ANNUAL ACCOMPLISHMENTS

Advancing Transportation Innovation
for the Public Good

January 2018

U.S. Department of Transportation
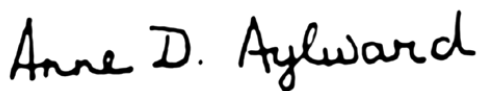**Volpe Center**

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 DOT's operating administrations, the Office of the Secretary, and other organizations. This document, our *Annual Project Accomplishments,* represents some of our best work of 2017 and underscores our sustained support to the DOT and others.

During this year of presidential transition, the Volpe Center again exhibited its ability to serve as DOT's go-to resource for tackling the nation's complex national transportation challenges, providing a historical perspective and supporting the Department's top priorities and strategic goals: **safety, infrastructure, innovation,** and **accountability.** A highlight of our year was welcoming U.S. Secretary of Transportation Elaine L. Chao back to the Volpe Center in April.

While the majority of the Volpe Center's work directly supports the DOT, we also lend key support to other federal, state, and local agencies, international organizations, and non-profit and private entities. The Volpe Center works to maximize the linkages throughout DOT and the broader transportation community. The Center continuously seeks synergies among our projects and works to transfer best practices, lessons learned, findings, and technologies across DOT and beyond.

We look forward to working with you in the upcoming year and continuing our role as a catalyst for innovation and a federal partner committed to public service, technical excellence, and the advancement of the national and global transportation systems.

Anne D. Aylward

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

January 2018

Message from the U.S. DOT Volpe Center Director

Safety

The U.S. DOT Volpe Center supports the Department's mission to ensure our nation has the safest transportation system in the world and works to reduce fatalities and serious injuries across all modes.

Highway Safety

Saving Lives with Pedestrian Detection Systems

It happens in the blink of an eye. You're driving and take your eyes off of the road to reach for your coffee cup or turn around to tell your kids to quiet down, and when you look ahead, a pedestrian is crossing the road right in front of you. You hit the brakes, but it may be too late.

Unfortunately, this scenario is all too common. One out of three vehicle-pedestrian crashes involves a vehicle going straight as a pedestrian crosses the road. Fatalities involving vulnerable road users, such as pedestrians, bicyclists, and motorcyclists, have increased over the past decade.

To prevent these crashes, automakers now offer a pedestrian detection system in some models. If the system detects a pedestrian in the vehicle's path, it alerts the driver or employs automatic emergency braking, preventing what could be a fatal crash.

Measuring Safety Benefits

In support of the National Highway Traffic Safety Administration (NHTSA), the Volpe Center analyzed the potential safety benefits of pedestrian detection systems, also known as pedestrian crash avoidance/mitigation (PCAM) systems, in terms of crash avoidance and crash mitigation measures.

Volpe experts used a quantitative measure to determine the effectiveness of PCAM systems. They devised a method using test data, real-world driver behavior data, and historical crash data to assess the safety impact.

This information helps NHTSA inform consumers about advanced safety features and also helps determine what safety benefits are important to consumers.

Technology Evolves

The Volpe Center team found that PCAM systems can potentially reduce up to 5,000 vehicle-pedestrian crashes and 810 fatal vehicle-pedestrian crashes per year, which account for 8 percent of crashes where cars strike a pedestrian and 24 percent of the same crash types where fatalities were involved.

The PCAM Safety Impact

In support of NHTSA, Volpe Center data experts recently analyzed how PCAM systems can save lives and prevent serious injuries. They examined two pre-crash scenarios.

A car is going straight while a pedestrian is **crossing the road.**

A car is going straight while a pedestrian is **walking in or adjacent to the road, stationary, or moving with or against the traffic.**
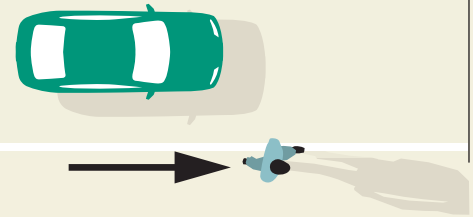
Over a recent two-year period, these scenarios annually average:

33,000 crashes

3,000 fatal crashes

$33.4 billion in comprehensive costs

Over this period, PCAM systems could have reduced:

5,000 of these crashes

810 fatal crashes

$8.2 billion in comprehensive costs

Source: U.S. DOT/Volpe Center

If a crash is unavoidable, PCAM systems could reduce the resulting number of injured pedestrians through impact speed reduction.

The steps taken by the team to conduct this safety research highlight the Volpe Center's superior technical capabilities in this area—from analyzing crash data or naturalistic driving data, or conducting system performance testing, crash avoidance simulations, or human-factor-based experiments. These capabilities can be applied to other areas of safety research involving advanced vehicle technology. **(Sponsored by NHTSA)**

Aviation

Human Factors Considerations for Integrating Unmanned Aerial Vehicles into the National Airspace System

The safe, successful integration of unmanned aerial vehicle (UAV) operations into the National Airspace System (NAS) requires the identification and mitigation of operational risks. The Federal Aviation Administration (FAA) has asked the Volpe Center to broadly examine human factors issues that impact UAV integration. The term UAV refers to the vehicle only, whereas UAS (Unmanned Aerial System) refers to the entire system, comprising the vehicle, the controls on the ground, the links between the two, as well as the pilot.

The Volpe Center provided FAA with recommendations to mitigate human factors risks associated with UAV operation in the National Airspace System. (Source: 123rf.com/Smithore)

This ongoing project seeks to quantify and understand the human factor risks through: 1) analyzing safety reports submitted by controllers, manned aircraft pilots, and UAV pilots, and 2) quantifying the severity of outcomes reported in Mandatory Occurrence Reports (MORs) involving UAV operations. This work will help to identify causal factors of risk and support the development of safety mitigations.

The Volpe Center team reviewed operational assessments, experimental research, incidents, and accidents in order to identify the human factors issues they described. The team then analyzed events submitted to the Aviation Safety Reporting System (ASRS). These reports describe events involving both large and small UAS operations. The analysis of UAV-related reports from the ASRS database yielded 220 relevant entries from controllers, pilots of manned aircraft, and UAV pilots.

The literature review and analysis of ASRS reports point to several operational issues. Controllers' reports described operational limitations of larger UAVs that affect controller tasks. While most small UAS operations do not require communication with air traffic control (ATC), communication issues with pilots of larger UAVs were identified (e.g., pilot understanding of ATC clearances). Pilots of manned aircraft described the need to be protected from UAV operations (both large and small), and the difficulty of seeing small UAVs within the time needed to initiate an avoidance maneuver. Both pilots and controllers described incidents of distraction caused by UAV activity. UAV operators' reports depicted situations that highlighted the need for clear guidance on operational restrictions.

Two common themes emerged from the ASRS reports: the need for better information, and for predictable UAV operations. Volpe Center experts recently published a report, *Human Factors Considerations for the Integration of Unmanned Aerial Vehicles in the National Airspace System: An Analysis of Reports Submitted to the Aviation Safety Reporting System*. In addition to topics for further research, the Volpe Center provided FAA with recommendations to mitigate the identified human factors risks:

- Training for both controllers and UAV pilots needs to continuously evolve to keep pace with changes in UAS operations.

- The information given to controllers on each UAV mission (such as flight plan, pilot contact information, lost link procedures, and contingency plans) needs to be routinely assessed and updated to ensure that controller's information requirements are met.

- The displays and decision support tools that controllers use should continue to evolve to support large UAV operations in controlled airspace (e.g., to include UAV performance characteristics in conflict prediction algorithms). **(Sponsored by FAA)**

Volpe Develops Streamlined Wake Classification Method for New Aircraft

Every aircraft in flight generates a wake, which could be hazardous to aircraft following in its path if not correctly accounted for by the pilot or air traffic controller. To enable aircraft to safely travel to airports, ATC ensures wake separation in the form of wake vortex separation minima and provides approaching aircraft with advisory information about nearby wake turbulence. When this information is unavailable, as in the case of new aircraft or aircraft changing International Civil Aviation Organization designation, the ATC assigns an automatic following distance of 10 nautical miles. This has shown to cause a severe ripple effect, creating delays and decreased airport capacity.

The FAA is developing a generic and repeatable way to classify the wake turbulence of new aircraft. Without this process, each new aircraft design would require its own wake turbulence documentation, followed by a panel review. The new process will provide a streamlined, continuously updated source of reference as opposed to the individual documentation that would otherwise be required.

The Volpe Center developed a categorization methodology that will form the basis of the final FAA methodology. Volpe staff developed the method by identifying the analytical tools that are best applied to different aircraft sizes, performance characteristics, and design features. A first draft of the methodology was submitted to the FAA in April 2017, with a second draft submitted in the fall of 2017.

During fiscal year 2017, the Volpe Center team used the new categorization methodology to recommend the classification of 37 new aircraft, with ongoing efforts to classify additional aircraft. Volpe staff provided technical expertise in multiple areas to develop the methodology, including wake turbulence, aircraft flight characteristics, and aircraft design principles.

Once in full operation, the streamlined wake classification method will lead to seamless integration of new aircraft type designators, allowing new aircraft to enter the NAS in ways that are both timely and wake safe. **(Sponsored by FAA)**

An oil train derailment took place on June 3, 2016 in Mosier, Oregon.

(Source: Patrick Mulvihill, Hood River News)

Hazardous Materials

Coordinating U.S. and Canadian Crude Oil Research

Both the U.S. and Canada face risks associated with crude oil transportation. The Crude Oil Research Coordination Steering Committee is sharing U.S. and Canadian crude oil research to improve protection of the transportation networks and public in both countries.

Public concern is growing over the safety of transporting large quantities of crude oil, particularly tight oil, over long distances. Tight oil is produced from petroleum-bearing shale formations. Since 2000, crude oil production in North America has increased significantly; tight oil is expected to make up most of U.S. oil production increases through 2040. Crude-by-rail transportation is of particular concern due to serious train derailments that have occurred over the past few years.

Studies conducted by the U.S. Department of Energy (DOE), the U.S. DOT, and Transport Canada (TC) identified wide-ranging variability in crude oil sample type, sampling method, and analytical method, limiting the adequacy of the available crude oil property dataset as the basis for establishing effective and affordable safe transport guidelines. More research was necessary to better understand and mitigate risks associated with transporting conventional and tight crude oil, such as

fires, explosions, and pollution. DOE and U.S. DOT initiated the Crude Oil Characteristics Research Sampling, Analysis and Experiment Plan (SAE) to characterize tight and conventional crude oils based on key chemical and physical qualities, including combustion characteristics for pool fires and fireballs.

In response to a U.S. DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) request, the Volpe Center administers the Crude Oil Research Coordination Steering Committee. Committee members include leaders and research experts from PHMSA, DOE, the Federal Railroad Administration (FRA), and TC, all of which have a role in advancing the safe transportation of crude oil. Its purpose is to support the SAE by sharing information; planning and coordinating U.S. and Canadian research efforts, including similarities and differences; monitoring and modifying research activities as appropriate; and discussing findings and conclusions.

The SAE crude oil research coordinated by the Crude Oil Research Coordination Steering Committee will provide a better understanding of crude oil combustion characteristics, benefiting both countries. **(Sponsored by the U.S. DOT Office of the Assistant Secretary for Research and Technology and PHMSA)**

Motor Carriers

FMCSA Initiates a Crash Preventability Demonstration Program

FMCSA, with Volpe Center support, is evaluating how to improve its ability to prioritize high-risk motor carrier companies for interventions.

Studies conducted by the Federal Motor Carrier Safety Administration (FMCSA) and other industry stakeholders have shown that a large truck or bus company's crash involvement, regardless of its role, is a strong indicator of future crash risk. With a new Crash Preventability Demonstration Program, FMCSA is evaluating whether considering a company's role in a crash will improve the agency's ability to prioritize the highest-risk companies for interventions. FMCSA's Safety Measurement System (SMS) uses state-submitted crash records, in addition to other safety performance data, to identify companies for interventions.

A team from the Volpe Center worked in support of FMCSA to develop and roll out the Crash Preventability Demonstration Program. Through the program, FMCSA accepts from carriers Requests for Data Reviews (RDRs) of certain categories of crashes through its national data correction system, known as DataQs. Volpe Center experts analyze the crashes and consider the role of a truck or bus company or driver to make recommendations to FMCSA for determining if the crash was preventable or not. As part of the program, crashes are displayed on the public SMS website with the results of the reviews: Not Preventable, Preventable, and Undecided. Truck or bus companies and drivers began submitting RDRs in DataQs on August 1, 2017 for crashes that occurred on or after June 1, 2017.

The Volpe Center was involved throughout the life cycle of the program. Volpe's role included supporting the design and development of a business process for crash review, updating FMCSA's DataQs system to allow for crash RDR submission; enhancing the public SMS website to display results of the reviews; providing training on the crash review process to onboard the review teams; and developing outreach and communications materials to educate the public, industry, and enforcement personnel on the program. As the program matures, the Volpe team will continue to support its operation and improvement efforts.

The Volpe Center is also assisting FMCSA in the evaluation of the Crash Preventability Demonstration Program. Information gathered from this program will be used to assess the

feasibility, costs, and benefits of making crash preventability determinations. The agency is analyzing the costs of operating and expanding this program; crash rates of companies that submitted RDRs; crash rates of carriers with Not Preventable crashes; and impacts to the SMS. **(Sponsored by FMCSA)**

Innovative Technology Improves Motor Carrier Safety on U.S. Highways

Reducing the number of vehicle crashes on the nation's highways each year is an essential part of U.S. DOT's safety goal. The Innovative Technology Deployment (ITD) Program is a critical piece of FMCSA efforts to improve commercial motor vehicle (CMV) safety nationwide. The ITD Program was established by the Fixing America's Surface Transportation (FAST) Act in 2015 and replaces the Commercial Vehicle Information System Network (CVISN) Program instituted under 49 U.S.C. § 31106 in 1994.

The ITD Program is an important part of FMCSA's work to reduce crashes, injuries, and fatalities involving large trucks and buses. The goals of the ITD Program are to:

- Improve the safety and productivity of motor carriers, CMVs, and their drivers

- Simplify and streamline roadside enforcement operations

- Improve the efficiency and effectiveness of CMV safety programs and credential administration

- Improve CMV data-sharing among states, and between states and FMCSA

- Reduce federal, state, and industry regulatory and administrative costs

The ITD Program provides states with federal grants to deploy the Commercial Vehicle Information Exchange Window (CVIEW), a state portal application that shares safety and credential information on CMV operations. CVIEW exchanges states' data with FMCSA Safety and Fitness Electronic Records (SAFER), the FMCSA central repository for state fuel taxes, vehicle registration, and electronic screening data. SAFER serves as the federal safety data source for CVIEW. SAFER and CVIEW comprise the federal/state information network that allows states to access a complete set of safety and credential information.

The ITD Program has helped states implement smart roadside technology that has improved inspection effectiveness and efficiency, resulting in reduced administrative costs. With the federal/state information network, roadside imaging systems provide inspectors with on-demand data to make critical enforcement decisions whether to stop and detain motor carriers with safety violations, or allow safe carriers to continue to operate. To date, 42 states have implemented CVIEW that interfaces directly with FMCSA to verify the accuracy and integrity of CMV operator credentials, electronically screen CMVs, and enable online application and issuance of CMV credentials.

Volpe Center staff have provided expertise in the areas of grant application review, state technology deployment, certification testing, core compliance monitoring, data quality evaluation, website development, data analysis, and process management. To date, the Volpe Center has completed 32 state grant application reviews and project summaries, conducted 5 state core compliance reviews remotely or onsite, performed monthly data quality assessments on state input data and performance, and facilitated a national ITD workshop in June 2017. **(Sponsored by FMCSA)**

> To date, 42 states have deployed CVIEW, a new online resource that verifies the accuracy and integrity of CMV operator credentials electronically, screens CMVs, and enables online application and issuance of credentials.

Offsite Safety Audits Help Streamline FMCSA New Entrant Process

FMCSA, as part of its New Entrant Program, conducts thorough safety audits of all new motor carriers within their first 12 months of on-the-road operations. Nearly 70,000 carriers entered the program each year between 2011 and 2015, with the number of new motor carriers continually growing. At the same time, Moving Ahead for Progress in the 21st Century Act (MAP-21) legislation mandated that FMCSA conduct safety audits sooner, even as enforcement resources remain unchanged.

To more effectively allocate its resources without compromising safety, FMCSA developed an offsite safety audit process. Before the new process was developed, auditors in each state conducted an onsite safety audit of every new motor carrier and reviewed records in person. The offsite safety audit uses a new IT system that allows motor carriers to submit the required documentation so auditors can conduct reviews remotely, eliminating the time and expense of traveling to every new motor carrier's place of business. Auditors still conduct onsite safety audits, but these are now reserved for motor carriers that pose the highest risk, such as hazardous materials carriers, passenger carriers, and those with other risk factors.

A Volpe Center team worked with FMCSA to develop and document the policy and process for offsite safety audits. Volpe Center staff also developed an IT system called the New Entrant Web System (NEWS) that allows carriers to submit required safety compliance documents online, by mail, or by fax. Auditors employ NEWS to review documents and manage the offsite safety audit process.
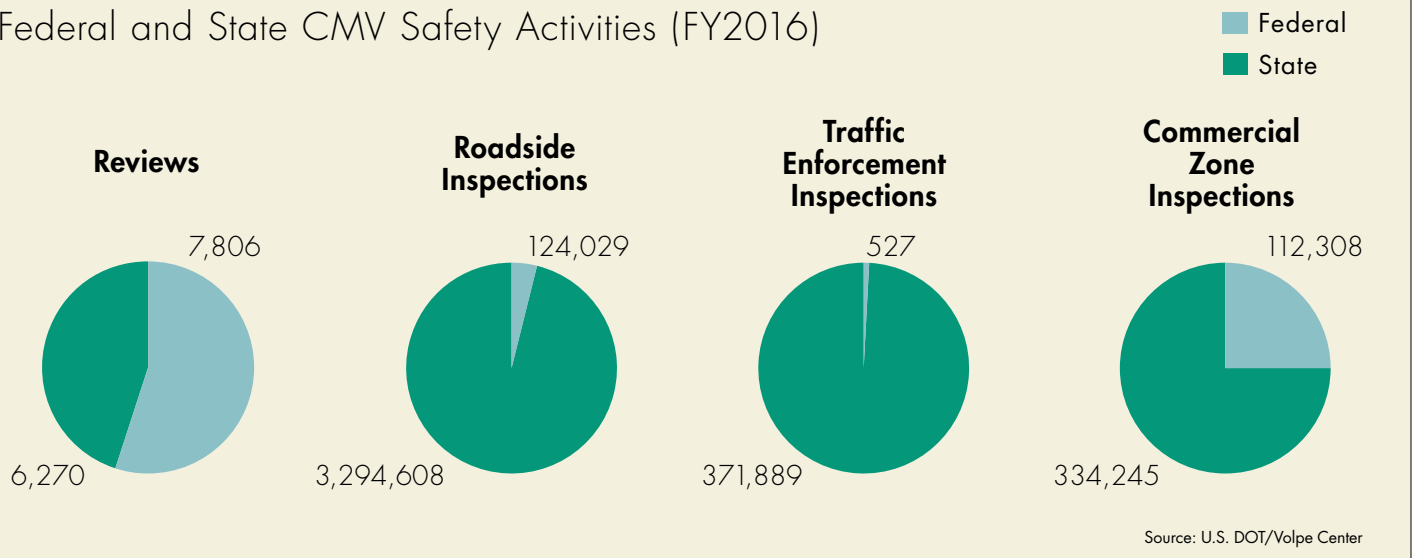
National rollout of the New Entrant Program's offsite safety audits was completed in July 2017, with nearly 80 percent of all safety audits now being conducted offsite. Over the course of the rollout, Volpe Center experts supported the development and delivery of training of more than 1,000 staff, including FMCSA and state employees. The Volpe Center will continue to support the national offsite safety audit process through continuous monitoring and improvements, including system enhancements and delivering ongoing training needs, such as refresher training with management and enforcement staff.

FMCSA continues to review the safety practices of all new motor carriers with the aim of keeping our nation's roads safe. FMCSA can now use offsite safety audits to address the majority of carriers and focus their resources toward onsite audits with carriers that pose the highest safety risk. As a result, FMCSA has been able to reallocate its resources and complete safety audits in less time, reducing the time between when a potentially high-risk carrier is identified and when an audit occurs. **(Sponsored by FMCSA)**

New MCSAP Funding Allocation Formula Prioritizes CMV Safety

FMCSA's Motor Carrier Safety Assistance Program (MCSAP) is critical to the agency's safety mission of reducing CMV crashes on our nation's highways. MCSAP grant funds are essential to maintaining FMCSA's national CMV safety enforcement programs and those of the states and territories. The grant assistance program ensures that FMCSA and states work in partnership to establish safety programs to improve motor carrier, CMV, and driver safety. More than half of FMCSA's operating budget was allocated in grant funding to states and territories in 2016, including over $230 million through MCSAP. The funding is critical to FMCSA's ability to conduct safety activities such as roadside inspections, reviews, and commercial zone inspections.

Federal and State CMV Safety Activities (FY2016)

Legend: Federal, State

Reviews
7,806
6,270

Roadside Inspections
124,029
3,294,608

Traffic Enforcement Inspections
527
371,889

Commercial Zone Inspections
112,308
334,245

Source: U.S. DOT/Volpe Center

The FAST Act introduced several provisions impacting MCSAP that focused on the consolidation of grants, the improvement of operational effectiveness, and the fostering of partnerships among all stakeholders involved in enforcing CMV safety. One critical provision in the FAST Act required the development of a new allocation formula for MCSAP grant funding, one that had previously remained unchanged for more than 16 years. Under the FAST Act, Congress required the U.S. Secretary of Transportation to establish a Working Group to analyze requirements and factors for the establishment of a new allocation formula and to submit a recommendation to the Secretary. The Volpe Center supported FMCSA in establishing the Working Group and providing the expertise needed to support a successful process and ensure the desired outcome of new allocation formula recommendations.

The Working Group was established in March 2016 and met regularly over the course of a year to produce the formula recommendations. During this period, the Volpe Center supported FMCSA in ensuring a systematic process that included analyzing the current formula, identifying areas for improvement, establishing objectives for the new formula, and evaluating potential formula elements and designs. Six in-person meetings were held, with additional web-based meetings. All in-person meetings were open to the public and held at locations across all four of FMCSA's Service Centers to encourage dialogue with states and other stakeholders.

The recommended allocation formula would apportion funding to states, territories, and the District of Columbia, with the aim of promoting effective and stable state safety activities. The Volpe Center helped to ensure the Working Group's recommendations resulted in an allocation formula that:

- Is safety-based (primary objective)

- Improves upon the previous formula

- Addresses FAST Act grant changes

- Meets FAST Act formula requirements

- Promotes stability in funding

- Responds to changes in crash risk

- Uses quality data sources

- Responds to changes in overall funding levels

The Volpe Center conducted analysis on formula designs, researched and analyzed potential data sources, and designed and created a tool to simulate formula allocation results to inform the Working Group's decision-making process. Volpe staff also supported FMCSA throughout the report development process including building consensus, meeting facilitation, report writing, and developing a strategy for FMCSA to communicate the Working Group's progress to the public.

By putting safety first, the proposed formula maximizes the impact on CMV safety by providing states with resources to address underlying crash risk—supporting FMCSA's primary mission to reduce crashes, injuries, and fatalities involving large trucks and buses. **(Sponsored by FMCSA)**

Rail Safety

Improving Service and Safety at Penn Station in New York City

Commuter railroads replace aging equipment and infrastructure on a routine basis, ensuring the railroad system is up-to-date, safe, and competitive. A modern rail system that is designed to accommodate growing ridership needs such as increased capacity and shorter trip times requires track infrastructure improvements to prevent derailments and other incidents. Yet, upgrading trains and track without disrupting passengers is a major challenge for the railroad industry.

This is especially true for Penn Station, one of the busiest passenger transportation facilities in the United States. Each day, Penn Station serves more than 600,000 commuter rail and Amtrak passengers.

Passengers wait to board a train at Penn Station, New York City. (Source: 123rf.com/brandonkleinvideo)

In late March and early April 2017, Penn Station suffered two train derailments within a week of each other, significantly impacting hundreds of thousands of passengers and commuters in New York City.

Following both derailments, the Volpe Center supported the FRA by deploying a mechanical engineer to inspect both sites, collect data and take measurements, and conduct a track and equipment data analysis.

In the first derailment, Volpe evaluated a geometric mismatch resulting from the connection of a new rail section with an existing worn rail section. In the second derailment, Volpe staff investigated a weakened track structure that caused spreading of the rails under load. This effort was complicated by Penn Station's heavy use and an extremely complicated track configuration.

To prevent future derailments, the Volpe Center recommends the rail industry improve track maintenance practices. It will also be important to incorporate such considerations in the Railroad Safety Advisory Committee's pending recommendations on track geometry limits, inspection requirements, and vehicle service requirements.

The track inspection and rail integrity data collected as a result of both train derailments will benefit not just Amtrak, but the rail industry as a whole. **(Sponsored by FRA)**

Evaluating the Effects of Pavement Markings on Driver Behavior at Grade Crossings

At highway-rail grade crossings there is a particular space between and next to train tracks called the "dynamic envelope." This is the critical space where a collision between a vehicle and a train could occur. In one recent year, roughly one-third of all rail-related fatalities happened at highway-rail grade crossings.

To help identify infrastructure that can make dynamic envelopes more visible and reduce the possibility of vehicles stopping on tracks, the Volpe Center conducted a short-term evaluation of new roadway pavement markings and signage at three crossings in Broward County, Florida.

The Volpe Center team worked with the Florida Department of Transportation (FDOT) to identify highway-rail grade crossings that received pavement markings and modified signage improvements. The team then installed video data collection systems at three of these crossings and evaluated driver stopping behavior before and after the installation to determine the effectiveness of the improvements in reducing instances of vehicles stopping on the tracks.

The evaluation covered a period of three weeks after pavement markings and signage were installed. At the Commercial Boulevard crossing in Fort Lauderdale, the proportion of vehicles that entered and stopped on the tracks decreased by 45 percent eastbound and 15 percent westbound. The Volpe team found an even greater impact in a long-term analysis conducted two years after this treatment was installed. From that analysis, the proportion of vehicles that entered and stopped on the tracks decreased by 49 percent eastbound and 29 percent westbound.

Pavement markings and signage at a grade crossing at Atlantic Boulevard in Pompano Beach led to mixed driver stopping behavior. Eastbound, the proportion of vehicles that entered and stopped on the tracks decreased by 13 percent. But in the westbound direction, driver stopping behavior did not improve.

The Volpe team analyzed one direction of travel at the Powerline Road crossing in Oakland Park. Vehicles entering and stopping on the tracks there decreased 21 percent after the treatments were installed.

Volpe Center analysis shows that the proportion of vehicles that entered and stopped on the train tracks decreased by 49 percent eastbound and 29 percent westbound when pavement markings and signals are present.

Following the success of the markings and signage treatments at Commercial Boulevard, FDOT decided to install the same treatments at three additional crossings in Broward County. Other railroads and state DOTs have explored similar pavement markings and signage treatments. Additional analysis is needed to determine why the treatments were more effective at some locations than others and what other treatments may be effective in eliminating vehicles stopping on railroad tracks. Volpe will continue to work with the FRA and the railroad industry to make grade crossings safer. **(Sponsored by FRA and Florida DOT)**

Preventing Stop Signal Overruns on the Nation's Railroads

Accidents resulting from trains passing stop signals are rare events, but they can cause enormous harm at great cost.

Stop signals tell the train crew that it is unsafe to enter the next track section as another train or work crew may be occupying that space. Passing a stop signal has resulted in several catastrophic accidents, including the Chase, Maryland accident in 1988 and the Chatsworth, California accident in 2008. As a result, Congress passed two Rail Safety Improvement Acts requiring increased regulation of the railroad industry and oversight from the FRA.

FRA's Office of Research, Development and Technology asked the Volpe Center to help several railroads identify why trains pass stop signals—and why they were experiencing an increase in stop signal overruns. Volpe's surface transportation human factors experts conducted case studies to identify why this was happening, and analyzed historical data on stop signal overruns and accidents related to these events. Volpe Center staff also observed where the unwanted events took place and interviewed railroad employees.

This study quantified the extent to which stop signal-related accidents have occurred in the United States over the past 30 years and their relationship to stop signal overruns that precede these accidents. Analysis determined that accidents resulting from stop signal overruns are relatively rare events occurring approximately once every 100 million train miles. When they occur, the accidents are costly—total costs resulting from fatalities, injuries, and property damage have varied

FRA asked the Volpe Center to help several railroads identify why trains pass stop signals—and why they were experiencing an increase in stop signal overruns.

between $10,000 and $10.8 million from 2003 to 2015. As precursors to these accidents, stop signal overruns varied between zero and 1.5 stop signal overruns/million train miles over a one year period between 2005 and 2015.

Results of this research offer explanations for why stop signal overruns occur and provide multiple recommendations for preventing related accidents in the future. Railroads will be able to use recommendations from this research to improve passenger safety and better target appropriate countermeasures.

The Volpe team also devised a template that FRA and the railroads can use to report stop signal overrun events and related accidents to aid in understanding why they are occurring at a particular railroad or to identify trends across the industry. **(Sponsored by FRA)**

Freight and Passenger Rail Accident Rate: 2003–2015

Source: U.S. DOT/Volpe Center
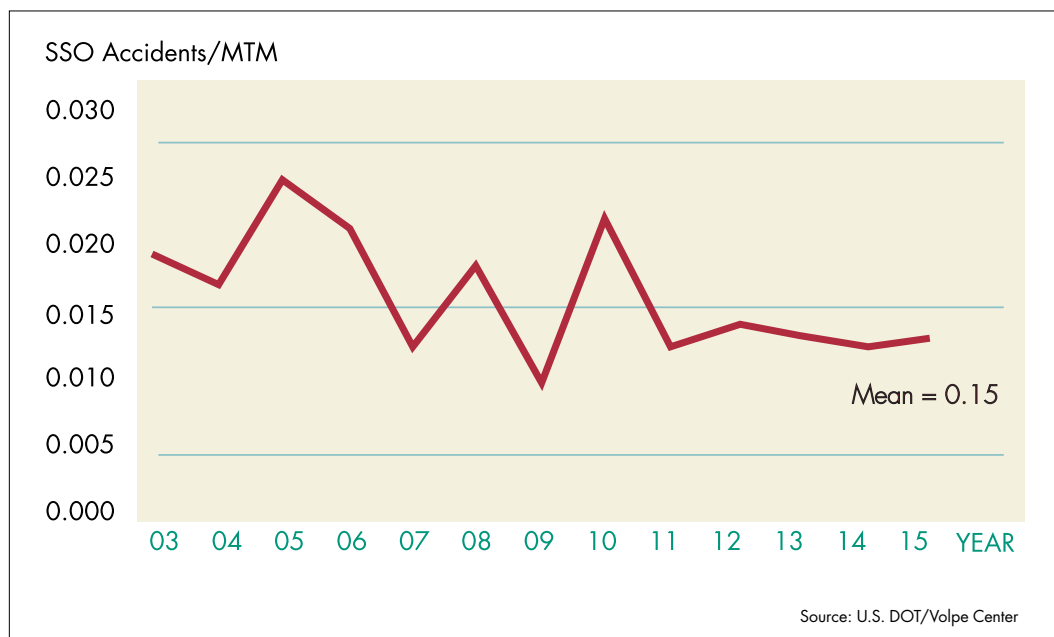
This chart illustrates the yearly accident rate for freight and passenger accidents involving stop signal overruns from 2003 to 2015. During this period, the accident rate averaged 0.15/million train miles.

Infrastructure and Resilience

The Volpe Center is a key partner in advancing the U.S. DOT's infrastructure goal and supports efforts that further U.S. economic growth and enable the more efficient movement of people and goods.

(Image: 123rf.com/W. Wapakphet)

Volpe Develops New Transportation Disruption Scenarios Model

Assessing the impacts of coastal flooding on specific transportation assets and operations has been studied for the past decade, however, calculating the cascading impacts across the transportation network and on transportation users is a new endeavor. As disruptive weather events occur with greater frequency, the U.S. DOT is working to develop a robust, nationally applicable model that can quantify both the direct and indirect costs to the nation's transportation infrastructure.

The Volpe Center built upon last year's Hampton Roads, Virginia coastal flooding project by integrating data, methodologies, and algorithms to support a new model that operates under a variety of transportation disruption scenarios. The result is a flexible multimodal prototype that can be used to assess threat impacts. The prototype is currently being driven with data from the Hampton Roads region for a series of coastal flood scenarios. Ultimately, the tool will become replicable for use throughout the nation and may be expanded to include additional threats.

The prototype model was developed to:

• Systematically identify exposed transportation assets

• Calculate direct costs due to exposure (e.g., costs for the transportation asset to return to business as usual)

• Estimate the extent of the disruption

• Calculate indirect economic costs to the region (e.g., lost wages, port disruptions)

• Describe the non-economic consequences (e.g., unavailability of emergency services and adverse impacts on military readiness)

• Present the results

The prototype can be run under baseline conditions that represent impacts that could occur today, assuming no intervention occurs. Future work will introduce a resilience component to simulate reduced impact if intervention were to occur. Comparing the two scenarios will provide broader-based evidence toward the benefits of various resiliency options for coastal flooding (as well as other hazards, as defined by stakeholders).

The Volpe Center led the technical effort for the prototype development, partnering with the Hampton Roads Transportation Planning Organization and several U.S. DOT modal agencies. The team made multiple visits to Hampton Roads and U.S. DOT to ensure stakeholder engagement and model calibration. Leveraging a range of Volpe Center expertise, including resilience experts, transportation planners, and economists, the team identified and gathered data, conducted targeted literature reviews to develop a component-based model, and then drilled down by component to identify potentially viable algorithms.

Direct and Indirect Cost Results

For coastal flooding, results suggest direct costs of debris cleanup may greatly outweigh transportation asset damage. However, the indirect costs of the economic and risk-based consequences on transportation users are greater than the estimated direct costs. With the current approach of estimating direct costs in transportation disruption analysis, the concern is that decision makers may not receive all of the information needed to identify the appropriate disruption mitigation strategy.

Conceptual schematic of the model.

Transportation Disruption Scenarios Model

Source: U.S. DOT/Volpe Center
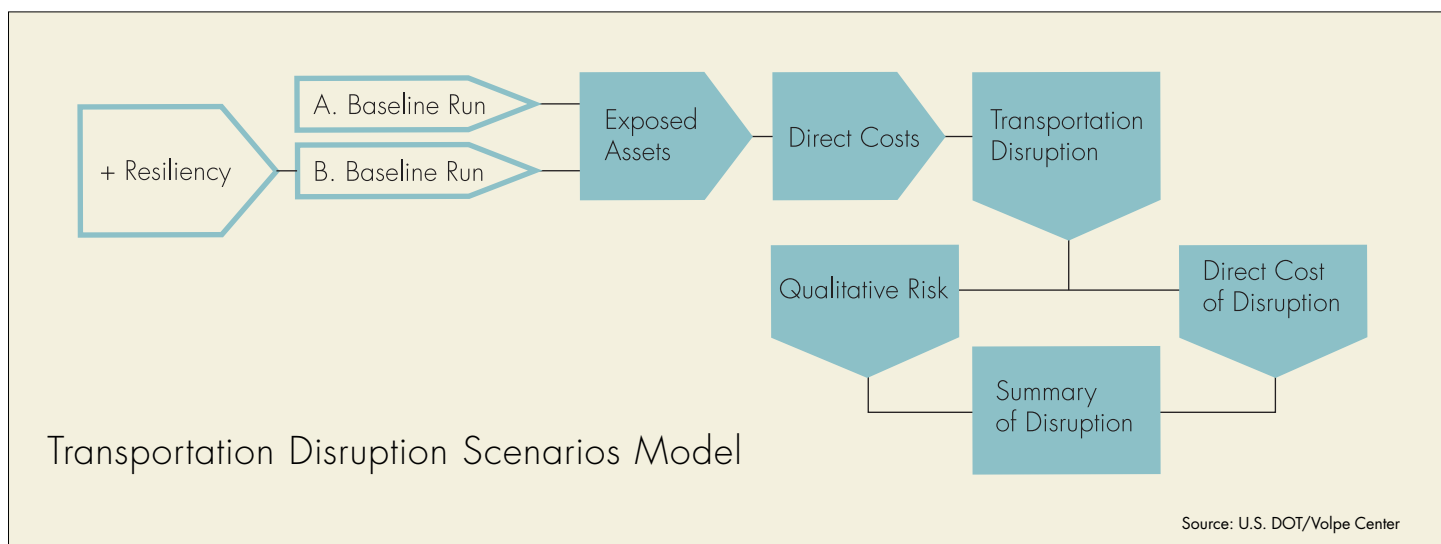
Through continued development, model results will allow decision makers to understand where transportation disruption may create the greatest impact on the economic vitality of a region. In addition, the model results will inform the magnitude at which the disruption (i.e., coastal flooding) becomes an issue. This information will help inform transportation infrastructure resiliency planning.

The new model was conceptualized in January 2017, and the Volpe Center presented the model prototype to U.S. DOT sponsors in mid-August. Volpe intends to continue to build, refine, and test the model throughout 2018. **(Sponsored by U.S. DOT, Office of the Secretary, FMCSA, FHWA, and FRA)**

Enhancing the U.S. Air Force's Energy and Transportation Infrastructure Resilience

Transportation plays a key role in the U.S. Air Force's (USAF) energy installations. From global flight operations, accessible fuel, and electrical power for equipment, vehicles, and aircraft to cyber-security logistics—transportation and energy are at the core of USAF's mission performance and infrastructure resilience. Starting in January 2016, the Volpe Center worked with USAF, the Department of Defense (DoD), and other partners to assess the risks and vulnerabilities

The Four Elements of the Volpe Resilience Framework

- Maintain Real-Time Situational Awareness
- Identify Dependencies and Plan for Threats and Vulnerabilities
- Retrofit and Upgrade Energy Distribution and Storage
- Diversify Generation Sources

Recognition and Response

- Detect Emerging Threats
- Monitor Unfolding Events
- Correct Draft (Identify and Address Degradation of Mission Critical Functions from Insufficient or Poor Quality Power)

Pre-Incident: Adaptive Prevention

Evolving Threats: Predictive Problem-Solving

Learning Performance Plateau

Rapid Decision Support

Post-Disaster: Response and Recovery

Disaster Unfolding: Alternative Operational Paths

- Mitigate Consequences
- Restore Normal Operations
- Collect Diagnostic Information to Inform the Next Prevention Phase
- Consider a New Steady State

Strengthen Network Enterprise-Level Strategy

- Shift to Redundant Sources of Distributed Power
- Reallocate Resources to Sustain Mission Critical Operations
- Take Advantage of Loose Coupling to Substitute Fuels or Communications Networks

Source: U.S. DOT/Volpe Center

of unreliable energy and identify strategies to enhance operational resilience. This effort builds on the USAF Energy Surety initiative and was sponsored by the USAF Assistant Secretary for Installation, Energy, and Environment.

Over the course of the project, the Volpe Center developed three reports in support of the USAF's initiative: a comprehensive resilience framework to quantify risk posed by power interruptions and unreliable access to energy during USAF installations; a risk assessment of unreliable centralized grid-electricity at Beale Air Force Base and strategies for operational resilience; and a cost and emissions savings assessment of DoD strategies designed to simultaneously improve operational resilience and energy assurance. Findings from these reports advance the Volpe Infrastructure Resilience Framework, an approach developed in 2014 to identify and mitigate vulnerabilities from the nation's infrastructure. This framework was used to demonstrate the effectiveness of Smart Grid technologies, such as micro-grids with storage, utilizing onsite generation using renewable sources, and employing distributed energy architectures, to enable an efficient, cyber-secure, and resilient solution that supports an installation's increasingly electrified transportation and energy infrastructure.

For the Beale Air Force Base examination, the Volpe team visited the installation along with other project partners to conduct a thorough assessment of the current infrastructure and available data. As part of this work, Volpe analysts applied a wide range of the latest resilience tools to help with statistical analysis and decision making. Approaches included Safe-to-Fail, Minimax-Regret, Bayesian statistical methods, Systems Theoretic Accident Modeling and Processes, and the Analytical Hierarchy Process (AHP). The team used the AHP, in particular, to help identify needs, prioritize wants, and evaluate alternatives for the USAF's upcoming Request for Proposals.

Findings from these reports will help USAF improve mission performance and resilience to disruptions, reduce energy-intensity of operations, and reduce energy consumption costs for their installations. **(Sponsored by USAF)**

Volpe Staff Respond to Hurricanes and Oroville Dam Overflow

The National Response Program, located in the Office of Intelligence, Security, and Emergency Response (S-60), coordinates the U.S. DOT's response to all disasters and emergencies. The program depends on over 150 staff nationwide to coordinate regional responses, with 10 Regional Transportation Representatives (RETREPs) leading transportation operations in Federal Emergency Management Agency (FEMA) operation centers during incident and event responses. RETREPs are highly trained subject matter experts who also coordinate activities between the various federal, state, local, tribal, and private sector entities involved in preparing for, responding to, and recovering from disasters and other incidents.
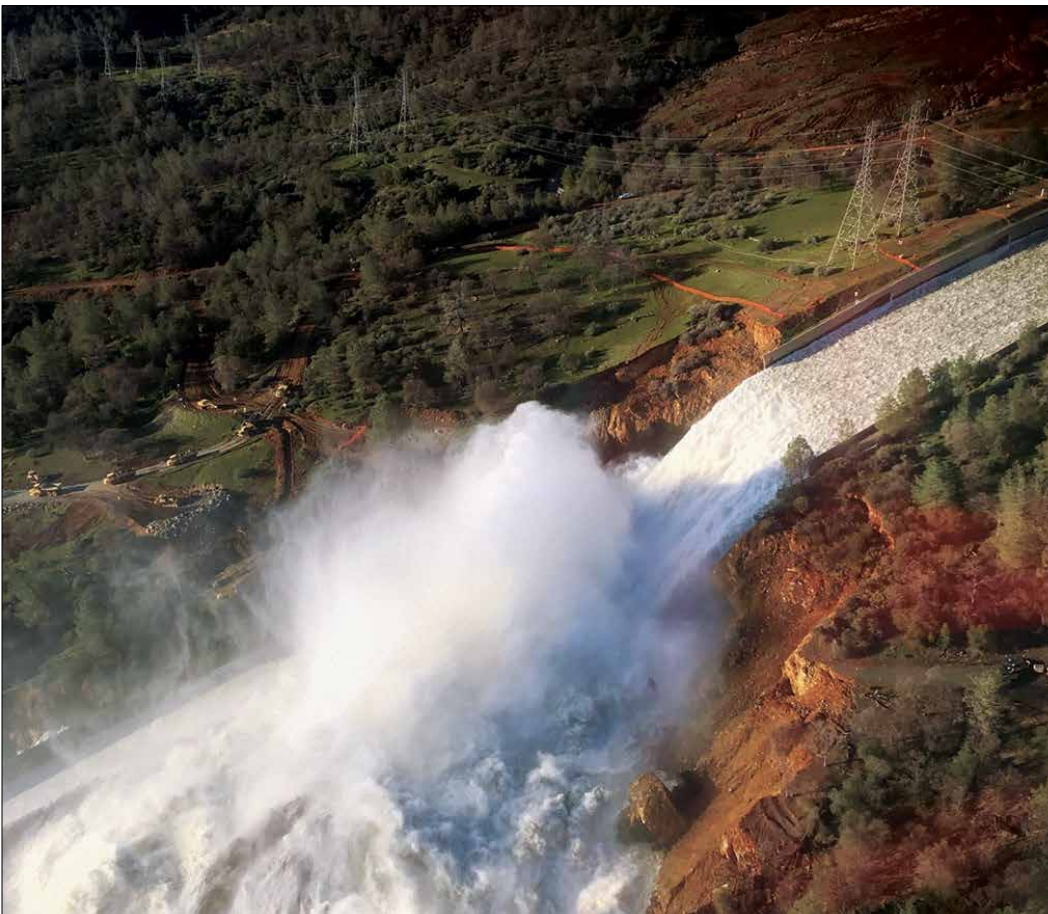
Heavy rains in Northern California caused the Oroville Dam spillway to overflow. (Source: Jim Robinson, R2 RETREP FAA)

A Volpe Center staff member serves as the RETREP for Region 1, and was activated in response to major events in 2017—the potential Oroville Dam failure and Hurricanes Harvey and Irma.

In February 2017, Volpe's emergency response transportation expert was deployed to Sacramento, California, in response to the potential failure of the Oroville Dam. The 2016-2017 rainy season was Northern California's wettest winter in over 100 years, causing record inflows to the Feather River. The Oroville Dam spillway was opened in January to relieve pressure on the river. However, erosion and damage to the dam's spillways caused concern about a potential collapse. A Volpe staff member developed an initial evacuation plan for the nearly 200,000 residents of the cities below the Oroville Dam. Volpe staff also developed a larger evacuation plan, which included plans for life-sustaining activities and mass care of affected communities. The plan has since been incorporated into the larger statewide evacuation framework, and is still in force today.

On August 23, 2017, FEMA activated the Texas Emergency Operations Center in Austin, Texas in response to Hurricane Harvey. The Region 6 U.S. DOT lead RETREP was deployed to the Regional Response Coordination Center in Denton, Texas. The Region 1 RETREP is the primary backup to Region 6 FEMA and RETREP and was issued a Mission Assignment activating the Transportation Emergency Support Functions (ESF-1) under the National Response Framework, which establishes a comprehensive all-hands approach to enhance the ability of the United States to manage domestic incidents and disasters. The Volpe Center is an integral part of the U.S. DOT ESF-1 contingent and must respond when activated. In September 2017, FEMA activated the Puerto Rico Emergency Operations Center in San Juan in response to Hurricane Maria. Hurricane Maria was regarded as the worst natural disaster on record in Dominica, the Virgin Islands, and Puerto Rico, causing catastrophic damage and triggering a major humanitarian crisis. To assist with response efforts, the RETREP for Region 1 established the U.S. DOT ESF-1 Road and Bridge Hotline to report roads that were unsafe or out of service. **(Sponsored by FRA, FTA, NHTSA, and OST-R)**

Implementing the Monitoring and Technical Assistance Program (MTAP)

The Volpe Center is helping the FRA promote safe, environmentally sound, reliable, and efficient rail transportation to meet the needs of customers today and tomorrow.

FRA administers grant and loan programs to assist states and other eligible entities in the planning, acquisition, design, construction, and operational readiness of high-speed and intercity passenger rail and freight rail projects. The agency is responsible for ensuring projects are delivered successfully, provide public benefits, and meet federal requirements.

To steward taxpayers' dollars and provide due diligence as a federal grant-making agency, FRA's Monitoring and Technical Assistance Program (MTAP) provides project oversight, technical assistance, and training support to its grant and loan recipients. Since 2014, MTAP has helped ensure successful delivery of over $14 billion worth of transportation investments across 175 projects throughout the United States.

FRA's goals for MTAP are at three levels:

1. Project: To proactively identify and mitigate risks, foster good solutions to challenges/issues, and ensure projects move successfully into revenue operations

2. Program: To develop an ongoing FRA oversight program with knowledge-sharing and partnering

3. Industry: To elevate the knowledge and level of practice of the U.S. rail industry

The FRA has engaged the Volpe Center to support all three.

The Volpe Center's ongoing MTAP effort is focused on high-speed and intercity passenger rail projects, on projects funded through U.S. DOT Transportation Investment Generating Economic Recovery (TIGER) grants, and on Amtrak Annual Capital Grant projects. Additionally, in 2017 the Volpe Center began monitoring the Build America Bureau's Railroad Rehabilitation & Improvement Financing (RRIF) program, which provides direct loans and loan guarantees to finance development of railroad infrastructure.

Monitoring and technical assistance contractors team with Volpe staff to support MTAP. In activity characterized by a high level of proactive engagement, dialogue, and problem solving with the recipients and FRA, the Volpe MTAP team performs oversight, fully understands the projects, considers project content and approach, advises and recommends alternative approaches, and evaluates risks.

In support of MTAP's project and program goals for the years 2016 and 2017, the Volpe MTAP team conducted 89 monitoring reviews of High-Speed Intercity Passenger Rail Program and TIGER grant projects and 74 monitoring reviews of Amtrak capital projects. Additionally, in relation to the RRIF program in 2017, Volpe staff attended and participated in the Acela Express 2021 Quarterly Meetings and the FRA/Amtrak RRIF Tier III Equipment Bi-Weekly Project Meetings.

To further MTAP's industry goal, Volpe staff coordinated FRA's third Rail Program Delivery Meeting, which fostered a sense of partnership and shared best practices, discussed lessons learned, and provided educational briefings. Grant recipients, railroad representatives, federal oversight contractors, and FRA staff attended the 2.5-day event. The Volpe Center also developed a series of 13 online videos that provide FRA's grantees with guidance on key aspects of rail program delivery.

The Volpe Center's MTAP work has contributed to the successful construction or improvement of thousands of miles of track, bridges, and tunnels; the procurement of new passenger rail equipment; and the upgrade of over 30 train stations. This work has improved safety, increased train reliability, added capacity, reduced travel times, and made stations and equipment more efficient and accessible. **(Sponsored by FRA)**

The Volpe Center, in support of FRA's MTAP, has helped improve rail safety, efficiency, and infrastructure.

FAA Terminal Facilities Project Modernizes Essential Infrastructure

Since 2012, the Volpe Center has assisted the FAA in fulfilling a congressional mandate to develop consensus recommendations, with input from labor and industry, on the modernization, realignment, and consolidation of ATC terminal services and facilities. In addition to saving funds, these realignments were the foundation for the implementation of Next Generation (NextGen) technologies.

In ATC terminal operations, flights within five miles of origin or destination are managed by the control tower via line of sight; outside of that boundary, flights within the controlled airspace are managed via Terminal Radar Approach Control (TRACON) alone, which can be performed remotely. Consolidating TRACON facilities can bring cost savings when a local tower must be replaced by eliminating the more expensive construction features required by a radar approach facility.

FAA formed a collaborative workgroup, comprising representatives from the FAA, the National Air Traffic Controllers Association, and the Professional Aviation Safety Specialists labor unions, to assess TRACON facilities for realignment and forge agreements among transferring and receiving sites.

The workgroup gathers and reviews the operational and technical requirements for the facilities undergoing analysis; considers existing agency assets, inventory, and workforce impacts; gathers and evaluates stakeholder input; and estimates the costs and benefits of potential realignments. The workgroup then makes its recommendation to the FAA. If the FAA concurs, the recommendation is posted for public comment, and is then presented to Congress.

Capital costs, plus critical operating costs and issues, must be factored in. Additionally, contract obligations and their impact on consolidations or realignment proposals, plus location-specific differences in other operating costs, make decisions on consolidation recommendations more complex.

The Volpe Center's critical end-to-end role in this process is to identify the consolidation options in advance and communicate choices, establishing the framework for consensus building toward a final recommendation. As part of the workgroup, the Volpe Center project manager:

- Identifies a transferring site on the basis of its age, traffic count, any existing plans for renovation or replacement, their timeframe, and projected cost

- Assesses its current airspace borders and potential for their merger to identify two alternative receiving facilities

- Evaluates the transferring and receiving sites' physical and personnel assets for possible relocation

- Calculates each alternative's potential cost savings over 15 years

The Volpe project manager is also the only workgroup member involved at every site.

Providing this detailed technical documentation from the outset enables the unions, local management, FAA, and other stakeholders to see opportunities and tradeoffs from the start of their discussions. The workgroup has successfully completed 60 assessments to date, recommending $52 million in consolidation savings. **(Sponsored by FAA ATC Facilities)**

Upgrading Radar and Air Traffic Control Systems in the National Airspace

Air traffic control and radar systems have evolved to manage airspace filled with large numbers of fast-moving aircraft. With the annual number of flights in the United States expected to grow significantly over the next 20 years, the number of civil and commercial aircraft traveling through airspace controlled by the DoD is also expected to grow. To support this expansion, the DoD National Airspace System (DoD-NAS) program is replacing outdated radar and air traffic control

Volpe Center electronic engineer installs a GPS antenna at a U.S. Air Force Base. (Source: U.S. DOT/Volpe Center)

systems in U.S. military airspace with digital technologies that are more reliable, and that will support growth in both military and commercial air traffic.

Volpe Center staff are supporting ongoing efforts to upgrade radar display systems with a newer technology known as the Standard Terminal Automation Replacement System (STARS). The new system provides recordable, digital voice, surveillance, and automation tools, allowing air traffic controllers to more effectively track air traffic. Throughout the process, Volpe staff performed site surveys and site preparation for all STARS installations, and served as lead engineers. To date, Volpe Center experts have upgraded 33 of 39 STARS systems and 28 of 36 ATC towers.

Volpe also provided engineering and optimization support for development of a deployable Radar Approach Control (D-RAPCON) system, an instantly-deployable ATC system aimed at supporting contingencies and disaster relief. The D-RAPCON program is based on the fixed DoD-NAS system, but uses a containerized, mobile configuration. The program completed the development phase this year and has entered contractor testing.

Finally, Volpe supports the U.S. Air Force's Foreign Military Sales (FMS) program, which assists in the engineering, deployment, and testing of U.S.-made air traffic control systems sold to allied nations. Installation and acceptance testing of the Romanian system is complete, while the Saudi Arabian and Polish programs are ongoing.

These radar and air traffic control upgrades provide more reliable, effective, and safer air traffic control systems in the United States and around the world. New digital technologies also allow the DoD to remain compatible with the FAA's air traffic control infrastructure, providing the groundwork needed to support the FAA's Next Generation of Air Traffic Management. Volpe's role in this work is expected to continue through 2020. **(Sponsored by USAF)**

Volpe Supports Cyber Physical Systems Security for DHS's Automotive Cybersecurity Program

The Volpe Center, in support of the U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Directorate, Cyber Security Division, is supporting an effort designed to promote automotive cybersecurity best practices and guidelines in the private sector. This work will conduct cybersecurity pre-competitive research by a consortium of auto manufacturers to address cybersecurity needs for motor vehicles. This initiative contributes cost-effective ways to mitigate cybersecurity threats of interest to the U.S. DOT, including NHTSA and FMCSA.

Volpe Center cybersecurity analysts contributed to establishing and developing a project portfolio for the Automotive Cybersecurity Industry Consortium (ACIC), a voluntary and technology-oriented public-private partnership involved in cooperative pre-competitive research to improve cybersecurity in motor vehicles. Currently, six auto manufacturers are members of the ACIC. The Volpe Center's direct involvement in ACIC helped consortium members identify and select mutually beneficial projects that will reduce the threat of cybersecurity risks to motor vehicles. In addition, the Volpe Center led an effort to harmonize vehicle cybersecurity research among federal agencies and their contractors by developing, hosting, and reporting on an Open Source tools workshop held at the Volpe Center in October 2016.

The graphic below illustrates vehicle connectivity to outside computer networks, highlighting potential cyber-attack surface threats of telematics systems.

Cyber Threats to Automobiles

CAN: Controller Area Network data bus, which is a vehicle standard to transmit data and control various parts of the vehicle

BCM: Body Control Module

ECM: Engine Control Module

OBD: On-Board Diagnostics port where the dongle (device) is attached and accesses data and information from the CAN bus on different parts of the vehicle

Engine
Transmission
Locks/Windows
Security
BCM/ECM
Cluster

CAN bus

OBD Dongle w/ Telematics

Base Station

Provider Network

Internet

Service Center
Fleet Manager
Who Else?

Connected to External Network

Interfacing with Public Network

Accessible by Anyone

Attack Surface Threats

Source: U.S. DOT/Volpe Center

Volpe Center cybersecurity experts developed a vehicle cybersecurity primer and guidance for government fleet managers. The primer helps federal and state fleet managers understand current cybersecurity vulnerabilities in telematics and fleet management systems, assess risks to their fleet, and select effective solutions. The Volpe team worked with the U.S. Computer Emergency Response Team of Carnegie Mellon University's Software Engineering Institute to conduct vulnerability testing of telematics devices. The General Services Administration is using this information to help guide future vehicle procurement requirements. **(Sponsored by DHS Science and Technology (S&T) Directorate, Cyber Security Division)**

Automation and Mobility

The Volpe Center, in collaboration with key stakeholders, is committed to the safe and efficient integration of automated technology into the transportation system.

Safely Integrating Remotely Piloted Aircraft into the National Airspace

The FAA projects that by 2021, the fleet of hobbyist and commercial remotely piloted aircraft (RPA) will reach 4 million. However, there are currently several technical, operational, and regulatory challenges related to integrating routine RPA operations in the NAS. The most prominent obstacle is the inability of an RPA operator to see-and-avoid other aircraft, as required by federal regulations. Approved mitigations for the absence of a see-and-avoid capability, such as a ground-based visual observer or a visual observer onboard a chase aircraft, are not always practical and frequently limit the number and type of missions RPAs can execute.

The Volpe Center, in partnership with the U.S. Air Force (USAF), MITRE, and Raytheon, is developing a Ground-Based Detect and Avoid (GBDAA) proof-of-concept (POC) capability that detects aircraft in the vicinity of an RPA by fusing aircraft position data from many types of ground-based radars and displaying these positions in real-time. This enables RPA operators to detect-and-avoid traffic at an equivalent level of safety as a manned aircraft's ability to see-and-avoid traffic. This work furthers the transportation and logistics enterprise by advancing capabilities to facilitate routine operations of RPA within the NAS.

Previous GBDAA POC configurations have focused on supporting operation of larger RPAs such as Predator, Reaper, and Global Hawk. The GBDAA POC configuration at Springfield-Beckley Municipal Airport (KSGH) in Ohio will enable RPAs that are too small for detection by local surveillance radars to utilize the GBDAA capabilities. Additionally, unlike previous GBDAA POC configurations, the capability configuration at KSGH is installed in a Mobile Command Center, and can be driven via roadways to the airfield. The Mobile Command Center is being evaluated for its capability to provide additional flexibility for configuring and deploying GBDAA solutions at airports and other locations that lack the infrastructure needed for a standard configuration.

GBDAA provides a promising solution for the USAF and other branches of the military, along with states and municipalities, to more seamlessly conduct critical missions and testing of new technologies involving the use of RPAs. As a result of this project, the Air Force Research Laboratory, the state of Ohio, and commercial operators will be able to safely test a wide range of RPAs within the operational NAS without being constrained by typical measures for complying with see-and-avoid. **(Sponsored by USAF)**
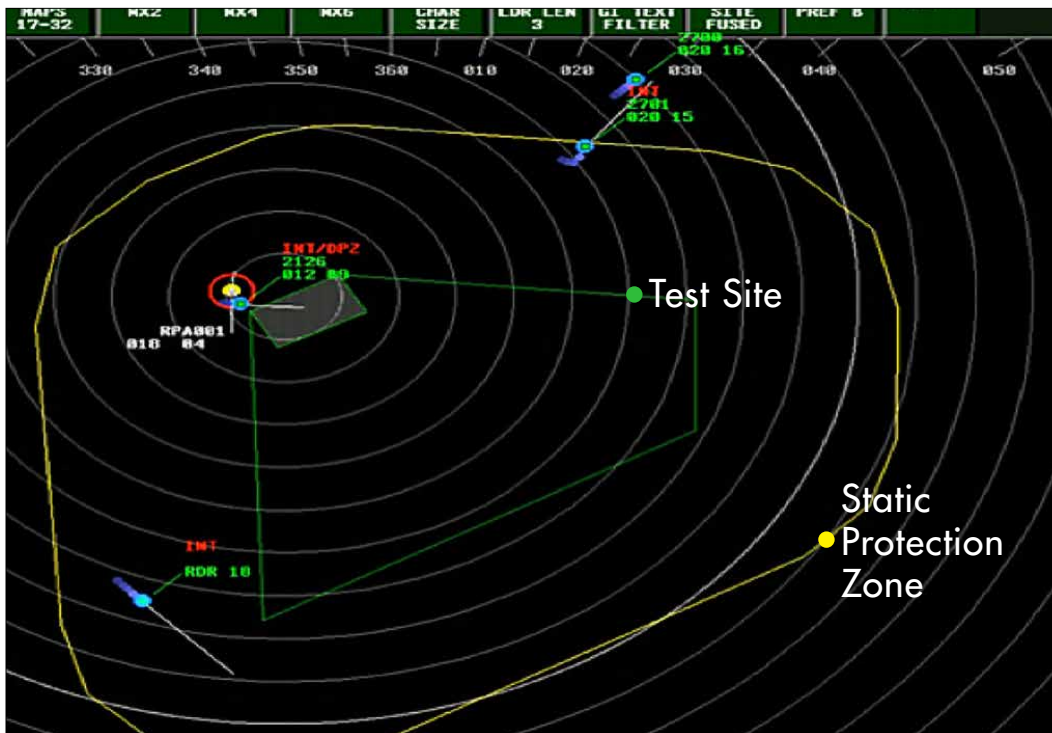
The GBDAA user interface, configured for traffic operations near KSGH. The green polygon is the planned operation area for the RPA test site. The yellow polygon is a monitoring line for incoming aircraft, known as the Static Protection Zone. The blue dots indicate real-time positions of aircraft within that zone.
(Source: U.S. DOT/Volpe Center)

Unmanned Aerial System (UAS) Traffic Management (UTM) Safety Risk Analysis

Many beneficial civilian applications of public and commercial small (less than 55 pounds), unmanned aircraft systems (small UAS) that operate below 400 feet (commonly called drones) have been proposed and are being developed. By 2021, it is projected there will be 4 million small UAS in the NAS, 442,000 of them commercial.

The introduction of small-UAS operations, however, is a modification of the NAS, and therefore requires risk analysis to ensure that an acceptable level of safety and security are maintained. FAA, National Aeronautics and Space Administration (NASA), other federal partner agencies, and industry are collaboratively exploring concepts of operation, data exchange requirements, and a supporting framework to enable multiple beyond visual line-of-sight UAS operations at low altitudes (under 400 feet above ground level) in airspace where FAA air traffic services are not provided.

UTM is a traffic management ecosystem for uncontrolled operations that is separate but complementary to the FAA's Air Traffic Management (ATM) system. UTM development will ultimately identify services, roles/responsibilities, information architecture, data exchange protocols, software functions, infrastructure, and performance requirements for enabling the management of low-altitude uncontrolled UAS operations.

The goal of the safety element within UTM is to develop a methodology for assessing safety risks and ensuring safe operations. As a key member of the NASA UTM Safety and Risk Analysis team, the Volpe Center is helping to lead and support the identification of current hazards through the analysis of civil, military, and other UAS accident and incident reports. Similarly, Volpe staff are identifying potential future safety hazards associated with increasing numbers of civil UAS operations by collecting and analyzing proposed UAS use cases from industry and government agencies. The Volpe Center provides guidance in the development of hazard analysis and safety risk assessment processes for the UTM system at both the UAS and UTM operational levels.

By 2021, it is projected that the UAS fleet will grow to 4 million in the NAS, 442,000 million of them commercial.

To date, this project has identified 14 potential hazards associated with small-UAS operations at the vehicle level, along with their possible causal and contributing factors. The associated risk of each of those hazards was assessed for various UAS vehicle weight classes, configurations (fixed wing, multirotor, and unmanned helicopter), and levels of operational complexity, ranging from single UAS operation under visual line-of-sight in a remote/rural area to fully autonomous, multi-UAS operations under beyond visual line-of-sight conditions in urban and congested environments.

The results of this safety risk analysis may be used to highlight important safety hazards and issues, identify improvement opportunities, make recommendations concerning the elements of the system that are most likely to contribute to future problems, and identify safety requirements to include in the system requirements and performance documents. **(Sponsored by NASA)**

The goal of the ATD-2 project is to reduce congestion on the airport surface and improve the efficiency of air traffic flows in proximity to airports. (Source: tham/iStock photo)

Air Traffic Management Technology Demonstration

NASA's Airspace Technology Demonstration 2 (ATD-2) project aims to reduce congestion on the airport surface and improve the efficiency of air traffic flows in airspace regions neighboring and downstream of major airports. Phase 1 of the demonstration program provides tools for scheduling departing aircraft in a manner that reduces runway congestion and allows departures to fit more efficiently into the overhead stream. The FAA will use the lessons learned from the ATD-2 demonstration to inform the future development of decision support systems.

Before the FAA can test ATD-2's traffic management tools at an operating airport, safety rules require that a Safety Risk Management (SRM) panel review the demonstration program. With the support of the Volpe Center, the FAA convened an SRM panel to review the ATD-2 Phase 1 demonstration in Charlotte, North Carolina on May 9–11, 2017. This panel brought together project stakeholders from the FAA, participating airlines, and NASA in order to identify any potential safety risks associated with the demonstration as well as to specify corresponding mitigations for risks identified. This review included an assessment of safety issues related to the

integration of the ATD-2 system with the FAA's Time Based Flow Management system and also analyzed issues associated with the operation of the ATD-2 system itself.

In addition to framing the analysis and facilitating the panel's deliberations, the Volpe Center produced the resulting SRM Document, which contained the panel's findings. The FAA approved this document in September 2017, thereby fulfilling one of the requirements before the demonstration could take place. A phased implementation of ATD-2 operations began on September 29, 2017. **(Sponsored by FAA)**

Estimating Benefits and Target Crash Populations for Automated Vehicle Concepts

In 2016, motor vehicle crashes claimed the lives of 37,461 people on the nation's highways. Research conducted by NHTSA has shown that 94 percent of serious crashes are linked to dangerous decisions people make while driving. The U.S. DOT and its partners are collaborating to help drivers make safer decisions, and driver-assistance technology is one tool that could reduce crashes and save lives.

Breakdown Process to Correlate Automated Vehicles to Crash Data

Location
- Intersection Related, Ramp Related
- Highway, Non-Highway
- Work Zone

Pre-Crash Scenario
- 37 Pre-Crash Scenario Typology

Driving Condition
- Lighting, Weather, Surface Condition

Travel Speed
- Low versus High Speed
- Posted Speed Limit as Speed Surrogate

Driver Condition
- Driving Error (Recognition, Decision, Erratic)
- Physiological Impairment

37 Pre-Crash Scenario Typology: Refers to the breakdown of all motor vehicle crashes into dynamically distinct scenarios that capture vehicle movements and critical events immediately prior to a crash.

Source: U.S. DOT/Volpe Center

This diagram shows the breakdown process to correlate automated vehicle functions to crash data.

New vehicles sold in the U.S. already include some level of proven automated safety technology to help drivers avoid crashes, warn of crash risk, or apply brakes or steering control when a driver reacts too slowly. NHTSA is committed to enhancing the capabilities of automated vehicles to eliminate motor vehicle-related crashes and fatalities on U.S. highways.

With the help of the Volpe Center, NHTSA is researching target crash populations–the first step in quantifying potential safety benefits of automated vehicles. The target crash population defines the size of the crash problem that could be addressed by specific automated vehicle functions, leading to quantifiable safety measures. This project estimated target crash populations for higher levels of automation, while also accounting for perceived benefits of lower automation levels that currently exist in the U.S. vehicle fleet.

The Volpe team developed a methodology to identify and correlate conceptual automated vehicle functions, the level of automation, and the operational relationship to historical crash data. The functions are mapped to national crash data using five distinct layers of information: location, pre-crash scenario, driving conditions, speed of travel, and condition of the driver. From this research, Volpe was able to link vehicle automation levels to crash records, and the analysis listed automated vehicle functions and their potential overlaps and gaps to mitigate crashes.

Evolving technology presents a significant hurdle to estimate the current safety of automated vehicles. Volpe's research and analysis, however, provides a thorough methodology to address the target crash size.

The findings of this project were presented at the 25th Enhanced Safety of Vehicles Conference held in June 2017 in Detroit, Michigan. The results have gained attention and the project was approved for revisions to update the target crash populations with modified mapping of automated vehicle levels and the most recent crash statistics. **(Sponsored by Intelligent Transportation Systems Joint Program Office (ITS JPO) and NHTSA)**

Test and Evaluation of Cooperative Automated Driving Systems

With emerging automated driving technology, cars may soon have the capability to talk to each other and form a platoon on the highway. Car platooning employs cooperative adaptive cruise control (CACC) and vehicle-to-vehicle communications to automatically synchronize the longitudinal movements of a string of vehicles. The lead vehicle would control the platoon's speed; the vehicles behind it would follow safely at close proximity, automatically responding with electronic awareness to the lead vehicle's speed changes. Platoon formations could improve travel time, increase lane capacity, and reduce congestion.

The Federal Highway Administration's (FHWA) Turner-Fairbank Highway Research Center (TFHRC) has undertaken a multi-stage, multi-year research effort to accelerate the deployment of cooperative automated driving systems. Over time, TFHRC plans to build, test, and evaluate the performance of an Integrated Highway Priority application that combines platooning, speed harmonization, and lane change/merge.

The Volpe Center is leading the evaluation of these cooperative automated driving systems in support of FHWA's TFHRC. The project team comprises experts from the Volpe Center's Advanced Vehicle Technology and Air Traffic Management Systems divisions. Under an agreement with TFHRC, the U.S. Army is performing the Volpe-developed testing procedures.

The research program's first stage objectives were to develop test procedures for car platooning, identify performance metrics and data needs, and evaluate a car platooning proof-of-concept. The

Volpe Center created the evaluation plan, devised the test procedures, defined performance metrics, identified the data elements, and cooperated with the Army to prepare the testing safety plan.

The first-stage tests of a proof-of-concept, CACC-based vehicle platooning system were performed in July 2016 at the Army's Aberdeen Test Center in Maryland and involved five 2013 Cadillac SRX passenger vehicles. The Army installed data acquisition systems and executed the test procedures with professional drivers. The test data were then transferred to Volpe for analysis.

As a result of the test data analysis, the Volpe team identified areas of improvement that will help designers build car platooning prototypes that achieve closer following distances, more stable travel speed, and a comfortable, safe ride. This project's baseline test procedures and performance metrics form an essential input to future standards and guidelines.

In its report, *Test and Evaluation of Vehicle Platooning Proof-of-Concept Based on Cooperative Adaptive Cruise Control,* the Volpe Center offered lessons learned and several recommendations concerning features of the CACC-based vehicle platooning system that should be further assessed and potentially improved in the next iteration of the application. **(Sponsored by FHWA Turner Fairbank Highway Research Center)**
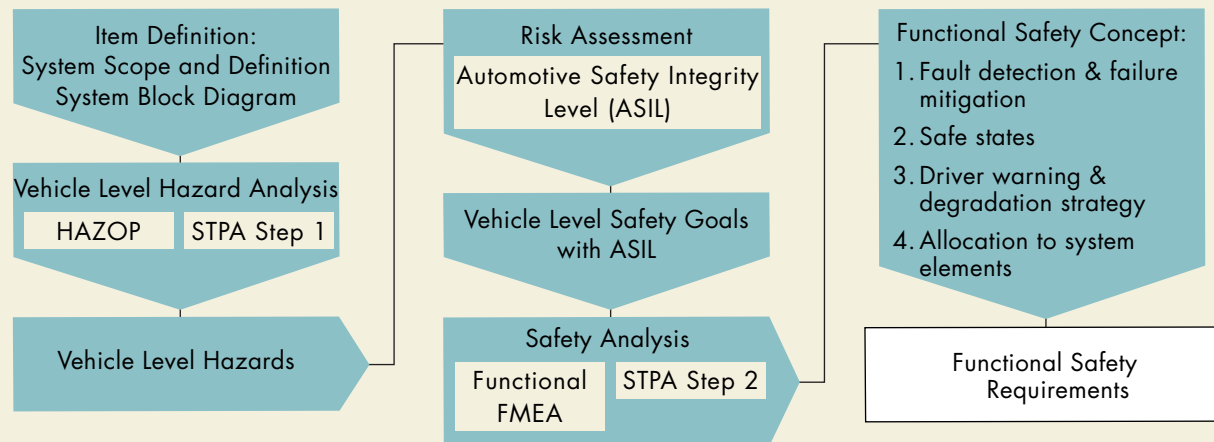
Functional Safety of Automated Lane Centering Controls

Automated Lane Centering (ALC) is a relatively new autonomous driving option in passenger vehicles. The ALC system senses the vehicle position in the lane and issues a command that is executed by the steering system in order to maintain the vehicle in the center of the lane. ALC provides sustained lateral control until it is disengaged.

Over a half-dozen automotive manufacturers currently offer some version of this system. As deployment of this and related technologies becomes more widespread, understanding any safety challenges and potential hazards will be essential to ensuring the safety of the evolving transportation landscape. At the request of NHTSA and the ITS JPO, the Volpe Center conducted hazard analyses and risk assessments toward this goal.

Volpe conducted functional safety assessments of a generic ALC system and foundational vehicle systems that included a standard electric power steering system and an alternative, generic "steer-by-wire" system. Instead of conventional steering linkages, this system uses electric motors to turn the wheels, sensors to determine how much steering force to apply, and steering feel emulators to give the driver haptic feedback. Because the brake system may be incorporated into future ALC designs, Volpe also assessed the functional safety of a generic hydraulic braking system with anti-lock brakes, traction control, and electronic stability control.

Automated Lane Centering Controls

Item Definition:
System Scope and Definition
System Block Diagram

Vehicle Level Hazard Analysis
HAZOP | STPA Step 1

Vehicle Level Hazards

Risk Assessment
Automotive Safety Integrity Level (ASIL)

Vehicle Level Safety Goals with ASIL

Safety Analysis
Functional FMEA | STPA Step 2

Functional Safety Concept:
1. Fault detection & failure mitigation
2. Safe states
3. Driver warning & degradation strategy
4. Allocation to system elements

Functional Safety Requirements

Note: ISO 26262 does not recommend or endorse a particular method for hazard and safety analyses. Other comparable and valid hazard and safety analysis methods may be used at the discretion of the analyst/engineer.

HAZOP: Hazard and Operability study
FMEA: Failure Modes and Effects Analysis
STPA: System Theoretic Process Analysis
- **STPA** Step 1: Identify Unsafe Control Actions
- **STPA** Step 2: Identify Causal Factors

Source: U.S. DOT/Volpe Center

This diagram is derived from the automotive industry's functional safety standard ISO 26262 and illustrates the analysis process applied in Volpe's research.

The study used the automotive industry's functional safety standard ISO 26262 to perform risk assessments that accounted for the "driver engagement" assumption in the systems' design—whether or not the driver is constantly monitoring their environment and is able to immediately resume control of the vehicle if the system malfunctions, or unforeseen conditions occur on the roadway. In addition, the study addressed many of the safety challenges associated with ALC systems, such as ensuring driver engagement, consideration of fault-tolerant architectures, and the impact of automation on the design needs for foundational vehicle systems (e.g., steering and braking).

The functional safety assessment of the ALC system identified five hazards and assigned risk levels to each hazard based on the level of system automation. Other hazards were identified for the steering and braking systems. Many of the ALC safety challenges apply to a broader range of automated driving systems, and this study is an important first step in ensuring their safe deployment in the future.

Volpe has prepared four separate reports on the ALC, conventional steering, steer-by-wire, and braking systems, and a fifth report that synthesizes the findings from studying these systems. These reports are currently undergoing NHTSA review in advance of publication. (**Sponsored by NHTSA and ITS JPO**)

Volpe Experts Conduct Foundational Research on Low-Speed Automated Shuttles

Under the broad umbrella of innovation, automation is a key work area, and low-speed automated shuttles are an emerging model for which there are significant unanswered research questions and a limited existing body of knowledge. For example, do these vehicles have the potential to integrate into the larger transportation system? Will users feel comfortable traveling in vehicles without a driver? Where might low-capacity shared vehicles complement public transportation or fill gaps? Would they have a negative or positive impact on traffic congestion? Without better information,

the U.S. DOT cannot assess appropriate next steps or provide guidance to interested stakeholders. In support of the ITS JPO, the Volpe Center is conducting foundational research into this novel technology to better inform DOT's thinking.

To frame the state of the practice, the Volpe team has been tracking low-speed shuttle deployments, and has identified more than 160 demonstrations and pilots globally, with approximately 40 percent in the United States, 40 percent in Europe, 15 percent in Asia, and 5 percent in Oceania. The Volpe Center has interviewed researchers, manufacturers, local governments, transit providers, and other stakeholders; conducted site visits; and developed an analysis of potential use cases.

Volpe has also convened the Low-Speed Automated Shuttle Deployment Information-Sharing Working Group, comprising 15 organizations actively investigating, planning, or conducting a demonstration of shared low-speed automated vehicles in the United States. These deployers are spread across 12 states and include transit agencies, local governments, state transportation departments, and universities.

The ultimate goals of the Working Group are increasing the successful deployment of relevant projects, ensuring efficient use of funds, and improving awareness and consideration of universal design and accessibility. The Working Group endeavors to:

• Facilitate collaboration and sharing of knowledge, experience, and resources among group members and other stakeholders

• Identify and build consensus on shared challenges, lessons learned, and best practices

• Identify research and implementation needs and priorities

The Volpe team's research has already identified many technical and policy/institutional challenges—in particular, the need for further consideration of accessibility and universal design, and for a path toward compliance with Federal Motor Vehicle Safety Standards. This is a rapidly evolving market; there are still many questions as to how these vehicles can provide a useful service and what the business cases will look like with regard to costs, benefits, and demand. There may be a federal role in some of the research, but private companies and state/local governments are also researching many of these aspects.

The immediate next steps in this project are further analysis of the findings from searches, interviews, and the activities of the Working Group, and their publication in a state of the practice paper. **(Sponsored by ITS JPO)**

Pictured is the automated Optimus Ride Shuttle at HUBweek in Boston, MA. (Source: U.S. DOT/Volpe Center)

Transportation Planning and Management

The Volpe Center develops and advances transportation system management and planning initiatives to promote greater efficiencies and inform transportation decision making.

(Image: 123rf.com/madpixblue)

Highway and Transit

Advancing Performance-Based Planning

In recent years, transportation planners and operating agencies have turned to data-driven, performance-based approaches to inform decision making. FHWA and the Federal Transit Administration (FTA) are advancing the practice of performance management within transportation planning and programming nationwide. In response to a congressional request, FHWA and FTA partnered with the Volpe Center to develop a report outlining how current planning practices are evolving to performance-based approaches and how state DOTs and Metropolitan Planning Organizations (MPOs) across the country are adapting these approaches. The report meets congressional requirements established by MAP-21 and reauthorized by the FAST Act in 2015. This report can be used as a baseline to better understand broad implementation of performance management under FHWA and FTA programs in Transportation Performance Management, Transportation Asset Management, and Transit Safety.

Volpe Center planners collaborated with FHWA and FTA on developing an analytical approach to address the congressional requirements; collecting and analyzing data; and drafting the initial report to Congress. The data collection effort involved developing a database of performance-based elements from 52 state DOT Long-Range Transportation Plans and Statewide Transportation Improvement Programs, a sample of 50 Metropolitan Transportation Plans and Transportation Improvement Programs, and results from a nationwide survey by the Center for Urban Transportation Research. The Volpe Center is currently working with FHWA and FTA to finalize the report based on U.S. DOT review.

As performance-based approaches evolve, this report will give Congress and U.S. DOT insights into the benefits and challenges of incorporating these approaches into transportation plans and investment decisions, and how to improve these approaches to advance the state of the practice in transportation. **(Sponsored by FHWA and FTA)**

Estimating Transit Ridership

The goal of transportation performance management is to help governments and stakeholders make data-driven decisions about investing transportation funds across modes. While average annual daily traffic is a nationally available, segment-level measure for highway usage, there is currently no corresponding ridership data source for transit. This is a challenge for agencies using performance management to compare the per-person benefit of potential roadway investments.

The Volpe Center undertook an exploratory project to determine how General Transit Feed Specification (GTFS) public schedule data, the data format that underlies transit directions in popular apps like Google Maps™, could be used to estimate road-segment-level bus and light rail ridership. GTFS is nationally available via the U.S. DOT National Transit Map. Having a framework for estimating segment-level transit ridership and comparing it to road usage will enhance an agency's ability to weigh tradeoffs and identify potential synergies between transit and road investments based on total person benefit per segment.

This project used GTFS and other nationally available inputs, such as U.S. Census and region-level ridership data from the National Transit Database, to develop an estimation model. The goal was to transform the data so that transit frequency and ridership (either modeled or calculated from transit agency measurements) could be compared to highway usage data already available from U.S. DOT through FHWA's All Roads Network of Linear Referenced Data (ARNOLD) and the linked Highway Performance Monitoring System (HPMS).

To build the model estimation tool, Volpe transportation planners, geospatial specialists, and analysts sought input and guidance from the Office of the Assistant Secretary for Transportation Policy (OST-P) and other U.S. DOT partners (particularly FTA and the Bureau of Transportation Statistics (BTS)). The team obtained calibration data from transit agencies in order to develop the ridership model, and created tools for mapping the results onto a spatial road network. The overall predictive power (r-squared) of this project's model for estimating segment-level bus ridership was determined to be 0.695, close to the 0.7 standard for strong models.

The Volpe Center and OST-P released the final report describing the project, methods, and results in December 2017. Volpe is making project code and tools available as open source via the GitHub website. Transit agencies, DOT partners, and others, including the Volpe Center, will be able to use them to refine the model and/or make use of it in performance measure development. **(Sponsored by the Office of the Assistant Secretary for Transportation Policy)**

Transit agencies use ridership data to make critical decisions about investing limited transportation funds across modes. (Source: 123RF.com/ meinzahn)

How Much Time Do Americans Spend Behind the Wheel?

America's roads exist to move people and goods quickly and efficiently. Assessing how the nation's roads are performing in those most basic and critical functions requires FHWA to have reliable, comprehensive data.

Two of the most important measures for understanding road system performance are travel speed and travel time. A team of Volpe Center data experts recently completed an in-depth study for FHWA and produced detailed statistics on travel speeds and vehicle hours traveled (VHT)—that can provide new levels of insight into how the nation's roads are performing.

Across the country, American drivers spent more than 84 billion hours driving during 2015, according to this new data.

The data that the Volpe team used on travel speed and travel time come from two distinct sources that describe the roadway. But the segments they use to describe the roadway system do not match between the sources—they contain information on different, sometimes overlapping road sections. The Volpe team used geospatial methods to match the data from these two sources.

The Volpe team sliced up the resulting VHT estimates in several different ways: by state and class of roadway, year-over-year changes, and detailed VHT results for specific road sections. They examined the number of hours licensed drivers spend traveling each day across every state.

According to this new, comprehensive VHT data, American drivers spend just under an hour driving every day—very close to the .96 hours per day average reported in the 2009 National Household Travel Survey, and 1.1 hours per day reported in the American Time Use Survey.

Daily Auto Travel per Licensed Driver

Average Hours per Day in 2015

Source: U.S. DOT/Volpe Center
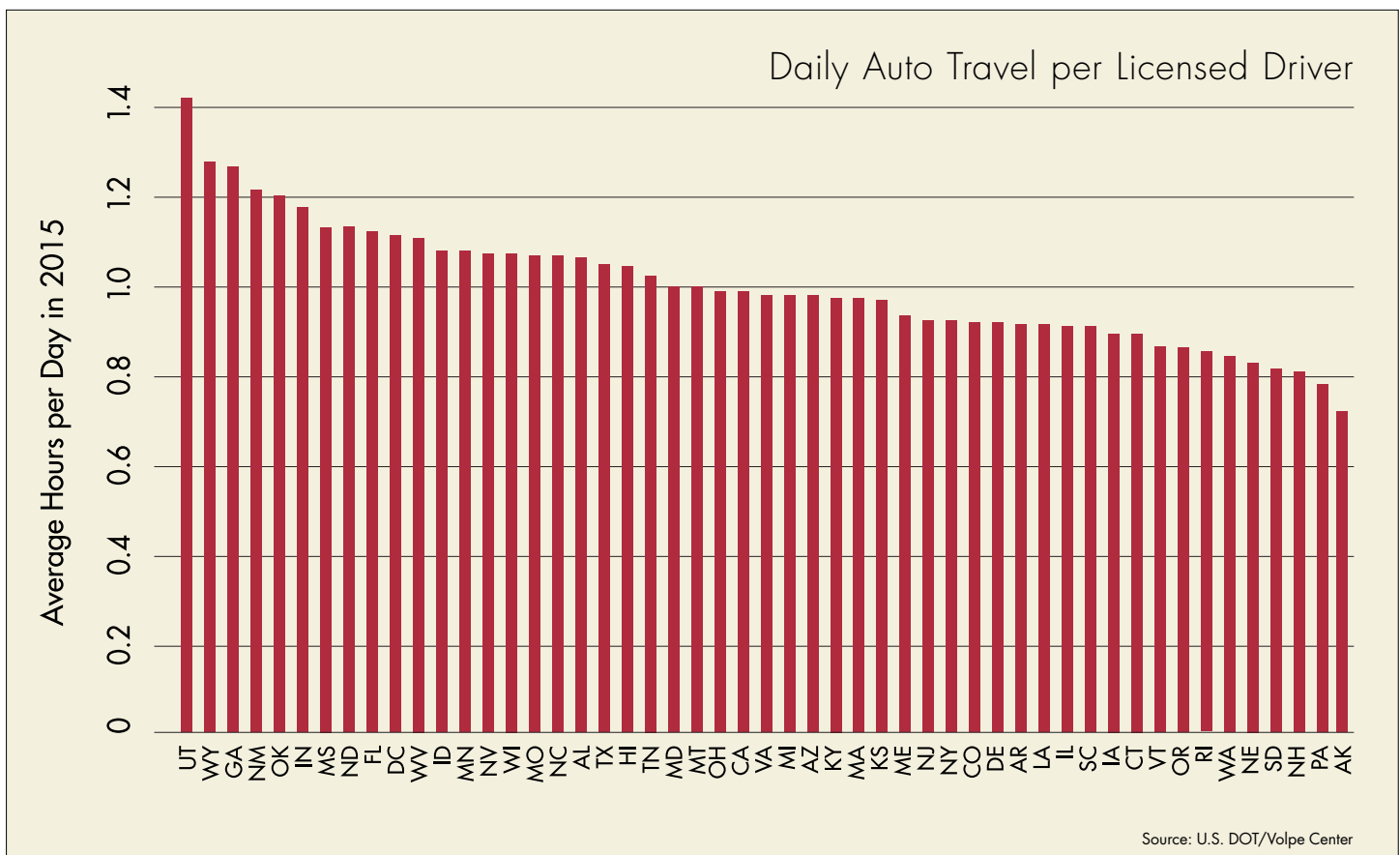
The new VHT data will provide the basis for transportation experts to develop reliable estimates of road travel delays for metropolitan areas and nationwide. Because the VHT estimates are constructed from detailed spatial and temporal data, transportation professionals will also be able to distinguish between normal rush-hour delays and delays caused by incidents, road construction projects, special events, or abnormal weather.

Finally, FHWA and Volpe are interested in how VHT data will shed light on the burden that road travel imposes on the time budgets of households and businesses. **(Sponsored by FHWA)**

In support of FHWA, the Volpe Center leads and performs evaluations in support of the Research and Technology Evaluation Program.

FHWA Research & Technology Evaluation Program

By applying a collaborative and strategic approach to conducting research, FHWA is getting innovative technologies into the hands of states, MPOs, and the private sector. The FHWA Research and Technology (R&T) Agenda addresses six of the nation's high-priority highway challenges:

1. Advancing safety toward zero deaths

2. Improving the mobility of people and goods

3. Maintaining infrastructure integrity

4. Enhancing system performance

5. Promoting environmental sustainability

6. Preparing for the future

Evaluation can improve technology transition by revealing the relationships among research, dissemination of research findings, the local decisions to adopt findings, and the benefits that accrue from adoption. The FHWA R&T Evaluation Program was initiated to guide further development of the R&T Agenda, and to identify and communicate its full range of benefits to the public. In its initial year, the program worked with 9 FHWA offices to identify 16 projects for evaluation across all program areas.

The Volpe Center provides FHWA with program management support on the program and leads and performs all evaluations. Previously, the Volpe Center scoped the evaluation process, which resulted in the identification of key performance metrics and development of a preliminary project timeline.

By the end of 2016, Volpe completed six evaluations. During FY2017, four more evaluation teams finished data collection and entered final publications review. The remaining six evaluation teams are at various stages of data collection. Three evaluations are expected to be completed over FY2018.

The FHWA R&T Evaluation Program seeks to answer these fundamental questions:

•   Are we doing the right kinds of research?

•   What portfolio mix best supports our strategic objectives?

•   What kinds and extent of risk should we take on?

•   Have the research results been deployed?

•   Is the research having the desired impact?

•   What is the public getting for the funds we spend?

Looking across individual project findings at the portfolio level has yielded some clear themes, enabling FHWA to apply the lessons learned to its research processes across programs and divisions. Cross-cutting recommendations include:

- Early in the project, perform market research to understand end-user and supplier needs and constraints; later, incorporate market and user considerations into communication strategies to increase market acceptance. An up-front understanding of technology requirements and barriers to adoption can lead to the development of appropriate, targeted strategies and activities, and will encourage more efficient use of program resources.

- FHWA should identify, support, and replicate successful programs and practices by maintaining stable funding and resources; funding and implementing programs on regular and frequent cycles; providing flexible funds to adapt to changing needs; and extending outreach to a wider, sometimes non-traditional audience. The benefits of these actions would enable end-users to plan their own programs and research accordingly, channel institutional knowledge of effective practices into program processes, and directly respond to customer and user feedback. **(Sponsored by FHWA)**

Rail

Amtrak Cost Validation Reports Track State-Supported Services with Precision

Amtrak's passenger operations are organized into distinct business lines: Northeast Corridor Services, Long-Distance Services, and State-Supported Services. In this last category, 21 state DOTs or independent rail authorities deliver passenger rail service on 29 routes nationwide. In FY2016, more than 14 million passengers used Amtrak's State-Supported Services, traveling nearly 2 billion total passenger miles.

To track the financial performance of these lines, the FRA Office of Railroad Policy and Development partnered with the Volpe Center to develop cost validation reports using Amtrak's financial systems. The monthly reports provide state partners with cost information they can use to understand and efficiently manage and plan for their services.

The Volpe Center worked with Amtrak and other key stakeholders to develop cost validation reports using Amtrak's financial systems. (Source: 123RF.com/vacclav)

Volpe Center staff provided critical technical expertise on Amtrak's financial reporting systems. In 2005, the Volpe Center team developed the Amtrak Performance Tracking cost accounting system used by Amtrak in its financial reporting. As a result of this long-term involvement in Amtrak's financial systems, the Volpe Center has a unique knowledge of its operations and reporting capabilities. With that knowledge, Volpe experts developed the prototype for each report and also wrote the database code needed to deploy each report within Amtrak's SQL database.

The Volpe Center team worked directly with Amtrak and the State-Amtrak Intercity Passenger Rail Committee (SAIPRC), which is composed of a coalition of state DOTs or rail authorities, Amtrak, and FRA, to develop the reports. Eighteen reports have been completed and produced for states on a monthly basis. The remaining reports are in development by Amtrak and the Volpe Center in consultation with SAIPRC.

The new cost validation reports enhance the reporting of financial information to states by Amtrak—helping those states manage their passenger rail services with greater precision. The reports facilitate the flow of Amtrak data to state agencies, giving them the information they need to make data-driven decisions and ultimately strengthening the relationship between Amtrak and its partners. **(Sponsored by FRA)**

Motor Carriers

Consent Agreement Tool Streamlines Improvement Process for Unsafe Motor Carriers

Motor carriers that fail to meet safety performance requirements identified by FMCSA may be given the chance to improve their performance by entering into a consent agreement. A consent agreement is a legal contract with FMCSA that specifies what actions a motor carrier must take to comply with safety regulations, and usually requires the carrier to submit regular reports on its operations that are reviewed by FMCSA enforcement staff. The current process for writing consent agreements and monitoring carrier compliance is largely manual and time consuming for enforcement staff.

FMCSA and the Volpe Center developed an automated tool to streamline the consent agreement process. The new tool is a module in the Activity Center for Enforcement (ACE), a web center that enforcement staff use to manage their day-to-day work. The module includes two parts: a

Below: Screenshot of the consent agreement generator tool. The tool walks users through the process of creating a consent agreement. (Source: FMCSA)

generator tool and a monitoring tool. The generator tool walks enforcement staff through creating a new agreement, and then produces a Microsoft Word document based on a standard template for legal review. The monitoring tool lets motor carriers upload documents electronically, or via fax or mail, and allows enforcement staff to review documents in a centralized place. The tool also alerts enforcement users to upcoming or missed reporting deadlines, resulting in a more efficient monitoring process.

Volpe Center IT staff provided the technical expertise to research, develop, and test the new consent agreement module. IT staff developed the module based on input from enforcement users and an FMCSA consent agreement working group. Volpe communications staff then developed a strategy to support the phased rollout to states testing the new module. The module was first tested in the Massachusetts Division, and then in a select number of states before national rollout.

Volpe Education, Learning, and Training staff trained FMCSA enforcement personnel on how to use the new module through a combination of on-site and remote learning techniques. These included a series of videos, webinars, and job aids aimed at raising awareness of the new automated process, and delivering the technical skills needed to use the new module.

The automated consent agreement module was rolled out in fall 2017. The new tool streamlines the consent agreement process, saving enforcement staff time, and improving motor carrier safety. **(Sponsored by FMCSA)**

Improving FMCSA Safety System Infrastructure for the Public Good

Efficient infrastructure is essential to ensuring the public can continue to access and rely on information systems. Recognizing this need, FMCSA, supported by the Volpe Center, improved the infrastructure of its motor carrier safety systems by transitioning to the Amazon Cloud. This transition will help FMCSA carry out its safety mandates and educational outreach to the public; commercial drivers; federal; state; and local enforcement agencies; the motor carrier safety industry; and safety groups to reduce bus and truck-related crashes. The public will be able to access information using the Cloud to keep informed about out-of-service orders and safety ratings for specific truck and passenger carriers.

This effort was part of the Data Center Optimization Initiative (DCOI), which aims to provision quality services for the public good. The DCOI was established as part of the Office of Management and Budget (OMB) Memorandum M-16-19.

The Volpe Center played a critical role in ensuring a successful transition to the Amazon Cloud. Volpe engineers and analysts offered information system expertise and advisory support to move from an on-site system to the Amazon Cloud. Volpe engineers prepared for the move on-site, but the final phase was performed off-site using private internet feeds. These feeds gave Volpe personnel direct access to the Cloud and enabled them to reduce data upload time during the transition. Volpe Center analysts also shared detailed documentation on the accessibility and configuration of the Cloud to provide a solid framework from which to manage this new environment moving forward.

Documentation and lessons learned from this move will be instrumental in supporting the trucking industry as it continues to grow. According to the American Trucking Associations, overall freight tonnage will increase by 35 percent between 2016 and 2027. FMCSA will continue to enhance its safety systems to support this growth. This transition also decreased the agency's power consumption by more than 95 percent, meeting the energy usage requirements in the Electronic Production Environmental Assessment Tool.

Giving the public, commercial users, and enforcement agencies better, more reliable access to the motor carrier safety systems will lead to more data-driven decisions. This will ultimately help to reduce crashes, injuries, and fatalities related to large trucks and buses on the nation's roads. **(Sponsored by FMCSA)**
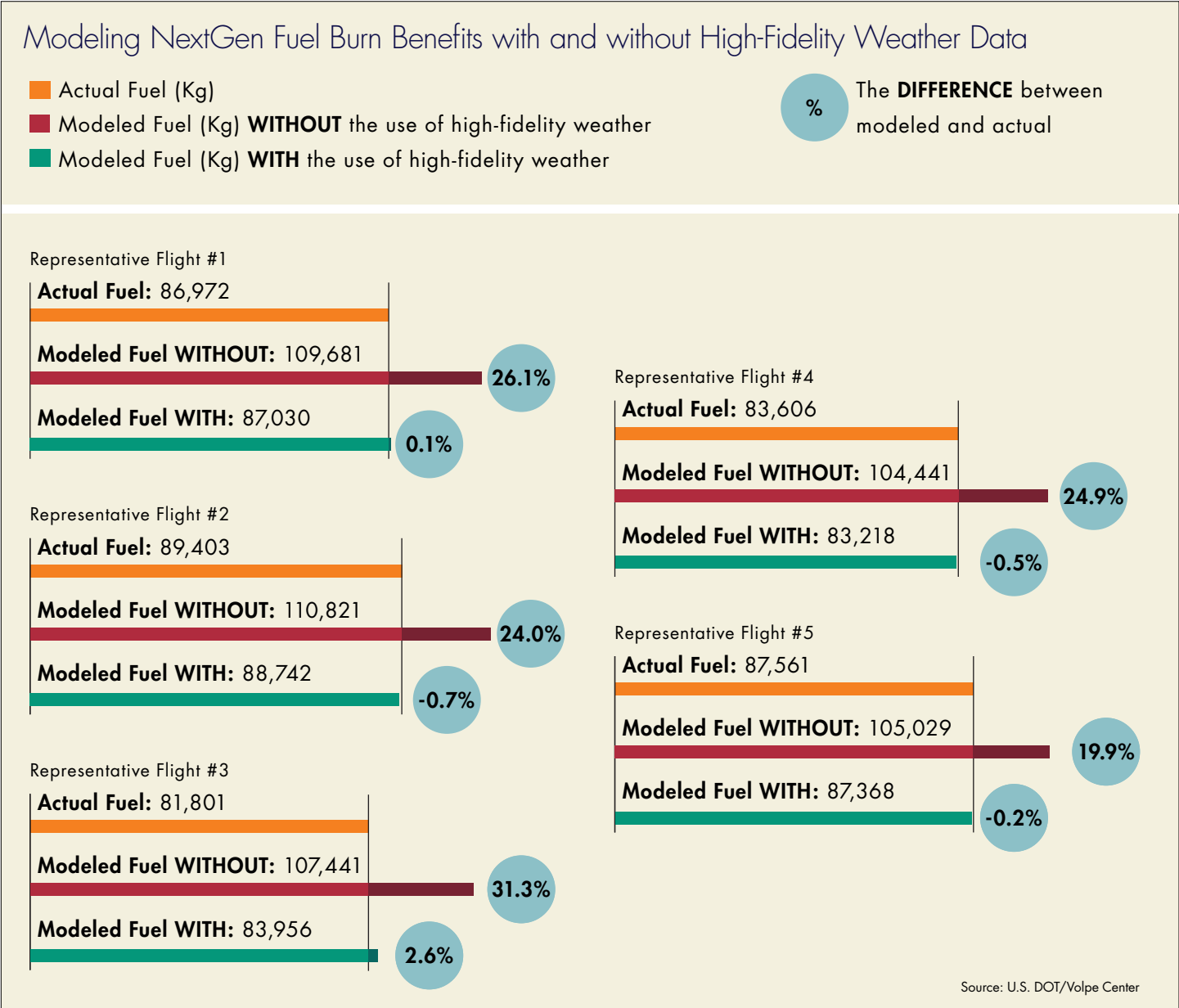
Aviation

Optimizing Performance-Based Navigation Planning

With U.S. air traffic expected to grow, airports, air traffic controllers, and airlines will need to continue to increase operational efficiency. One way to do this is by optimizing the paths that aircraft fly.

Performance-based navigation (PBN) is advanced air navigation that uses satellite data to create 3D flight paths. Relying on satellite positioning allows aircraft avionics to navigate a flight path more

Modeling NextGen Fuel Burn Benefits with and without High-Fidelity Weather Data

- Actual Fuel (Kg)
- Modeled Fuel (Kg) **WITHOUT** the use of high-fidelity weather
- Modeled Fuel (Kg) **WITH** the use of high-fidelity weather

% The **DIFFERENCE** between modeled and actual

Representative Flight #1
Actual Fuel: 86,972
Modeled Fuel WITHOUT: 109,681 — 26.1%
Modeled Fuel WITH: 87,030 — 0.1%

Representative Flight #2
Actual Fuel: 89,403
Modeled Fuel WITHOUT: 110,821 — 24.0%
Modeled Fuel WITH: 88,742 — -0.7%

Representative Flight #3
Actual Fuel: 81,801
Modeled Fuel WITHOUT: 107,441 — 31.3%
Modeled Fuel WITH: 83,956 — 2.6%

Representative Flight #4
Actual Fuel: 83,606
Modeled Fuel WITHOUT: 104,441 — 24.9%
Modeled Fuel WITH: 83,218 — -0.5%

Representative Flight #5
Actual Fuel: 87,561
Modeled Fuel WITHOUT: 105,029 — 19.9%
Modeled Fuel WITH: 87,368 — -0.2%

Source: U.S. DOT/Volpe Center

precisely and accurately than legacy navigational systems. With PBN, flights use less fuel, emit fewer pollutants, and save time in the air.

There are already more than 9,000 PBN procedures and routes in the national airspace. Volpe developed the FAA's Aviation Environmental Design Tool (AEDT) to help the NextGen program office determine the efficiency of new PBN procedures, using fuel consumption as the primary metric for quantifying efficiency improvements.

Volpe modeling experts incorporated high-fidelity aircraft performance data (from EUROCONTROL) and weather data (from NASA) into this tool. Because AEDT draws on high-quality data, the difference between modeled and actual fuel consumption is much smaller compared to previous modeling tools. This means FAA staff can be sure that outputs from the tool will closely match real-life outcomes, and they can confidently make PBN policy decisions.

Before Volpe developed this optimized AEDT tool, differences between modeled and actual fuel consumption were on the order of 25 percent. Now, the average difference can be as low as 1 percent, though the actual differences will be a function of the input data quality. The tables on the previous page show these differences before and after adding high-fidelity weather data for five actual flights departing from a major U.S. airport. **(Sponsored by FAA)**

Authorizing Drone Operations in the National Airspace System

The technology for small UAS, also known as drones, has proliferated over the past decade. Drones are used for aerial photography, geographic mapping of farmland, and for surveying terrain that is difficult or too expensive to reach by conventional means. Drones are also used to evaluate the integrity of buildings and infrastructure, either during construction, as part of routine maintenance, or after a natural disaster. The range of possible uses has grown extensively as UAS technology has become an attractive investment target for both the public and private sectors.

Safety issues regarding UAS have become a concern for the U.S. military, especially when the intended operation of drones is within the controlled NAS, in which conventional military aircraft operate. In 2016, FAA added a new Part 107 to Title 14 Code of Federal Regulations (14 CFR) to address these concerns. The new rule allows for routine civil operation of UAS in the NAS and stipulates safety rules for drone operations.

Drones are used for aerial photography, geographic mapping of farmland, and surveying of terrain that is too difficult to reach by foot or vehicle. (Source: Jay Cox)

The rule addresses airspace restrictions, remote pilot certification, visual observer requirements, and operational limits in order to maintain the safety of the NAS and ensure national security is not threatened. It also provides the procedure by which an application for a proposed UAS operating area and time period can be reviewed and either approved or denied. After a comprehensive operational and technical review of an application, a Certificate of Authorization (COA) may be issued by FAA. If necessary, provisions or limitations may be imposed as part of the approval to ensure the drone can operate safely in the airspace.

When Part 107 first went into effect, the Volpe Center supported the FAA over an 8-month period, processing applications and preparing hundreds of COA approval letters on the FAA's behalf. The Volpe Center team provided application and airspace analysis support, enabling the FAA to process a greater volume of COA applications during this initial period of high user demand. The Volpe Center team worked with stakeholders and the air traffic control facility or military facility governing the controlled airspace, to clarify both requests and operational constraints as needed.

A major challenge for this project was to meet FAA's goal of processing every request within 90 days, and the Volpe Center met it. Once a processing system was established and the team was in place, Volpe staff helped FAA maintain an approximately 40-day turnaround for requests.

By enabling FAA to allow commercial operators to fly drones in controlled airspace within specific areas and altitude limits, Volpe's work promoted commerce by enabling large areas to be surveyed or documented without the use of surface vehicles or larger, manned aircraft. **(Sponsored by FAA UAS Integration Office (AFS-80))**

Federal Lands Management

Updating the Alaska Federal Lands Long-Range Transportation Plan

Over the past several years, federal lands management agencies developed their first regional long-range transportation plans (LRTPs). These LRTPs are policy-level plans that help agencies navigate transportation funding and management decisions over the next 20 years, similar to LRTPs developed by state DOTs and MPOs. LRTPs require periodic updates to reflect current conditions. Currently, the Volpe Center is supporting a multiagency effort to develop the first LRTP update for federal lands in Alaska.

The update to the Alaska Federal Lands Collaborative LRTP will be the first such update for a federal lands management agency. The original Alaska Federal Lands LRTP, completed in 2012, was a pioneering effort to develop the first multiagency LRTP for federal lands. It was a collaborative endeavor between six agencies, including the Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, and the Alaska Department of Transportation and Public Facilities, and was led by the FHWA Western Federal Lands Highway Division.

FHWA is managing the multiagency update with the Volpe Center supporting the effort by researching existing conditions, advancing performance management, and conducting financial analyses of available funds, needs, and gaps based on available data from each agency. The Volpe Center will also develop the updated content for publication.

The update will reflect new requirements and funding opportunities established in the 2015 FAST Act, as well as other national guidance for federal lands management agencies. It will incorporate updated data, report on accomplishments since the 2012 plan, and build on the team's progress to

develop performance measures and monitoring systems. The Alaska Federal Lands LRTP update is expected to be complete by December 2018.

In addition, as part of the update, the multiagency team will document their process to provide a template for other federal lands management agencies to follow when updating their LRTPs. **(Sponsored by FHWA)**

International Partnerships

Investing in Transportation to Support Economic Development

Transportation is an integral part of economic growth in developing countries. Ensuring that people have access to well-maintained multimodal networks, enabling them to reach markets, jobs, and services, is key to improving economic well-being.

Since 2015, the Volpe Center has supported the Millennium Challenge Corporation (MCC), an innovative, independent U.S. foreign aid agency, to research and advise on transportation opportunities across several countries where MCC is developing and implementing investment strategies.

After conducting analyses to help identify investment options in Liberia, the Volpe Center is supporting implementation of MCC investment decisions in that country. In 2017, Volpe made nine trips to Liberia to help develop road management and maintenance projects. The Volpe team completed a comprehensive count and analysis of traffic on Liberia's primary road network, and trained government staff to conduct similar work in the future. As a result, MCC provided Liberia with a comprehensive set of traffic data that will be an important part of planning efforts and road investment decisions moving forward.

During 2017, Volpe Center experts continued to support MCC in Côte d'Ivoire, building on previous work by providing transport expertise to help assess proposed infrastructure projects in and around the major port city of Abidjan. Volpe worked with MCC to refine and reduce risks of proposed projects through discussions with key stakeholders. Volpe also completed a white

Volpe Center staff member Hannah Rakoff (fifth from left) with the MCC Côte d'Ivoire team conducting a site visit at the Port of Abidjan.

(Source: MCC)

Volpe Center transportation planning expert William Lyons (left) and an MCC project team perform a traffic intersection assessment in Colombo, Sri Lanka. (Source: U.S. DOT/Volpe Center)

paper detailing key transport sector activities of other international donors that are helping MCC coordinate and position its investments to achieve maximum positive impacts. Finally, Volpe shared a long-range transportation planning framework with the government of Côte d'Ivoire based on international best practices. This resulted in recommendations to MCC on institutional capacity building and improved coordination of transport services to ensure the sustainability of its investments.

The Volpe Center has also supported MCC activities in Nepal to assess opportunities related to cross-border trade and transport facilitation. Volpe developed an analysis based on discussions with government agencies, local stakeholders, donor agencies, and a variety of data sets, including those on wait-times associated with the transport of goods to and from seaports through Nepal's land ports of entry. Volpe partnered with other agencies to support U.S. DOT's Office of the Secretary to organize a workshop on regional connectivity and cross-border trade, with U.S. State Department financial support in collaboration with MCC. The workshop was held in Kathmandu in June 2017 and included senior government representatives from across Southeast Asia. Volpe supported the development of the workshop content; staff traveled to Nepal to help facilitate it.

Volpe is expanding the range of expertise it is providing to MCC, assessing opportunities for institutional and policy reform and the human and environmental implications of a broad range of multimodal projects in diverse national contexts. Volpe has started to evaluate MCC investment opportunities in the Philippines, including a nautical highway with roll on-roll off ferries. The Volpe Center is also working in Sri Lanka, where staff assisted with extensive analysis of investment opportunities and project concepts, including how proposed urban multimodal projects, including an advanced traffic management center and modernization of the bus system, can strengthen the national economy. Volpe experts are working with MCC economic and social inclusion teams and field staff in both countries to analyze the benefits and costs of the proposed projects.

Looking ahead, the Volpe Center will continue to broaden and enhance its support to MCC by providing expertise to strengthen MCC's transport practice in transportation planning technical assistance, regional connectivity, multimodalism, and the effects of proposed projects on the built and natural environments. **(Sponsored by MCC/OST)**

Energy and Environment

The Volpe Center collaborates with the U.S. DOT and other agencies to address the nation's most pressing transportation-related energy and environmental challenges.

New Fuel Standards for Passenger Vehicles and Light Trucks Could Reduce Petroleum Consumption in the U.S.

The Energy Policy and Conservation Act requires the U.S. Secretary of Transportation to set Corporate Average Fuel Economy (CAFE) standards at maximum levels feasible, taking into account potential safety impacts and balancing factors including technological practicality, economic viability, and energy conservation. The Volpe Center's Fuel Economy Research and Analysis project provides much of the analytical foundation for establishing new CAFE standards for passenger vehicles and light trucks produced for sale in the U.S. During 2017 and 2018, the U.S. DOT will set new fuel standards for model years through 2025; the analysis produced under this project will help inform those standards.

The Volpe Center developed a significantly updated version of the CAFE model to analyze fuel efficiency standards. Volpe staff created a detailed characterization of current vehicle production by working closely with individual automobile manufacturers whose vehicles make up the new vehicle fleet. Volpe experts and NHTSA then worked collaboratively with Argonne National Laboratory in using Argonne's "Autonomie" full vehicle simulation system, which is widely used by industry, academic, and government researchers to estimate vehicular fuel consumption. Together, they developed a large-scale database of fuel consumption estimates for more than 100,000 combinations of specific fuel-saving technologies. This effort provided essential input to the Volpe Center's CAFE model.

Designing, maintaining, and applying the CAFE modeling system, Volpe analysts helped develop and identify model inputs. Volpe then used the CAFE model to analyze potential regulatory alternatives, and participated in developing the rulemaking package (i.e., preamble and regulatory impact analysis).

A typical new passenger car uses about 500 gallons of fuel per year, and the average new light truck about 700 gallons. Although U.S. Department of Energy forecasts suggest fuel prices may grow slowly in coming years, new car buyers who anticipate low fuel prices and purchase less efficient vehicles are vulnerable to sudden price increases. In addition, the average price of a new vehicle sold in the U.S. is nearly $35,000. Future consumers could be less willing to absorb price increases for new fuel-saving technologies in a cheaper energy environment, where a decade of efficiency

improvements have already reduced fuel consumption and eroded the value of fuel economy improvements.

Analyses published by U.S. DOT in 2016 suggest that new standards, if set at levels provisionally announced in 2012, could reduce petroleum consumption on the order of 3 billion barrels, at a cost of approximately $200 billion. Volpe's work in this area updates these estimates and evaluates a wider range of alternative new fuel efficiency standards. **(Sponsored by NHTSA)**
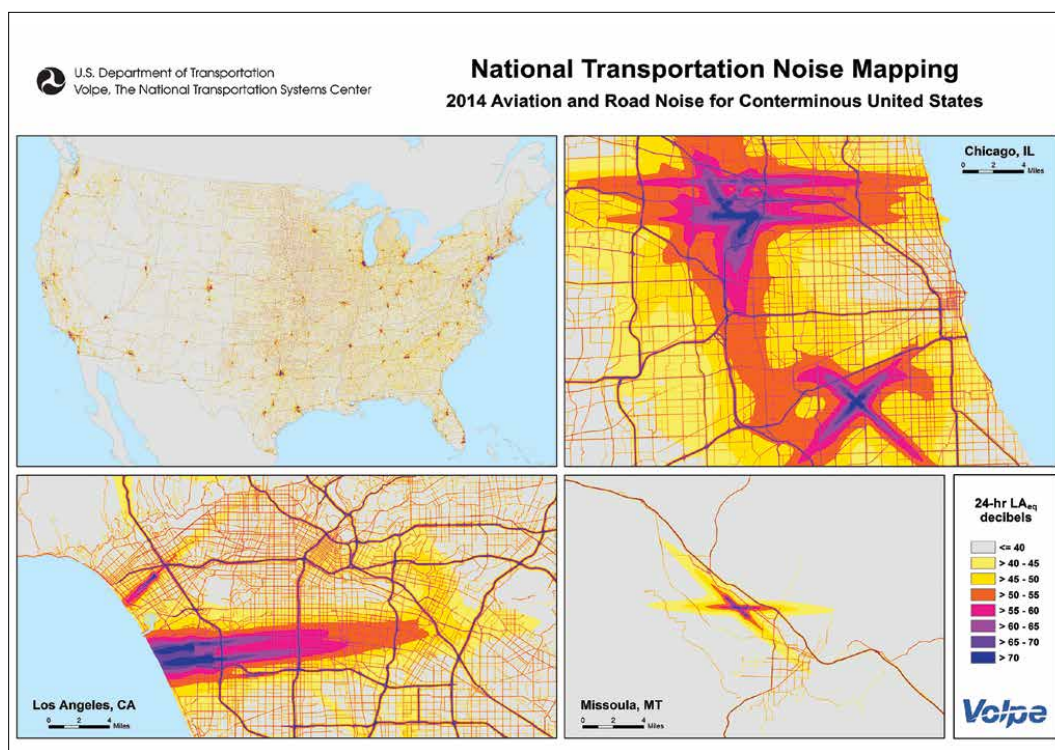
Creating a National Transportation Noise Map

Whether in urban, suburban, or rural environments, many Americans are impacted by noise levels from different kinds of traffic—from motor vehicles on our roads, ships maneuvering waterways, trains passing through rail corridors, or planes in the sky.

With the U.S. population expected to grow by more than 100 million by 2050, heightened transportation demands may increase the burden of high noise levels across the U.S.

On March 15, 2017, President Donald Trump, U.S. Secretary of Transportation Elaine L. Chao, and EPA Administrator Scott Pruitt held a roundtable with auto industry executives, announcing plans to re-open the process to establish new fuel economy standards through 2025. (Source: U.S. EPA)

Aviation and highway noise for 2014 for the nation, Chicago, Los Angeles, and Missoula, Montana. The highest noise levels are in blue; the lowest noise levels are in gray.

(Source: U.S. DOT/Volpe Center)

To better understand transportation sound levels, using simplified noise modeling, Volpe Center acousticians and geographic information systems (GIS) experts developed a process to create annual national transportation noise layers. National noise layers for the year 2014 were released in March 2017.

This national, multimodal, transportation-focused, modeled noise dataset—known as the National Transportation Noise Mapping Tool (NTNMT)—is currently provided as GIS services that allow users to view airplane and road noise separately, or view the cumulative noise for the modes.

Noise maps can help inform decisions to invest in highway noise barriers, airport sound insulation programs, and quiet vehicle technologies. Land use decisions can also be tailored to take noise levels into consideration.

Upon subsequent releases, planners and environmental researchers will be able to compare noise levels across years, to track increases or decreases in transportation noise. The yearly trends in noise levels that NTNMT can provide will be particularly useful to policy makers and community planners in understanding the effect of decision making and the relationship between different transportation modes.

NTNMT may also be used to demonstrate the impacts of large-scale noise mitigation efforts, as well as provide a true multimodal context to the public.

To create this tool, a Volpe Center team used many data sources from FAA and FHWA. Using FAA's Aviation Environmental Design Tool and conservative assumptions, the Volpe team modeled flights representing the average annual day from airports across the country. To model road noise, a simplified version of FHWA's Traffic Noise Model was used in conjunction with data from the Highway Performance Monitoring System to obtain the average annual daily traffic values for automobiles and medium and heavy trucks. The modeled aviation and road data are provided as GIS services that can be viewed online or in a GIS program.

As the NTNMT moves into future phases, the Volpe team hopes to include noise data from additional transportation modes, including rail and maritime.

The GIS services can be accessed from within the Data section of BTS's Geospatial Portal at https://www.bts.gov/maps/.

This project supports U.S. DOT's innovation strategic objective by strengthening coordination and promoting efficiency across modes. This project provides the potential to use the noise level map to highlight areas for noise research and to make multimodal investment decisions to mitigate the effects of transportation-related noise. **(Sponsored by BTS)**

Emissions Calculators Support the Congestion Mitigation and Air Quality Improvement Program

The Congestion Mitigation and Air Quality Improvement (CMAQ) Program provides funding for transportation projects that improve air quality and reduce congestion, such as diesel engine retrofits, intersection improvements, and transit services. Since 1990, CMAQ has provided more than $33 billion in funding for over 38,000 transportation projects. One fundamental funding criterion for CMAQ is the project sponsor must demonstrate that the transportation project reduces emissions of criteria pollutants. Emission reduction estimates are required for the CMAQ annual reports and the CMAQ emission reductions performance measure.

Over the years, some states have developed their own methodologies or hired contractors to conduct the emissions analysis, while others have depended on simpler, in-house estimation practices.
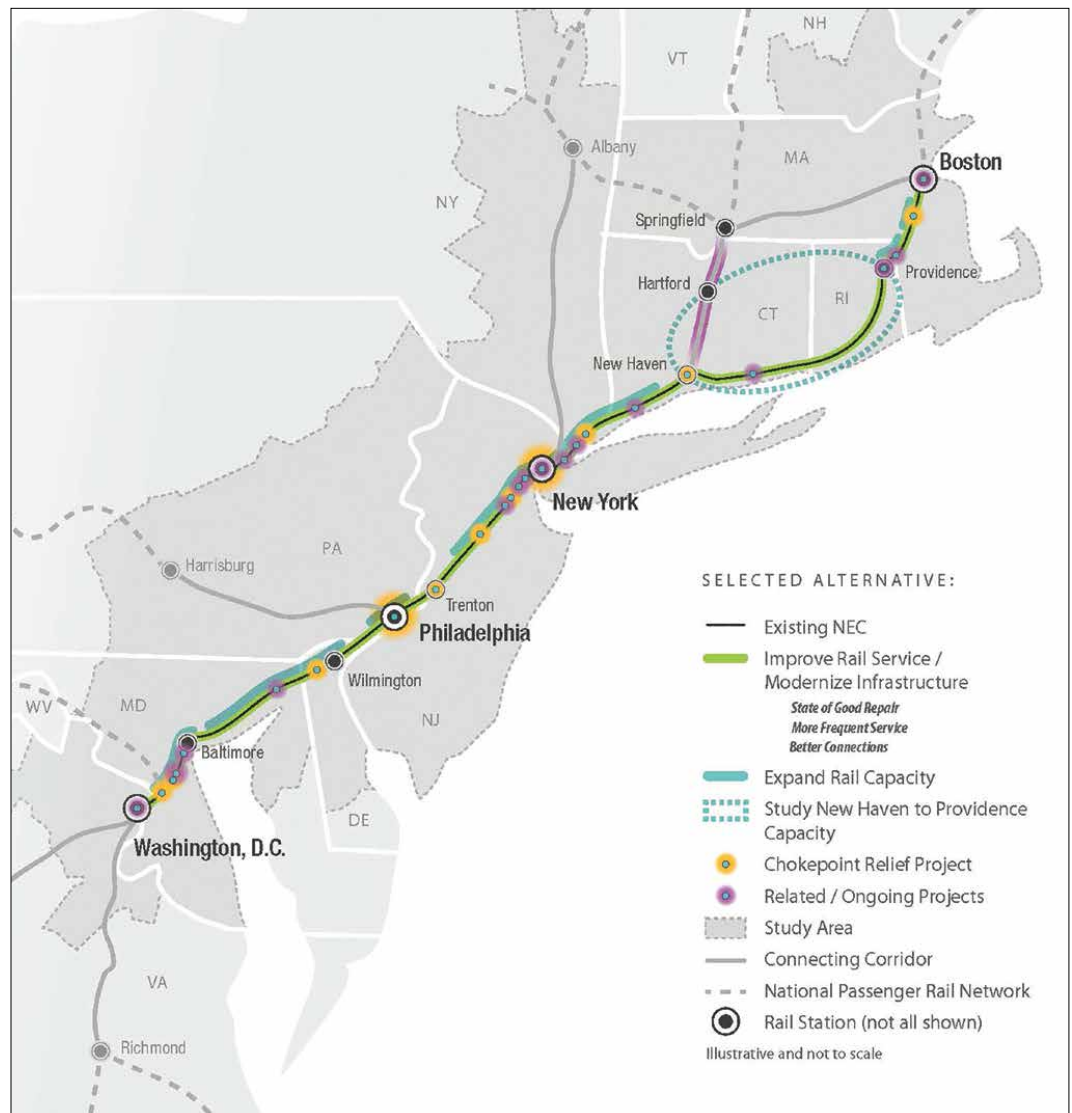
In response to transportation stakeholders' request for assistance in estimating emissions benefits of CMAQ-funded projects, FHWA partnered with the Volpe Center to develop a series of emissions calculators. The CMAQ Emissions Calculator Toolkit spreadsheets help state and local project sponsors meet the reporting and performance management requirements of the CMAQ program, and easily estimate emissions benefits of projects. The toolkit also establishes consistent data inputs and methodologies across projects, ensuring that FHWA receives comparable information for similar projects across the U.S. To date, Volpe and FHWA have developed and released tools that calculate the emissions benefits from traffic signal synchronization, intersection improvements, roundabouts, carpooling, vanpooling, diesel retrofits, and infrastructure supporting alternative fuels.

The Volpe Center has supported FHWA in all aspects of developing the tools, beginning with identifying types of transportation projects suitable for scenario development. For each tool, Volpe staff conducted literature reviews to identify available methodologies, relevant data, and gaps in information that require additional analysis. Volpe air quality specialists refined the methodology to develop simplified tools using national emissions rates. Volpe experts then developed spreadsheet-based tools and accompanying user documentation with a question and answer format that is easily understood by the user. Each tool is reviewed and beta-tested by other federal, state, and local agencies such as the U.S. Environmental Protection Agency (EPA), FTA, and MPOs.

Once completed, the calculators were posted on FHWA's website for public download. Volpe has worked to raise awareness about the CMAQ toolkit through presentations at transportation conferences, including the Transportation Research Board Annual Meeting and the Association of Metropolitan Planning Organizations Annual Conference.

The CMAQ Emissions Calculator Toolkit saves individual agencies time and money by eliminating the need to develop custom tools or hire contractors. Volpe staff are currently working on tools that will calculate emissions benefits for additional project types, including transit bus retrofits and replacements, transit bus service expansion, truck idling reduction, and bicycle and pedestrian access. **(Sponsored by FHWA)**

SELECTED ALTERNATIVE:

— Existing NEC

— Improve Rail Service / Modernize Infrastructure
   State of Good Repair
   More Frequent Service
   Better Connections

— Expand Rail Capacity

⋯ Study New Haven to Providence Capacity

● Chokepoint Relief Project

● Related / Ongoing Projects

▦ Study Area

— Connecting Corridor

- - - National Passenger Rail Network

◉ Rail Station (not all shown)

Illustrative and not to scale

Applying Multidisciplinary Expertise to the NEC FUTURE Planning Effort

NEC FUTURE is FRA's comprehensive plan for the Northeast Corridor (NEC). The NEC is an economically vital 457-mile rail line from Washington, D.C. to Boston, which transports 750,000 passengers daily. The purpose of NEC FUTURE is to upgrade aging infrastructure and to improve the reliability, capacity, connectivity, performance, and resiliency of future passenger rail service on the corridor for both intercity and regional trips, while promoting environmental sustainability and continued economic growth.

Because of NEC FUTURE's complexity, FRA has relied on the Volpe Center for extensive technical expertise including contract oversight and technical guidance on the environmental evaluations and other work required for the Tier 1 Environmental Impact Statement (EIS). Volpe Center staff have served in the roles of FRA Deputy Program Manager, Environmental Lead, and Ridership Lead in support of the program. The Volpe team spans multiple disciplines, including project management, EIS preparation, noise analysis, air quality, the built environment, travel demand forecasting, and service and operational planning. In addition, Volpe Center staff were involved in the development and execution of a new ridership model for the NEC.

Engaging Stakeholders in the NEC FUTURE Process

Throughout the NEPA process, the FRA, with support from the Volpe Center, worked closely with stakeholders and the public, including eight states and the District of Columbia, railroad operators, federally recognized Indian tribes, federal and state agencies, regional planning organizations, and communities along the NEC. The FRA invited the FTA to be a cooperating agency because of its likely involvement as a funding source for future projects and for its expertise related to commuter rail operations along the NEC.

The FRA released the Record of Decision on July 12, 2017, concluding the Tier 1 NEPA process. The Volpe Center was a significant partner in reaching this milestone. In making its decision, FRA considered the information and analysis detailed in the Tier 1 Draft and Final EIS, public and stakeholder comments, and U.S. DOT and FRA policy objectives. The selected improvement program will substantially grow the role of rail in the NEC and across the Northeast, helping provide the transportation services necessary to maintain a vibrant and competitive economy in the region.

FRA has committed to ongoing collaboration with stakeholders for implementation of NEC FUTURE. The Volpe Center will continue to support FRA in NEC FUTURE's next step, creating the Service Development Plan, a planning process used by the FRA to understand phased implementation of proposed improvements. **(Sponsored by FRA)**

Thought Leadership

The Volpe Center convenes government leaders, prominent academics, and forward-thinking industry and non-profit leaders to anticipate future transportation issues, consider fresh approaches to emerging issues, and inform decision making.

Welcoming U.S. Transportation Secretary Elaine L. Chao to the Volpe Center

Continuing her long history with the U.S. Department of Transportation's Volpe Center, U.S. Secretary of Transportation Elaine L. Chao returned April 21, 2017, to learn how the Volpe Center provides innovative multimodal expertise for partners at U.S. DOT, other government agencies, and the private sector.

Secretary Chao first visited Volpe as Deputy Secretary of Transportation in 1990 when the center was renamed for John A. Volpe, the former Massachusetts governor and second Transportation Secretary.

During her visit in April, Secretary Chao toured Volpe's car, rail, and airplane simulators, global maritime domain awareness center, and air traffic management center. She also learned about Volpe's support for automated technologies, and shared her vision for the nation's transportation future.

"I want to challenge all of our U.S. DOT centers of excellence to be kind, compassionate, humane, and take time to address and explain what they're doing. We must make the effort to address concerns so many of our residents and citizens feel about the accelerated rate of changing technology."

"When I was here 30 years ago, we were trying lots of ways to engage people on what to do when they come to a railroad crossing. We did campaigns to educate the public, supported better signage at crossings—but it wasn't working. At Volpe today, what I'm seeing is we are finding out how to be even better at improving safety across modes, and how the human component interacts with new automated technologies."

"The Volpe Center is special. I'm here now as Secretary of Transportation to say that the Volpe Center is indeed one of the Department's crown jewels. The Volpe Center team— all of you—exemplify the pursuit of excellence and also the pursuit of the future."

"What is so impressive to me and my colleagues is how much you love what you are doing. It is so wonderful to see the passion you display and how much you care about your work."

The Ongoing Transformation of the Global Transportation System

Automation, artificial intelligence, robotics, sensing technology, and computing will transform the future of travel and commerce. Technological advances continue to change the national and global transportation landscape at an unprecedented pace.

As the private sector drives innovation across all modes, there is potential for dramatic impacts on the safety and efficiency of the future transportation system and the composition of the nation's transportation workforce.

The U.S. DOT Volpe Center's 2017 speaker series—*The Ongoing Transformation of the Global Transportation System*—explored challenges and opportunities affecting the advancement of transportation systems. Read on for insights from seven distinguished experts convened from academia, government, and the private sector— and visit **https://www.volpe.dot.gov/events/transforming-transportation** for news articles and video highlights.

"Autonomy for humans for me means a human-centric vision of what cities might be, not an automobile-centric one. I think that's what this revolution in transportation is all about."

Jeffrey Schnapp, Founder and Director, metaLAB at Harvard University

"I know that often, particularly in human factors or cognitive engineering domains, we've accepted the architecture and then we've quibbled over the interface, the training, and the procedures. What I'd like to do is say, 'Is this the right overall structure?'"

Amy Pritchett, PhD, Professor and Head, Department of Aerospace Engineering, Pennsylvania State University

"We've seen a pretty dramatic increase in the number of crashes on our roads and highways, and in the number of fatalities. We can't ever forget that this is a tremendous cost that we as a society pay every day for our ability to get around. But we have the opportunity to change all that."

Harry M. Lightsey III, Executive Director of Emerging Technologies Policy, Global Public Policy, General Motors

"We have this tremendous infrastructure in the United States of over 5,200 public use airports, on average one within a half-hour drive of wherever you are in the country. Most people don't even know that they exist."

Carl Dietrich, PhD, Co-founder and Chief Technology Officer, Terrafugia

"We measure use of the nation's highway system in excruciating detail, but we know much less about how the system is performing. And so this project was an effort to develop a comprehensive measure of how well the U.S. highway system is performing."

Don Pickrell, PhD, Chief Economist, Volpe Center

"Here's the test to know whether you've done your job in transportation for an aging society: Can you get an ice cream cone when you want it? Not can I go to the doctor. Not can I go to the grocery store. You will get those trips. Quality of life is based not on what you need, but that moment on a hot July night when you say, 'I want a soft serve ice cream. Can I go get it?'"

Joseph Coughlin, PhD, Founder and Director, Massachusetts Institute of Technology AgeLab

"What I'd like us to think about is, with great connectivity comes great responsibility. We should only add that connectivity when we are certain we can rise to the level of commensurate care."

Joshua Corman, Chief Security Officer, PTC

Volpe Center 2017 Sponsors

U.S. Department of Transportation

Bureau of Transportation Statistics

Federal Aviation Administration

Federal Highway Administration

Federal Motor Carrier Safety Administration

Federal Railroad Administration

Federal Transit Administration

Maritime Administration

National Highway Traffic Safety Administration

Pipeline and Hazardous Materials Safety Administration

Saint Lawrence Seaway Development Corporation

Office of the Secretary of Transportation

Other Federal Agencies

Department of Agriculture (USDA)

  U.S. Forest Service

Department of Commerce

  National Oceanic and Atmospheric Administration

Department of Defense

  Air Mobility Command

  Defense Threat Reduction Agency

  Joint Improvised-Threat Defeat Organization

  Office of the Chief of Naval Operations

  Office of the Secretary of Defense

  U.S. Africa Command

  U.S. Air Force

  U.S. Army

  U.S. Navy

  U.S. Naval Forces Africa

  U.S. Navy International Programs Office

  U.S. Transportation Command

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Environmental Protection Agency

Millennium Challenge Corporation

National Aeronautics and Space Administration

National Capital Planning Commission

U.S. Access Board

U.S. Capitol Police

State and Local

Chicago Metropolitan Agency for Planning

City of Cambridge

City of Colorado Springs

City of New York

City of San Francisco

Delaware Department of Transportation

Maryland State Highway Administration

Massachusetts Bay Transportation Authority

Massachusetts Department of Transportation

National Association of City Transportation Officials

New York State Energy Research and Development Authority

Oregon Department of Transportation

State of Arizona

State of Maryland

Washington Metropolitan Area Transit Authority

Other

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National Motor Freight Traffic Association, Inc.

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United Kingdom Ministry of Defence