transportation systems.

The Volpe team worked closely with OST officials and experts from U.S. DOT modal administrations to incorporate extensive feedback from manufacturers and technology developers, infrastructure owners and operators, commercial motor carriers, the bus transit industry, and state and local governments.

Through an iterative process, the *AV 3.0* team developed the document along with supporting materials. *AV 3.0* advances U.S. DOT's commitment to supporting the safe, reliable, efficient, and cost-effective integration of automation into the broader multimodal surface transportation system.

Secretary of Transportation Elaine L. Chao released *AV 3.0* during an event at U.S. DOT headquarters in early October, along with leaders from U.S. DOT and federal modal agencies, and key stakeholders from communities representing people with disabilities and emergency management professionals. **(Sponsored by OST, ITS JPO)**

Streamlining Data Exchange for Safe Automated Vehicle Deployment

Open, easy access to roadway information and data can enable automated vehicle (AV) deployment. Accuracy and consistency will improve the exchange of information between AVs, transportation infrastructure, and traffic information services. Facilitating access to essential data will accelerate the safe implementation and integration of AVs into the surface transportation system.

In December 2017, U.S. DOT hosted the Roundtable on Data for AV Safety, bringing together more than 60 participants from federal, state, and local government, businesses, nonprofit organizations, universities, and research centers. The roundtable validated and refined the federal approach to enabling voluntary data and information exchanges among AV stakeholders.

Participants provided their individual feedback on U.S. DOT's draft *Guiding Principles on Data for AV Integration* and the draft *Framework for Data for AV Integration,* current versions of which are online at https://www.transportation.gov/av/data. Attendees also discussed their insights on near-term priorities for voluntary data exchanges that can accelerate the safe deployment of AVs. These topics included:

- Monitoring planned and unplanned work zones
- Providing real-time road conditions
- Diversifying AV testing scenarios
- Improving cybersecurity for AVs
- Improving roadway inventories
- Developing AV inventories
- Assessing AV safety features and performance

Roundtable participants articulated key parameters for each issue and proposed federal roles for addressing them in the near term. The roundtable demonstrated multimodal alignment around the One DOT approach to federal AV policy, and marked the beginning of a new phase of dialogue with public- and private-sector stakeholders to accelerate AV deployment.

Volpe managed and executed all aspects of the roundtable. This included interviewing AV experts within and outside U.S. DOT, identifying key participants, developing agendas and information materials, communicating with participants before and after the roundtable, and co-facilitating table discussions. Volpe experts continue to support this initiative through partnership development, strategic planning, production of communication materials, and workshops.

As a result of the roundtable, FHWA and the Intelligent Transportation Systems Joint Program Office (ITS JPO) have formed a voluntary coalition with state DOTs in Colorado, Iowa, Kentucky, and Michigan, with the Pennsylvania Turnpike Authority, and with five private-sector AV developers and digital infrastructure mapping services, to create a

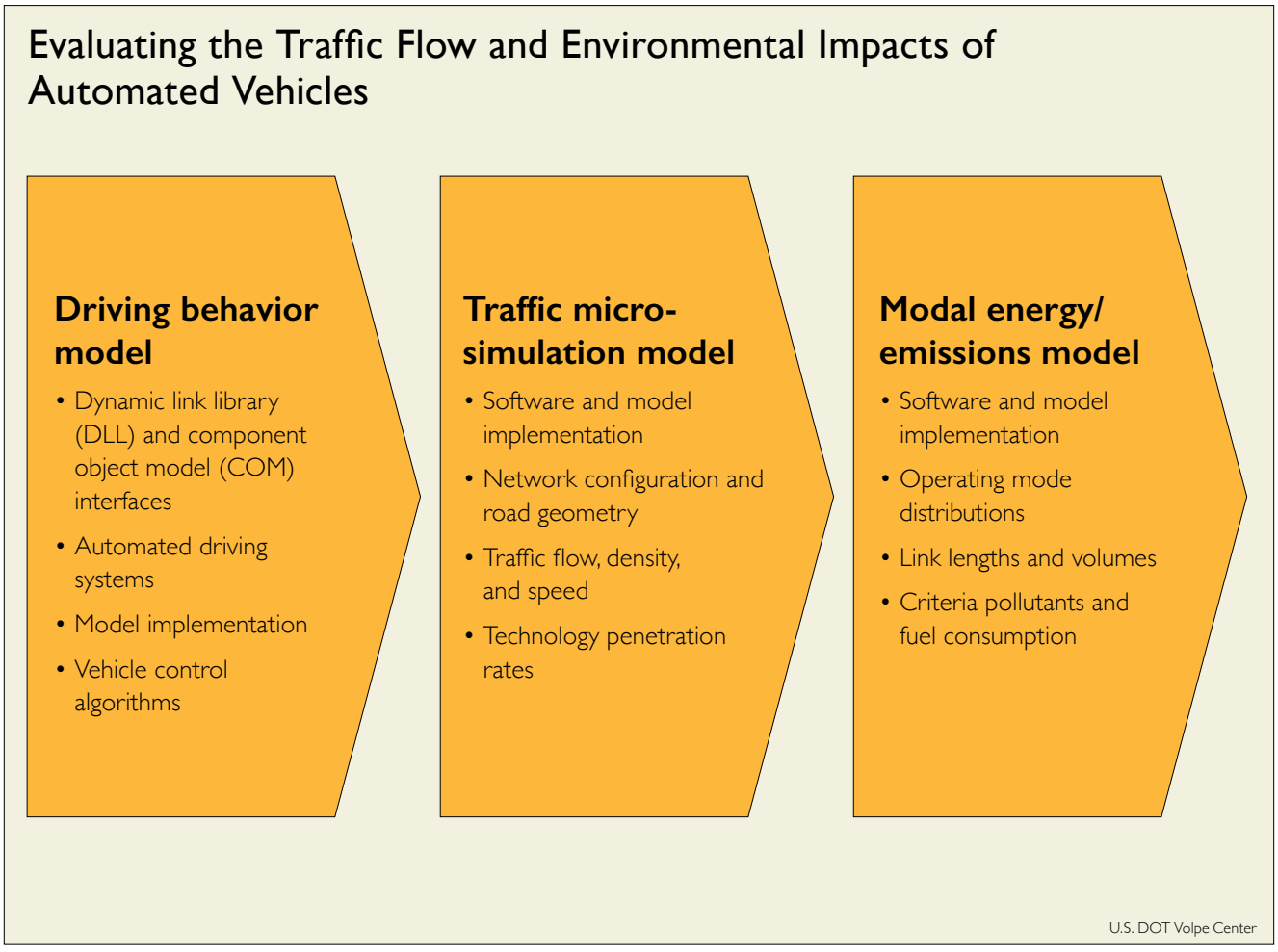
harmonized specification for work zone data sharing, dissemination, and publication. As this project reaches maturity, the harmonized specification will lead to more consistent generation and use of accurate data to enable AVs and conventional vehicles to safely navigate work zones. **(Sponsored by ITS JPO)**

Using Microsimulations to Evaluate Automated Vehicle Fuel Use and Emissions

Connected and automated vehicles (CAVs) have the potential to radically transform surface transportation systems in the United States. Near-term CAV applications—such as cooperative adaptive cruise control (CACC)—can improve traffic flow, energy efficiency, and air quality.

Some research has shown that automation will lead to a significant increase in vehicle miles traveled, due to increased mobility and empty trips for CAVs. ITS JPO is evaluating whether CAVs will increase road capacity, save fuel, and reduce emissions enough to offset increased travel demand, and how those metrics can be measured.

ITS JPO turned to the Volpe Center's multidisciplinary experts to develop detailed simulation modeling of the operational and environmental impacts from vehicle automation and connectivity. Volpe experts created the CAV microsimulation framework



Conceptual diagram of modeling sensitivities for evaluating the traffic flow and environmental impacts of connected/automated vehicle applications. (Source: U.S. DOT Volpe Center)

by testing a three-layered modeling approach using: 1) a CACC driving behavior model provided by FHWA's Turner-Fairbank Highway Research Center, 2) PTV Vissim for traffic microsimulations, and 3) the Motor Vehicle Emission Simulator (MOVES) to assess energy and emissions.

To test this framework on a real-world network, Volpe conducted a case study of vehicles equipped with CACC systems on Interstate 91 near Springfield, MA. Results varied by highway segment—indicating a high sensitivity to network geometry—but they showed that CACC driving would decrease fuel consumption and emissions over manual driving, especially with higher traffic volumes. In a sensitivity analysis of 50 and 100 percent CACC network penetrations at varying volumes, results showed up to a 16 percent reduction in fuel consumption and up to a 21 percent reduction in fine particulate matter. Volpe described this modeling framework and sensitivity analysis at the January 2018 Transportation Research Board Annual Meeting and the July 2018 Automated Vehicles Symposium.

With Volpe's research, ITS JPO can assess the impacts of how CAV applications can reduce congestion, improve fuel efficiency, and reduce air pollution. **(Sponsored by ITS JPO)**

Interactive Gaming Can Validate Potential Impacts of Automated Vehicles

Transportation planners recognize that the public may be uncertain about automated vehicles. Scenario techniques, in which stakeholders respond to a range of possible futures, can help address this uncertainty.

The Volpe Center has been exploring an innovative interactive game to transfer AV research into practice. Using this game, Volpe experts, along with European and Japanese research partners, are working to validate a framework for assessing the impacts of widespread AV deployment.

Volpe experts and their research partners created plausible scenarios describing possible operational and societal outcomes from AV deployment. The Volpe Center and its partners tested one scenario in detail in an interactive session during the 2018 Intelligent Transportation Systems World Congress in Copenhagen, Denmark. This approach allowed Volpe experts to engage a variety of technical experts to validate the framework. The interactive game was an innovative way to share the results of U.S. DOT's AV research and to engage with stakeholders to validate and improve the returns of that research.

For inspiration in defining the scenarios, the Volpe Center turned to recent FHWA and European scenario-development work. Volpe also identified wild cards—possible future events outside the control of policy makers. Finally, Volpe experts in system dynamics defined how distinct elements of AV deployment scenarios could impact other factors. Volpe Center experts worked closely with research partners from U.S. DOT, the University of Leeds in the United Kingdom, and the VTT Technical Research Centre of Finland.

Volpe is now taking the work to a broader audience by incorporating the materials into an Intelligent Transportation Systems Professional Capacity Building course currently in development. **(Sponsored by ITS JPO)**

Strategic Transit Automation Research Plan

Transit bus automation has the potential to deliver safety and operational benefits, but transit agencies need additional research and policy guidance to make informed decisions about deployment. The U.S. transit industry is typically conservative when adopting new technologies, services, and business models. Although funding and policy constraints may play a role, there is also a reasonable unwillingness to risk public funding, or to undertake new operational models, without the available facts, data, and federal guidance to justify adoption.

Toward this end, a cross-divisional Volpe team worked with FTA to develop the five-year *Strategic Transit Automation Research (STAR) Plan,* which establishes a research and demonstration agenda for FTA to move the transit industry forward. Published in January 2018, the *STAR Plan* was developed with input from other U.S. DOT agencies engaged in surface transportation automation research.

The *STAR Plan* focuses on buses, defined as both traditional buses and innovative vehicle designs, like driverless shuttles. The *STAR Plan* considers a broad range of automation, from collision-avoidance technologies for human-operated buses to full vehicle automation.

Built on a foundation of stakeholder engagement, use case analysis, and an extensive literature review, the *STAR Plan* defines activities to explore the non-technical factors of automated transit vehicles:

- *Enabling research* to build a common understanding of foundational issues such as human factors, federal policy, and costs and benefits.

The *Strategic Transit Automation Research Plan* defines a five-year approach that will establish a research and demonstration framework to move the transit industry forward. (Source: ©123rf.com/cheskyw)

- Up to seven FTA-sponsored transit automation *demonstration projects,* of which the resulting lessons learned and project evaluations will be widely disseminated.
- *Strategic partnerships* to improve the quality and usefulness of research by others and distribute findings to the broader community.

These activities seek to provide understanding about the effectiveness of automated buses, consumer acceptance factors, potential workforce impacts, and other topics. If not properly addressed, these issues could slow or stop the development and deployment of transit automation technologies. Combined, they will increase the confidence level of transit agencies considering deployment of automated transit services, and accelerate the entry of manufacturers and suppliers into automation.

The *STAR Plan* closes the gap between the transit bus industry and earlier adopters of automation technologies. The Plan aligns with U.S. DOT's objectives, as the expected benefits of automation include safety and operational improvements along with cost savings. Automation may also enable new forms of transit service increasing mobility, flexibility, and convenience. By providing leadership and guidance at the federal level while incorporating the strengths of external stakeholders and partners, the *STAR Plan* strategically enables transit agency innovation in order to improve the safety and performance of public transportation across the nation. **(Sponsored by FTA)**

Supersonic Transport, Commercial Space and Acoustics

Building a Research Roadmap for Commercial Space Launch Noise and Sonic Boom Research

As new companies enter the commercial space sector, policy makers and the public need to know how space flight affects the environment and human health. Measuring and documenting how space vehicles affect communities is an emerging challenge for regulators, since space vehicles create different noise than civil aircraft.

To inform potential necessary future regulation, Volpe Center environmental measurement experts began by researching the business landscape of the commercial space market. They explored modern space vehicle design from an acoustic community impact, and identified 37 rockets and space vehicles—14 of them are operational—across 17 companies designing, developing, and launching commercial spacecraft in the U.S. Volpe experts also identified gaps in noise modeling and metrics, to help FAA understand noise impacts generated by current and planned space vehicle travel, and identified metrics and models to measure those impacts.

Finally, the Volpe Center defined critical steps to achieve an acoustic regulatory framework, including National Environmental Policy Act (NEPA) compliance, for sonic booms and community noise related to commercial space operations. Volpe delivered a final report with a robust research roadmap on space vehicle noise to the FAA Office of Environment and Energy. **(Sponsored by FAA)**

Get up to Speed on Supersonic Boom Testing

The U.S. is a leader in developing supersonic flight technology that can **cut long-distance air travel time in half**, while meeting global demand and bringing new economic opportunities and high-quality jobs.

New aircraft designs, new technologies, and lighter materials may open the skies to supersonic civil aviation. Civil aircraft are currently prohibited from flying at supersonic speeds **over land.**

Noise experts at the **U.S. DOT Volpe Center** are helping to build confidence in low-boom flight technologies, supporting **NASA**'s quiet supersonic research flights through:

- sonic boom modeling
- flight test planning
- noise measurement
- real-world testing

A team of **NASA** engineers, **Volpe Center** noise experts, and others designed a flight test near Galveston, TX, in November 2018. Here's how F-18 jets simulated quiet supersonic flight:

1. Over two weeks, F-18 jets flew offshore near rural and urban areas of Galveston, executing up to eight **low-boom dive maneuvers** daily to simulate sonic thumps over land and to rehearse survey techniques.
2. Volunteers from Galveston and surrounding areas provided **feedback** during the two weeks of flight testing.
3. **Noise monitors** were also set up in and around Galveston to measure acoustic exposure.

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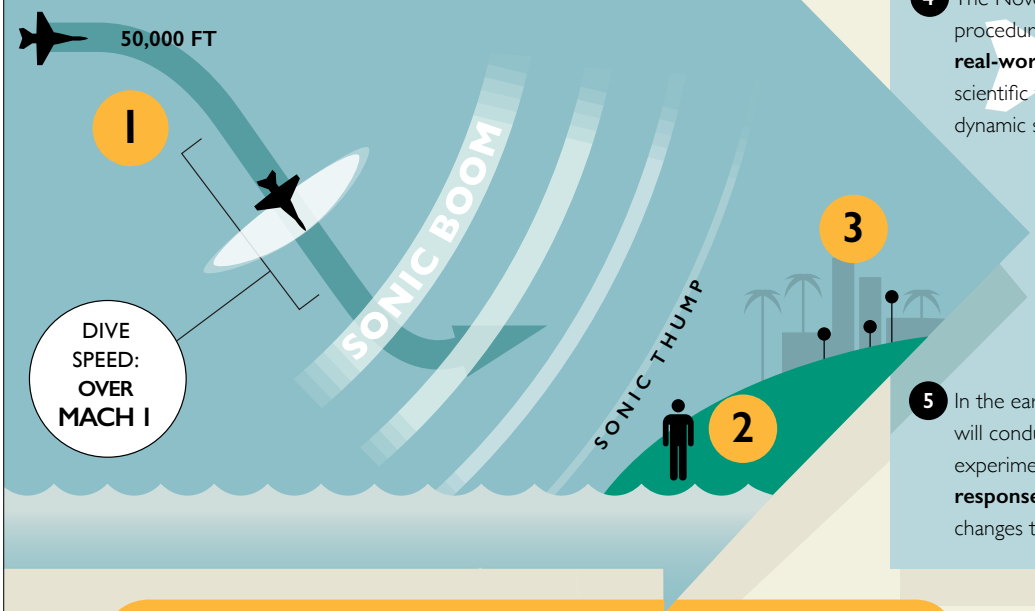


FUTURE TESTING

4. The November 2018 test will inform procedures and surveys for **additional real-world testing** that will set the scientific foundation for an economically dynamic supersonic aviation market.

5. In the early 2020s, NASA will conduct noise tests with its X-59 experimental aircraft. **Community responses** will inform potential changes to supersonic flight regulations.

"You hear that rumble in the distance? That's a sonic thump. That's what we expect people to hear in the community."

— Peter Coen, project manager of NASA's Commercial Supersonic Technology Project

U.S. DOT Volpe Center

Investigating Low-Boom Supersonic Air Travel

The U.S. is a leader in developing supersonic flight technology, and Volpe Center noise experts are helping build confidence in low-boom flight technologies through sonic boom measurement, modeling, and minimization.

Supersonic civil flight will likely first emerge with smaller aircraft, such as business jets. Public confidence in the low-boom technologies may lead to supersonic aircraft designs with larger passenger capacity. Volpe noise experts are developing the science and gathering data to support regulatory processes and potential changes to FAA's supersonic civil flight ban, which applies to overland flight only. Some companies are considering business models with supersonic flight over water.

Volpe is supporting the National Aeronautics and Space Administration (NASA) Quiet Supersonic Flight 2018 (QSF18) tests and is designing acoustic and subjective testing and analysis protocols for a demonstration vehicle used to gather data that will inform international rulemaking. Volpe is assisting with the design of the experiments and is engaged in sonic boom modeling, flight procedures analysis, acoustic measurement protocols, and survey and community engagement.

Volpe helped NASA, Applied Physical Sciences (APS), and industry partners design and conduct the QSF18 flight test near Galveston, Texas in November 2018. This test used NASA F-18 jets to simulate quiet supersonic flights by creating sonic "thumps" over Galveston, where residents were recruited to provide feedback on the sounds they heard. The test helped refine testing protocols and gather sample data. The QSF18 test will inform future assessments with NASA X-59 aircraft over different regions in the U.S., and in developing a human response database that the FAA and the International Civil Aviation Organization (ICAO) can use to evaluate potential changes to international supersonic flight regulations.

This testing is a precursor to a national effort to understand how people react to the sound of quiet supersonic aircraft flying overhead. These tests will help inform the best ways to engage communities, collect acoustic data, and conduct surveys in response to sounds that people do not normally hear. The results will also inform ongoing ICAO activities in support of the reintroduction of commercial supersonic flight.
(Sponsored by NASA)

Reducing Helicopter Noise for Communities

Noise from low-flying helicopters is an issue for many communities. Metropolitan areas such as New York City and Los Angeles face challenges in reducing noise from helicopter tours, charters, and emergency operations.

One way to reduce helicopter noise is with noise abatement techniques. Developing noise abatement techniques for rotorcraft is challenging because helicopter noise characteristics are more complex than those of fixed-wing aircraft.

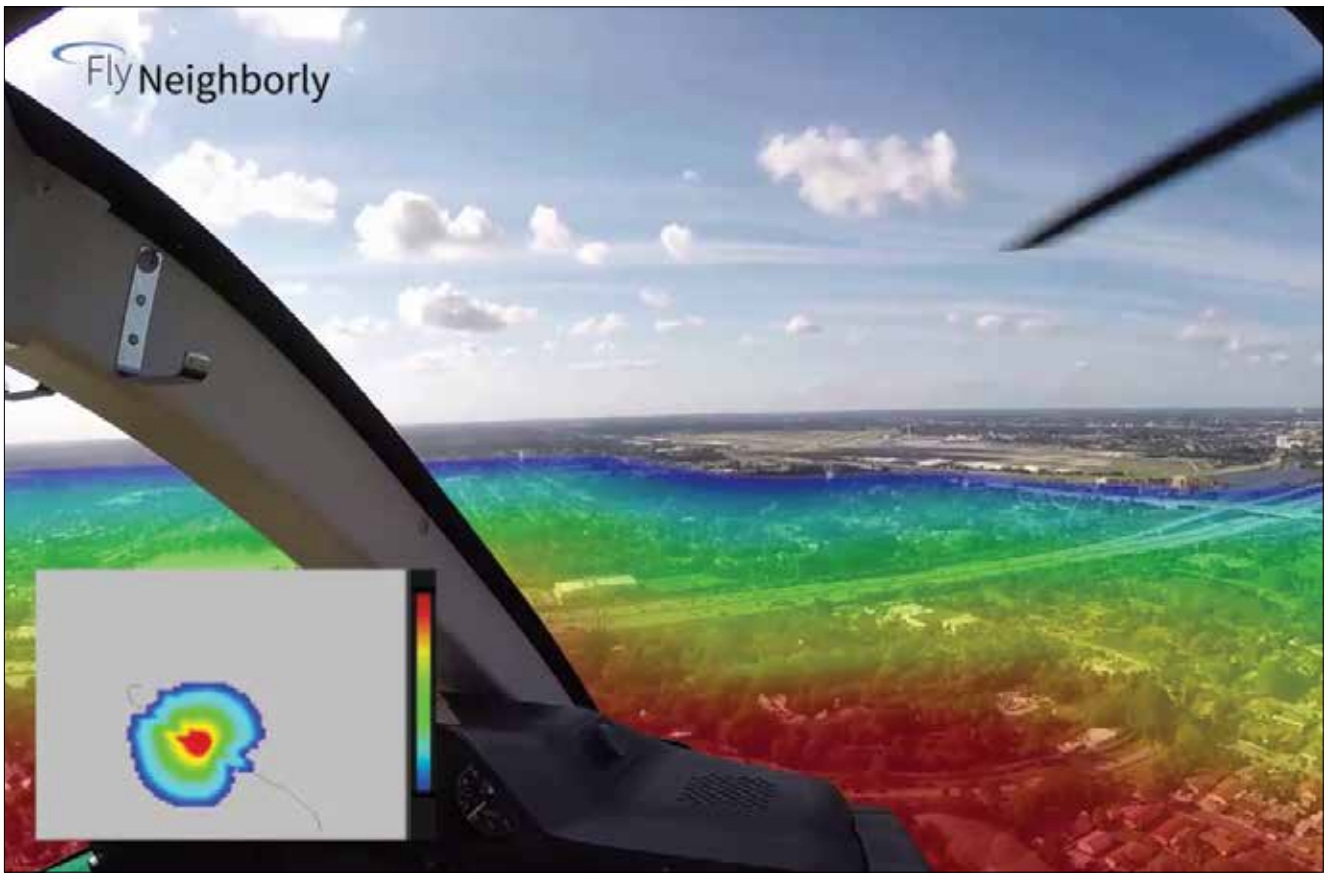
The Volpe Center's environmental measurement experts have extensive experience in noise abatement, and have provided subject matter expertise, onsite field support, and

analysis across all modes of transportation. FAA asked the Volpe Center to develop and scientifically validate noise abatement techniques for helicopter operations.

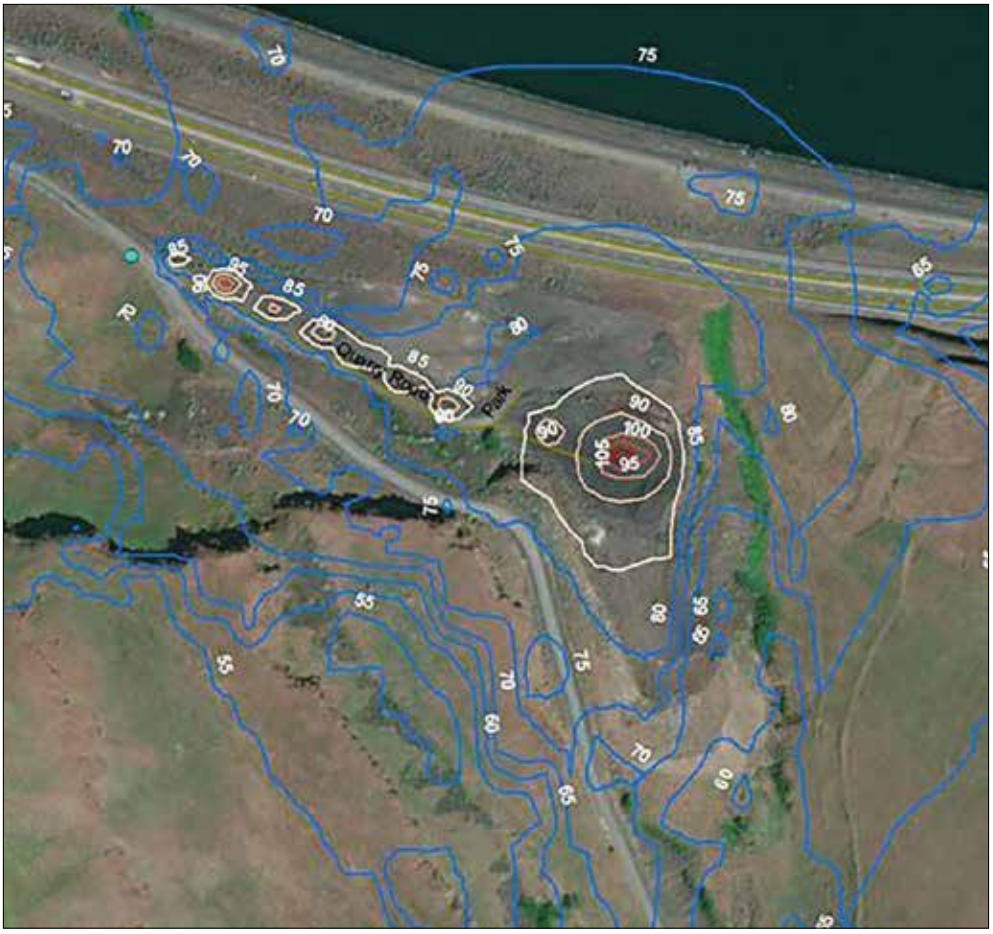
Volpe experts partnered with FAA and NASA to develop and test helicopter noise abatement procedures. The team produced situational awareness tools and developed and conducted online and in-person training forums and courses for pilots and operators, through the FAA's WINGS Pilot Proficiency Program. Educational resources include videos that let students visualize noise from flight maneuvers through noise exposure heat maps generated by the helicopter flight path and overlaid on cockpit video footage. The Helicopter Association International, an FAA cooperating partner, initiated the pilot training concept—called Fly Neighborly—to improve relationships between communities and helicopter operators using noise mitigation techniques and proactive communications.

Several U.S. airports have already adopted noise abatement procedures. Volpe is now developing a Fly Neighborly demonstration program to improve trainings, which may lead to wider adoption of flight techniques that reduce helicopter noise. The hope is that the noise abatement guidance will be incorporated into mandatory FAA flight training for pilots.

With greater industry use of noise abatement procedures, helicopter industry growth can continue without a commensurate increase in public complaints and the potential burden of increased regulation and operational limits. The result will be more opportunities to provide essential helicopter transportation, emergency, and other services for tourism, offshore energy development, news media, and first responder industries. **(Sponsored by FAA in partnership with NASA)**



An example of a helicopter noise exposure 'footprint' overlaid on the cockpit video. These videos are used during pilot training to increase awareness of helicopter noise generation. (Source: U.S. DOT Volpe Center)



The Volpe Center developed a GIS-based Quarry Noise Model to help ODOT develop noise predictions around quarries in Oregon. (Source: Kira Glover-Cutter, Oregon DOT)

Mapping Quarry Noise for the Oregon Department of Transportation

The Oregon Department of Transportation (ODOT) maintains quarries to mine rock and gravel for construction, maintenance, and emergency repair projects throughout the state. Rock is extracted, processed, and removed from the quarries, and airborne noise is a major concern for ODOT and residents who live near those quarries.

The recent listing of sage grouse as endangered prompted ODOT to assess whether activities at its quarries comply with environmental impact mitigation regulations from the Oregon Department of Fish and Wildlife (ODFW).

ODOT turned to the Volpe Center's environmental measurement and modeling experts to develop a quarry noise analysis tool. Volpe delivered a Geographic Information System (GIS)-based Quarry Noise Model (QNM) that maps noise around a quarry. The QNM is helping ODOT optimize the timing and design of quarry operations across the state to comply with noise regulations from ODFW and the Oregon Department of Environmental Quality.

The QNM will also help ODOT meet its mission of providing Oregon communities with a safe and reliable quarrying system that supplies materials for transportation infrastructure. The full impact of the QNM will be determined in several years.
(Sponsored by ODOT)

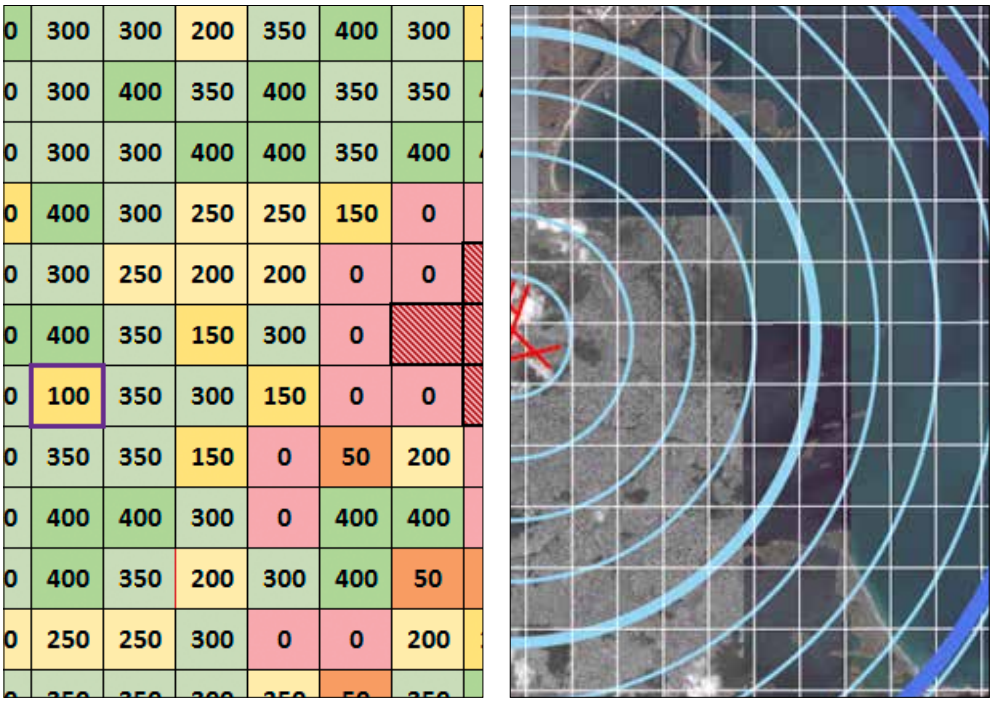
A Quantitative Model to Support Automated Approval Processes of Small Unmanned Aircraft Systems Operations

FAA projects an increase from 1.1 million small-model hobbyist Unmanned Aircraft Systems (sUAS) in 2017 to 2.4 million in 2022, and from 110,604 commercial, small non-model drones in 2017 to 451,800 in 2021. This demand is expected to grow as new uses for sUAS are identified.

FAA's Part 107 Rule allows sUAS to fly at low altitude, in controlled airspace, near airports; more than 20,000 requests for authorizations have been made in the first year since the rule came into effect in August 2016. FAA typically reviews each request manually, approving within 60 days of the request date. FAA is developing automated systems to safely and efficiently approve an increasing number of requests, as demand grows.

The Volpe Center's air navigation experts have extensive experience in system analysis and testing. FAA asked the Volpe Center to develop a quantitative model to evaluate the approval of sUAS operations using current and future FAA automated systems.

To meet this need, Volpe analyzed manned aircraft track data from over 40 airports to determine altitudes where sUAS would be sufficiently separated vertically from manned aircraft from a statistical perspective. Preliminary results for all Class B airspaces and a number of Class C and D airspaces were determined and shown in one-minute-by-one-minute grids. The analysis helped to uncover areas where manned aircraft operate frequently at low altitudes, such as medical and police helipads, seaplane bases, and training/instructional flight areas.



0	300	300	200	350	400	300
0	300	400	350	400	350	350
0	300	300	400	400	350	400
0	400	300	250	250	150	0
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0	350	350	150	0	50	200
0	400	400	300	0	400	400
0	400	350	200	300	400	50
0	250	250	300	0	0	200

Volpe developed a prototype model to examine risk of sUAS operating in controlled airspace near airports. The graphics show sample manned aircraft flight altitudes (to recommend UAS to fly below them) and a UAS facility map for Boston Class B airspace. (Source: U.S. DOT/ FAA)

The model provides a data-backed, quantifiable, and repeatable approach. Results are generally conservative in the busiest airspaces, but are consistent among airspaces of the same class and type. Results can be compared to air traffic controllers' and subject matter experts' qualitative assessments of airspaces. Volpe's methods, assumptions, and data, as well as recommended model enhancements can be incorporated by the FAA into future systems.

Quantitatively assessing airspaces can improve the safety of sUAS operations and increase the reliability of automated approval systems, while fostering sUAS industry growth. With more detailed information on manned aircraft traffic, Part 107 requests can be approved faster and more efficiently.

A report on the Volpe Center's quantitative model to automate the approval process of sUAS operations can be found at http://www.tc.faa.gov/its/worldpac/techrpt/tc18-30.pdf. **(Sponsored by FAA)**

Safely Integrating Drones into the National Airspace System

Unmanned aircraft systems (UAS) are experiencing constant growth in the NAS and have been used recently for environmental monitoring, law enforcement, and disaster relief for hurricanes and wildfires. By 2022 there could be nearly four million model and non-model drones—an increase in airborne vehicles that places a tremendous burden on the FAA to maintain safety standards.

Federal regulations require pilots operating in the NAS to see and avoid neighboring aircraft. For remote operators of UAS to comply with this regulation, either ground-based observers or an additional aircraft following the drone are necessary. This has the potential to limit the flexibility of UAS operations.

Volpe experts engineered a mobile command center outfitted with ground-based detect and avoid equipment that allows remote pilots to control UAS operations from multiple locations. (Source: U.S. DOT Volpe Center)

Experts in air traffic management systems and operations at the Volpe Center have worked with the U.S. Air Force (USAF) to develop and deploy an automated solution to this challenge. The Ground-Based Detect and Avoid (GBDAA) capability integrates real-time track and position data from ground-based radar(s) into a single display, allowing remote UAS operators to detect and avoid other aircraft.

FAA has certified that GBDAA provides a level of safety equivalent to a pilot operating under visual or instrument flight rules (VFR, IFR). GBDAA provides a probability of detecting other aircraft of 95 percent, well above the requirement of 80 percent for terminal radar sources.

The Volpe Center collaborated with USAF and the Ohio DOT to deploy GBDAA at Springfield-Beckley Municipal Airport. Volpe experts engineered an innovative solution—a mobile command center outfitted with a full suite of GBDAA equipment—that allows remote pilots to control UAS operations from multiple locations. The deployment is an important benchmark, demonstrating that GBDAA can be effective across geographic locations that have unique operational characteristics.

Volpe's next step is to conduct flight trials of UAS using the mobile GBDAA system, laying the groundwork for requesting a Certificate of Authorization from the FAA for operations beyond visual line-of-sight, without chase aircraft or ground observers. The Springfield deployment paves the way for implementing GBDAA across the country to meet critical needs of UAS missions. **(Sponsored by USAF)**

Data Driven Decision Making

Improving Operational Efficiency of the St. Lawrence Seaway

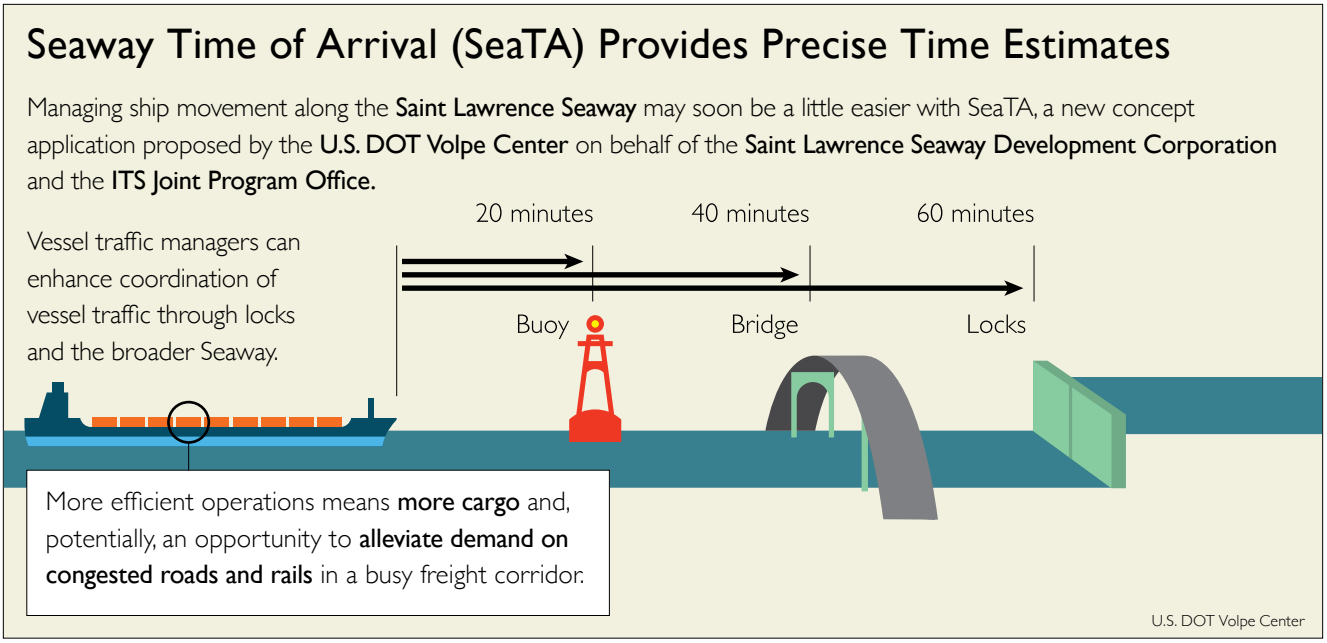
Maritime transport is essential to the global economy, which is why it is critical to maintain the safe and efficient operation of the St. Lawrence Seaway and the broader Great Lakes-St. Lawrence Seaway System. The Seaway is a vital transportation link for the United States and Canada, accounting for one-quarter of U.S. GDP and half of the monetary value of North America's manufacturing and services industries. The Seaway also directly provides nearly one-quarter of the population of North America with goods and commodities.

The Volpe Center initiated a project with the ITS JPO to examine opportunities to improve operational safety and efficiency of the Seaway through ITS technology.

Volpe experts led the project; conducted background research; convened a project oversight group with ITS JPO, the Saint Lawrence Seaway Development Corporation in the U.S., and the St. Lawrence Seaway Management Corporation in Canada; collected input and feedback from Seaway partners, stakeholders, and users; and developed a final concept of operations.

This project produced three publications:

- *St. Lawrence Seaway: Overview of Safety, Efficiency, Operational, and Environmental Issues: Discussion Paper.* Volpe summarized existing safety,



environmental, and economic conditions on the Seaway, documented numerous operational challenges across the broad spectrum of stakeholders, and identified preliminary opportunities to apply ITS technology to improve Seaway safety and efficiency.

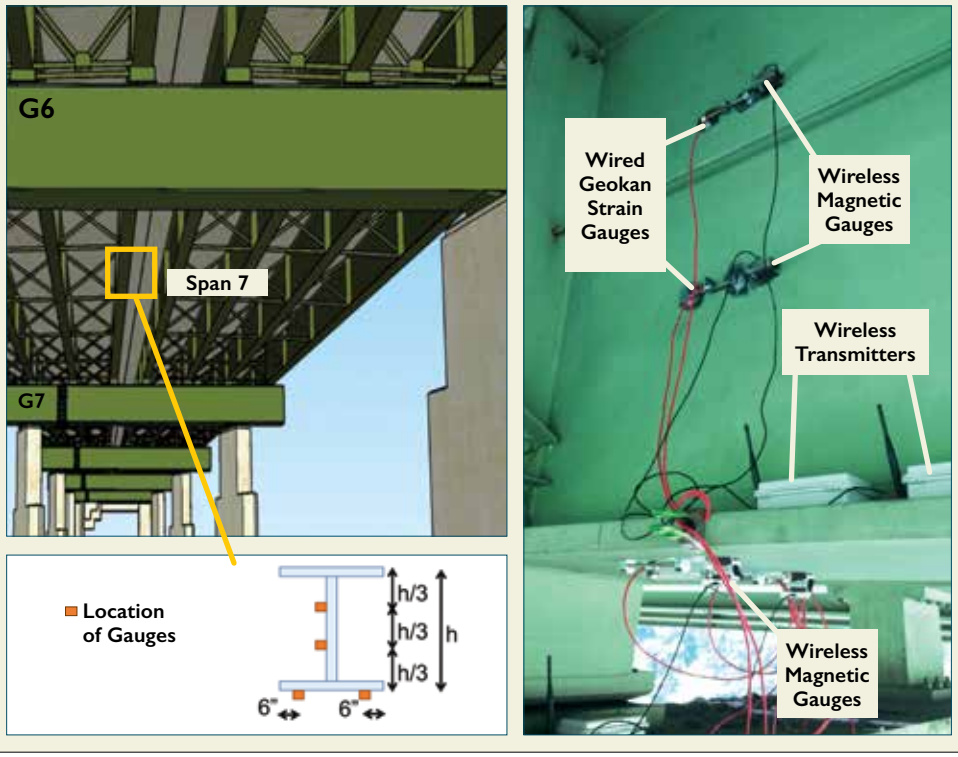
- *St. Lawrence Seaway: Potential Opportunities for the Application of Information and Communication Technologies: Discussion Paper.* Volpe documented applications of ITS and other technologies used in maritime transportation around the world. The Volpe team also identified several candidate technology applications through initial research and stakeholder outreach.
- *Concept of Operations: SeaTA–Enhanced Travel Time Estimates and Traffic Management Practices for the St. Lawrence Seaway.* Volpe proposed a computer-based application–Seaway Time of Arrival (SeaTA)–to collect real-time operational data from ships operating on the Seaway. The application would estimate vessel arrival times from waypoints along a planned route. SeaTA could improve the accuracy of vessel arrival times; enhance system efficiency and situational awareness for Seaway operators and vessels; reduce operating costs of vessels and Seaway infrastructure; and enable efficiencies for the region's heavily traveled road and rail networks.

(Sponsored by ITS JPO)

Roadway Innovation with FHWA's Exploratory Advanced Research Program

FHWA's Exploratory Advanced Research (EAR) Program funds long-term, high-risk, breakthrough research that may lead to dramatic, ongoing improvements toward planning, building, renewing, and operating safe and environmentally sound transportation systems. The program addresses underlying gaps in applied highway research programs, anticipates emerging issues, and reflects broad transportation industry goals and objectives.

Wireless Monitoring of Structural Integrity



Installation schematic and on-site installation of sensors on underside of Pencoyd Viaduct, located just outside of Philadelphia, Pennsylvania.
(Source: Drexel University)

More than 30 percent of bridges in the U.S. have exceeded their 50-year lifespan. Installing conventional wired sensors to monitor the structural integrity of large transportation infrastructure is time consuming and costly. Low-cost monitoring systems, such as wireless sensors, are well-suited for providing early warnings of serious structural deterioration. They can also provide state and local agencies with substantial savings for bridge inspection and maintenance. They are easy to install, battery-powered, accurate and durable, and can provide high data sampling rates.

The EAR Program sponsored a Drexel University research team to design, develop, and validate a suite of wireless, multipurpose sensors for bridge inspection. FHWA turned to the Volpe Center to assess the Drexel University research—Multipurpose Wireless Sensors for Asset Management and Health Monitoring of Structures. Volpe reviewed Drexel's wireless sensor project and generated technical summary reports and transition plans. The transition plan is a critical deliverable for technology transfer. The transition plan provides the following:

- A roadmap for follow-on research and development to advance the maturity of the technology.
- Use cases for the technology as it matures.
- Future technology users and stakeholders.

In helping FHWA disseminate EAR research results and improve the quality, consistency, and efficiency of the EAR peer review process, Volpe is making it more likely that transportation stakeholders will implement EAR investments. **(Sponsored by FHWA)**

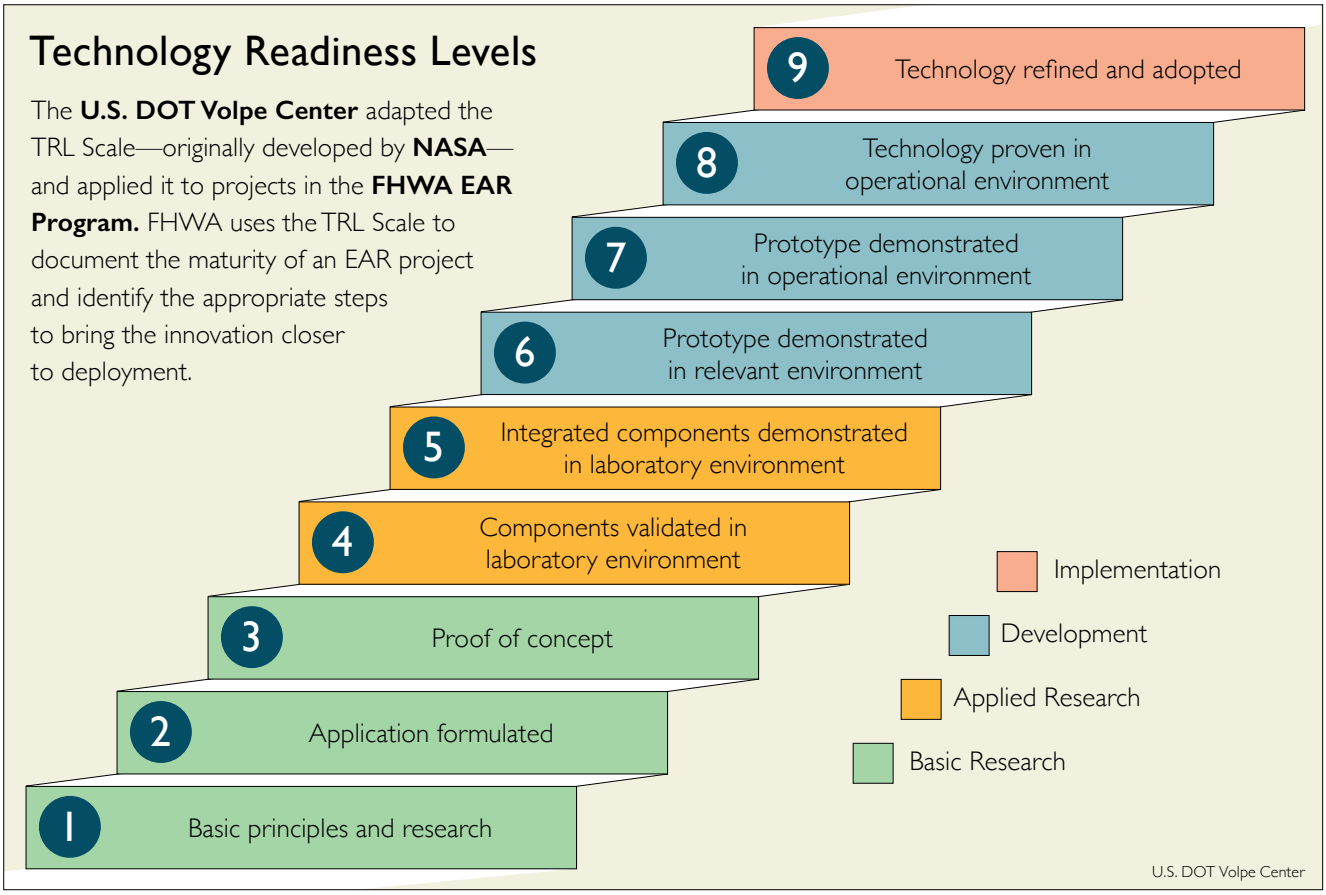
Integrating Technology Readiness Levels into Innovative Travel Modeling Pilots

From 2012 to 2016, the Volpe Center collaborated with the FHWA EAR Program to develop a metric that lets experts and non-experts understand the maturity of innovative research. Technology Readiness Levels (TRL) for highway research are based on a scale that NASA first developed. The scale poses questions, with answers indicating how close a technology is to deployment. The TRL process also helps project sponsors identify reasonable next steps to advance the maturity of a complex technology.

Volpe Center technology experts worked with the FHWA Office of Planning to use the TRL process to organize three peer reviews of several SHRP2 pilots on advanced travel models. Three highway-focused projects took place in Atlanta, Maryland, and Ohio. A transit-focused project took place in San Francisco and Seattle.

These projects, which integrated activity/agent-based modeling with dynamic traffic/transit assignment, addressed the need to develop integrated travel demand models with detailed temporal and spatial resolution. These detailed models help transportation professionals assess the impacts of modern capacity and operational improvement strategies such as signal coordination, freeway management, and variable tolls.

The Volpe team designed, facilitated, and documented the peer reviews. Project teams and the expert external panelists used TRLs to document the readiness of the technology for deployment and identify next steps. The TRLs showed that the agent-based modeling



project had advanced significantly since its original incarnation under the EAR Program in 2015. A summary of the projects and the results of the TRL peer reviews are available in *TravelWorks Integrated Models: Final Report,* which can be found at https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/integrated_models/. **(Sponsored by FHWA)**

Integrating Shared Mobility into Multimodal Transportation Planning

Shared mobility—the shared use of a vehicle, bicycle, or other mode—is an innovative transportation strategy that gives users short-term access to transportation modes. Even though new shared mobility services have become increasingly common and are important modes of travel in U.S. cities, regional transportation planning practices are only beginning to adapt in response.

Metropolitan Planning Organizations (MPOs) and their partners are facing a critical challenge—bring shared mobility into the transportation planning process in order to develop higher-performing regional multimodal systems. Even though private sector companies are quickly becoming important providers of transportation services in many urban areas, it is still unclear how people will use these shared mobility options and related technologies in the near future. This rapidly changing transportation environment calls for integrating shared mobility into transportation planning to ensure the public has a voice, public goals are being considered and addressed in parallel with business goals, and transportation plans and programs remain effective.

Why should shared mobility be part of the planning process?

Shared Mobility is an increasingly popular mode of travel.

User behavior is changing in response to new services.

Transportation Planning Goals may be easier or harder to achieve as a result.

Metropolitan Transportation Planning needs to account for shared mobility to accomplish regional goals.

Planning Issues Related to Shared Mobility

- Ensuring a safe transportation system
- Enhanced mobility for persons without a vehicle
- Equitable access to shared mobility services
- First/last mile connections and expanded access to public transportation
- Impacts on congestion
- Air pollution and greenhouse gas emissions
- Sustainable urban density and land use
- Implications for public infrastructure revenue models

U.S. DOT Volpe Center

The Volpe Center's transportation planners have proven expertise in project planning and programmatic support for many different kinds of transportation planning initiatives at the national, state, and local levels. The FHWA Office of Planning directed the Volpe Center to research and author a white paper titled *Integrating Shared Mobility into Multimodal Transportation Planning: Improving Regional Performance to Meet Public Goals,* which examines how and why to include shared mobility in regional multimodal transportation planning.

The white paper provides a framework and examples to assist transportation agencies—MPOs, state DOTs, transit agencies, and local governments—in anticipating and planning for shared mobility as part of a higher-performing regional multimodal transportation system. Published in February 2018, the white paper includes noteworthy examples of shared mobility planning in 13 metropolitan areas sourced from online research and conversations with planning practitioners; identifies challenges and opportunities; and provides recommendations for future research into improving planning practices related to shared mobility. The Volpe Center is now working on four additional in-depth case studies that focus on the MPO role in shared mobility planning. A future case study webinar is planned.

This project provides FHWA with a forward-thinking resource to help transportation agencies better integrate new transportation technologies and services into the planning process, and makes long-range, multimodal plans more relevant and reflective of transportation innovations. **(Sponsored by FHWA)**

Freight and Fuel Transportation Optimization Tool Evaluates Transport Scenarios

The U.S. economy depends on the efficient movement of goods, including critical energy commodities. Government agencies are working to understand changing transportation needs and potential impacts. This will lead to improved federal policies and regulations and more efficient supply chains with fewer environmental and safety effects.

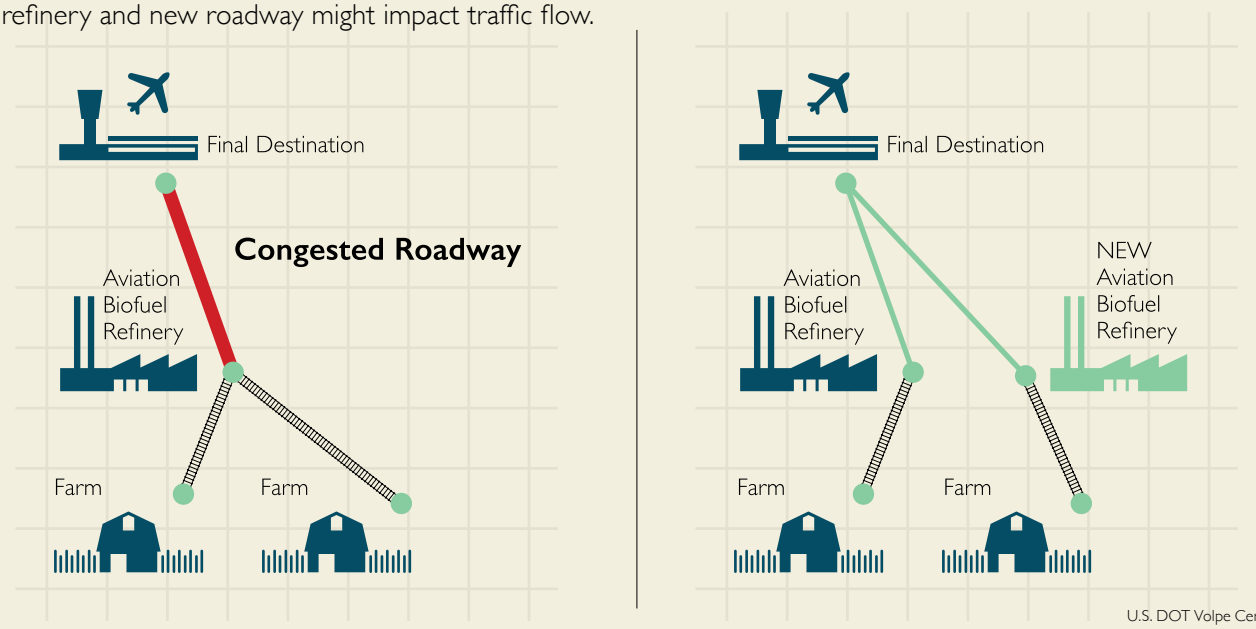
To analyze freight and fuel transport options, Volpe created the Freight and Fuel Transportation Optimization Tool (FTOT) on behalf of the FAA, the Department of Energy (DOE), and the U.S. Navy's Office of Naval Research.

FTOT draws on a range of data to help government agencies analyze freight and fuel transport options and hone in on optimal multimodal transportation flow patterns and emissions associated with potential freight and energy scenarios. Users can explore how potential changes in production and demand will affect those optimal patterns. In addition, users can evaluate how future infrastructure scenarios—such as the gain or loss of transportation links, or changes in capacity on roadways or other modes—will affect a given route, and apply what they learn to freight planning.

Many federal agencies recognize the value and opportunity in using FTOT to explore future freight and fuel scenarios. The Volpe team has worked with sponsors to develop the overall FTOT capabilities that are relevant to multiple sponsor efforts as well as tailored capabilities and scenario analyses. Volpe Center policy and environmental experts can

Exploring Transportation Flow Scenarios With the Freight and Fuel Transportation Optimization Tool (FTOT)

The **U.S. DOT Volpe Center** created FTOT in support of FAA, DOE, and DoD to analyze freight and fuel transport options. In this simple example, FTOT can show how a new biofuel refinery and new roadway might impact traffic flow.



Results from two hypothetical FTOT freight flow scenarios in the Massachusetts region demonstrating changes in flow resulting from variations in intermediate handling facilities. (Source: U.S. DOT Volpe Center)

adapt FTOT functionality to specific agency needs, leveraging existing capabilities to avoid duplicative efforts, and maximizing return on investment.

Analyses with FTOT have been used in several peer-reviewed journal articles. One recent article describes Volpe's collaborative analyses of future alternative jet fuel scenarios with FAA, DOE, the National Renewable Energy Laboratory, and researchers from the FAA ASCENT Center of Excellence. The article discusses the potential for reaching a billion gallons of domestically produced alternative jet fuel from waste materials by 2030, which would contribute to energy security and environmental performance in the aviation sector. Volpe experts used FTOT to optimize the movement of raw materials and fuels in these future deployment scenarios to show flow patterns, potential delivery points, and transportation-related costs and modal options.

In the past, Volpe has used FTOT to analyze greenhouse gas life cycle emissions and water usage impacts from transportation flows of canola-based alternative jet fuel. FTOT has also been used to explore potential effects of lock renovations on patterns of coal and crude oil flow, and analyzed potential flows and delivery patterns for alternative jet fuel. Volpe's ongoing FTOT analyses are investigating agricultural and alternative jet fuel supply chains in the Southeastern U.S. and other regional-scale supply chains, crude oil movements and potential changes, and long-range freight planning.

The Volpe team continues to enhance FTOT's suite of capabilities and is working toward a publicly releasable version of the tool, expected in 2019. **(Sponsored by FAA, DOE, [former sponsor Department of Defense])**

(Source: ©2018 Callahan7Photography/John Callahan)

Infrastructure and Resilience

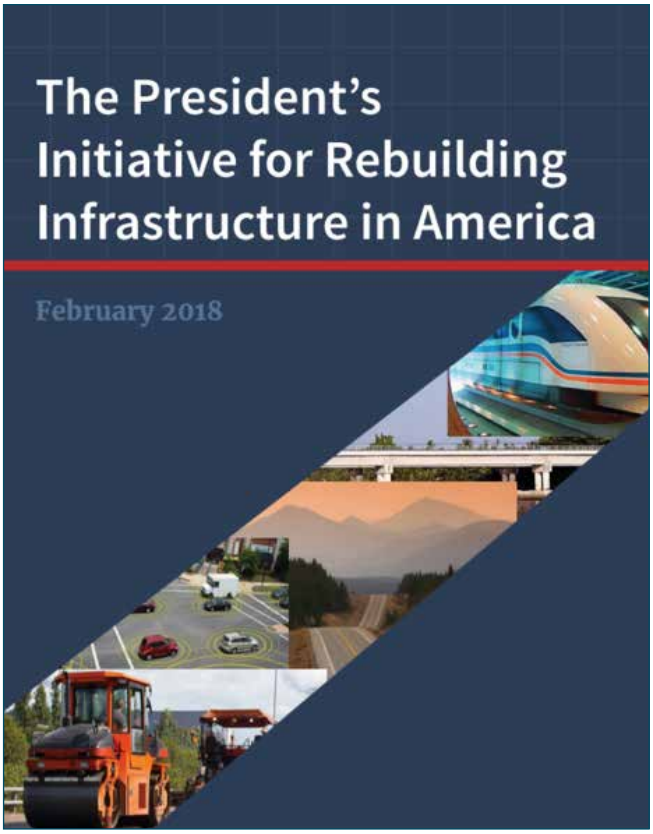
The Volpe Center supports key programs and infrastructure initiatives that stimulate economic growth and ensure safety, mobility, and accessibility.

Administration Priorities

Rebuilding Infrastructure in America

In February 2018, the Administration announced the President's initiative to rebuild America's infrastructure. The President's plan presents solutions to key challenges facing the nation's infrastructure, including improvements to all modes of transportation through regulatory reforms, new funding approaches, and transformative technologies.

In support of the Office of the Secretary of Transportation, the Volpe Center helped produce *The President's Initiative for Rebuilding Infrastructure in America*. The booklet aligns with the priorities and key principles put forth in the Legislative Outline for Rebuilding Infrastructure in America and describes the benefit associated with each action.



The President's Initiative for Rebuilding Infrastructure in America promotes solutions for improving all modes of transportation. (Source: U.S. DOT)

President Donald J. Trump's plan calls for at least $1.5 trillion in private and public infrastructure investments, refocuses the federal role on transportation projects of regional and national significance, and puts local

and state projects back in the hands of those entities. The plan also proposes a number of solutions aimed at connecting people to jobs, addressing the needs of rural Americans, and improving the safety and well-being of all Americans.

The booklet builds the case for each of the solutions described in the plan, including reforms to federal highway, transit, rail, aviation, maritime programs, and environmental review and permitting processes.

Volpe Center policy experts leveraged existing experience and augmented it with quick but extensive research that provided context and support for each principle. This information was then paired with strategies to execute the principles, forming the content for the booklet. In collaboration with the Office of the Secretary, the Volpe Center team developed the layout, created original graphics, and produced the final booklet.

The resulting 61-page booklet serves as a vital reference and conveys U.S. DOT's vision for rebuilding America's transportation system in a timely and efficient manner. **(Sponsored by OST-P)**

Promoting Transparency and Accountability for INFRA and BUILD Grants

"These INFRA grants will empower states and communities to make significant long-term infrastructure improvements that will shape transportation and mobility for decades to come."

Elaine L. Chao, U.S. Secretary of Transportation, June 8, 2018

Two highly competitive U.S. DOT grant programs are providing funds to states and localities to spur high-impact transportation investments. The Infrastructure for Rebuilding America (INFRA) program replaces the FHWA's FASTLANE program. INFRA uses innovative approaches to address critical issues facing our nation's highways and bridges. It improves processes for building significant infrastructure projects, and increases project accountability.

The Better Utilizing Investments to Leverage Development (BUILD) program replaces the Transportation Investment Generating Economic Recovery (TIGER) program. BUILD funds road, rail, transit, and port projects that will have a significant local or regional impact and that promise to achieve U.S. DOT objectives. Projects selected for INFRA and BUILD grants will improve safety, relieve congestion, address infrastructure needs, and provide new travel options. INFRA grants announced in June 2018 total $1.5 billion, compared to only $800 million available through FASTLANE in fiscal year 2016.

INFRA and BUILD applicants must submit benefit-cost analyses (BCAs) that quantify the net societal benefits of proposed projects. Volpe Center economists collaborated with their counterparts in other DOT agencies in the economic review teams for INFRA and BUILD projects as part of the evaluation process to support U.S. DOT decisions on funding levels. Including BCAs in evaluation allows projects to be compared in a systematic way and ensures that scarce funding resources are applied to the projects that will have the greatest value to the traveling public. Maximizing grant efficiency aligns with U.S. DOT's strategic goal of achieving accountability.

Volpe's evaluation work involves checking an applicant's data sources and assumptions, validating calculations, identifying potential methodology concerns, and verifying compliance with U.S. DOT's benefit-cost guidance. Reviewers document their work in a written summary that becomes part of the evaluation file. In many cases, Volpe reviewers

performed an extensive rework of the BCAs submitted by project applicants, addressing methodology issues and recalculating overall results. The team also performed secondary reviews, checking the work of primary reviewers to ensure methodological issues were handled consistently across projects.

Compared to Volpe's role during TIGER project reviews, Volpe's role in the BUILD project reviews was expanded to include technical evaluations and readiness assessments. In this role, Volpe reviewers worked with other U.S. DOT offices to review grant applications and evaluate how they aligned with program objectives, contributed to national transportation goals, and complied with grant requirements. For the readiness assessments, Volpe staff with expertise in environmental policy reviewed applicants' environmental documentation, ensuring that projects selected for funding were ready to proceed to construction. In 2018, the Volpe team reviewed approximately 45 projects for INFRA and conducted 91 benefit-cost reviews for BUILD.

Volpe will continue to support the Office of the Secretary by evaluating BCAs and performing technical evaluations and readiness assessments for INFRA and BUILD. **(Sponsored by OST-P)**

Synchronizing Environmental Permitting to Finish Transportation Projects Faster, Cheaper

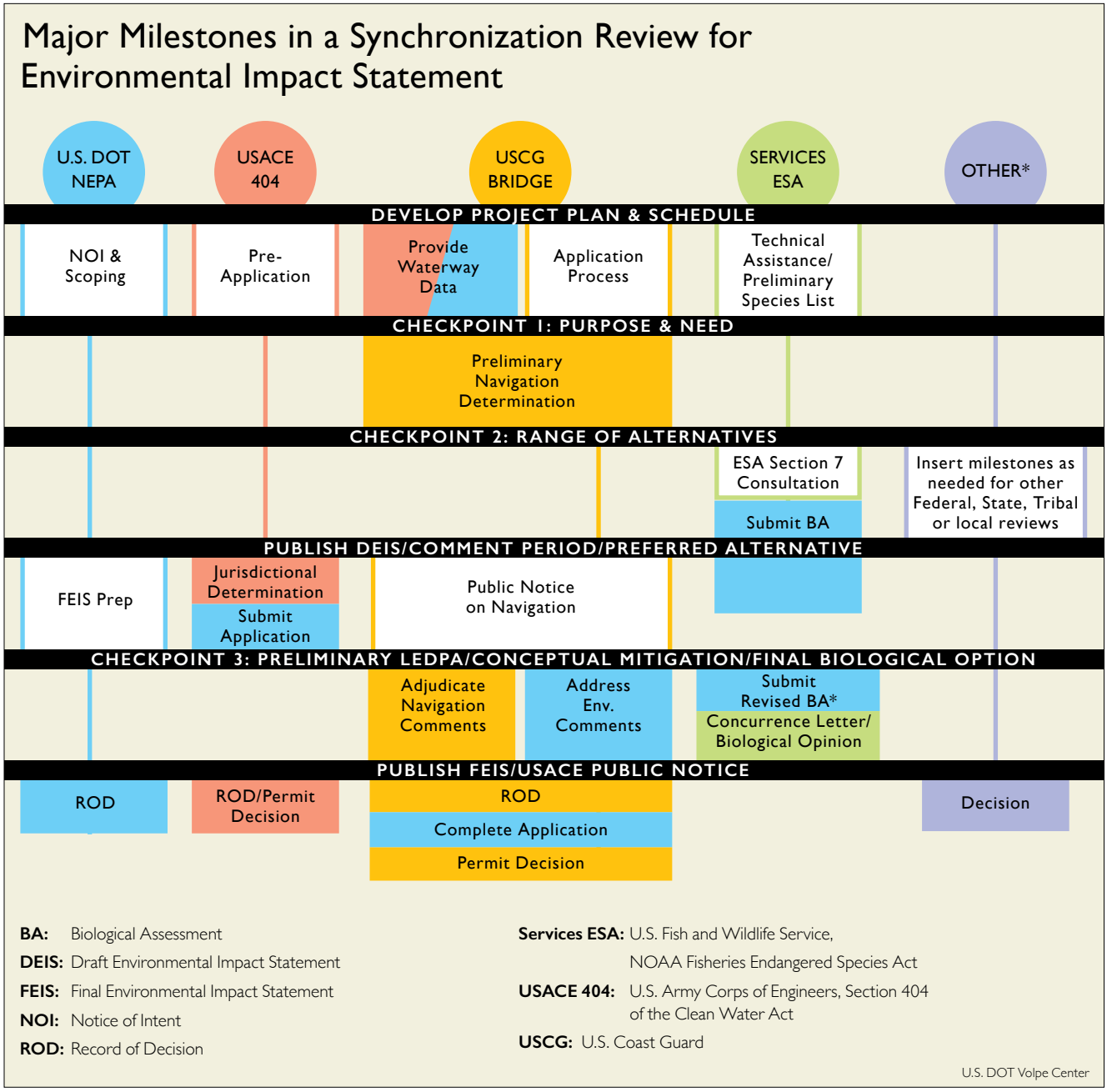
One way to complete transportation projects faster and make them more cost effective is to have agencies work together on permitting and review processes. NEPA requires any agency receiving federal funding for a project to consider the potential environmental impacts of their actions and work cooperatively with other federal and state agencies during the environmental review process. Transportation projects also require multiple federal permits as part of regulations such as the Clean Water Act, National Historic Preservation Act, and Endangered Species Act.

An agency funding a transportation project, such as FHWA, and a regulatory agency, such as the U.S. Army Corps of Engineers (USACE), may duplicate elements of the permitting and review process. The Every Day Counts-4 (EDC-4) Integrating NEPA and Permitting initiative promotes synchronized processes, so that transportation projects can be completed more quickly and for less money.

Eighteen states participate in this EDC-4 initiative, which offers the following contributions to transportation project delivery:

- Technical assistance to state DOTs to create formal coordination plans and permitting agreements with regulatory agencies.
- Support for states to develop robust stream and wetland mitigation programs.
- Workshops and peer exchanges among agencies involved in permitting to encourage coordination early and often in the environmental review process.

Integrating NEPA and Permitting has reduced project delays related to permit approvals and has increased trust between state DOTs and regulatory agencies, according to



initiative participants. As part of the EDC-4 team, Volpe helps organize site visits, peer exchanges, workshops, and trainings; develop technical materials; draft programmatic and other formal agreements; and deliver trainings.

The EDC-4 team is helping South Carolina, Iowa, and Georgia draft programmatic agreements in coordination with the USACE to streamline permitting for impacts to wetlands and historic and cultural resources. These agreements encourage earlier, more frequent coordination among agencies, which helps to eliminate duplication during environmental reviews and reduce delays in permit approvals.

The team is also helping states develop more robust stream and wetland mitigation programs. A lack of appropriate mitigation during project development can cause permitting delays of months or years. The team is working with state DOTs and USACE

districts in Texas, Idaho, and South Dakota to conduct needs assessments and develop banking, public-private, and other innovative approaches to wetland mitigation. **(Sponsored by FHWA, USACE [contributor])**

Aviation Modernization

Improving On-Time Performance with Better Flight Delay Reporting

Airlines want to get passengers to and from their destinations on time. But unforeseen problems can arise, and some flights do not arrive on schedule. Problems such as bad weather, air traffic delays, and mechanical issues are hard to predict and often cannot be controlled.

The Air Traffic Operations Network (OPSNET) is FAA's official system for reporting flight delay data. The system identifies the number of delays and related causes—such as weather, air traffic volume, equipment status, and runway conditions. FAA has prioritized upgrading this system because it has concerns over data deficiencies—notably, 25 percent of airborne holding events and gate delays under 15 minutes are not reported.

FAA's OPSNET Replacement (OPSNET-R) program will expand and improve how the network collects and records flight delay data. The new network will be more accurate and will improve reporting, reduce manual data entry, and automate synchronization of operational data from FAA automation and decision-support systems. Upgrades will include a significant increase in the percent of delays reported—including those under 15 minutes—and automatic identification of the delay cause. Across the national airspace, users will see improved flight planning and efficiency, reduced operational costs to the airlines, and improvements in productivity.

The prototype proof-of-concept OPSNET-R software shows diverted flights and pop-up information for selected flights. (Source: U.S. DOT Volpe Center)

Volpe Center aviation systems engineering experts partnered with the OPSNET-R Program Office to develop a proof-of-concept (PoC) for an updated OPSNET-R system. Volpe experts validated the technical feasibility of requirements, mitigated technical risks, identified different approaches in delay metrics and reporting structures, validated data integrity, and identified benefits.

Volpe experts developed the software and procured the hardware for the PoC program. The team also reviewed documentation for FAA streaming data services and developed algorithms to match the same flight within and across different data services. Volpe experts demonstrated to FAA and its stakeholders the potential benefits of combining FAA's streaming data sources, modern database architectures, and the latest open-source and commercial-off-the-shelf tools for displaying and reporting data-based analytics. The team also documented requirements for the updated OPSNET-R system and prepared an online survey for legacy system users. Survey results will help Volpe economists quantitatively estimate future system benefits.

By demonstrating the use of cost-effective, cutting-edge technologies to validate new FAA requirements—such as near-real-time delay reporting—Volpe is laying the groundwork for the future OPSNET-R system. **(Sponsored by FAA)**

Modernizing Yesterday's Air Traffic Control Systems for the U.S. Air Force

The Department of Defense (DoD) controls nearly 25 percent of the U.S. airspace. The number of flights in the NAS is expected to grow by 40 percent in the next 20 years. That means more coordination will be needed between civilian and military air traffic control (ATC) systems. Improved surveillance, automated tracking and safety features, and reliable communications between pilots and ATC are key to ensuring efficient flight operations as the NAS expands.

The DoD-NAS program is modernizing outdated ATC equipment at military air control infrastructure around the country. New systems are technologically innovative and provide recordable, digital voice, surveillance, and automation tools to controllers. The program allows DoD to remain interoperable with the FAA's air traffic systems, and supports FAA's NextGen modernization efforts.

Volpe Center experts have worked on DoD's ATC systems for two decades and provide expertise for three major programs:

- DoD-NAS program
- U.S. Air Force (USAF) Deployable Radar Approach Control (D-RAPCON) program
- USAF Foreign Military Sales (FMS) program

USAF developed D-RAPCON to support worldwide contingencies and disaster relief. This system is based on fixed DoD-NAS systems, but is mounted in a contained, mobile platform. For USAF's FMS program, Volpe assists in engineering, deploying, and testing U.S.-made ATC systems sold to allies.

Much of this work takes place at 177 USAF, Air National Guard, and Air Force Reserve bases in the U.S. and around the world, plus Saudi Arabia, Poland, and Ukraine.

Volpe aviation infrastructure experts recently completed site preparation and cutover for Standard Terminal Automation Replacement Systems (STARS) at 30 of 36 control towers and 33 of 39 RAPCONs. The Volpe team performed surveys, engineering, site preparation, and installation of all USAF airfield automation systems. Volpe staff served as lead engineers for optimizing airport surveillance radar systems, STARS, and automated protocol exchangers. Volpe staff also provided engineering and optimization expertise to the D-RAPCON program and led the foreign installation and integration projects.

Over the past year, Volpe achieved the following:

- Completed 12 optimizations of combined Digital Airport Surveillance Radar (DASR)-STARS systems;
- Conducted 2 environmental surveys for 2 new DASRs;
- Installed 4 motor generators to serve European bases;
- Completed 12 site surveys for STARS installations and performed site preparation at 3 more STARS locations;
- Installed 3 STARS systems into their final positions; and
- Removed 3 legacy automation systems.

(Sponsored by USAF)

Results-Driven Investments

Promoting Rail Safety and Accountability with the Monitoring and Technical Assistance Program

FRA administers grant and loan programs to help states and other entities plan, acquire, design, construct, and prepare operational readiness of high-speed, intercity passenger and freight rail projects. To steward taxpayer dollars and provide due diligence as a federal grant-making agency, FRA's Monitoring and Technical Assistance Program (MTAP) has provided grant and loan recipients with project oversight, technical assistance, and training support since 2014.

MTAP identifies risks and recommends corrective actions to keep rail projects on schedule and budget. The program ensures that over $11 billion in transportation investments across 86 projects is successfully delivered nationwide, and that those projects provide public benefits and meet federal requirements.

Since 2014, the Volpe Center's MTAP team has helped FRA fulfill its mission of promoting safe and environmentally sound rail transportation. Volpe and FRA collaborate in monitoring grant recipients' efforts on high-speed and intercity passenger rail (HSIPR)

Construction of a new locomotive maintenance shop at Amtrak's King Street Yard in Seattle, Washington. (Source: U.S. DOT Volpe Center)

projects, the U.S. DOT TIGER grants (now BUILD grants program), and Amtrak capital and operating activities.

Volpe provides FRA with program management and strategic planning, and helps employ contractors to provide additional resources and subject matter expertise for oversight and technical support. Monitoring and Technical Assistance Contractors (MTACs) collaborate with the Volpe MTAP team to provide monitoring and technical assistance to FRA grant and loan recipients at 45 sites across the country. In 2017, the MTAP team completed 29 annual monitoring reviews of HSIPR and TIGER grants, with 15 reviews planned during 2018.

The Volpe Amtrak oversight team conducted project monitoring reviews of Amtrak capital projects in 2017, with additional reviews planned for 2018. The Volpe team also provided recurring oversight of Amtrak's mechanical department, including maintenance facility site reviews and oversight of Amtrak's positive train control program. The team continued its annual support to the Accessible Stations Development Program, assessing Amtrak's conformance with Americans with Disabilities Act requirements, performing site visits, and reviewing station designs.

To promote partnerships and share best practices and lessons learned, in 2017 FRA and the Volpe MTAP team coordinated the annual FRA Rail Program Delivery Meeting, with attendees from FRA, grant and loan recipients, and members of the railroad industry. The Volpe team also developed videos on key aspects of rail program delivery.

Working closely with FRA and grant recipients, Volpe's MTAP team has contributed to the construction or improvement of thousands of miles of track, the procurement of new passenger rail equipment, the upgrade of over 65 train stations, and safety-critical improvements to tracks and bridges, highway-rail grade crossings, grade separations, and signal systems. This has resulted in increased train reliability, added capacity, reduced travel times, and more efficient and accessible train stations and equipment. **(Sponsored by FRA and OST)**

Establishing a Performance Management Reporting System for the National Park Service's National Long Range Transportation Plan

From the historic carriage roads laid by hand in Acadia National Park to trailhead parking lots in Yosemite, transportation assets in America's national parks are seeing record numbers of visitors—and transportation at national parks goes well beyond roads and bridges. Some areas are only accessible by trails, ferries, airplanes, or public transportation. All modes need to function safely and efficiently for visitors to enjoy these natural and cultural resources.

In July 2017, the National Park Service (NPS) released its first National Long Range Transportation Plan (LRTP), a 20-year vision for transportation that Volpe Center planners helped develop for the Facilities Planning Branch.

The NPS National LRTP is a performance-based plan that provides comprehensive analysis and recommendations covering transportation investment priorities for an expansive system. NPS maintains approximately 5,500 centerline miles of paved roads, 120 million square feet of paved parking areas, more than 1,400 bridges and tunnels, 4,600 miles of trails, 950 trail bridges, 130 transit systems, and 130 miles of constructed waterways.

The LRTP establishes 14 performance measures and sets realistic performance targets based on anticipated funding levels. Volpe is helping create an accountable performance management reporting system that will let NPS demonstrate progress to stakeholders like the FHWA. The system will also support NPS' effort to establish a more data-driven approach to transportation system maintenance and modernization.

Volpe planners documented procedures and protocols for performance data collection and processing, and produced both an initial performance report and a performance management handbook in summer 2018. This process identified performance measures which are on track to meet targets, as well as some which require additional work and better data to accurately measure. In fiscal year 2019, NPS plans to continue refining its performance management processes, building on the foundation of this initial round.

By developing, tracking, and reporting performance measures, NPS is better able to gauge and communicate its progress in meeting its strategic goals, as outlined in the National LRTP. These include providing a well-maintained, safe, and efficient transportation system that meets the NPS mission of providing access for all users, and protecting natural and cultural resources. **(Sponsored by NPS)**

A bus transports visitors in Denali National Park and Preserve. Cars are not allowed on Denali Park Road in order to protect park resources and wildlife and provide a high-quality visitor experience. (Source: NPS)

National Park Service Optimizes Transit Performance Management

Managing vehicle fleets and optimizing transit system performance is an important goal of the NPS. The NPS Transit Inventory and Performance Report is a tool that provides the agency with a comprehensive understanding of its transit system operations across the country. NPS transit systems are as varied as the parks themselves and include ferries, shuttles, airplanes, and trolleys. The transit inventory collects park system data, which allows NPS to communicate the impact and importance of transit within national parks.

The objective of the transit inventory is to advance transit performance management, and capture asset and operational information to communicate recapitalization needs for NPS transit vehicles. These objectives support U.S. DOT priorities by helping the NPS understand transit system performance and providing the agency with greater accountability in predicting future vehicle needs.

The first NPS Transit Inventory and Performance Report was completed six years ago, and is updated annually. The Volpe Center helps initiate the transit inventory and continuously improves the data collection effort. Volpe staff collect park level data on NPS annual operating statistics and vehicle information, complete quality control and assurance on the data, and translate the data into final reports.

Key findings from the annual report include statistics related to ridership, business models, fleet characteristics, and funding sources. Performance measures include information on emissions, as well as vehicle age and replacement dates. The report provides readily available data to the NPS that assists in holistically understanding transit at all levels and answering administrative inquiries. Most recently, NPS regions used data collected by the inventory to help understand capital needs for recapitalization of transit vehicles over the next 5–10 years for the upcoming reauthorization of the surface transportation bill.

From 2012 to 2017, passenger trips on NPS transit systems increased by over 10 million, from 33.6 to 43.7 million. The large increase in national park visitors utilizing transit services demonstrates their importance within the national parks. The need for reliable and efficient transit systems that provide access and connectivity to national parks is likely to grow as visitation to parks increases. **(Sponsored by NPS)**

Ensuring the Reliability and Safety of Lowell's Historic Trolleys

Visitors usually access national parks with personal automobiles, which can make traffic congestion part of the park experience. To reduce congestion, parks use multimodal transportation systems that integrate automobiles with other modes, including transit and bicycle and pedestrian linkages.

Lowell National Historical Park (NHP) includes 19 buildings and other historical sites across a 141-acre urban campus in downtown Lowell, Massachusetts. The park preserves and celebrates the early years of the American Industrial Revolution and each year welcomes more than 560,000 visitors. Visitors travel between sites on trolleys that run on 1.5 miles of rail through several rights-of-way shared by local streets. Some of the trolleys are 30-year-old reproductions, while others are nearly 100-year-old refurbished cars. The NPS maintains the trolleys and is responsible for system reliability.

Volpe Center multimodal infrastructure divisions have strong working relationships with Lowell NHP staff based on a previous planning study that assessed opportunities to expand the park's trolley line. NPS asked the Volpe Center to perform a comprehensive condition assessment of the park's historic trolley system and rolling stock—including track, overhead line, poles, power substation, station platforms, garage, and supporting facilities.

The Volpe team used its multimodal expertise to assess Lowell NHP's mixed-use, shared transportation infrastructure, including:

- Trolley tracks
- Trolley power supply system
- Passenger station platforms

Lowell National Historical Park Trolley. (Source: NPS)

- Roadways and traffic control devices for public transit vehicles, private and commercial automobiles, bicyclists, and pedestrians

The Volpe team performed on-site physical inspections of the trolley infrastructure, wrote interim and final inspection reports, developed schematic design alternatives drawings, and wrote draft and final technical specifications and work statements. Based on their findings, the Volpe team completed an on-site final condition assessment of the trolley system.

As Lowell NHP looks toward long-term requirements, Volpe Center infrastructure team members are helping identify innovative technologies and operational best practices that ensure the trolley system continues to be reliable and safe. Volpe's in-depth assessment provides NPS with a 10-year prioritized maintenance plan for the Lowell NHP trolley, so park managers can prioritize system needs and strategically target future investments. **(Sponsored by NPS)**

Improving Park Service Ferry Safety at Isle Royale National Park

Half of reported fatal boating accidents are caused by passengers or crew falling overboard, according to U.S. Coast Guard (USCG) data from 2000 to 2016. Incident response time is critical to increasing the odds of survival when someone is in the water.

Isle Royale National Park is a remote archipelago in Lake Superior 60 miles from the park's headquarters in Houghton, Michigan. Ranger III, a 165-foot long NPS ferry, makes this six-hour journey several times a week from spring to fall to transport visitors, park personnel, and supplies. Built in 1957, much of Ranger III's onboard equipment is original. Until recently, personnel used four open-top lifeboats to rescue passengers and crew or assist during emergencies. Personnel lowered these craft into the water by hand crank. During an

Ranger III with new rescue boat (under blue cover) and davit installed on boat deck. (Source: U.S. DOT Volpe Center)

emergency, it took several minutes to launch each lifeboat, which then had to be rowed to the incident location.

The Volpe Center's infrastructure engineering and technology division has extensive experience in vessel safety and security. NPS asked the Volpe Center to identify improvements for passenger and crew safety on the Ranger III.

Volpe Center staff developed specifications, designed and implemented safety modifications, purchased USCG-approved equipment, and provided contractor oversight during renovation. Original lifeboats and davits were removed and a new fast rescue boat and davit were installed. These improvements have reduced incident response time and improved safety aboard Ranger III. Other safety improvements included new USCG-approved handrails, more deck lighting, and a fire control and lifesaving equipment plan.

The Volpe Center worked within a compressed timeframe during the off-season at Isle Royale headquarters in Houghton, allowing Ranger III to return to service for the 2018 season. If a passenger or crew member falls overboard during the round-trip ride to Isle Royale, the new lifeboat and powered davit vastly improve Ranger III's rescue capabilities. **(Sponsored by NPS)**

Projecting Vessel Traffic and Usage on the Chicago River

The Chicago Riverwalk is a well-known, unique pedestrian waterfront area with recreational and commercial attractions. The city of Chicago recently proposed improvements to bring similar recreational and commercial opportunities further south along the Chicago River.

The Chicago Department of Transportation (CDOT) is evaluating proposed enhancements and improvements to the two-mile long South Branch riverfront between Ping Tom Memorial

South Branch of the Chicago River at Adams Street Bridge.
(Source: U.S. DOT Volpe Center)

Park and Wolf Point, where the North, Main, and South branches of the Chicago River converge. CDOT is also reviewing safety and navigability issues that the USCG-Marine Safety Unit, and the industrial, commercial and private users raised over the potential increase of vessel docking, berthing, and marine traffic congestion on this busy waterway.

Volpe Center's Infrastructure Engineering and Deployment division has a strong working relationship with CDOT, dating back to a 2003 independent analysis of how a planned development of the Riverwalk along the Main Branch of the Chicago River would affect vessel traffic. For the current proposed improvements, CDOT asked the Volpe Center to forecast recreational, industrial, and commercial vessel traffic on the South Branch of the Chicago River and to assess potential changes to river usage and safety issues.

The Volpe Center is analyzing present and expected river usage in and around the confluence of the three branches of the Chicago River, focusing on the South Branch. To ensure all stakeholders understand the scope of the project, Volpe staff interviewed representatives from local organizations, commercial and industrial businesses impacted by river traffic, and officials from CDOT, local law enforcement, USCG, and USACE. Volpe will share with CDOT the findings from the qualitative interviews and quantitative analyses of waterway traffic and other usage data.

Findings from Volpe's assessment will help CDOT ensure the river is safe for all vessels and users as Chicago pursues its vision to improve and expand the popular downtown Riverwalk. **(Sponsored by Chicago DOT)**

U.S. Coast Guard Ballast Water Management Program

When non-native species are introduced to aquatic ecosystems and become established, they can adversely affect the nearby economy, environment, and human health. Ballast water discharge from ships represents a major risk of introducing non-native species.

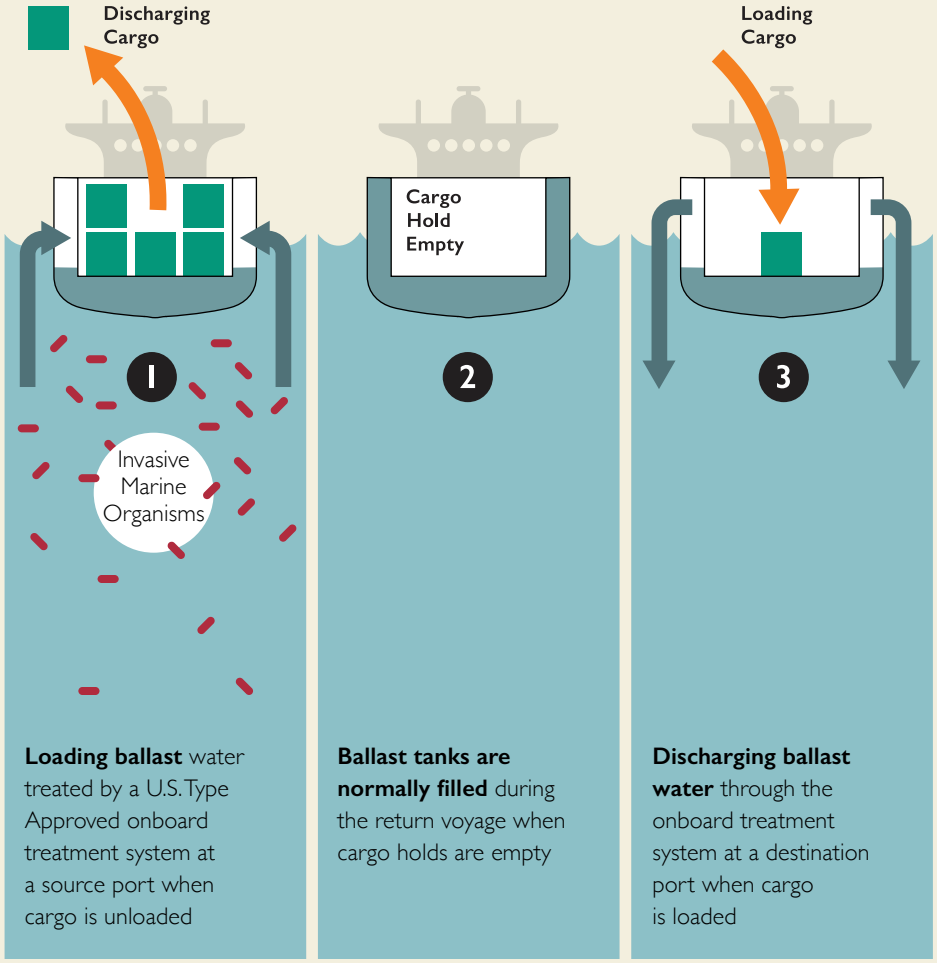
A team of experts from the Volpe Center performed engineering and research for the USCG that led to the development of ballast water discharge standards to prevent aquatic invasive species from entering U.S. waters. USCG's Final Rule, *Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters*, requires that ships manage ballast water to comply with the discharge standard. The final rule from USCG sets discharge standards that all vessels with ballast tanks operating outside of the U.S. Exclusive Economic Zone—extending roughly 200 nautical miles from U.S.-controlled shoreline—must meet before entering U.S. waters.

Before this rule, ships would replace coastal ballast water with open ocean water. Ballast water is held in tanks to improve ship stability. The implementation of the final rule means the previous practice of mid-ocean ballast water exchange will no longer be an option for ships entering U.S. waters. USCG expects that most ships will meet the discharge standard by using water treatment technologies, though some options still exist for managing ballast water without treatment. Volpe Center technical expertise is essential for evaluating treatment technologies.

In 2018, the Volpe review team conducted technical evaluations of scaling studies that ballast water treatment system manufacturers submitted in seeking U.S. Type Approval. Each scaling study aims to verify that a technology or system that is successful on a small

Vessel Ballasting Operations

- Ballast water is added to or discharged from cargo vessels to maintain stability.
- **U.S. DOT Volpe Center** experts lend key support to the **U.S. Coast Guard's** Ballast Water Management Program.



- **U.S. Type Approved onboard treatment systems** are now available to **prevent the spread of invasive marine organisms.**
- The Volpe Center assisted in the development of the U.S. Coast Guard's Final Rule on discharge standards.
- Technical experts at the Volpe Center are validating the specifications of manufacturer's models to ensure treatment system performance will be effective on a large scale.

U.S. DOT Volpe Center

scale will be effective on a larger scale. The Volpe team has evaluated seven ballast water treatment system scaling studies, and additional reviews are underway.

Volpe experts also serve as technical agents in two other related efforts:

- *Shipboard Technology Evaluation Program*—USCG may approve experimental systems that satisfy ballast water management requirements.
- *Alternate Management System Program*—A manufacturer whose ballast water management system is approved by a foreign government and meets international standards may request that USCG allow that system as an approved alternate management system.

(Sponsored by USCG)

Investing in Bus Modernization and Institutional Capacity in Sri Lanka

Developing countries depend on efficient transportation systems for economic growth and access to markets, jobs, and key services. Since 2014, the Volpe Center has supported the Millennium Challenge Corporation (MCC), an innovative, independent U.S. foreign aid agency that invests in developing countries around the world to foster economic development and alleviate poverty.

The MCC is managed by a board of directors, chaired by the Secretary of State, including the Secretary of the Treasury, the Director of USAID, U.S. Trade Representative, and private sector members. Through a federal interagency agreement, Volpe works closely with MCC in assessing the agency's potential multimodal investments in transportation infrastructure and institutional capacity projects in developing countries.

Sri Lanka faces challenges from a rapidly urbanizing population that has placed growing strains on its infrastructure. MCC is investing in projects that will reduce the country's urban traffic congestion, improve interregional movement of goods and people, and support government initiatives to strengthen land administration.

The Volpe Center has provided transportation expertise to MCC in The Gambia, Liberia, Nepal, the Philippines, and Côte d'Ivoire. Most recently in Sri Lanka, Volpe experts provided extensive support in assessing a range of potential road and public transport investments, including performance improvements at the multimodal systems level.

Volpe experts partnered with MCC economic and social inclusion teams and the government of Sri Lanka to identify potential projects that will reduce congestion and travel times, improve mobility and accessibility for freight and passengers, and contribute to shared goals of economic development and poverty relief. Volpe performed an extensive assessment of national, provincial, and transport agency capacity to plan and manage a modernized 6,000 bus system in the Colombo metro area. The Volpe team also assessed traffic management projects and the related capacity of national government, provincial authorities, and road and public transport agencies.

Volpe worked with MCC to develop specific metrics and outcomes for bus modernization and traffic management to evaluate reductions in congestion and travel time delay and to improve mobility and accessibility consistent with the goals of the client country and MCC. The Volpe team is also working with MCC to establish rigorous baselines and processes to monitor results over MCC's five-year investment period in the Sri Lanka program.

MCC is a committed partner with the people of Sri Lanka, supporting sustainable development throughout the country. The Volpe Center has the proven expertise to continue its collaboration with MCC in evaluating transportation constraints and providing guidance in improving economic growth and alleviating poverty in the Sri Lankan region. **(Sponsored by MCC)**

(Source: U.S. DOT)

"The Forces to Flyers research initiative recognizes the importance of helping returning veterans find good jobs while helping communities find solutions for the growing pilot shortage. This initiative will help address our country's serious pilot shortage as well as provide a career path in aviation for our country's veterans, to whom we owe so much."

Elaine L. Chao, U.S. Secretary of Transportation, November 16, 2017

Transportation Workforce

The Volpe Center is supporting U.S. DOT efforts to address the nation's transportation workforce challenges.

Addressing the Nation's Growing Pilot Shortage

The U.S. is facing a pilot shortage. To keep pace with air travel demand, North America alone will need more than 112,000 new pilots by 2035, according to research from Boeing. The Regional Airline Association reports that in just three years there will be a shortage of 19,000 pilots in the U.S.

The pilot shortage has in part led to reduced air service to small and rural communities, reducing opportunities for economic development. To begin to address the pilot shortage, U.S. DOT launched the Forces to Flyers (F2F) research initiative to identify ways for veterans who do not have military flying experience to be trained as airline pilots.

As part of F2F, Volpe Center analysts designed an innovative demonstration that is being used to train 44 veterans. The demonstration covers all stages of training for veterans to become qualified as commercial pilots and to become certified flight instructors for instrument operations (CFI-I). Once a participant is certified, they will be eligible to work as a flight instructor to get the flight hours they need to qualify as an airline pilot.

Secretary Elaine L. Chao announced the F2F research initiative on November 16, 2017. Market research began December 21, 2017, and contracts were awarded on May 14, 2018—less than five months later.

The Volpe team informed the design of the training demonstration through research on the pilot shortage, the career pathways for becoming an airline pilot, types of flight schools, existing benefits and financial support available to veterans who want flight training, and other issues. The Volpe team also identified possible procurement approaches, developed the solicitation seeking proposals from flight training schools, contracted with the selected flight schools, and will oversee those contracts.

The first students began training in August 2018, and they will complete their training within 18 months. F2F is a three-year initiative that will end September 2020. Research and evaluation of the demonstration will provide lessons learned on methods to assist veterans in becoming airline pilots as a measure to alleviate the current pilot shortage.

(Sponsored by U.S. DOT Office of the Secretary)

(Source: U.S. DOT Volpe Center)

Thought Leadership

Data analytics, automation, artificial intelligence, and machine learning are impacting the global transportation system at full tilt. Mobility is being transformed. As the transportation enterprise becomes more data-driven and automated, there is the potential to realize greater safety and efficiency benefits for the public good.

Thought leaders, decision makers, and stakeholders from across the global transportation enterprise visit U.S. DOT's Volpe Center to discuss future transportation issues, generate fresh approaches to emerging issues, anticipate transportation trends, and inform decision making.

Artificial Intelligence and Predictive Analytics

Volpe's 2018 speaker series, *Transportation in the Age of Artificial Intelligence and Predictive Analytics,* explored the age of artificial intelligence and predictive analytics in the context of the global transportation system.

Analytics and Artificial Intelligence in a Federal Framework That Encourages Transportation Innovation

Derek Kan

Under Secretary of Transportation for Policy
U.S. Department of Transportation

> "We hope to prepare for the future and encourage innovation without compromising safety. Under this approach, we will not pick winners and losers among technology innovations. We will remain tech-neutral and let the quality of safety performance and market interest drive the evolution of innovative technologies."

(Source: U.S. DOT Volpe Center)

Forecasting Freight Transportation Rates: A Moving Target

Chris Caplice, PhD

Executive Director
Massachusetts Institute of Technology
Center for Transportation and Logistics

> "The thing to remember for truckload operations is that it's like a taxi cab, as opposed to a bus. So, you might pick up a load at Reno, take it to Rapid City, drive empty to Denver, pick up another load, and so forth."

(Source: U.S. DOT Volpe Center)

The New Mobility Operating System

Stephen Goldsmith

Daniel Paul Professor of the Practice of Government
Director of the Innovations in American Government Program
Harvard University's Kennedy School of Government

> "If we think about the user experience of mobility, if we design a system around the user, that's different than designing a system around the user of a bus, or a taxi, or a transportation network company, or a bike. If we're thinking about a system designed around the omni-channel experience of the user, and if we could come up with that orientation, it would dramatically change things."

(Source: U.S. DOT Volpe Center)

Kyle Vogt

Founder and CEO
Cruise Automation, Inc.

> "It only happens maybe once every ten years or several decades where you have this convergence of high social impact, deeply challenging technology problem, and big market opportunity. When those three things come together it creates something really special. I see self-driving cars today as the Apollo program of this generation."

(Source: U.S. DOT Volpe Center)

(Source: U.S. DOT Volpe Center)

Transformational Technologies: A State Government Perspective

Kirk T. Steudle

Director
Michigan Department of Transportation

> “It’s easy for us in the technology transportation space to think forward. In my job, and my counterparts across the country, we have to balance what’s possible—what’s utopia 50 years from now—versus what’s possible next year. And how do you manage for the maybe 50 years in the middle?”

(Source: U.S. DOT Volpe Center)

Delivering the Benefits of Self-Driving Technology Safely, Quickly, and Broadly

Chris Urmson

Co-founder and CEO
Aurora

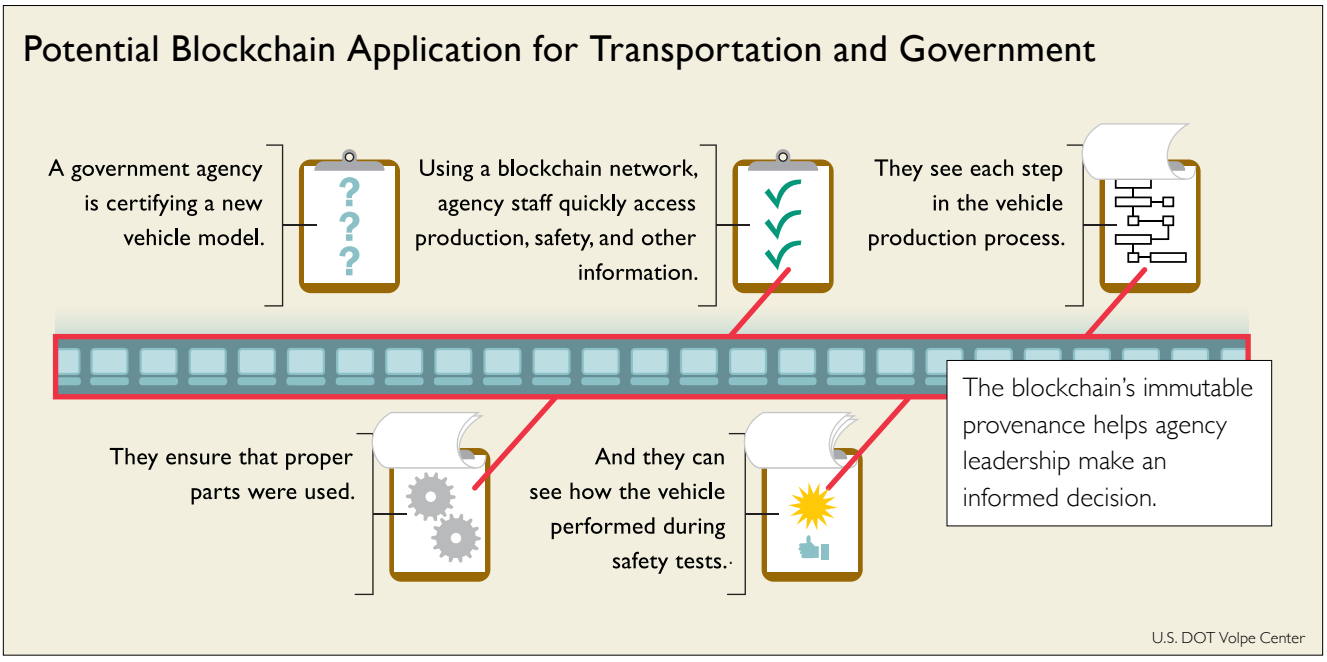
> “We think about the opportunity to save 140 lives a day. We think about the fact that 6 million people don’t have access to transportation that they should, and by bringing this technology to market we can enable them to have the mobility that we all take for granted.”

(Source: U.S. DOT Volpe Center)

What Blockchains Could Mean for Government and Transportation Operations

Experts across modes are exploring ways to use blockchains in transportation. A blockchain is a digital, openly shared, and decentralized log of transactions. The freight logistics sector could benefit greatly from blockchains. There is the potential for digital, interconnected proof-of-delivery processes. Any business or government involved in moving goods could efficiently and securely update a shared, digital bill of lading—a blockchain. Toll payments may be made simpler with blockchains. Blockchains will also find applications in aviation, including for aircraft maintenance, passenger and crew identity management, ticketing, loyalty programs, air cargo, customs clearing, flight planning, and more.

In January 2018, the Volpe Center published a high-level primer on blockchains and their applications in a well-received white paper, "What Blockchains Could Mean for Government and Transportation Operations."



(Source: ©123rf.com/Ryan DeBerardinis)

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