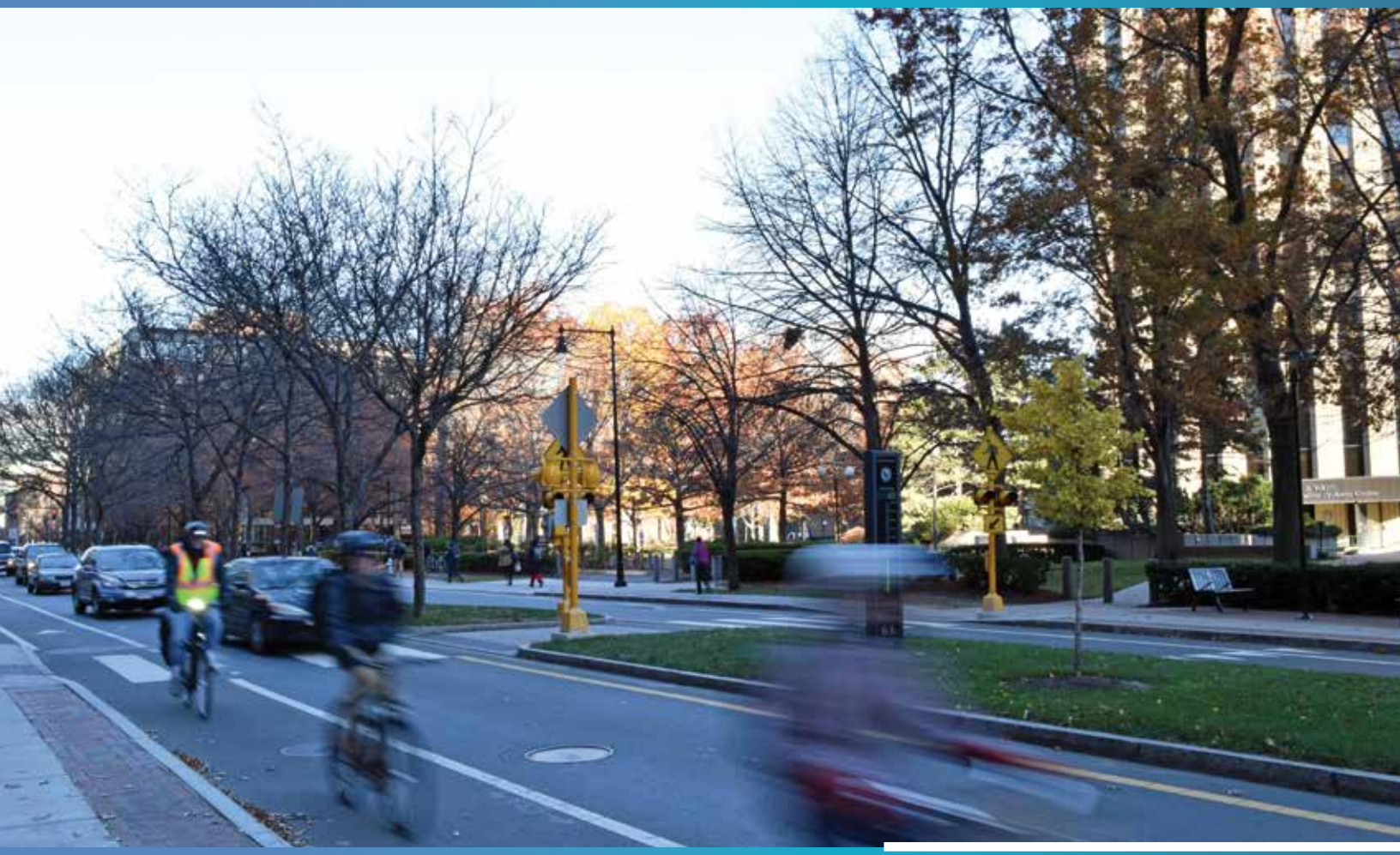
ANNUAL ACCOMPLISHMENTS

Advancing Transportation Innovation for the Public Good

January **2017**

U.S. Department of Transportation
Volpe, The National Transportation Systems Center

Volpe



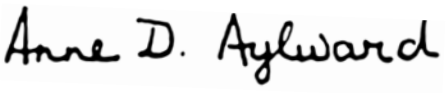
Message from the Volpe Center Director

I am pleased to present the U.S. Department of Transportation Volpe Center's Annual Project Accomplishments. This document highlights some of the Center's best work of 2016 and is illustrative of our sustained impact on making the transportation system safer, more efficient, globally competitive, sustainable, and resilient.

For nearly 50 years, the Volpe Center has worked in collaboration with U.S. DOT, other federal agencies, and the broader transportation community to advance transportation innovation for the public good. By developing fresh approaches and new solutions, we have successfully addressed some of the most complex national and global transportation challenges.

At this time of presidential transition, the Volpe Center provides a remarkable historical perspective and institutional memory that cannot be found elsewhere. This is illustrated in the timeline on the following pages. As the home to world-renowned multimodal and multidisciplinary expertise, our work has always reflected pressing and shifting national needs and priorities.

With an eye to the horizon, we remain committed to anticipating and tackling emerging and future transportation issues.



Anne D. Aylward

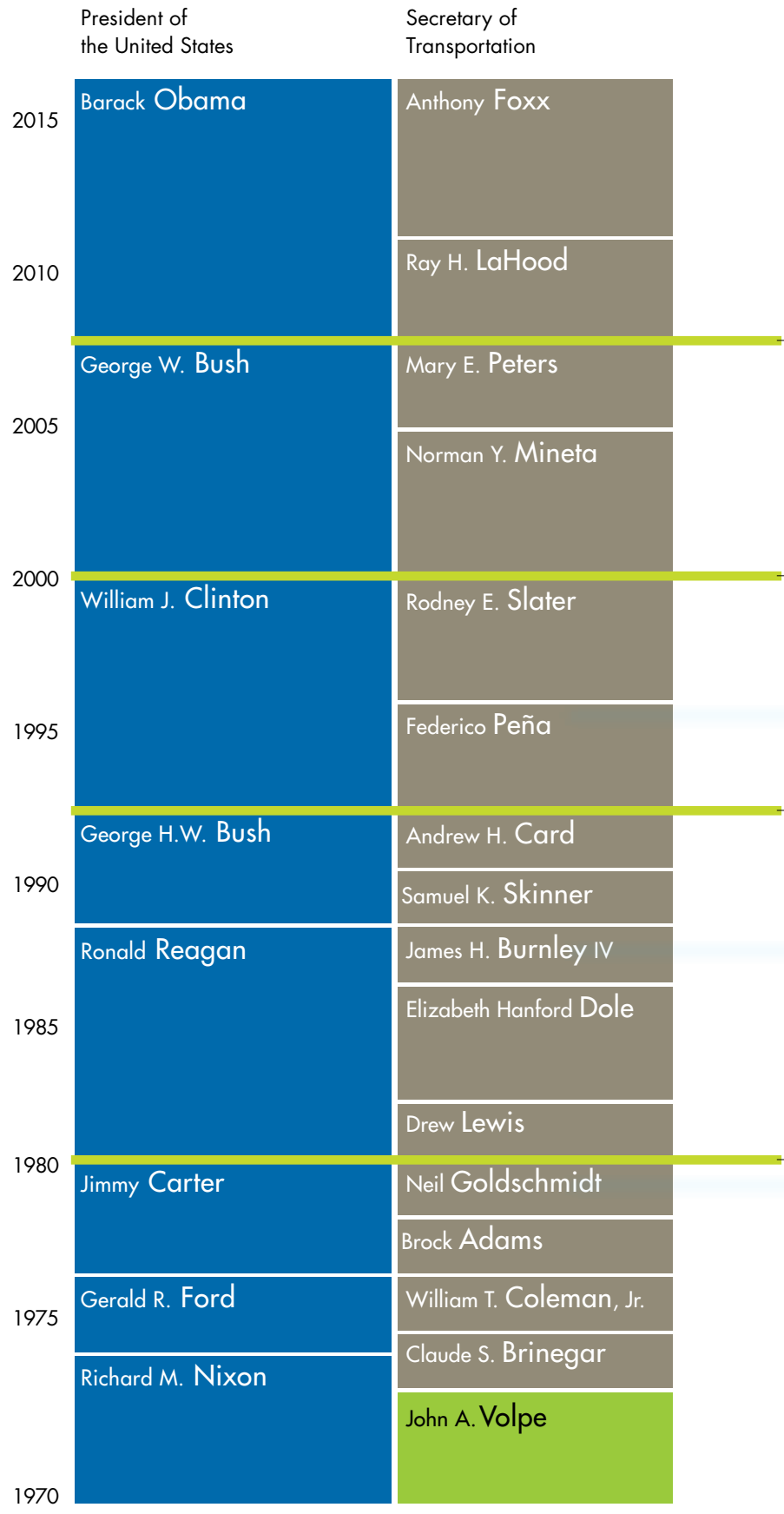
Opposite: Located in the heart of Kendall Square in Cambridge, Massachusetts, the U.S. DOT's Volpe Center is an innovative transportation resource dedicated to advancing transportation innovation for the public good.

Photo: U.S. DOT/Volpe Center.

Volpe Center Highlights:

Key Contributions

1970 – 2016



- Supporting **NextGen**—FAA's Next Generation Air Transportation System
- Advancing safety of **crude oil and ethanol by rail** initiatives
- Supporting **connected and automated vehicle** research, evaluation, and planning
- Pioneering Global Positioning System (GPS) **spectrum interference protection**
- Supporting **high-risk motor carrier prioritization**
- Supporting development of ***Beyond Traffic 2045***
- Leading analysis that informs new **fuel economy standards**
- Bolstering development of the first-ever **aviation CO_2 emissions standard**
- **Accelerating infrastructure project delivery** and aligning federal reviews
- Responding to natural disasters, including **Superstorm Sandy** and **Hurricane Matthew**

- Advancing **motor vehicle crash avoidance** research
- Performing groundbreaking research and analysis on **GPS vulnerability**
- Developing a multinational **maritime situational awareness network**
- Supporting installation of a **communications-based train control system** in Iraq
- Strengthening analysis of **federal motor carrier safety** programs
- Contributing to ***Transportation Vision 2030***
- Supporting the **Intelligent Transportation Systems** program
- Supporting U.S. DOT's response to the **September 11 attacks**

- Laying the foundation for Amtrak's all-electric **Acela** high-speed service
- Developing and installing a real-time communications and navigation system in the **Panama Canal**
- Providing key support to White House **National Science and Technology Council** transportation initiatives
- Assessing the **crashworthiness of rail passenger equipment**
- Developing the system to calculate **aviation's contribution to global fuel burn and emissions**
- Supporting development of U.S. DOT's policy **architecture for transportation decision making**

- Developing the **Enhanced Traffic Management System** for FAA
- Contributing to **Moving America**: A Statement of National Transportation Policy
- Conducting a **port needs study** for the U.S. Coast Guard
- Evaluating **the ridership, cost forecasts, and performance** associated with federally funded **transit projects**
- Studying the effect of the **65 mph speed limit** on highway safety
- Assessing the use and design of **flight crew checklists and manuals**
- **Enhancing port security** and DoD's **strategic mobility and logistics**
- Supporting the **intelligent vehicle highway system safety** program
- Undertaking major **environmental remediation** at U.S. DOT and Superfund sites

- Pioneering the use of **alcohol breath analysis** for transportation safety
- Developing and deploying navigation aids along the **St. Lawrence Seaway**
- Contributing to the **financial analysis of the motor vehicle industry**
- Measuring **noise levels** from aircraft and motor vehicles
- Developing **anti-hijacking** airport security screening systems
- Developing first-ever U.S. DOT-DoD **Federal Radionavigation Plan**
- Conducting first federal study on **automated fare collection**
- Informing the first **Corporate Average Fuel Economy standards**
- Supporting introduction of advanced **urban transit** technologies

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NEXT GENERATION AIR TRANSPORTATION SYSTEM

SURFACE AUTOMATION AND MOBILITY

INFRASTRUCTURE MODERNIZATION AND RESILIENCY

ENERGY AND ENVIRONMENT

TRANSPORTATION MANAGEMENT AND PLANNING

THOUGHT LEADERSHIP


TOP
PALACE
bees
5603
GOLDEN TOUCH
transportation
718-863-5600
BUS CHARTER
SIGHTSEE
TOWN CARS
SUVS · VANS
EMPLOYEE
SHUTTLES
FANTASTIC

Safety

The Volpe Center is relentless in its efforts to help the U.S. Department of Transportation achieve its primary goal: transportation safety. Our multimodal safety expertise enables us to leverage proven practices from one mode to improve safety in others.

CONNECTED VEHICLES

Laying the Foundation for Vehicle-to-Pedestrian Communications

When a car hits a pedestrian, the pedestrian takes the full brunt of the severe and sometimes fatal injuries. Between 2014 and 2015, pedestrian fatalities in the U.S. increased by 9.5 percent.

Vehicle-to-pedestrian (V2P) communications can help avoid impacts or reduce the consequences when light vehicles—10,000 pounds or less—collide with pedestrians.

Volpe Center experts analyzed data from national crash databases that code hundreds of thousands of real crashes to help the National Highway Traffic Safety Administration (NHTSA) understand the scenarios that lead up to vehicle-pedestrian crashes and how V2P technology can help avoid them.

Opposite: In 2015, 76 percent of pedestrian fatalities were in urban areas and 72 percent occurred at non-intersections. Photo: 123rf.com/Philipp Oscity.

V2P-based crash avoidance systems use wireless communication to transfer information between vehicles and pedestrians using dedicated short-range communications, Wi-Fi, global positioning system (GPS) tracking via cellular networks, or other wireless technologies.

V2P communications can help make drivers and pedestrians aware of each other, and avoid potential collisions. To minimize interventions based on false positives, V2P systems must also be able to discern between driving situations where a crash is imminent and benign driving conditions.

Volpe Center researchers identified five priority pre-crash scenarios that make up 91 percent of fatal crashes between light vehicles and pedestrians, where the first event in the crash is the vehicle striking a pedestrian:

- Vehicle going straight and the pedestrian crossing the road;
- Vehicle going straight and the pedestrian in the road;
- Vehicle going straight and the pedestrian adjacent to the road;

- Vehicle turning left and the pedestrian crossing the road; and
- Vehicle turning right and the pedestrian crossing the road.

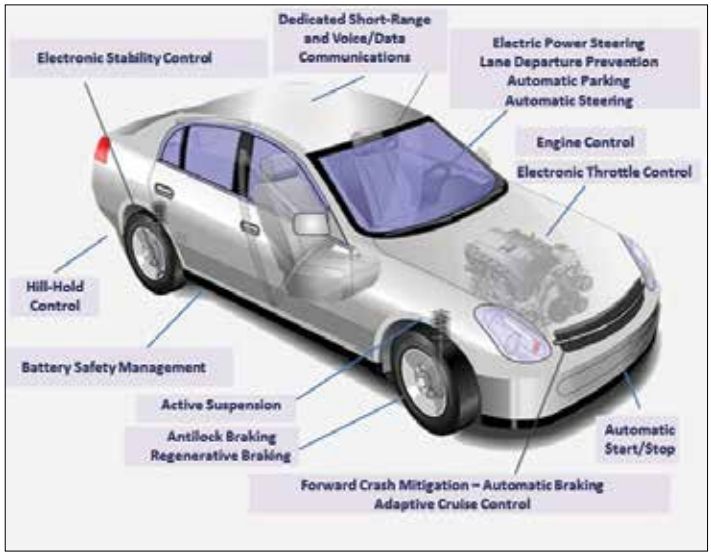
This project lays the foundation for new V2P safety applications by identifying research areas and knowledge gaps. NHTSA will use the Volpe Center's work to improve the effectiveness of V2P crash avoidance and advance V2P technologies that can compensate for limitations of vehicle-based pedestrian crash avoidance systems that use radar, Lidar, or vision sensors.

(Sponsored by NHTSA)

CONNECTED VEHICLES

Safer and More Reliable Automotive Electronic Control Systems

The number of electronic components used in the construction of motor vehicles has accelerated in recent years. Electronics play a crucial role in developing optimized technological solutions to improve a motor vehicle's drivability, enhance its safety features, and lower environmental impacts. Today's motor vehicles incorporate an increasingly complex array of electronic systems including sensors, actuators, microprocessors, instrumentation panels, controllers, and displays. Advances in this area have contributed to the development and deployment of safety features such as electronic stability control, tire-pressure monitoring, lane-departure warning, adaptive cruise control, forward crash warning, and automatic braking.



Some examples of electronic safety systems in modern vehicles. Source: NHTSA.

This rapid evolution of electronic control and connectivity has increased challenges for vehicle safety assurance. In 2015, NHTSA reported the auto industry recalled nearly 64 million vehicles because of safety problems; this number exceeded the total for the previous three years combined.

Part of NHTSA's mission is to research methods for ensuring the safety and reliability of safety-critical electronic control systems in motor vehicles. NHTSA and the Volpe Center have a strong, collaborative relationship in performing engineering analyses to enhance the safety of advanced technologies in vehicles. NHTSA turned to the Volpe Center's nationally recognized advanced vehicle technology team to assess the safety and reliability of emerging electronic control systems.

The Volpe team performed the research and collaborated with NHTSA's Electronic Systems Safety Research Division in writing the final report, *Assessment of Safety Standards for Automotive Electronic Control Systems*. The focus was to define and prioritize safety-critical automotive electronic control systems, assess industry and government safety standards currently being used to ensure the functional safety of motor vehicles, review the state-of-the-art technology of vehicle health management systems, and assess vehicle failure response mechanisms and driver information.

The report is part of a series of publications that describe NHTSA's initial work in the automotive electronics reliability program. Findings will provide NHTSA and the automotive industry with significant data to address the reliability of evolving safety-critical, automotive electronic control systems. NHTSA now has the foundation to draft

near-term research topics that will ensure motor vehicles can be safely operated, despite the increasing complexity of advanced electronic controls, escalating use of information technology, and increased wireless connectivity to in-vehicle and external systems.

(Sponsored by NHTSA)

CONNECTED VEHICLES

Dynamic Crash Research with Connected Driving Simulators

NHTSA estimates that human error is the leading reason for a crash in over 90 percent of collisions. A better understanding of what takes place during the last few seconds leading up to a crash, and what drivers can do to reduce crash risk are critical to future traffic safety improvements. Even though more than one-third of crashes involve more than one vehicle, most human factors testing involves only one laboratory, operating one simulator, and testing solutions from one driver's viewpoint.

To investigate the feasibility of implementing progressively more interconnected simulation capabilities, Volpe Center human factors experts took the lead in developing and delivering the Cross-Modal Distributed Simulation Workshop at the 2016 Transportation Research Board meeting. The workshop was the first to explore the vehicle simulation problem in detail. Experts considered how best to provide researchers access to connected driving simulators in order to share simulators and achieve distributed simulation. This will enable simulators in different locations to communicate over a network. Participants also discussed how to leverage distributed simulation to investigate interactions between autonomous and non-autonomous vehicles.

Panelists included representatives from the Ohio Supercomputer Center; the Texas A&M Transportation Institute's Center for Transportation Safety; the Traffic Operations and Safety Laboratory at the University of Wisconsin-Madison; the National Advanced Driving Simulator at the University of Iowa; and Realtime Technologies, Inc.

Workshop attendees included simulator vendors, researchers, and officials from federal, state, and county organizations—along with international colleagues from Afghanistan, the Democratic Republic of Congo, Germany, the Netherlands, Spain, and the United Kingdom.

Workshop discussions provided insight into work that is underway to connect simulators at Ohio State University and the University of Massachusetts, Amherst. The dialogue also informed efforts to develop distributed driving simulator capacity as part of the U.S. DOT's University Transportation Centers program.

(Sponsored by U.S. DOT/Volpe Center)

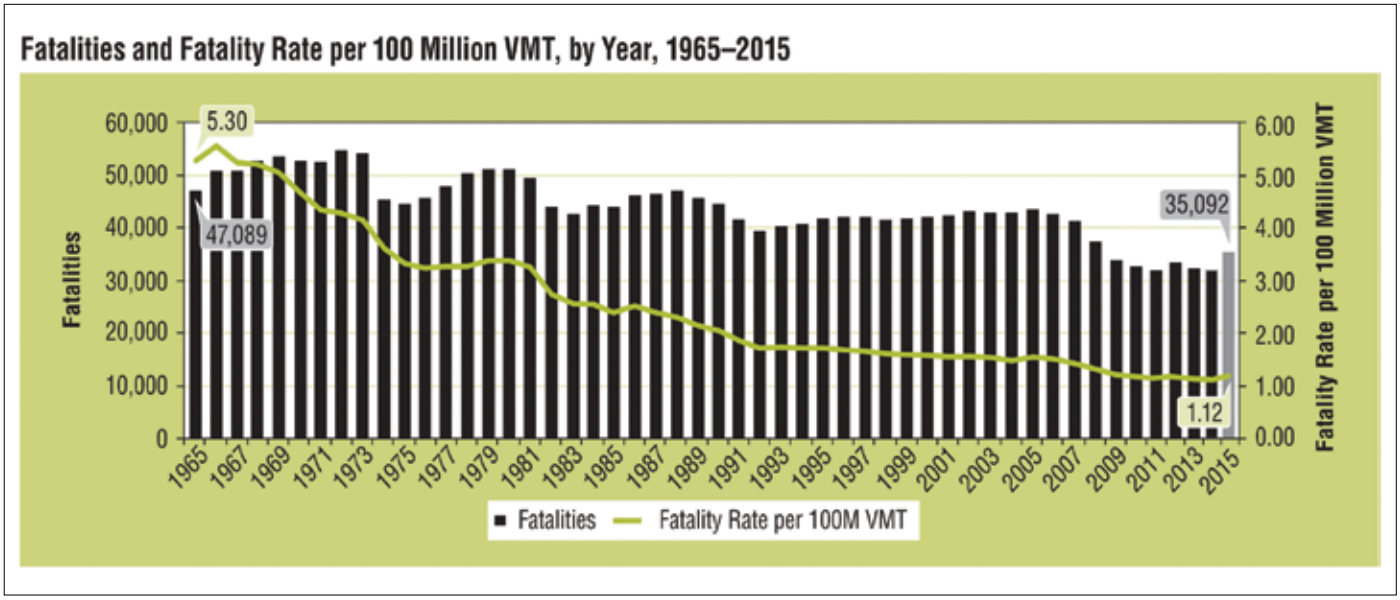
CONNECTED VEHICLES

Intelligent Vehicles: The Hope, the Help, the Harm

Imagine a world full of intelligent vehicles that wirelessly communicate with one other. Crashes are rare. There is less congestion. There are fewer carbon emissions and people everywhere are more mobile.

Compare that vision to today's realities. Every year, about 1.25 million people die from road traffic crashes, according to the World Health Organization. Congestion costs hundreds of billions of dollars in lost productivity in the U.S. alone, and fossil fuel combustion is by far the largest contributor to carbon emissions.

Intelligent vehicles can mitigate or prevent 70 to 80 percent of vehicle crashes involving unimpaired drivers, and reductions among impaired drivers could even be greater with automated vehicles. Lives will be saved, however, only if drivers learn to trust intelligent, fully automated vehicles. More than a half century of research in human factors suggests that as long as humans are in the loop, transportation researchers will need to pay careful attention to human behavior, and to how people interact with intelligent vehicles.



U.S. fatalities and fatality rate per 100 million vehicle miles traveled for 1965-2015. Sources: 1965–1974: National Center for Health Statistics, HEW, and State Accident Summaries (Adjusted to 30-Day Traffic Deaths by NHTSA); FARS 1975-2014 Final File, 2015 Annual Report File (ARF); Vehicle Miles Traveled (VMT): FHWA.

For the transportation community to conduct human factors research going forward—and for the world to take advantage of the life-saving, time-saving, and emissions-saving benefits of intelligent vehicles—it's helpful to take stock of where the research is today. Volpe Center human factors experts were invited to submit an article on human factors and intelligent vehicles to the inaugural issue of the Institute of Electrical and Electronics Engineers' (IEEE) *Transactions on Intelligent Vehicles*.

The peer-reviewed article includes more than 100 references to seminal human factors research that answers and refines questions on the safety and use of intelligent vehicles. It was officially accepted for publication and is now in print.

IEEE's publication will reach its more than 429,000 members, including leading researchers in academia, industry, and policy and planning. This article gives readers a window into the human factors challenges that may come from a global fleet with many more intelligent vehicles, and potential solutions.

(Sponsored by U.S. DOT/Volpe Center)

PEDESTRIANS AND BICYCLISTS

Protecting Vulnerable Road Users

Side guards save lives. When trucks with high ground clearances strike vulnerable road users, such as bicyclists and pedestrians, those users can fall into exposed space between the front and rear wheels and suffer fatal crushing injuries. Side guards cover that open space. In 2016, the Volpe Center and the U.S. DOT's Office of the Assistant Secretary for Research and Technology (OST-R) published the first national voluntary side guard standard, providing consistent specifications for use by cities, manufacturers, and fleets. The Volpe Center's research has led to side guards being included as safety strategies in the Portland, Oregon Vision Zero Action Plan and the Seattle, Washington Freight Master Plan.

The Volpe Center has been a national champion for side guard use, performing research, providing recommendations, and reviewing and analyzing international best practices, and then works with municipalities on implementation.

The city of Cambridge demonstrated its pilot side-guard deployment in 2015, including several side guard designs advised by Volpe. Photo: U.S. DOT/Volpe Center.

The city of Boston asked the Volpe Center to help expand its truck side guard pilot—which was informed by Volpe Center research—and to craft the nation's first side-guard ordinance for private truck fleets. Boston's mandatory side guard ordinance for public and private trucks took effect in May 2015. More than 230 trucks in Boston now have side guards.

The Volpe Center's research also informed efforts in New York City (NYC). NYC enacted a law requiring side guards on 10,000 city-owned and regulated trucks by 2024, as well as the nation's first incentive program for early voluntary adoption. Based on the NYC rate of several fatalities each year involving their 2,500 truck sanitation fleet, the trucks that have been retrofitted should start saving about one life per year and preventing about 10 serious injuries.

Based on the Volpe Center's recommendations, San Francisco plans to phase in side guards on all city-owned trucks in 2016.

The Volpe Center is also supporting San Francisco in working with the National Institute of Standards and Technology Manufacturing Extension Partnership to build a broad supplier base for side guards that will meet the Volpe Center's technical criteria on the West Coast.

The District of Columbia became the first jurisdiction to require large trucks registered in the state to incorporate side guards. Enacted in July 2016, the law requires all heavy-duty vehicles registered in the District of Columbia to be equipped by 2019.

Several private truck fleets are voluntarily following suit, including 31 trucks at the University of Washington in Seattle; Fresh Direct, Coca-Cola, and Action Carting trucks in New York; and Save That Stuff trucks in Boston. Because of the Volpe Center's successful partnerships, at least 500 side-guard-equipped trucks were on U.S. roads at the end of 2015, with thousands more to come over the next few years.

The Volpe Center team that investigated and promoted life-saving truck side guards won a national 2016 Federal Laboratory Consortium Excellence in Technology Transfer award. The team also partnered with the OST-R's Technology Transfer (T2) Program to develop and implement a formal T2 plan that will map out and engage stakeholders to accelerate adoption across the United States.

(Sponsored by the cities of Boston, New York, San Francisco, and Cambridge; and Tetra Tech)

RAIL

Innovative Ideas for Preventing Right-of-Way Fatalities and Trespassing

Trespassing on rail lines is the leading cause of all rail-related deaths in the United States. In 2015, there were 470 deaths and nearly as many injuries, with most of these incidents involving pedestrians. Preventing rail right-of-way (ROW) trespassing is a major safety concern for the Federal Railroad Administration (FRA), railroads, and the communities where railroads operate.

In recent years, FRA hosted two workshops to identify solutions on preventing ROW fatalities and trespassing. Building on their success, FRA sponsored a three-day ROW Fatality and Trespass Prevention Workshop in Charlotte, North Carolina. The goal was to share leading practices and explore new ideas and strategies to reduce the number of ROW trespasser incidents and fatalities. FRA turned to the Volpe Center's systems safety and engineering experts to lead the activity.

The major workshop objectives were to update FRA and its stakeholders on ROW fatality and trespass prevention activities, brainstorm future activities and research priorities, share existing leading practices, and explore new strategies to reduce the number of ROW trespasser incidents and fatalities. Attendees came up with more than 110 recommended actions across five topic areas and classified 24 of these actions as high priority.

Motion-activated camera photos showing trespassers along a rail ROW in Brunswick, Maine. Photos: U.S. DOT/Volpe Center.

A Volpe-led pilot study is testing driver behavior at road-rail crossings with gates. Photo: U.S. DOT/Volpe Center.

The Volpe Center team assembled a steering committee for the workshop comprised of federal, state, and industry stakeholders, including the Association of American Railroads, North Carolina Department of Transportation, Operation Lifesaver, and CSX Transportation. The Volpe Center also developed the agenda, facilitated the workshop, and delivered a final report on workshop findings to FRA.

The 170 participating stakeholders represented a wide cross-section of transportation experts from federal, state, and local governments, railroads, transit agencies, the enforcement community, academia, non-government organizations, and consultants. Experts from Canada and the United Kingdom also participated.

FRA expects the results from this workshop to be used by the U.S. DOT modal administrations and their stakeholders to enhance safety on the nation's rail network.

(Sponsored by FRA)

RAIL

Modeling Driver Behavior at Grade Crossings

Grade crossings are the points where roads and rails intersect. Crossings often have gates—red-and-white striped arms that come down across a road when a train is approaching. Road-rail intersections are safe when drivers stay on the right side of those gates. But, that doesn't always happen.

FRA recorded 1,286 injuries and deaths at grade crossings in 2015. Fifty-five percent of those incidents occurred at crossings with active gates.

The reason more than half of serious incidents occur at crossings with gates is people drive around a gate, rather than wait until a train safely passes. Research has shown it is difficult for people to determine how quickly a train that looks far away will actually reach them.

To better understand motorist decision making at grade crossings, the Volpe Center developed a pilot study in May 2016 using its driving stimulator. If successful, the results of this project may be used to validate a theoretical paper on driver decision making at grade crossings.

The study will explore a novel experimental design and may inform FRA of the potential impacts that new technologies may have on drivers. For example, the addition of crosswalk-style countdown timers at crossings has been proposed for use, but it remains unclear if this additional information will improve safety or provide a cue for increased risk taking.

(Sponsored by FRA)

RAIL

Saving Lives on the U.S. Rail System

Each year, an average of 280 people lose their lives by suicide on the U.S. rail system. Volpe Center human factors experts play an integral role in a number of activities to reduce rail suicides in the U.S., including the Global Railway Alliance for Suicide Prevention (GRASP), conspicuous signage in the transit system for help with depression, and responsible reporting.

GRASP Shares Best Practices

Volpe Center experts in human factors helped form GRASP with FRA and the Association of American Railroads (AAR) in 2014. GRASP brings together leading minds on rail suicide prevention—from more than a dozen rail companies and professional associations—to develop and share best practices in preventing railway suicides around the world. The group has helped the Volpe Center and FRA shape their research into rail suicide prevention, and establish key relationships with U.S. rail carriers to implement suicide countermeasures.

There is an imperative for rail industry players around the world to work together. The rail suicide rate is much higher in other countries. In the United Kingdom, for example, there were 252 suicides in 2015, even though their population is one-fifth the size of the U.S. population.

GRASP held its third annual meeting in Washington, DC in January 2016, with participants from rail companies and associations in Australia, Canada, Finland, Sweden, the United Kingdom, and the U.S. Through GRASP, the Volpe Center and FRA learn from and provide insights to global rail suicide prevention experts to understand how other countries are addressing rail suicide.

Collaboration with the Samaritans

Suicide incidents don't just affect the individual involved and their friends and family. Train crews who witness an incident may be traumatized, and rail passengers can experience lengthy delays.

MBTA, Samaritans, and the Volpe Center are working to spread awareness of Samaritans' services through digital signage in MTBA stations. Photo: U.S. DOT/Volpe Center.

In January 2016, the Massachusetts Bay Transportation Authority (MBTA) initiated a campaign to advertise the Samaritans crisis phone and text line—877-870-HOPE (4673)—at transit stations. The Volpe Center assisted in facilitating this partnership and helped Samaritans develop a strategy to evaluate the impact of this collaboration. Initial data suggest that before the launch of this effort, only 25 percent of MBTA ridership were aware that Samaritans offers a confidential, anonymous crisis line, all day every day.

By continuing to monitor and evaluate the impact of this collaboration, Volpe Center human factors experts hope to provide empirical evidence that signage campaigns like the one launched in Boston can save lives and encourage other rail carriers to consider similar efforts.

Responsible Reporting Leads to Change

Scientific literature has established that media coverage of suicide fatalities can lead to copycat suicide attempts, including on rail systems.

Volpe Center staff are studying the language that media outlets use to describe rail suicides, to help FRA understand if reporters follow widely available guidelines for suicide reporting.

Volpe Center experts have found that while nearly all recommendations for suicide reporting discourage using the word "suicide" in the headline, about 25 percent of all reports about suicide incidents do. Only 5 percent of articles about rail suicide included information about help services, such as the National Suicide Prevention Lifeline.

There is evidence that responsible reporting can lead to notable change. In the 1980s, Austria experienced a large increase in rail suicide attempts. An agreement to follow guidelines for reporting on suicide or not reporting on these incidents at all led to a 75-percent reduction in suicides.

The Volpe Center will release rail-specific recommendations to help encourage more responsible reporting following rail suicide incidents. This work will provide rail carriers and

No trespassing signs along railroad rights-of-way warn people of the dangers of crossing tracks. Photo: U.S. DOT/Volpe Center.

first responders with information about how to encourage responsible reporting from media outlets, toward reducing copycat suicide attempts on the U.S. rail network.

(Sponsored by FRA)

RAIL

Understanding Automation's Affect on Human Performance

Train automation technologies enhance efficiency and safety by providing the operator with advisory information or by taking over control from the operator under dangerous circumstances. What impact might these new technologies have on operator performance? This is a point of focus for FRA, which is constantly researching new automation advances in the rail industry.

The Volpe Center collaborates with FRA by providing research support to the agency's Cab Technology Integration Laboratory (CTIL) program. CTIL is a mobile, full-sized locomotive simulator configured with tools for analyzing crew performance given new cab technologies and configurations. The Volpe Center's ongoing support of FRA's CTIL lab is an essential part of the CTIL program.

Recently, Volpe Center experts provided technical and program management support for two important projects conducted by General Electric (GE) and Alion Science and Technology. GE developed a framework for human factors analysis of in-cab automation technologies and then used it to inform a next-generation concept for its Trip Optimizer (TO) fuel management system. GE built a prototype of this system in CTIL and then looked at operator performance differences between using the prototype and using current-generation TO. GE examined tradeoffs of the two systems by using various cognitive, safety, and efficiency measures.

Alion was tasked with identifying potential human errors within two rail automation technologies: TO and the

Left: Computer monitors in the Volpe Center CTIL lab show a simulated locomotive cab and track. Right: An FRA employee trains in the CTIL lab using the simulated locomotive cab. Photos: U.S. DOT/Volpe Center.

Interoperable Electronic Train Management System, a Positive Train Control safety system. Alion staff observed locomotive engineers as they worked through several challenging scenarios in CTIL, and conducted interviews with them afterwards. The human error opportunities associated with the two systems can be used to further improve locomotive cab human-machine interactions and overall training techniques.

The Volpe Center worked with vendors to install these technologies in the CTIL lab, offered scenario design guidance and development, and provided rail expertise. Additionally, Volpe Center staff aided in data collection, as well as data reduction once the projects were concluded.

While the GE and Alion projects are in their final stages, the Volpe Center's support of the CTIL program will continue.

(Sponsored by FRA)

MOTOR CARRIERS

High-Risk Motor Carrier Prioritization Program Enables Early Intervention

Today, the Federal Motor Carrier Safety Administration (FMCSA) can intervene with unsafe motor carriers sooner than ever before. A new high-risk motor carrier prioritization program enables safety investigators to take more immediate action with motor carriers that pose the greatest safety risk. The Volpe Center's motor carrier safety analysts worked closely with FMCSA leadership, field staff, and state partners to develop and roll out the new High-Risk Prioritization Program. The Volpe Center's role involved designing a new policy, employing updated technology, analyzing data, and conducting the solid analysis necessary to create an algorithm that is fair to industry and effective at identifying carriers for intervention.

FMCSA's new high-risk motor carrier prioritization program enables safety investigators to take immediate action on motor carriers that pose the greatest safety risk. Photo: FMCSA.

The new policy responded to recommendations from motor carrier federal and state partners working in the field and a Federal Aviation Administration (FAA) independent review team's report titled "The Blueprint for Safety Leadership: Aligning Enforcement and Risk." The review team recommended that FMCSA sharpen its priority-setting focus and provide more timely investigation of motor carriers with the highest crash risk.

The old process to identify and investigate an unsafe motor carrier took roughly seven months. Once the new high-risk motor carrier prioritization program was in place, the timeframe dropped to a one-month average from carrier identification to investigation by FMCSA.

The Volpe Center also worked to incorporate input received from the field to transform FMCSA's training approach and inform the strategic communications and outreach plan.

Feedback from the field has been consistently positive. FMCSA successfully launched the Activity Center for Enforcement (ACE) system in January 2016.

Making more effective, data-driven decisions will allow safety investigators to take immediate action on carriers with the highest crash risk. This will help reduce the number of crashes, injuries, and fatalities involving large trucks and buses on the nation's highways.

(Sponsored by FMCSA)

MOTOR CARRIERS

Data Quality Key to Motor Carrier Safety Advancements

Effective transportation safety programs need high-quality data. At the FMCSA, data is central to its mission to reduce the number and severity of crashes involving large trucks and buses. FMCSA, state partners, and the Volpe Center have forged a strong partnership which has resulted in higher quality crash and inspection data. In a major step forward for the partnership, the Volpe Center supported the redesign and implementation of a new website that now serves as the centerpiece of FMCSA's Data Quality Program.

The new online portal makes state safety data more actionable, accessible, and easier to understand. It features a simplified look and feel, allowing users easy and efficient access to state safety data and trends. Helpful resources and educational information are now at the fingertips of the motor carrier safety community working nationwide.

"The improved Data Quality website is great," said Holly Skaar, of the Idaho State Police and Chair of the Commercial Vehicle Safety Alliance's Information Systems Committee. "The simplified website navigation makes it easier to find information, adding heightened efficiency to monitor data quality performance and identify resources to help improve data quality."

FMCSA's new web portal makes state safety data more actionable, accessible, and easier to use and understand.

Source: FMCSA.

Motor carriers and drivers can access DataQs, a resource that allows stakeholders to request and track a review of federal and state data issued by FMCSA that they feel may be incomplete or incorrect. Additionally, the website provides links to two related data-driven FMCSA websites—the Safety Measurement System and the Pre-Employment Screening Program, so that companies and drivers can understand how data are used, and ensure their accuracy and improvement.

Collaboration, communication, and transparency will continue to be the keys to success for those involved in making major improvements to FMCSA's data quality and advancing motor carrier safety.

(Sponsored by FMCSA)

PUBLIC TRANSIT

Benefit-Cost Analyses Support Prioritization of Safety Investments

In 2013, 6,800 transit agencies in the U.S. provided more than 10 billion passenger trips. While public transportation is safe, improvements can further reduce injuries and fatalities that do occur. From 2004 to 2013, transit agencies reported over 40,000 incidents, 2,000 fatalities, and 76,000 injuries to the Federal Transit Administration's (FTA) National Transit Database. During the same period, the National Transportation Safety Board reported on 9 transit accidents resulting in 15 fatalities, 297 injuries, and more than $30 million in property damage.

MAP-21 legislation has created a stronger federal role for ensuring safety on the nation's surface transportation system. FTA's goal is to encourage the transit industry to adopt Safety Management Systems and address other safety concerns. To meet the MAP-21 mandate, FTA is developing several safety-related rulemakings, but compliance costs and the associated safety benefits must first be validated before the rulemaking can move forward.

Benefit-cost analyses provide transportation regulators with a full scope of the effort and expense associated with new rules, along with their potential impacts on the traveling public. Economists at the Volpe Center are working with FTA's Office of Budget and Policy to prepare benefit-cost analyses and other regulatory impact studies for several high-profile rulemakings, including Transit Asset Management, Public Transportation Agency Safety Plans, and revisions to the State Safety Oversight Program.

The Volpe Center team collected and analyzed data, including docket comments and National Transit Database entries, to understand the likely impacts of the proposed rules and developed a benefit-cost framework. The team also prepared regulatory impact analysis documents and made revisions based on input from FTA, Office of the Secretary (OST), and the Office of Management and Budget.

Benefit-cost analyses prepared by the Volpe Center are providing FTA with a body of information to prioritize investments with a strong return on safety compared to total costs.

(Sponsored by FTA)

HAZARDOUS MATERIALS

Helping Communities Prepare for Hazardous Materials Incidents

Millions of shipments of hazardous materials pass through states, territories, and tribal lands, presenting some level of risk. In 2014, the Pipeline and Hazardous Materials Safety Administration (PHMSA) reported 32,450 hazardous materials incidents, 488 of which PHMSA considered "serious." In 2015, there were 31 hazmat-related incidents, including 10 fatalities. To help communities better prepare for and respond to multimodal hazardous materials transportation incidents, PHMSA provides Hazardous Materials Emergency Preparedness (HMEP) grants for emergency planning and first responder training.

PHMSA turned to economists at the Volpe Center to assess the original HMEP grant allocation formula and provide recommendations for updating it to better reflect grantee priorities and needs, and current data. Prior to the Volpe Center project, the grant cycle relied entirely on highway data and was allocated using a formula developed in the

early 1990s. Drawing upon their expertise in data-driven decisions and management, the Volpe Center devised a solution aligning allocations with current hazardous materials transportation risk, to help high-risk states better prepare for hazardous materials incidents.

The Volpe Center team first evaluated data sources in the existing HMEP formula, and then looked at new, publicly available data sources. The team developed a framework for a risk-based formula and a series of spreadsheet tools to analyze a variety of models and data sources, and presented findings to PHMSA stakeholders, the National Association of Superfund Amendments and Reauthorization Act Title III Program Officials, and PHMSA leadership. Starting with the 2016 grant cycle, PHMSA implemented an updated HMEP formula allocation built from the Volpe Center's risk-based formula recommendations.

The Volpe Center's updated formula incorporates risk of incidents from air, rail, and water transport of hazardous materials, and aligns HMEP grant allocations with hazardous materials transportation risk. While this new approach is still in its first year of implementation, there are high expectations it will help communities better prepare for a hazardous materials incident.

(Sponsored by PHMSA)

Firefighters inspect a fuel truck for a simulated flammable liquid leak at a bulk fuel facility during a hazardous materials drill.

Photo: 123rf.com/Tracy Fox.

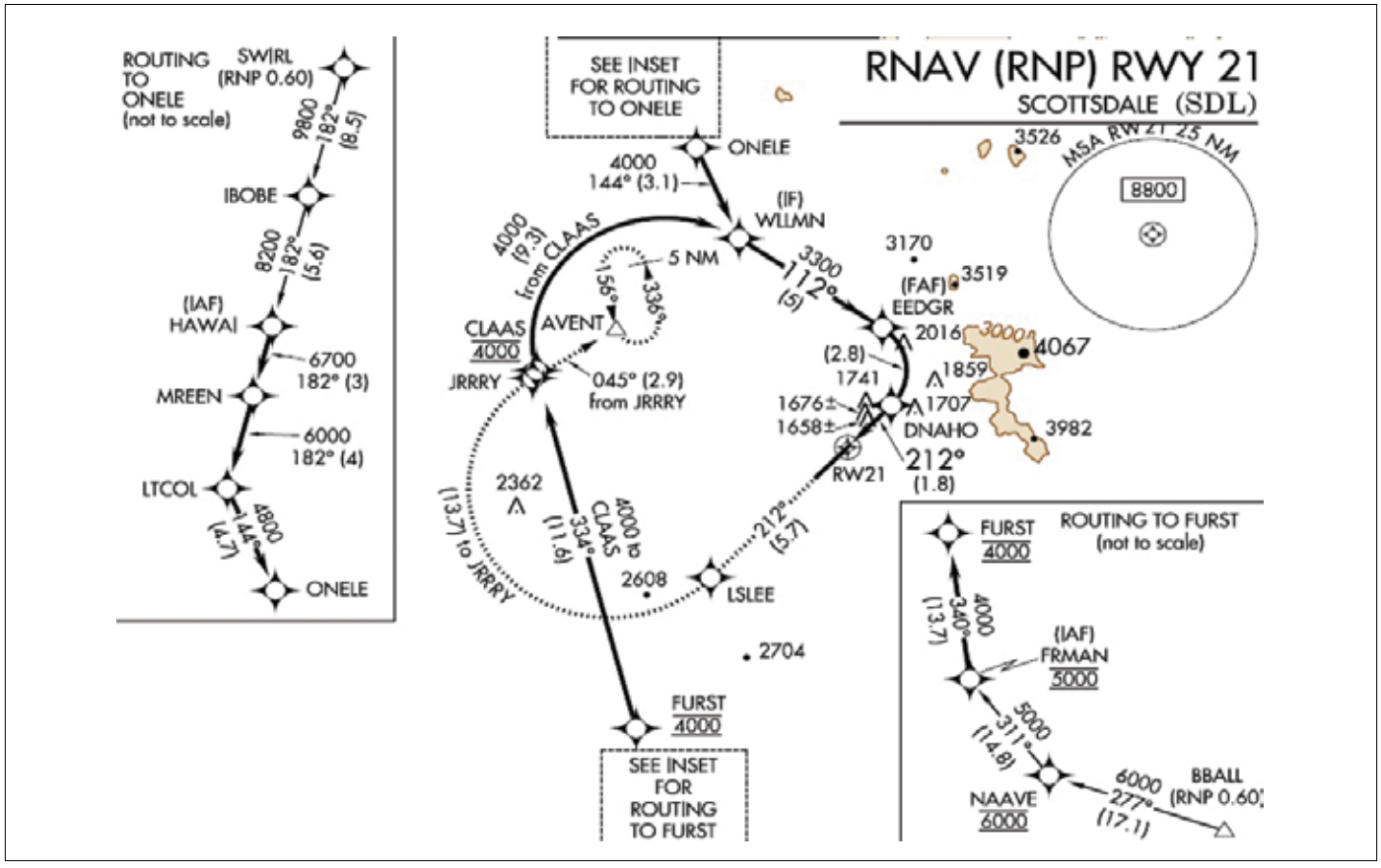
Line Pilot Perspectives on the Complexity of Instrument Flight Procedures

Advanced navigation technologies have profoundly improved safety and efficiency of flight operations. These technologies allow the development and publication of new flight routes, known as instrument flight procedures (IFPs), into and out of airports. FAA is focused on improving the design and usability of these arrival, departure, and approach IFPs because they must be flown precisely as intended.

Despite significant efforts to prepare for operational implementation of new IFPs, the process does not always go smoothly. Shortcomings of new IFPs are often attributed to "human factors," resulting in complexities that pilots must resolve. Examples of complexities that require an extra mental or physical step by the pilot include visually noncontiguous flight paths, non-standard map layouts, and route variability, to name a few.

Volpe Center human factors researchers conducted a study for FAA to understand flight path design and charting issues that create difficulties for pilots. The Volpe Center's research consisted of conversations with pilots from major and regional airlines, an air taxi operator, and corporate operators to learn how they understand and fly different IFPs. The Volpe Center developed a comprehensive list of complexity factors and organized it into a framework. The discussions also provided insights into how pilots use charts in modern flight decks, with Flight Management Systems and other types of automated systems.

The Volpe Center has been the lead research organization for this effort since 2007, and has conducted a series of studies to understand the different complexities associated with IFPs. The Volpe Center has also collected and analyzed



Plan view of the Scottsdale, Arizona (SDL) chart for RNAV (RNP) RWY 21 with radius-to-fix legs and noncontiguous paths drawn with insets. Source: FAA, 2016.

data, and shared findings with FAA and industry leaders. This research will help FAA identify issues and develop human factors guidelines for the design, depiction, and usability of IFPs and related aeronautical charts.

Recommendations were produced for a variety of stakeholders and are being considered by both government and industry to ease the transition toward NextGen airspace operations. A summary paper was published and presented at the Digital Avionics Systems Conference in September 2016.

(Sponsored by FAA)

MARITIME SAFETY AND SECURITY

Maritime Domain Awareness Advances Safety and Security on the Global Seas

Ten years ago, on behalf of the U.S. Navy Sixth Fleet, Volpe developed a successful global maritime domain awareness (MDA) network known as the Maritime Safety and Security Information System (MSSIS). Since then, MSSIS has been essential in aiding vessel traffic flow, combating illegal maritime activities, fostering global economic stability, and stimulating trust and cooperation between nations.

In summer 2014, Volpe developed and conducted a six-week MDA Administrator and Technician Workshop, on behalf of U.S. Africa Command (AFRICOM), for nine military and government officials from West African nations. This train-the-trainer workshop taught students how to sustain and maintain the Automatic Identification System (AIS) and other tracking systems in their countries.

The workshop also provided comprehensive training on global maritime awareness display software, called TV32, and a web-based version of TV32 called SeaVision. Participants were also trained in information technology and networking, radar theory, operation, and project management. The workshop included hands-on equipment instruction, labs, and demonstrations on how to install and maintain radar and AIS systems. The course was replicated in 2015 for 10 personnel from Kenya, Ghana, Cameroon, and other West African nations.

Building on the success of the first two seminars, 20 representatives from Cabo Verde, Cameroon, Ghana, Togo, Benin, Mozambique, Senegal, Tanzania, and the Philippines came to Volpe in 2016 to take the course. Ten of the participants were from the Philippines. Their attendance was funded by the Naval Education and Training Security Assistance Field Activity. The Philippines faces many of the challenges that MSSIS can help alleviate, such as illegal fishing, smuggling, and human trafficking.

The expanded curriculum for the 2016 session included a Radar Operation and Maintenance course, which Volpe staff orchestrated with Captain Brian Hall, a professor at the United States Merchant Marine Academy (USMMA). Professor Hall and his colleague, Captain Mike Murphy, developed and taught a curriculum customized to the unique needs of the attendees' home nations, and to the overall course agenda. Participants had an opportunity to visit the USMMA, where they got firsthand experience with radar simulators.

Volpe's train-the-trainer MSSIS sessions continually bring together multinational participants to discuss challenges and best practices in maritime safety, and to learn how Volpe-developed vessel tracking technologies can improve the safety and efficiency of their waterways.

(Sponsored by DoD)

MARITIME SAFETY AND SECURITY

Information Sharing Strengthens Marine Domain Awareness

Knowledge and information are powerful tools. As technologies advance and become more innovative, so too do the methods used for collecting and sharing critical information.

The U.S. Department of Defense (DoD)–Office of the Executive Agent for Maritime Domain Awareness needed help to determine if the coastal surveillance system (CSS) could serve as the Information Sharing Infrastructure (ISI) for the Maritime Information Sharing Environment (MISE). The CSS is an open, web-based architecture for

rapid technology insertion and quick information sharing. The MISE allows data providers and consumers to manage and share maritime information through common data definitions and security features, resulting in a web-accessible, unclassified information-sharing capability. Together, these tools help users share and manage critical maritime information efficiently.

The Volpe Center provided support to DoD by researching the impact of national information-sharing frameworks and policies of the DoD, U.S. DOT, and the U.S. Department of Homeland Security (DHS) in relation to the MISE. This involved reviewing potential infrastructure options including government-owned, government-leased, and commercial-leased cloud technology platforms.

The Volpe Center was the first U.S. DOT agency to successfully procure Amazon Web Services cloud technologies. This was due to the findings of a final technical report, which were acknowledged and well received by the sponsor.

Additionally, the Volpe Center performed a thorough technical evaluation of the CSS product line, comparing CSS with capabilities that were defined in the National MDA Architecture Plan, which seeks to provide a secure, collaborative, information-sharing environment for data users.

The Volpe Center managed the entire research effort and produced a robust engineering study that included the following elements:

- Evaluation of the CSS and its services;
- In-depth research into various cloud hosting platforms for different government information classification types and purposes, including a cost/benefit analysis;
- Review and analysis of pertinent U.S. DOT, DHS, and DoD information-sharing policies and regulations; and
- Critical evaluation of the National MDA Architecture Plan to inform and guide decision making.

This Volpe Center-led project advised the MDA Executive Steering Committee (MDA ESC) on the direction and infrastructure hosting options for the ISI. It also provided technical recommendations and a course of action for MISE implementation. The Volpe Center's work will further help the MDA ESC innovate, aid in maritime safety and security, and successfully accomplish mission goals and priorities.

The Volpe Center's completed engineering study was honored as 1 of 13 listed accomplishments in the MDA ESC 2015 record of accomplishments in support of the National Maritime Domain Awareness Plan and its implementation objectives.

(Sponsored by DoD–Office of the Executive Agent for Maritime Domain Awareness)


DELTA
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CONNECTION

Next Generation Air Transportation System

In partnership with FAA and other key stakeholders, a multidisciplinary Volpe team is supporting efforts to accelerate NextGen components that will yield near-term benefits and support critical mid- and long-term programs.

A New Era in Aviation: Safely Integrating UAS

Rapid innovations in avionics, sensing technology, and software are enabling a revolution in unmanned aircraft. Over the next few years there will be millions more unmanned aircraft systems (UAS)—also called drones—in the air.

Aviation analysts expect the value of the drone hobby market alone to multiply many times over in the next several years.

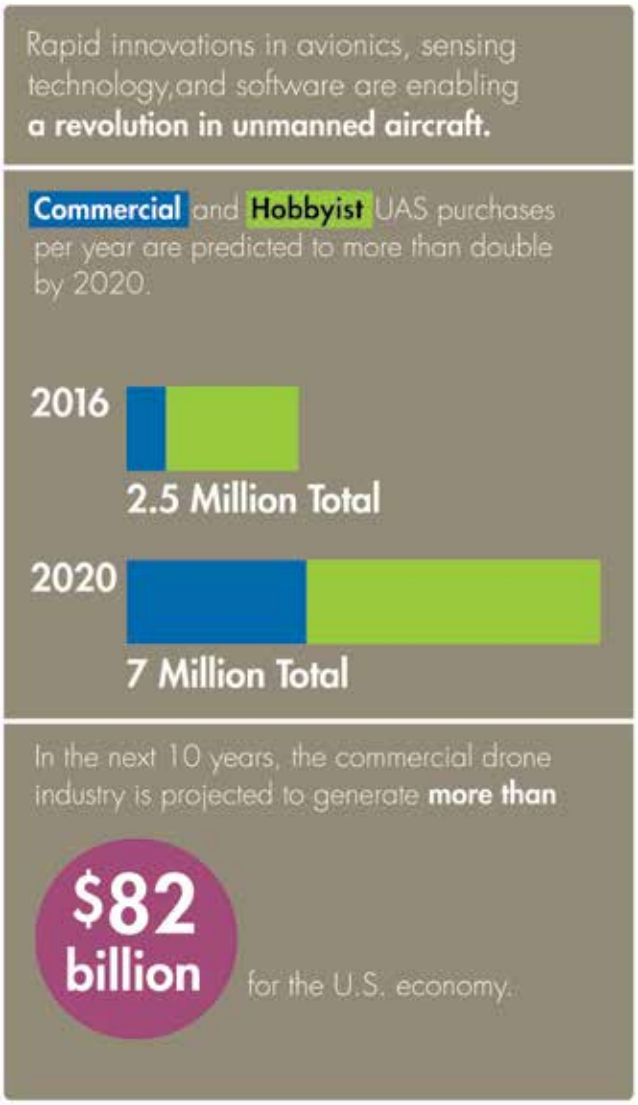
Safe, efficient introduction of these unmanned aircraft into the national airspace is a shared responsibility. At the Volpe Center, multidisciplinary, multimodal teams of engineers and technology, policy, and data analysts are working with partners at FAA, DoD, the National Aeronautics and Space Administration (NASA), and other agencies to advance UAS integration.

Opposite: FAA is changing the operational procedures at our nation's major airports to allow for more departures and fewer delays, under specific conditions.

Photo: 123rf.com/Joerg Hackermann.

Volpe Center experts also collaborate with UAS researchers in government, industry, academia, and across the entire transportation community. Here are just a few examples of the Volpe Center's work in the emerging area of unmanned aircraft systems.

- **To improve UAS safety**, the Volpe Center creates models and fast-time simulation systems; designs minimum operational performance standards and functional requirements for command-and-control communications; and plans and executes ground-based sense-and-avoid systems that provide government UAS operators with real-time displays of aircraft in nearby airspace.
- **To increase efficiency**, the Volpe Center is working on national airspace integration planning and research through the design and evaluation of automated flight systems; is developing processes for UAS operators to apply for airspace authorization; and is reviewing how more drones in the national airspace will affect current and planned operations and infrastructure.
- **To ensure sustainability**, the Volpe Center analyzes the noise characteristics of drones; provided a benefit-cost analysis and



Source: U.S. DOT/Volpe Center.

recommendations for using drones in U.S. Forest Service operations; and is developing an operational safety assessment for measuring high-altitude atmospheric radiation; and

- **To provide industry and policy analysis**, the Volpe Center collaborates with public, private, and academic institutions to establish plans for UAS integration; identifies technologies that will enable growth for the military and commercial drone markets; and provides intelligence on complex multimodal systems toward integrating drones into new modes, such as for pipelines and rail inspections.

(Sponsored by DoD, DOE, FAA, NASA, and USDA)

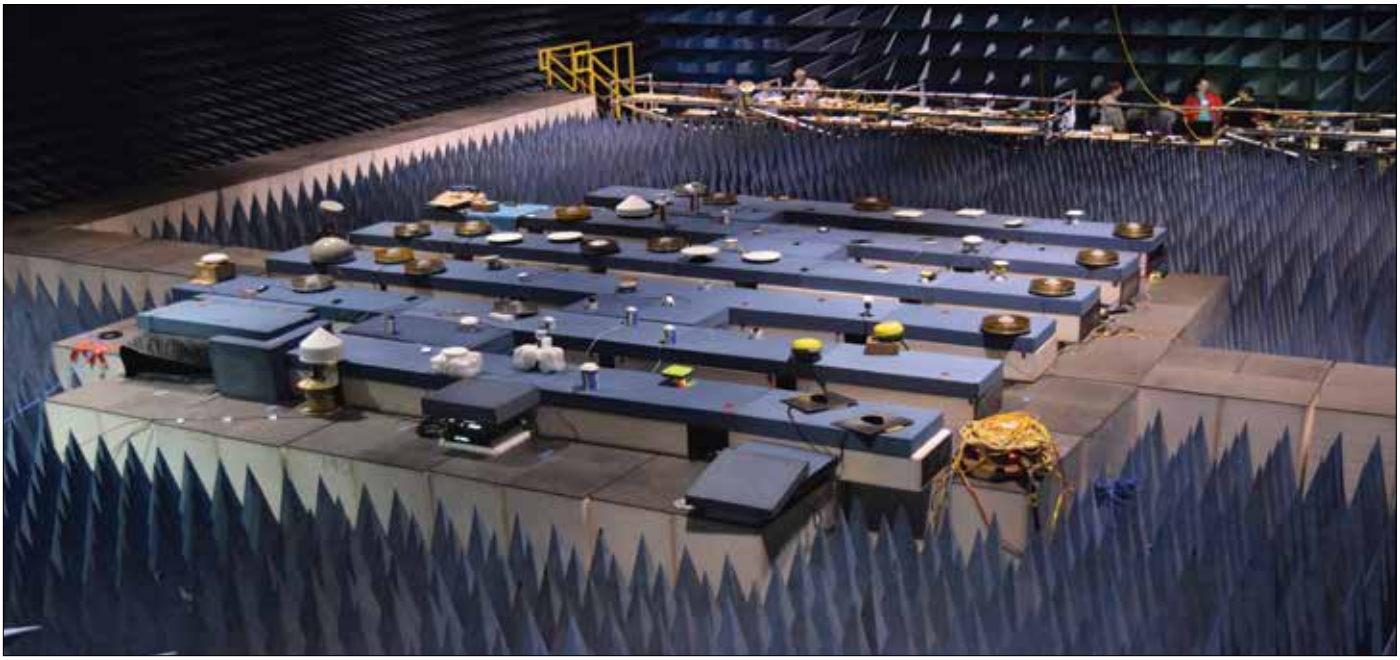
Keeping America Competitive and Safe with the Global Positioning System

Wireless networks connect people to goods and services, provide access to transportation, support public safety and security, and keep America productive in a competitive global economy. America's economic and national security needs depend on the availability of radiofrequency spectrum, including radiofrequencies used for the global positioning system (GPS) and Global Navigation Satellite Systems (GNSS).

GPS/GNSS is a radio navigation system that receives and digitally processes signals from a satellite constellation, providing position, velocity, and time. Given that signals for GNSS are broadcast at very weak power levels from approximately 20,000 kilometers in space, the GPS Adjacent Band Compatibility Assessment Program is developing GPS spectrum interference criteria to inform proposals for non-space, commercial uses of the bands that operate next to GPS/GNSS signals.

The recommended criteria would ensure that future proposals for commercial use of the bands adjacent to GPS/GNSS signals are implemented without compromising space-based Position, Navigation, and Timing services essential to the nation's economic, public safety, scientific, and national security needs. This work directly supports a 2010 Presidential memorandum on wireless broadband use, which requested that 500 MHz of federal and nonfederal spectrum be made available over the next 10 years.

The Volpe Center drafted and released a final GPS Adjacent Band Compatibility Test Plan designed to collect data that will be used to develop Interference Tolerance Masks (ITMs) to reflect the power levels that can be tolerated by GNSS receivers. The ITMs will be developed based on a 1-dB degradation in the carrier-to-noise density ratio, and will be used in conjunction with propagation modeling and use case scenarios to propose acceptable power levels of adjacent band transmitters. The Volpe Center also drafted a detailed test procedure outlining the setup, configuration, test runs, and equipment necessary to conduct testing.



GPS Adjacent Band Compatibility testing at the Army Research Laboratory's Electromagnetic Vulnerability Assessment Facility anechoic chamber, White Sands Missile Range, New Mexico. Photo: WSMR staff.

In April 2016, the Volpe Center coordinated a large-scale GPS/GNSS receiver test campaign at the Army Research Laboratory, Electromagnetic Vulnerability Assessment Facility at the White Sands Missile Range in New Mexico. Federal and industry partners, including GNSS receiver manufacturers, tested 80 receivers.

Data from the test will be used in conjunction with models and algorithms being developed to propose acceptable power levels of transmitters that can be used in the adjacent spectrum. This will enable better and more efficient use of the radiofrequency spectrum, while protecting GPS/GNSS use for transportation applications related to aviation, maritime, surface, and space—in addition to the numerous other applications for first responders, law enforcement, surveying, precision agriculture, earthquake monitoring, and commerce.

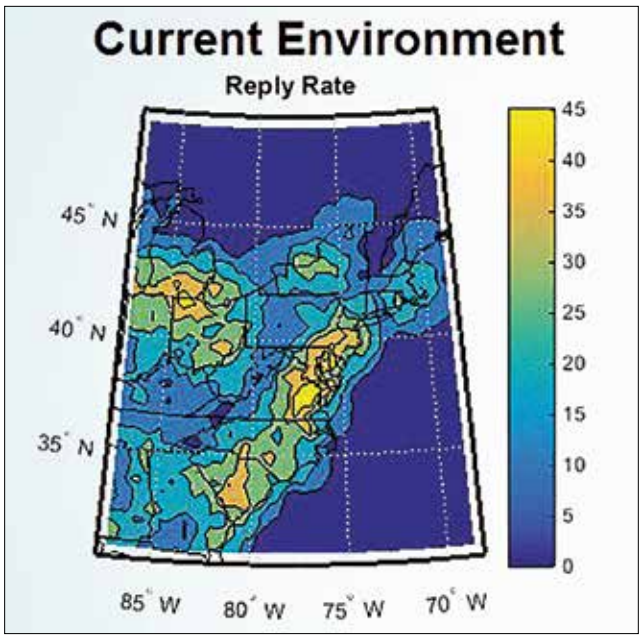
(Sponsored by FAA and OST-R)

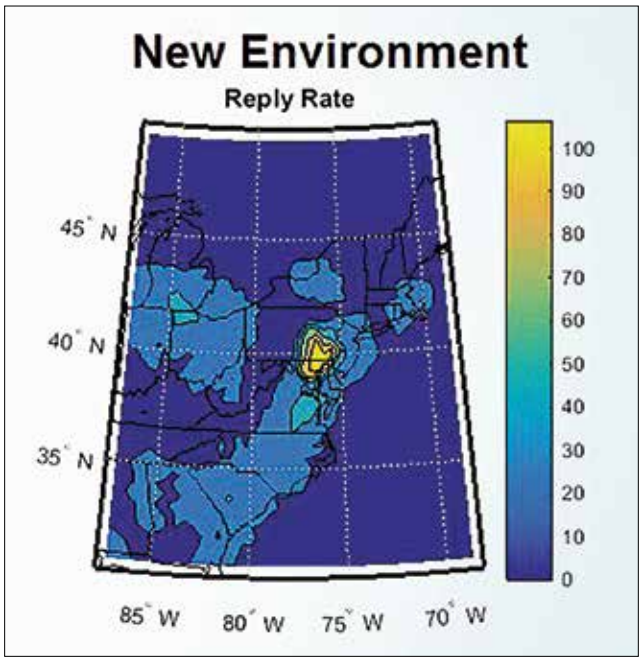
Enabling NextGen: Spectrum Protection for Surveillance Systems

Communication is an essential aspect of safe flight, not only between pilots and air traffic control towers, but also the communication that takes place between technological systems. A disruption between radio navigation tools could cause problems for pilots during the most critical moments of flight. Air traffic controllers losing a plane's identification, altitude, or speed could potentially put passengers, crew, and other airborne vehicles in danger.

FAA Spectrum Engineering Services rely heavily on the 1030 and 1090 MHz transmission frequencies to ensure adequate protections for safety-of-flight systems. The frequencies, however, are also regularly used by DoD for identification system development and radar training. Use of the 1030/1090 MHz bands above their performance threshold could degrade or deny FAA's use of aeronautical radio navigation services (ARNS) supporting air traffic control and aircraft collision avoidance.

Seeking a resolution, FAA, DoD, and the National Telecommunications and Information Administration, the agency that governs federal spectrum use, came together in the Identification Friend or Foe Technical Working Group to solve the problem. A 1030/1090 MHz spectrum environment and system performance model built from the ground up with oversight by both agencies was seen as an





The Volpe Center 1030/1090 MHz Analytical Environment and System Performance Model Reply Rates. Source: U.S. DOT/Volpe Center.

adequate solution that would allow DoD use of the bands when necessary.

On behalf of FAA, the Volpe Center used its wealth of on-site technology and expertise to develop all of the components for an interim model, which would better protect the lines of communication vital to air transportation. A Volpe Center team, in collaboration with FAA, built the interim model and crafted its architecture and taxonomy.

The model charts the locations of air traffic control surveillance systems and uses color gradients to indicate the impact DoD use would have on the systems. The Volpe Center's support of FAA for this project will continue into the foreseeable future.

(Sponsored by FAA)

Electronic Data Communications Reduce Takeoff Times at the Nation's Airports

Data communication is the backbone of NextGen, FAA's national airspace modernization program. With support from the Volpe Center, many air traffic controllers can now send routine instructions, such as departure clearances (DCLs), electronically and directly to flight decks.

Electronic data communication cuts down on potential miscommunications that can occur during radio exchanges. Because electronic data communication is instantaneous, it can reduce takeoff times and departure delays when controllers revise routes.

Volpe Center technical experts were instrumental in leading tests of automated systems that issue DCLs at Memphis, Tennessee, and Newark, New Jersey air traffic control towers. The Volpe Center partnered with the FAA Data Communications Program Office and Harris Corporation to conduct these trials, which allowed the Volpe Center and FAA to refine requirements for DCLs, develop strategies to reduce risks, identify benefits of electronically communicated DCLs, develop lessons learned, and stimulate interest in data communications from the airline and avionics community.

These tests demonstrated reduced takeoff times for aircraft equipped with DCL services. As a result, electronic DCL communications have been installed at more than 56 airports, where controllers can transmit complex instructions and route information directly into the flight management system of an aircraft. Volpe Center staff served as lead subject matter experts for eight DCL installations,

Starting January 1, 2020, aircraft must be equipped with ADS-B Out to fly in controlled airspace. Source: U.S. DOT/Volpe Center.

including at airports in New York, Boston, Philadelphia, and Houston.

The Volpe Center's electronic data communications efforts on behalf of the FAA have resulted in significant benefits, including reduced voice traffic on air traffic control clearance frequencies and reduced controller workload. The work has also allowed initial and revised routes to be auto-loaded into flight management systems, and air operations center messages are synced with flight decks, reducing time between taxiing and departure.

In 2016, Volpe Center staff were also assigned the Federal Aviation Regulations Part 129 program coordinator role and were responsible for bringing international operators into the DCL program. In this capacity, Volpe staff coordinated with FAA principal operating inspectors to update international operations specifications for DCL use in the U.S.

(Sponsored by FAA)

ADS-B Service Availability Prediction Tool Increases Flight Efficiency

The Automatic Dependent Surveillance-Broadcast (ADS-B) Service Availability Prediction Tool (SAPT) is an XML-based web service, used by flight planning software to check for ADS-B compliance with navigation integrity and accuracy. ADS-B is a critical component of FAA's NextGen system. It combines GPS data with aircraft identification and altitude information. Aircraft avionics broadcast this highly accurate information to ground stations, which is then relayed to air traffic controllers.

SAPT takes into account aircraft avionics and the location and time of GPS satellites. Prior to departure, pilots, dispatchers, and airlines are able to verify whether performance requirements will be met for the duration of the flight. If not, SAPT will provide an authorized flight deviation, provided alternate surveillance is available.

Starting in 2020, the FAA's ADS-B Final Rule will require aircraft in certain airspace within the Continental United States, Alaska, Hawaii, and U.S. territories to transmit ADS-B Out messages that meet specific performance requirements. Pilots and airline dispatchers use SAPT to determine if their planned route will provide air traffic controllers with accurate position information for the entire flight. If the performance values are below ADS-B requirements, it may mean certain airspace cannot be used efficiently.

In 2010, the FAA tapped into the Volpe Center's expertise in program management and system engineering to design, develop, deploy, and manage SAPT, using the FAA system engineering process. The Volpe Center continues to provide technical and program support and has taken a lead role in testing and evaluation; reaching out to industry forums and working groups, providing feedback to the FAA, and making system enhancements based on FAA requirements. The SAPT system is deployed at the William J. Hughes Technical Center in Atlantic City, New Jersey.

SAPT allows pilots and dispatchers to conduct more reliable flight planning. This enables airlines to have a higher number of available routes, and in turn decreases delays and increases throughput in the national airspace system (NAS). The result is improved efficiency, fuel savings, and increased revenue.

(Sponsored by FAA)

Surface Weather Observation Systems Improve Runway Range Visibility

Innovative weather-sensing technologies at our nation's airports help aircraft takeoff and land safely in adverse conditions, making air travel safe for passengers and crew. FAA called upon the Volpe Center to gather data to determine if surface weather observation system visibility sensors could effectively provide critical runway information at airports not equipped with Runway Visual Range (RVR) sensing systems. Per FAA regulations, RVR information is needed when low-visibility conditions exist in order for pilots to know if they can safely and legally take off or land.

Pictured above are the Belfort PV (left) and PC-RVR sensors (right). These sensors support precision landing and takeoff operations in the NAS during adverse weather conditions.

Photos: U.S. DOT/Volpe Center.

Surface weather observation systems are located at airports to monitor weather conditions, and are used for surface visibility and viewing obstructions such as fog or dust. Different categories of equipment have their own sensor capabilities. The Volpe Center conducted research and testing to determine the technical limitations of the visibility sensors contained in these weather observation systems. Researchers then compared the surface weather observation system visibility data to visibility data produced by RVR systems at a low-visibility field test site—the Volpe Center Aviation Weather Research Facility at Joint Base Cape Cod—and at multiple airports around the country.

The Volpe Center and FAA found that when co-located, surface weather observation system visibility data closely tracks RVR system visibility data. A findings report was completed, describing three alternative methods for using surface weather observation system data to provide reliable and accurate RVR-like information to support low-visibility operations at airports that do not have an RVR system. The report also contains an initial analysis of the number of U.S. airports that would potentially benefit from this alternative method of measuring visibility in the runway environment, and provided guidance for a follow-on business case analysis.

This concept could increase the capacity and efficiency of the NAS by enabling low-visibility operations without requiring substantial infrastructure investments if an RVR system is not already in place. It would be especially helpful at smaller airports, where the purchase and installation of an RVR system may be a significant financial burden, and may reduce technological redundancies at airports around the country.

This effort provided FAA with data needed to prioritize investments in NextGen weather-related systems.

(Sponsored by FAA)

Wake Turbulence Analysis Improves Airport Efficiency

Volpe Center technical experts collect, process, and analyze aircraft wake turbulence data from airports, and provide the FAA with recommendations to improve terminal air traffic safety and increase efficiency. These analyses address safe alleviation of both closely spaced parallel runways (CSPRs) and single runway wake turbulence constraints on arrivals and departures.

Recently, FAA achieved several significant milestones with support from the Volpe Center.

Wake Turbulence Recategorization I (RECAT I) has been implemented in 11 Terminal Radar Approach Controls (TRACONS) and 23 airports, including the New York TRACON. The new standards allow more efficient arrival and departure sequences that have had a positive impact on surface movements—especially during peak operation periods. In New York, RECAT has enabled John F. Kennedy International Airport to operate minus one runway due to a runway renovation, without any overall loss of efficiency.

Likewise, the CSPR Arrival Rule Change has had a positive impact at San Francisco International Airport (SFO). SFO ATC has increased the instrument condition called rate for runway 28s from 30 to 34 arrivals per hour. Operational experience indicates that at times the actual throughput is higher than 34.

Recategorization Phase II or RECAT II is an enhancement of the aircraft single runway spacing defined in the early implementation of RECAT I. RECAT II is based on additional data and analysis and establishes a set of static pair-wise, instead of categorical, wake separation minima for both aircraft arrivals and departures. Optimization and categorization for implementation of RECAT Phase II pair-wise separations occurs after the approval of the pair-wise separation minima, allowing customization of implementation on a site-specific basis. Phase II's safety assessment was approved in October 2015 and the pair-wise separations were accepted. The first implementation was completed in September 2016 at Southern California TRACON.

(Sponsored by FAA)

Integrating Space Vehicle Operations into the National Airspace System

With the introduction of commercial space vehicle operators, the number of orbital and sub-orbital passenger space flights is expected to increase significantly over the next decade. FAA's NAS Future Concepts program conducts critical research to understand the impact of space vehicles on routine aircraft operations.

FAA's NextGen Space Vehicle Operations (SVO) concepts focus on the introduction of space vehicle trajectories into existing NAS human and automation systems. While FAA currently blocks large areas of airspace for extended periods around space vehicle activities, SVO concepts introduce automation procedures to block airspace dynamically, and only when needed. This reduces the impact of space vehicles on air traffic, while also maintaining a high level of safety.

FAA conducted a series of SVO Hazard Risk Assessment and Management (HRAM) Human-In-the-Loop (HITL) activities to demonstrate and evaluate the SVO concept for space vehicle launch and re-entry. HITL test procedures were performed at the NextGen Integration and Evaluation Capability (NIEC) facility at the William J. Hughes Technical Center in New Jersey.

The Volpe Center supported the activity by modifying the Enhanced Traffic Management System software to process and display space vehicle trajectories and the associated hazard areas, or no fly zones. The Volpe Center integrated and tested the software in the NIEC lab, and actively supported two weeks of demonstrations of the SVO concepts with air traffic controllers and subject matter experts. The Volpe Center-modified software, known as NextGen Traffic Management System (NTMS), supports concept demonstration and evaluation by air traffic managers.

Following the success of this project, the Volpe Center continues to support the FAA by further enhancing NTMS to evaluate a spectrum of space vehicle configurations and scenarios. NTMS is contributing to other activities, including research and evaluation of advanced automation capabilities for future air transportation systems.

(Sponsored by FAA)

Surface Automation and Mobility

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

Assessing Current Regulations and Challenges of Automated Vehicles

Automated vehicles could profoundly transform the nation's transportation network over the next decade. Companies such as Google and Audi, among others, are already testing automated vehicles on public roads and highways. The benefits of this emerging technology could include thousands of lives saved each year, improved accessibility to all modes of transportation, and lower operating costs for moving goods and people.

To prepare for this coming wave of new technology, policy makers, public agencies, technology developers, and automotive manufacturers must understand how the existing regulatory environment applies to automated vehicles. The Volpe Center, in support of the Intelligent Transportation Systems Joint Program Office (ITS JPO) and in coordination with the NHTSA, conducted a review of the Federal Motor Vehicle Safety Standards (FMVSS) to understand the extent to which the existing standards might create certification challenges for manufacturers producing increasingly automated vehicle technologies. NHTSA establishes the FMVSS, which are minimum safety standards for motor vehicles and vehicle equipment. Standards requiring further review were identified to ensure existing regulations do not unduly stifle innovation, while confirming automated vehicles perform their functions safely.

Volpe Center staff reviewed each of the FMVSS to identify references to a human driver, as well as standards that could create challenges for automated vehicle capabilities and concepts. Volpe staff identified many standards that refer to a driver in a way that could be ambiguous for automated vehicle concepts. The review revealed there are few barriers for automated vehicles to comply with FMVSS, as long as the vehicle does not significantly diverge from a conventional vehicle design. Automated vehicles that push the boundaries of conventional design—alternative cabin

Opposite: The city of Columbus, Ohio was selected as the winner of the U.S. DOT's Smart City Challenge, due in large part to its holistic plan for using advanced technology to connect citizens with more opportunities.

Photo: iStock/aceshot.

layouts or omission of manual controls—would be constrained by the current FMVSS or may conflict with FMVSS policy objectives.

At the request of NHTSA, the Volpe Center summarized the research findings and published a report, *Review of Federal Motor Vehicle Safety Standards (FMVSS) for Automated Vehicles*. The report was made available to the public as part of a NHTSA press release on March 11, 2016. NHTSA Administrator Mark Rosekind said, "The Volpe Center report is a great first look at the current standards, and it highlights the need for the actions Secretary Foxx outlined in January." These actions included a budget proposal for a 10-year, $3.9-billion investment in advancing autonomous vehicle technology.

The report helped set a strong foundation for public meetings on the topic of automated vehicles and significantly informed the landmark Federal Automated Vehicles Policy released by the U.S. DOT on September 20, 2016. In a March 16, 2016, speech at the Autonomous Car Detroit conference, Administrator Rosekind referred to the report as "comprehensive and authoritative." "It is extraordinarily helpful to NHTSA to have the Volpe Center's careful and detailed third-party analysis as a roadmap for our future activities." The report has been widely cited in a number of technology, policy, and industry journals.

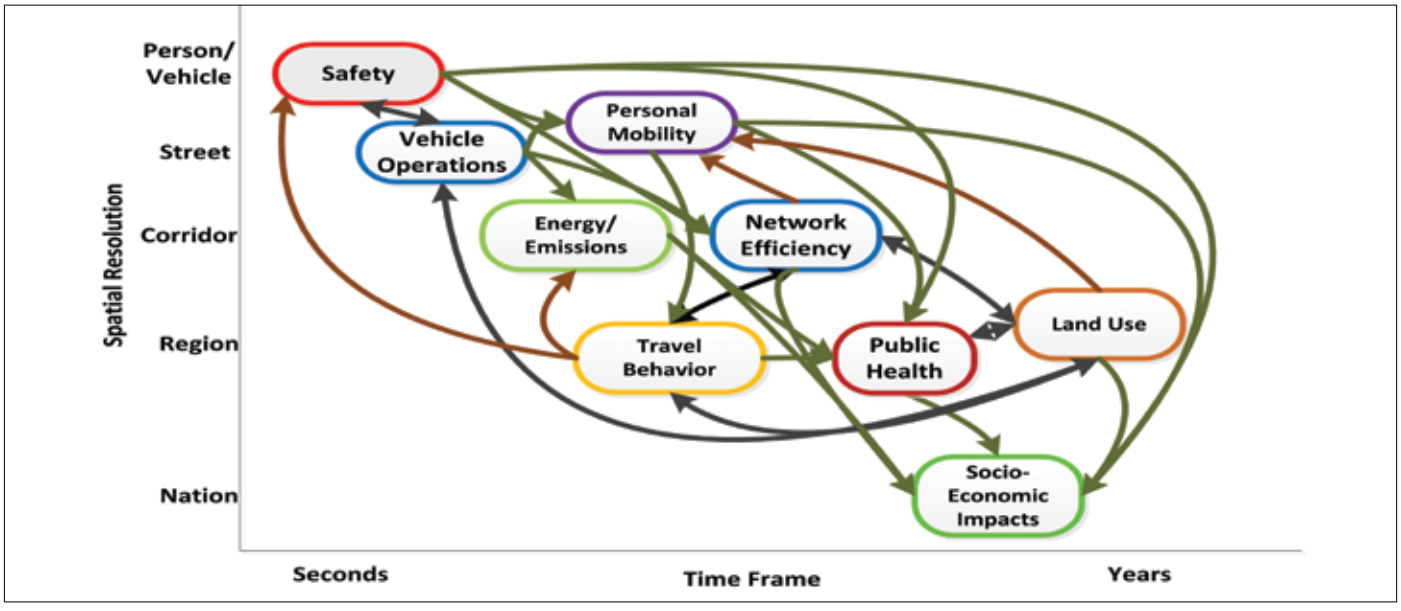
(Sponsored by ITS JPO and NHTSA)

A Framework for Automated Vehicle Impacts

Automated vehicles could potentially change the surface transportation system in the very near future. The benefits of automated vehicles may include improved safety on the nation's highways, a more efficient transportation network, reduced energy/emissions, and improved personal mobility.

Automated vehicles are being introduced into a complex transportation system. Second-order impacts, such as the possibility of increased vehicle-miles traveled, are of significant concern. Given the complexity of the impacts, the ITS JPO turned to the Volpe Center to develop a modeling framework that would facilitate the assessment of the broader impacts of automated vehicles.

The Volpe Center's modeling framework includes the following areas: safety, vehicle operations, personal mobility, energy/emissions, network efficiency, travel



Elements of the Automated Vehicle Benefits Framework. This diagram illustrates the challenges of determining the far-reaching impacts of automated vehicles. Source: U.S. DOT/Volpe Center.

behavior, public health, land use, and socio-economic impacts. Federal and state DOTs may use this framework to support policy analysis. State DOTs and metropolitan planning organizations may use it for long-range scenario-based planning, where various automation futures are envisioned. Automakers and after-market equipment manufacturers may use the framework to better understand the potential benefits of their offerings.

An initial report on the framework was published in late 2015. It was presented at the Automated Vehicles Symposium, the Transportation Research Board Annual Meeting, the Society of Automotive Engineers Government Industry Meeting, and the Field Operational Test Networking and Data Sharing Support workshop in the United Kingdom. The Europe-United States-Japan Automation in Road Transportation Working Group is currently considering the framework in its effort to harmonize automated vehicle impact assessment around the world.

(Sponsored by ITS JPO)

Global Outreach for Automated Vehicles

Automated vehicles have captured the attention of industry, government, academia, and the general public. As a result, a wide range of stakeholder groups have become increasingly interested in the potential benefits of automation, such as better vehicle safety and improved mobility for those currently unable to drive.

In support of the ITS/JPO, the Volpe Center has played a key role in conducting and coordinating stakeholder outreach activities around automated vehicles, both domestically and internationally. Stakeholder outreach informs development of the ITS JPO's research program and provides participants with new information and opportunities to learn from each other. For example, the Volpe Center team organized a state roundtable discussion on automated vehicles, bringing together representatives from DOTs and Departments of Motor Vehicles from states that have enacted automated vehicle-specific legislation. As part of the roundtable, these early adopter states discussed the unique policy and regulatory challenges they faced from the introduction of highly automated vehicles and highlighted the importance of federal coordination in this area.

The Volpe Center automated vehicles team has also helped develop an automation webinar series with the ITS JPO's Professional Capacity Building Program, to raise awareness and educate key audiences on the topic. Topics have included Fundamentals of Automated Road Transport,

Members of the July 2016 Tri-Lateral EU-US-JP Automation in Road Transportation Working Group meeting facilitated by the Volpe Center. Photo: U.S. DOT/Volpe Center.

Automated Vehicles and Policy, Transportation Planning and Road Transport Automation, and Automation in Europe.

In addition to direct stakeholder outreach, the Volpe Center participated in a variety of working groups, panels, and committees within the research community, such as the American Association of Motor Vehicle Administrators, National Cooperative Highway Research Program, American Association of State Highway and Transportation Officials, and the Society of Automotive Engineers to support information exchange and coordination on behalf of the U.S. DOT.

International research exchange builds upon the work of the Europe-United States-Japan Automation in Road Transportation Working Group, a multi-sector government-to-government group facilitated by the Volpe Center, under the guidance of existing bilateral agreements between OST-R and the Volpe Center's international counterpart agencies. The relationships developed with colleagues around the world allow researchers to learn from one another.

(Sponsored by ITS JPO)

Using Naturalistic Driving Data to Create a Baseline of Real-World Truck Platooning Behavior

A truck platoon is a group of vehicles traveling together in the same lane with short following distances. Grouping heavy trucks in platoons can increase road capacity, improve safety, save fuel, and reduce greenhouse gas (GHG)emissions. These benefits can only be achieved, however, if the vehicle platoon functions in an automated, coordinated manner.

Enabling technologies for automated vehicle controls are currently a major research focus of the U.S. DOT and private sector. However, there is little real-world data on how trucks follow other vehicles on freeways, making it difficult to assess the possible impacts of automated truck platooning on vehicle safety, fuel efficiency, and emissions.

FHWA's Turner-Fairbank Highway Research Center asked the Volpe Center to generate a baseline of information the agency could use to develop automated truck platooning applications. The Volpe Center's advanced vehicle technology experts studied heavy truck platooning behavior

The U.S. DOT is studying automated vehicle controls for heavy trucks, which may increase road capacity, improve safety, and reduce GHG emissions. Photo: 123rf.com/Carolyn Franks.

using in-house naturalistic driving datasets, which contain objective data that represents how truck drivers drive on freeways in the real world. The results quantified how trucks follow other vehicles in various environmental conditions and how closely a truck follows a lead vehicle when other vehicles cut in.

The Volpe Center used this information to assess the safety impact of trucks following at different gaps by estimating the probability of a rear-end crash, using the in-house Safety Impact Methodology (SIM) tool. The SIM tool is a Monte Carlo, computer-based simulation tool that estimates how crash frequency in various driving conflicts would be affected by different conditions. It simulates driver response conditions based on studies of how drivers respond to rear-end crashes.

Key results showed that trucks follow at average headways of about 2 seconds on freeways. Trucks generally follow at shorter headways when they were following a passenger car compared to a heavy truck, on state freeways compared to interstates, in clear weather compared to rain or snow, and during the day compared to at night. Cut-ins generally did not occur when trucks were following a lead vehicle at less than 25 meters or a 1-second headway. Crash risk increased considerably at headways of less than 1 second for manual response times, and very little crash risk was observed even at 0.5 second headway for automated response times.

The Volpe Center has pioneered the research in this area. Previous studies did not break down real-world heavy truck following behavior by lead vehicle type under a variety of driving conditions, quantify cut-in behavior of other vehicles during following scenarios, or evaluate the potential impact of different headways.

Results from this study will be useful to FHWA when the agency develops automated truck platooning applications. Based on the Volpe Center's findings, headways of around 1 second might satisfy the following behavior criteria of an automated truck platoon; feel natural and comfortable for the truck driver; prevent other vehicles from cutting in between platooning trucks; and minimize crash risk.

(Sponsored by FHWA)

Investigating Wearable Sensors in Transportation Research

For decades, the travel diary has been one of the transportation researcher's most valuable tools. Participants in travel studies use diaries to record where they go, how they get there, and other key information.

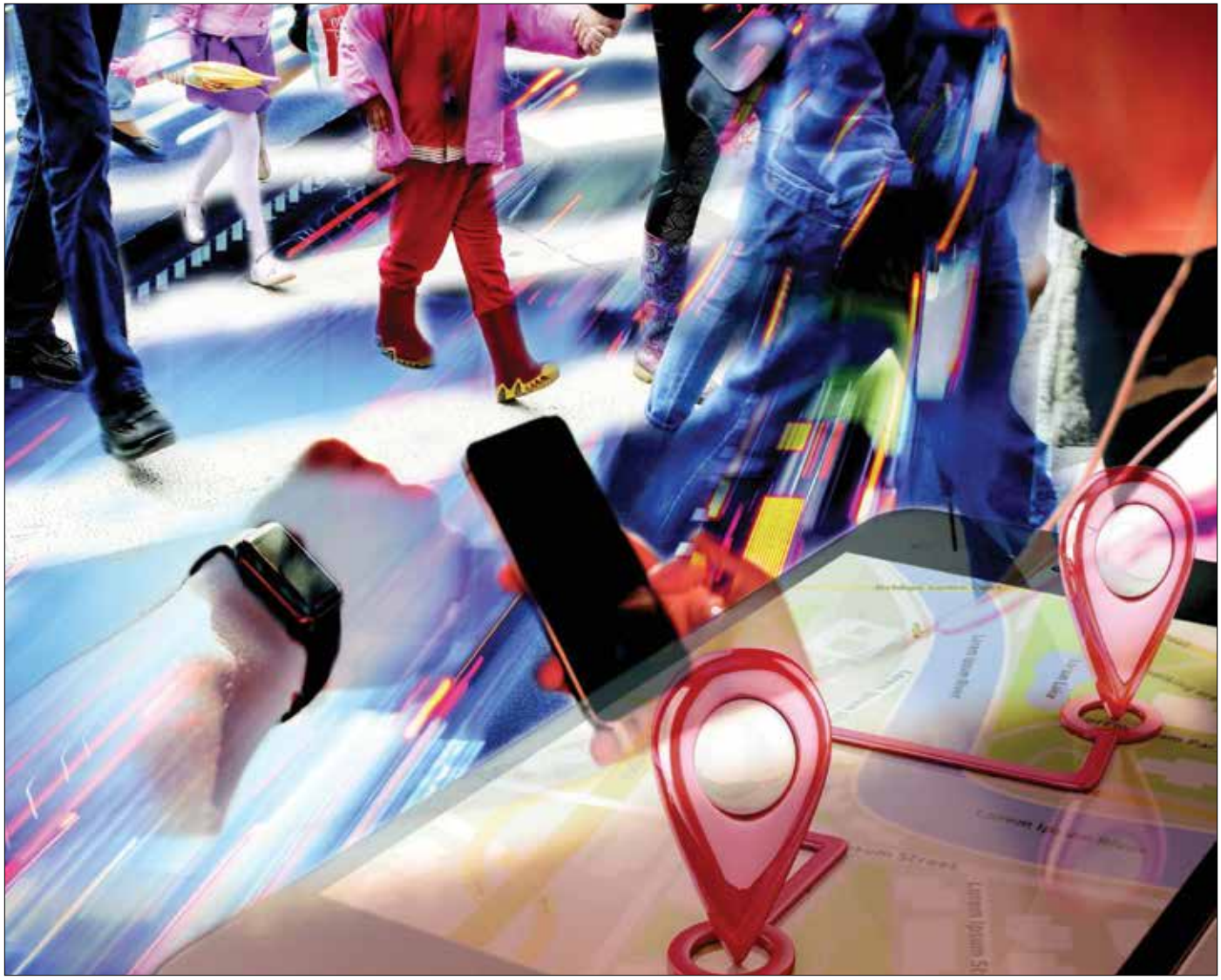
The emergence of wearable sensors has opened up new levels of data granularity for transportation researchers. Wrist sensors, for example, can tell researchers with pinpoint accuracy where participants have been, the routes they have taken, and how much time they spend traveling.

Volpe Center planners interviewed researchers from federal agencies, local governments, and the private sector to produce an investigatory paper on the state of the practice for wearable sensors, and the challenges in using them for transportation research.

Today's wearable sensors are small, efficient, and accurate enough for certain kinds of transportation research. They are often carried directly on a person's body, typically as a wristband or jewelry. But, some research-grade sensors can be prohibitively expensive and bulky, particularly for air-quality monitoring.

Volpe Center experts found that transportation agencies are moving slowly to adopt wearable sensors in their research. Having great data is one thing; knowing what to do with it is another. Many transportation agencies, particularly at the local level, do not have data science expertise. Robust data storage and analysis are essential for getting the most out of datasets with previously unseen levels of detail. At the time of publication, the Volpe team identified only one transportation agency—the Nashville Area Metropolitan Planning Organization—that has used wearable sensors to collect data related to health and active transportation.

Ethics rules for the sciences were developed around traditional biomedical research, and these rules have not kept up with questions raised by always-on wearable sensors that measure very personal variables. Participants' comfort with sharing information can also depend on



Wearable sensors have opened up new levels of data granularity for transportation researchers. Photo: Dreamstime.com

demographics and socioeconomics. A technology enthusiast may willingly share information while someone who is wary of the government may not.

Few transportation agencies today use wearable sensors in their research, largely due to privacy and data management challenges. Volpe Center experts found that the benefits of using fine-grained detail to make the best choices for transportation systems are compelling enough that the authors expect more agencies will overcome these challenges and use wearable sensors in the future.

(Sponsored by FHWA)

Multimodal Payment Applications Encourage Alternative Modes of Transportation

National and international cities are wrestling with traffic congestion and the negative impact of automobile-dependent travel on air quality and climate. Smart cities are embracing initiatives that reduce congestion and manage travel demand by encouraging travelers to make less use of their vehicles and instead take advantage of alternative modes.

The key to this has been encouraging the linking of transit use with shared-use services for personal travel. The range

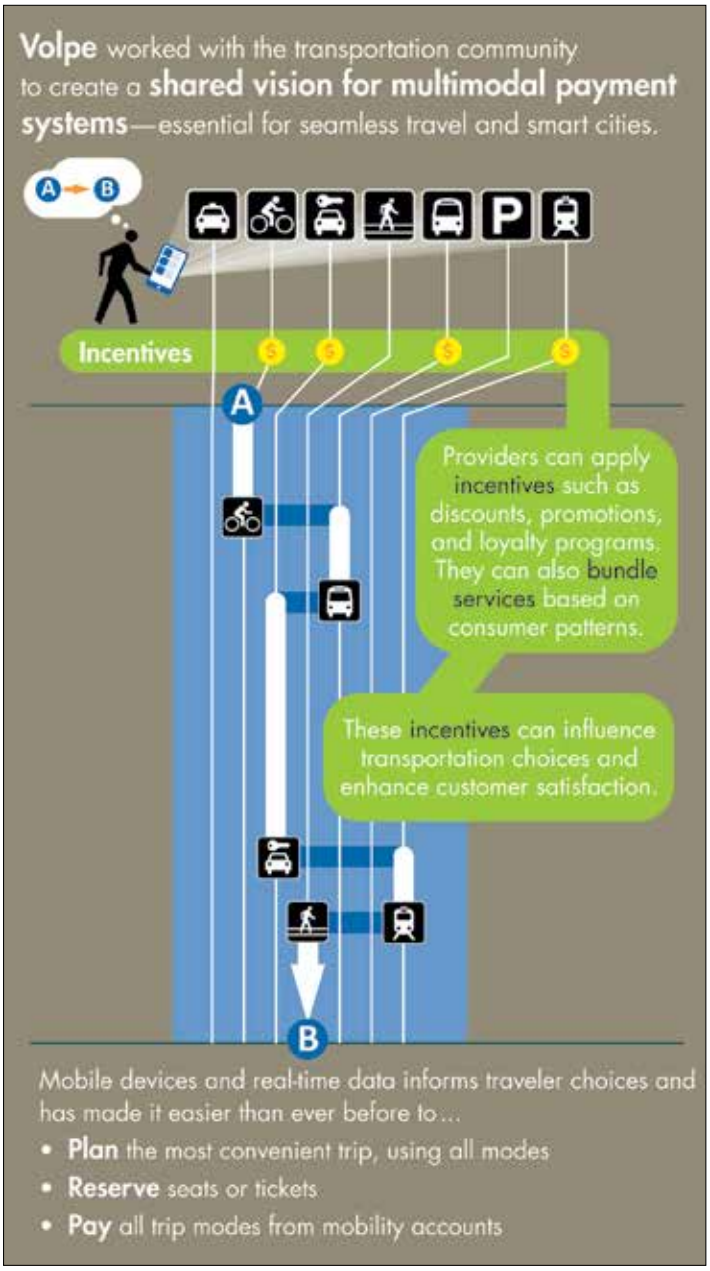
of transportation options in recent years has expanded to include innovative private-sector ridesourcing services such as Uber and Lyft, as well as transit-operated and public-private bike-share and car-share systems. This trend has been facilitated by an assortment of websites and mode-specific smartphone apps that travelers can use to plan their trips, make reservations, and/or pay for the trip in advance. For example, over 70 percent of transit riders in many cities have mobile devices. FTA is sponsoring $8 million in demonstration projects through the Mobility on Demand Sandbox Program, some of which involve multimodal payments.

The challenge for smart cities is how to maximize both the extent and rate of public willingness to break the private-car habit in favor of transit combined with new mobility options. The Volpe Center, with its multimodal expertise and decades of experience in payment innovation, has a vision for making this a reality. That vision is multimodal payment convergence, accomplished through a mobile device app that plans the optimal trip using all available modes, makes reservations if needed, and—most importantly—takes care of payment from a single account. All the user needs to do is plan, select and pay, and travel.

To be successful, this application must capture the imagination of public agencies, the private sector, and the traveling public. On its own initiative, the Volpe Center has taken this innovative idea to conferences and associations over the past three years in an effort to create interest and demand. Presenting the vision, leading workshops, and facilitating interaction with stakeholders has produced tangible industry actions for implementing multimodal payment approaches.

Managing travel demand through multimodal payments is a potential major benefit to smart cities and their transit agencies, and is a main driver in developing and adopting this tool. Los Angeles, famous for its freeway congestion, is creating multimodal payment accounts using its customer relationship management system. Linking customer travel data has helped the city incentivize drivers to switch to riding express buses in a dedicated freeway lane in exchange for a toll credit.

In 2016, multiple transit agencies in Dallas, Texas; Chicago, Illinois; and Portland, Oregon, as well as private sector companies reported progress implementing the Volpe Center vision at major industry conferences, including MIT's Disrupting Mobility Summit, the Smartcard Alliance's 2016 Payment Summit, and American Public



Volpe is a leader in creating interest, encouraging a uniform approach, and giving momentum to advance multimodal payment systems nationwide. Data on payments and travel demand will help optimize services for everyone. Source: U.S. DOT/Volpe Center.

Transportation Association's (APTA) Fare Collection Workshop and Revenue Management Summit.

The Volpe Center will continue to follow progress and carry this innovative concept to new audiences and the public.

(Sponsored by FHWA/JPO and FTA)

Volpe Cargo Tracking System Reaps Efficiencies for UK Ministry of Defence

The United Kingdom's Ministry of Defence (MOD) turned to Volpe's situational awareness and logistics experts to design and develop the infrastructure needed to track and reconcile all payments made on the movement of goods by the MOD. Like the U.S. Department of Defense, the UK MOD relies upon both military and commercial transportation to move its valuable equipment around the world.

After pulling troops from Afghanistan and Iraq, the MOD realized that they did not have all of the required controls in place to track and reconcile payments made on imports and exports. Without proof of payment, these goods are taxable. This will result in import duties being assigned against the original cost of the materials, in addition to the UK Value Added Tax being ascribed to the items at 20 percent each. With the MOD transporting several billion dollars' worth of equipment each year, it was very likely that hundreds of millions of pounds could be levied against them. To address the situation, the MOD set up Programme Waterguard to comply with Her Majesty's Revenue and Customs (HMRC) tax regulations related to the export and re-import of military equipment.

Experts at the Volpe Center, in support of the MOD's Waterguard team, designed and developed the infrastructure to track and reconcile all payments made on

Cargo processed by the Volpe-developed Interim Cargo System (ICS) is being loaded for shipment to forward-operating locations at Royal Air Force Base Brize Norton. Photo: RAF BZN Movements Squadron.

the movement of MOD goods. The Volpe Center has a proven track record in military cargo operations worldwide, and a longstanding working relationship with the MOD.

The Volpe Center took the Internal Cargo System (ICS) developed for the MOD in 2010—an aircraft loading system providing real-time active management of the MOD cargo operations worldwide—and quickly provided the Waterguard team with detailed records of items being moved through ICS. Throughout the first six months of 2016, the MOD reported saving hundreds of millions of British Pounds Sterling.

The Volpe Center performed system development work on-site and provided off-site installation support at various MOD locations in the UK. Additionally, the Waterguard project has had positive impacts in several areas. Not only has the MOD saved millions in taxes already, but with Volpe's assistance they have also made efficiency improvements to the cargo movement process. Perhaps the most tangible long-term result will be a single intermodal transport system to track MOD movements of goods across its joint services, largely based on the Volpe Center's ICS system.

(Sponsored by the UK Ministry of Defence)

Infrastructure Modernization and Resiliency

The Volpe Center collaborates with federal agencies to support civilian and defense infrastructure modernization, maintenance, and resiliency efforts that help accelerate the nation's economic growth and productivity.

Critical Upgrades to the National Airspace Underway

DoD continues to replace outdated equipment in radar approach control facilities it owns and operates across the globe. These upgrades align with FAA equipment and standards, providing essential infrastructure to support a broad range of radar and surveillance systems. The Volpe Center recently completed optimizing the last Airport Surveillance Radar Model 11 (ASR-11), which will provide DoD with state-of-the-art surveillance capabilities.

ASR-11 is an integrated primary (passive) and secondary (active) radar system that is operated at some of DoD's busiest bases. The technology communicates with existing and digital automation systems, providing a calibrated national weather service that enhances situational awareness for controllers and pilots.

Opposite: Hurricane Matthew washed out highways and local roads in Goldsboro, North Carolina in October 2016. Photo: Reuters.

Over the last several years, the Volpe Center has supported the upgrade of DoD's radar display system with newer technology called the Standard Terminal Automation Replacement System (STARS). In 2016, they also added the air traffic control (ATC) NextGen backbone, or ADS-B to several U.S. Air Force sites. This new digital technology is more reliable, has added features, and is able to self-diagnose most failures—allowing DoD to remain compatible with the FAA's ATC infrastructure.

This cooperative effort between DoD and the Volpe Center marks the completion of site preparations for ADS-B deployment at several facilities. DoD will test whether ADS-B is suitable for implementation across the U.S. Air Force by allowing these terminal air traffic control sites to integrate ADS-B with STARS. This work will improve the national airspace by providing more reliable, effective, and safer ATC systems to the DoD. This will benefit U.S. military flight operations as well as civil and commercial aircraft that transit military airspace.

Throughout the entire upgrade process, Volpe Center staff performed site surveys and site preparation for all of the STARS installations. They also served as lead

Volpe Center electronic engineer, Roni Rostom, installs a GPS antenna at Mountain Home Air Force Base in Idaho. Photo: U.S. DOT/ Volpe Center.

engineers for STARS and ASR-11, and managed ASR-11/ STARS optimization. This worldwide effort by DoD and the Volpe Center to upgrade critical radar and ATC systems in the national airspace has been ongoing since 1999, and is expected to run through 2020.

(Sponsored by U.S. Air Force)

Assessing Fire Life Safety Systems at FAA Air Traffic Control Towers and Radar Facilities

Prior planning is the best prevention for the unexpected. The FAA Fire Life Safety (FLS) Program works to ensure the safety of employees and equipment during fires in air traffic control towers (ATCT), radar facilities, and other areas critical to the operation and safety of the NAS. The FLS program provides employees and the NAS with safe, efficient, and dependable FLS systems—ensuring the safety of employees, facilities, and the flying public.

With FLS systems in over 550 facilities located throughout the nation, FAA tapped the Volpe Center to lead a team of experts to develop a standardized process to assess the condition of FLS systems and provide a risk-based ranking method to prioritize facilities in the greatest need of upgrade.

FAA facilities are constantly changing due to evolving technology, required updating of existing equipment, and continuous 24-hour operation. This means that FLS systems can degrade over time, even with systematic maintenance, inspection, and testing.

The Volpe Center organized a panel of FLS and facility condition experts for a three-day discussion of existing

conditional assessment processes, the unique safety issues associated with FLS systems at FAA facilities, and how to strategize the condition assessment and prioritization process. Attendees included representatives from the Volpe Center, FAA, the General Services Administration, and industry representatives. The Volpe Center also established and led a smaller team of experts that focused solely on developing the condition assessment and prioritization process for FAA. The group produced an FLS condition assessment and prioritization process that will be used nationwide.

This process identifies FLS systems with the highest risk for failure and allows FAA to prioritize them for upgrades, reducing the risk of failures at critical facilities and increasing the safety of employees, vital NAS equipment, and passengers.

(Sponsored by FAA)

Hampton Roads Economic Quantification Study to Strengthen Transportation Infrastructure Resiliency

Our national transportation infrastructure is increasingly vulnerable to the effects of climate change and severe weather. Coastal flooding is becoming a more challenging and disruptive occurrence, especially for communities located near tidal zones. Current climate research suggests that global sea-level rise will continue to increase by 0.7 to 6.6 feet by the end of this century. Because of this, coastal communities have an increasing risk to flooding and may be significantly impacted over the coming decades.

The Volpe Center is collaborating with various agencies across U.S. DOT to create a tool that will estimate direct costs and indirect economic impacts of transportation disruption caused by climate change in Hampton Roads, Virginia. Hampton Roads was selected for this project because of its extreme vulnerability to coastal flooding and sea-level rise, which threatens transportation systems and military operations in the area.

Hampton Roads has strategic significance to the U.S., home to the nation's largest concentration of federal facilities, including the world's largest naval station. Environmental experts at the Volpe Center are developing a method that will provide voluntary grantee input for costs associated with infrastructure planning due to climate change and the effects of severe weather.

The Volpe Center's work builds upon similar U.S. DOT climate resilience assessments that have focused on the vulnerability of transportation infrastructure to flooding, sea-level rise, and storm surge. Instead of focusing on one specific asset or limiting the research to specific system consequences, this study takes a holistic view of the full range of economic impacts and indirect costs caused by severe weather. This information is especially useful for decision makers helping to prioritize long-term transportation projects, and will ensure sufficient information is included in asset data management systems. This is the first U.S. DOT project to consider the comprehensive direct and indirect economic costs associated with extreme weather events.

The first phase of the project was completed with the delivery of a baseline study. Conducted collaboratively with several DOT modes, the study summarizes available data, methodologies, and tools that will inform analyses of weather-related disruptions on regional transportation infrastructure. The next phase will utilize this information to develop a method for capturing the economic consequences related to nuisance flooding, sea-level rise, and storm surge in Hampton Roads. In the final phase, the methodologies will be tested at a pilot location in the Hampton Roads area, and later expanded for regional analysis.

The Volpe Center serves as the project's technical lead and has collaborated with stakeholders from Hampton Roads and U.S. DOT, leading the methodology development and ensuring quality deliverables. The baseline study was well received after the Volpe Center team quickly and efficiently responded to over 500 comments from more than 20 government, academia, and industry groups.

This work has fostered strong working relationships between the Volpe Center and the Hampton Roads Transportation Planning Organization and the Hampton Roads Planning District Commission. Representatives from these organizations joined with the Volpe Center team to

present findings during the baseline study briefing held at U.S. DOT headquarters in September 2016.

(Sponsored by U.S. DOT OST-R and FHWA)

On-the-Ground Support during Natural Disasters

Louisiana Flooding

A catastrophic flood struck the state of Louisiana in August 2016, inundating many of the southern parishes. More than 6.9 trillion gallons of rainfall pounded Louisiana in one week, prompting the governor to declare a state of emergency. Considered a once in a thousand year event, the severe flooding stranded tens of thousands of people in their homes and vehicles, and damaged roughly 146,000 private residences. More than 30,000 people were evacuated from submerged vehicles and homes by local law enforcement, firefighters, the Louisiana National Guard, the U.S. Coast Guard, and fellow residents. The Louisiana flooding is considered the worst U.S. natural disaster since Superstorm Sandy in 2012.

To support emergency efforts on the ground, the Volpe Center's Region 1 Regional Emergency Transportation Representative and Emergency Support Function One—Transportation (ESF-1) expert was dispatched to aid the Federal Emergency Management Agency (FEMA) Joint Field Office in Baton Rouge. With thousands of Louisiana residents displaced, FEMA and Volpe Center experts coordinated the deployment of hundreds of Mobile Housing Units (MHUs) to provide temporary housing to survivors. MHUs were deployed in addition to the more than 11,000 state-operated shelters already in place.

Storm cleanup and debris removal were also major priorities. To clear federal-aid highways for emergency

Volunteers help local residents along River Road fill sandbags as the Vermilion River begins to spill over the top of a levee in Youngsville, Louisiana. Photo: Scott Claus/USA TODAY Network.

vehicle access and delivery of reserve supplies, the Volpe Center coordinated with the Louisiana Department of Transportation and Development and state emergency management agencies to secure permits and waivers for debris removal.

Throughout the event, the Volpe Center provided critical transportation situational awareness to the U.S. DOT's Crisis Management Center, regional, state, and federal organizations, voluntary organizations, and the private sector. These efforts were vital for getting manpower and equipment to the areas of Louisiana impacted the hardest by the flooding.

This was not the first time ESF-1 turned to the Volpe Center to coordinate emergency response efforts. Previous ESF-1 deployments include: Regional Response Coordination Center for the 2013 Boston Marathon bombing and the January 2014 and 2015 winter storms; New York City Emergency Operations Center for Superstorm Sandy in 2012; and the Joint Field Office in Vermont for Hurricane Irene in 2011.

Hurricane Matthew

During and after Hurricane Matthew, in October 2016, the Volpe ESF-1 team was on the ground providing critical oversight of emergency response operations in eastern North Carolina. Toll-free emergency routing numbers and additional staff were established to aid FEMA, its trucking contractors, and other federal and state responders with critical routing, road closures, and detour information. Approximately 400 inquiries were successfully answered through the North Carolina Emergency Operations Center. Additionally, the team provided assistance to emergency responders coming into North Carolina from other parts of the country.

Once the storm abated, the ESF-1 team was instrumental in managing the flow of information from four simultaneous response operations, including search and rescue efforts in four states. The team arranged for preliminary damage assessments of rural transit agencies, coordinating with FTA to begin the recovery process. ESF-1 also collaborated with FAA and the U.S. Department of Health and Human Services Administration for Children and Families to provide timely information and considerations for air evacuation and relocation of North Carolina's most vulnerable populations.

(Sponsored by FEMA)

Resilient Transportation Planning in Our National Forests

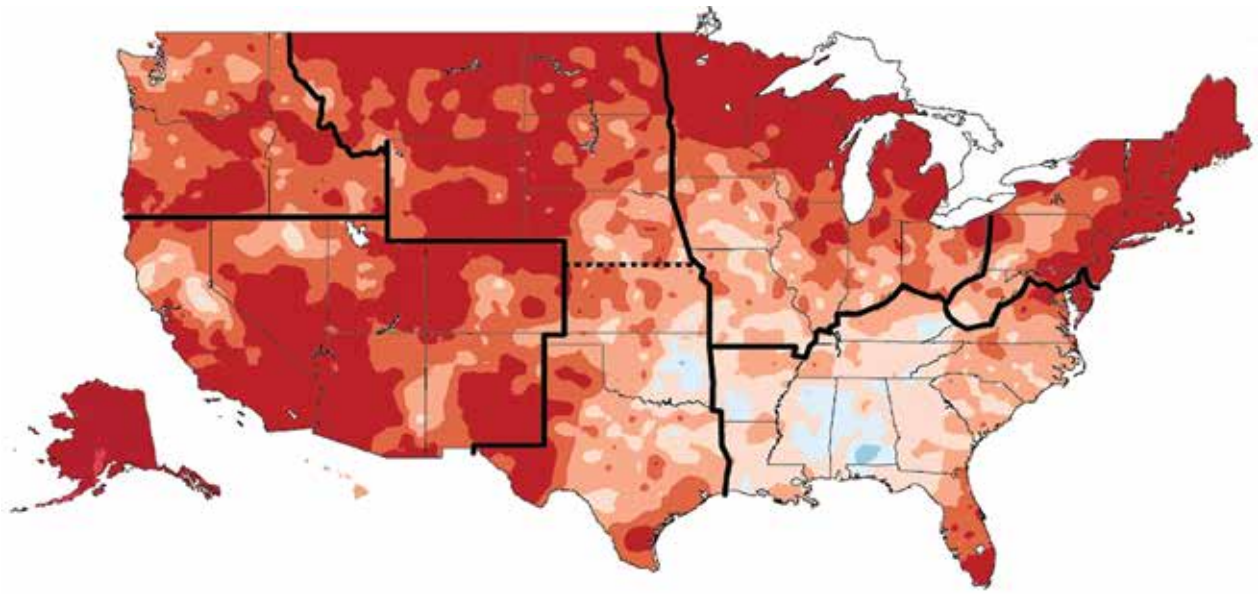
Transportation networks across the nation will need to withstand new climate extremes over the coming decades, and the Volpe Center is moving resilient transportation forward with planning efforts on behalf of the U.S. Forest Service.

The average temperature in the U.S. has increased by 1.3°F to 1.9°F since 1895, with most of the increase happening since 1970. Arctic sea ice along the northern Alaskan coast has retreated dramatically over the past 30 years. Parts of the country are experiencing more extreme precipitation conditions—either much wetter, or much dryer over the past century—with National Forests found in all regions.

As part of its resiliency planning, the Volpe Center helps the U.S. Forest Service transportation program take a proactive approach in assessing climate-related vulnerabilities and adaptation options for transportation systems in the National Forest System.

Severe drought and invasive insect species have led to massive tree mortality in National Forests over the past decade. Some areas may lose 80 percent or more of their trees. Tree fall hazards, increased fuel load, heavy logging traffic, and erosion will substantially impact transportation systems in National Forests.

Several severe storms have led to flooding and washed-out roads. Hurricane Irene in 2011 and the 2013 Colorado floods respectively shut down transportation networks for months in the Green Mountains National Forest and the Arapaho-Roosevelt National Forest.



Average temperatures across the country are increasing. Source: NOAA NCDC/CICS-NC.

A blown out culvert on a trail in Mount Baker Snoqualmie National Forest. Culvert damage from heavy precipitation events is one threat to transportation infrastructure. Photo: U.S. DOT/Volpe Center.

To prepare for increased tree mortality, extreme precipitation, and other severe events, Volpe Center planners compiled lessons learned on climate-related challenges in National Forests. In addition to documenting climate stressors, the Volpe Center has provided national leaders and planners with an inventory of research and analytical resources, case studies, reports based on interviews with Forest Service staff, and process improvements that can make Forest Service transportation networks more resilient.

This project will continue to build a foundation of knowledge that Forest Service leaders will use to make the case for proactive climate change adaptation, and will result in a guidebook for Forest Service planners to improve transportation system resiliency.

(Sponsored by U.S. Forest Service)

Modernizing the Department of Defense's Rail Fleet

The DoD-owned rail fleet includes more than 110 locomotives with an average lifespan of 50 years. This fleet critically needs new, modern equipment to increase the efficiency, reliability, and safety of operations on U.S. Army installations and at U.S. Navy facilities.

An aging rail fleet means increased toxic emissions, poor operational readiness, high maintenance costs, and replacement parts for older trains. The Volpe Center supports DoD's rail modernization efforts, which are lowering the age of DoD's locomotive fleet, reducing harmful emissions, decreasing oil dependency, and improving safety for rail workers.

The program has replaced 30 conventional locomotives with Ultra-Low Emitting multi-engine GenSet locomotives,

The U.S. Army's newest addition to their locomotive fleet, the USAX 6524 is an EPA Tier 4-certified locomotive. Photo: U.S. DOT/ Volpe Center.

which are quieter, more reliable, emit fewer pollutants, and require less fuel. A multi-engine GenSet locomotive, depending on the design, uses two or three engines to equal the power of a conventional single-engine locomotive.

A conventional locomotive might have a 2,000-horsepower engine, while a comparable GenSet would have three 700-horsepower diesel engines. When pulling a relatively light load with a GenSet locomotive, not all engines need to be operating, and the locomotive conserves fuel.

In addition to providing overall program management of the DoD rail modernization effort, the Volpe Center:

- Conducts engineering and safety compliance inspections;
- Develops technical specifications;
- Ensures proper integration of new equipment with existing DoD railway infrastructure;
- Facilitates a monthly teleconference for end users, maintenance personnel, and others;
- Oversees delivery and final acceptance of railroad rolling stock for DoD;
- Provides acquisitions expertise;
- Provides technical and cost analyses; and
- Performs quality assurance inspections.

The U.S. Army's newest addition to its locomotive fleet is an Environmental Protection Agency (EPA) Tier 4 locomotive, which produces significantly cleaner emissions than older engines.

(Sponsored by the U.S. Army Tank-Automotive and Armaments Command–Life Cycle Management Command and U.S. Navy Naval Facilities Engineering Command–Engineering and Expeditionary Warfare Center)

Improving Security at the United States Merchant Marine Academy

Security logistics are challenging at the 82-acre United States Merchant Marine Academy (USMMA) campus in Long Island, New York. There is public access to various facilities, including a Navy Exchange store and a maritime museum. Several student training vessels are located on Long Island Sound, and a subterranean public space links dormitories and dining facilities.

Aerial view of the U.S. Merchant Marine Academy campus in Kings Point, New York. Photo: USMMA Public Relations.

The Volpe Center responded to a U.S. Maritime Administration (MARAD) request to evaluate USMMA's security needs and install a modern security system. The Volpe Center drew upon its extensive experience in designing and deploying physical security systems for federal facilities that have high levels of public access, including for the U.S. Capitol Police in Washington, DC.

Security experts at the Volpe Center collaborated with USMMA, MARAD, and U.S. DOT officials on a needs assessment, then designed and installed a modern security system that meets the unique needs of a federally operated academic institution. Over a three-year period, the Volpe Center technical team, along with legal and acquisitions staff, has issued contracts and managed the installation of hundreds of security devices throughout the campus—all connected by miles of wiring and fiber-optic cable. The team coordinated logistics with local police and emergency services and also trained USMMA midshipmen and staff in implementing a new access system.

The Volpe Center addressed several physical challenges related to this USMMA campus security project. Remote locations for emergency call boxes required access to electric power and communications systems. Devices on piers and waterfront facilities had to withstand the impacts of salt water and high winds. Existing fire and smoke detection systems had to be seamlessly integrated with the new security hardware.

The security system developed by the Volpe Center has significantly reduced risks at USMMA. U.S. DOT, MARAD, and USMMA have recognized the Volpe Center for exceeding expectations. The Volpe Center continues to oversee security upgrades that further strengthen and enhance the core security system at the USMMA campus.

(Sponsored by MARAD)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Energy and Environment

The Volpe Center is a proven leader in helping the nation address its most pressing transportation-related energy and environmental challenges.

Estimating the Impacts of National Fuel Economy Standards

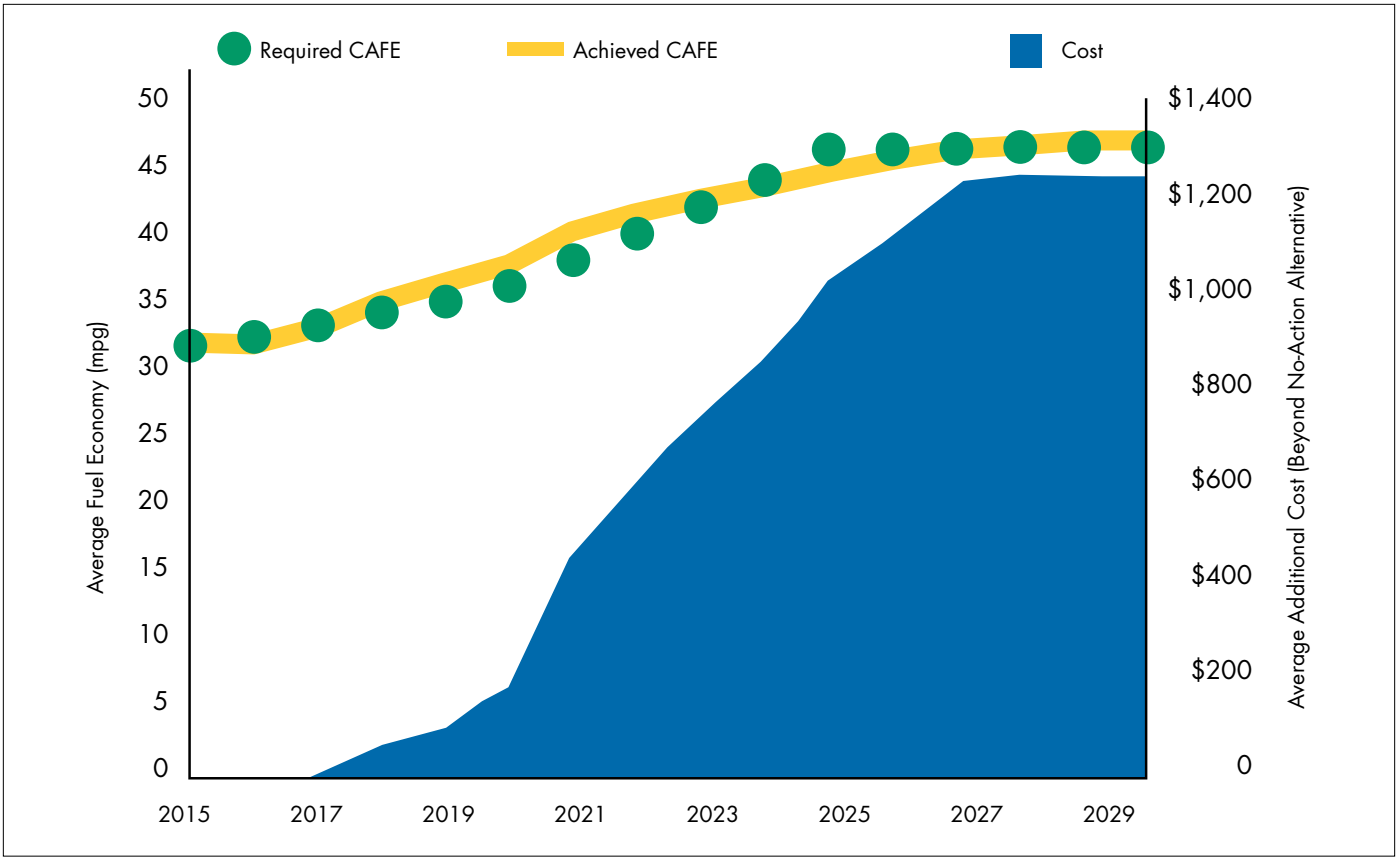
Corporate Average Fuel Economy (CAFE) standards are fleet-wide fuel economy averages that automakers must achieve each year. When CAFE standards are raised, the result is more fuel-efficient cars and light trucks, improvements to the nation's energy security, consumer savings at the pump, and reduced GHG emissions.

Final CAFE standards are in place for the U.S. through 2021. In July 2016, NHTSA—jointly with the EPA and the California Air Resources Board—published a draft Technical Assessment Report (TAR) to inform later CAFE and GHG standards for light-duty vehicles. CAFE standards beyond 2021 remain subject to formal proposal, public review and comment, and finalization. The Volpe Center's latest analysis indicates that if standards are ultimately set at those levels, manufacturers may need to significantly increase the application of fuel-saving technologies such as turbocharging, advanced transmissions, and hybrid-electric powertrains.

The Volpe Center is NHTSA's primary technical resource for the CAFE program, providing key technical analysis for the "midterm review" of current and pending light-duty vehicle CAFE standards through 2025, and the implementation of final fuel consumption standards for medium- and heavy-duty (MDHD) vehicles through 2027.

To provide this support, the Volpe Center has developed and continues to refine the CAFE Compliance and Effects Modeling System, which is used to calculate fuel savings, emission reductions, compliance costs, and consumer and societal benefits of potential new CAFE standards. The team advised NHTSA and the Department of Energy's (DOE) Argonne National Laboratory on a groundbreaking large-scale vehicle simulation study, providing key input to the CAFE modeling system and generating most of the analysis for the draft TAR. NHTSA, EPA, and the Volpe Center

Opposite: The Volpe Center continues to serve as a primary technical resource for NHTSA's Corporate Average Fuel Economy program. Photo: 123rf.com/Peter Titmuss



Estimated average required CAFE levels, CAFE levels achieved in response to those requirements, and increase in cost to purchase a new light-duty vehicle. Source: U.S. DOT/Volpe Center.

also collaborated on proposed standards for MDHD vehicles drafting the final rule (and associated regulatory and environmental impact analyses) and using the CAFE modeling system to analyze the heavy-duty pickup and van segment of the MDHD market.

Fuel economy standards have already led to significant reductions in highway vehicle fuel consumption, and will lead to even further reductions in the future. Because carbon dioxide is a direct result of petroleum combustion, CAFE standards could also reduce GHG emissions nationwide by more than 1 billion metric tons, save more than 90 billion gallons of fuel, and produce net benefits to society exceeding $100 billion through the 2030 model year. A final rule on standards for medium- and heavy-duty vehicles was published in August 2016.

(Sponsored by NHTSA)

Eco-Logical: Celebrating 10 Years of Ecosystem-Based Transportation Planning

A decade ago, the FHWA and signatories from seven other federal agencies collaborated to develop a groundbreaking transportation planning process called Eco-Logical. An ecosystem-based method, Eco-Logical helps federal organizations identify natural resources and coalesces avoidance, minimization, and mitigation practices into a systematic process. This environmental approach can streamline transportation infrastructure projects, leading to better environmental outcomes. The Eco-Logical approach can also help planners define environmental processes applied at the project level, as well as programmatic mitigation that must occur before the project begins.

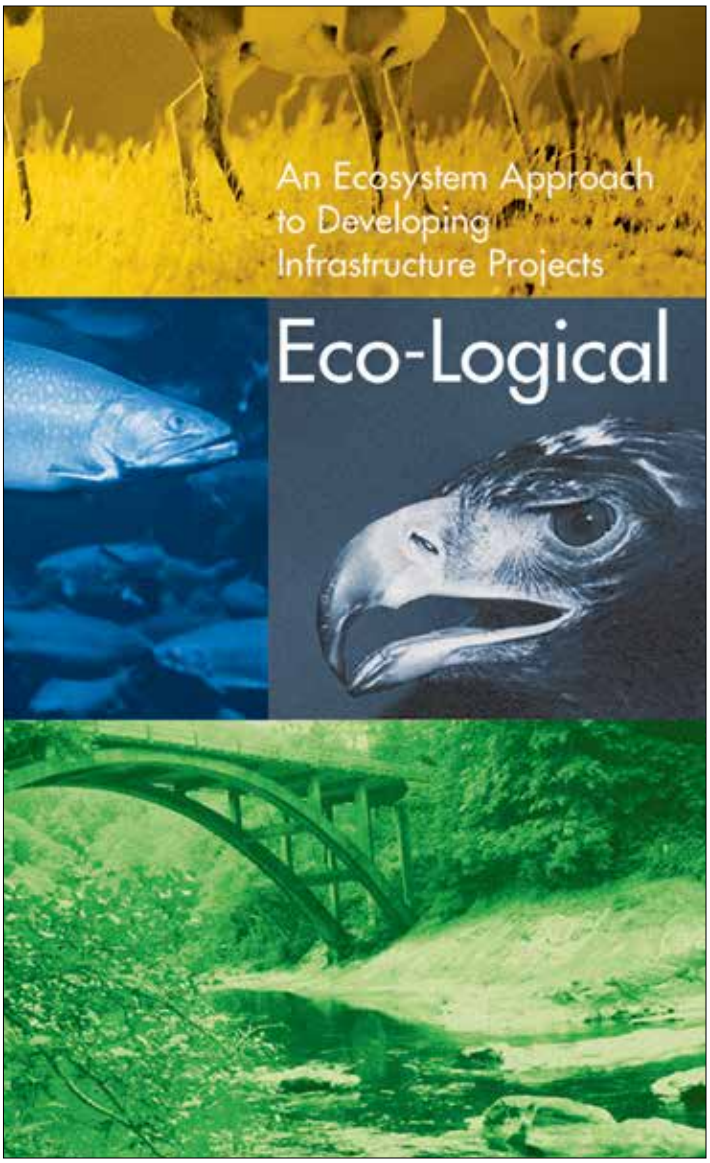
There has been a recent, major shift across government in using this planning approach. Today, federal agencies recognize the advantages of integrated, ecosystem-scale planning for infrastructure projects. Eco-Logical is now standard business practice for dozens of states and regional transportation agencies who collaborate with partners using this approach. As a result, agencies have reported improved relationships with resource and regulatory agencies, more efficient processes, and better integration of planning and permitting activities.

Volpe Center planners have supported FHWA's Eco-Logical initiative from the beginning. They developed a strategic path for the Eco-Logical program while collaborating with FHWA's federal partners. Additionally, Volpe Center staff conducted outreach, performed technical assistance, and undertook critical research to understand the impacts of Eco-Logical.

Recent Volpe Center contributions include:

- An update of the Synchronizing Environmental Reviews for Transportation and Other Infrastructure Projects: 2015 Red Book.
- White House Council on Environmental Quality and Office of Management and Budget Memorandum on Incorporating Ecosystem Services into Federal Decision Making (October 2015).
- Department of the Interior Landscape-Scale Mitigation Policy (October 2015).
- Presidential Memorandum on Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment (October 2015).
- Hosted four peer exchanges, which were attended by staff from 95 organizations, including funding recipients and their partners, who shared project successes and discussed challenges.

Over the past year, FHWA and its partners have worked to extend the benefits of Eco-Logical to other U.S. DOT modes. In March 2016, signatories discussed multimodal opportunities with the FRA, FAA, FTA, and the Office of the Assistant Secretary for Policy. Most recently, the Volpe Center engaged the eight original signing agencies to create a reaffirmation document and a video to raise awareness and expand the reach of the Eco-Logical approach.



2016 marks the 10–year anniversary of Eco-Logical, a shared vision of how infrastructure development and ecosystem conservation can be integrated to harmonize economic, environmental, and social needs and objectives.

Source: FHWA/Volpe Center.

(Sponsored by FHWA)

Assessing Greenhouse Gas Emissions from Transit Projects

In the U.S., transportation is a leading source of harmful emissions, accounting for the second largest percentage of GHGs after electricity production.

The National Environmental Policy Act requires federal agencies to analyze and disclose the environmental effects of their proposed activities, including the impacts of their actions on global climate change. FTA considers it feasible to assess GHG emissions and climate change for transit projects at a programmatic level. This programmatic assessment describes whether proposed transit projects merit a detailed analysis of GHG emissions and potential climate impacts. It also provides a source of data and analysis for FTA and its grantees to reference in future environmental documents. This information is useful for transit activities in which detailed, project-level GHG analysis offers only limited information beyond what is collected and considered in the programmatic assessment.

The assessment presents results of an analysis and estimates the direct and indirect GHG emissions generated from the construction, operation, and maintenance phases of transit projects across modes. The results can inform stakeholders who are considering the implications of GHG emissions on future transit investments, or those who might want to evaluate the benefits and costs of those investments.

The Volpe Center developed the study methodology, collected and analyzed environmental data, collaborated with external researchers, and wrote the draft programmatic assessment report. As part of this project, Volpe Center analysts also developed a GHG Emissions Estimator Tool, a spreadsheet that allows users to calculate partial lifecycle GHG emission estimates by transit mode based on limited data input. FTA released the draft assessment and tool in November 2016 for public comment.

Initial results suggest that bus rapid transit and streetcar projects generate low levels of GHGs primarily due to low infrastructure needs and vehicle miles traveled (VMT). Light rail projects with high ridership, regardless of length, alignment, and number of stations resulted in a net reduction of GHG emissions. Similarly, commuter rail projects with a high ratio of displaced VMT to transit VMT are expected to have net reductions in GHG emissions. Heavy-rail projects may have similar impacts, but the sample size was too small to draw meaningful conclusions at this time.

(Sponsored by FTA)

Enhancing the Alternative Fuel Transportation Optimization Tool

As the frequency and ease of travel increases, so too does the need for reliable means of fuel transportation. To better understand future energy scenarios and their implications for transportation needs and impacts, the Volpe Center developed the Alternative Fuel Transportation Optimization Tool (AFTOT) in support of FAA, the DOE, and the Navy's Office of Naval Research.

The AFTOT model is a scenario-testing tool, one that analyzes the transportation needs and constraints associated with fuel and raw material collection, processing, and distribution. The tool optimizes travel routes using a geographic information system module and an optimization module, and produces important data regarding transportation-related costs, carbon dioxide emissions, VMT, and other key performance metrics.

The Volpe Center is currently developing the third phase of AFTOT, which will enhance the tool's flexibility, accommodate fossil resources, better represent pipelines, and include the addition of background flows over the roadway network as a point of comparison for future scenario results.

The Volpe Center AFTOT team will also analyze supply-chain scenarios generated by the Department of Agriculture, FAA's ASCENT Center of Excellence Supply Chain Project, the Commercial Aviation Alternative Fuels Initiative, and the interagency Farm 2 Fly 2.0 initiative to

better understand how a scaled-up alternative fuel industry will affect the nation's transportation network and the environment.

The Volpe Center will evaluate scenarios for the DOE to assess the challenges of shared transport for future fossil and alternative fuels.

(Sponsored by FAA, DOE, and U.S. Navy)

Partnership Advances Marine Hydrokinetic Technology

It is widely known that water conducts electricity, but technology is proving water can create electricity as well. The Volpe Center is providing its expertise to Advanced Research Project Agency-Energy (ARPA-E) to further evaluate environmental challenges and benefits of its unique Marine Hydrokinetic Energy Harvesting device. The partnership between the Volpe Center and ARPA-E continues after a successful first round of testing during the summer of 2015.

Hydrokinetic technology turns the energy produced by waves, tides, and currents into electricity. ARPA-E built the device as part of the "Leading Edge" research team, a group of Brown University researchers and area engineers, scientists, and entrepreneurs. The Volpe Center contributed expertise and feedback regarding environmental implications of design decisions to the team.

The technology harvests energy utilizing oscillating hydrofoils driven by flowing water, similar to a wind turbine on land. The movement of the hydrofoils feeds a generator, which converts the energy into electricity. The geometry and motion of the hydrofoil allows for use in deep or shallow locations, with a required flow speed as little as 1 knot.

Studies to date have not identified any adverse effects of the Leading Edge hydrokinetic energy device on marine life. Behavioral and hormonal data show fish that encounter the hydrofoil do not alter their swimming behavior or experience elevated levels of stress.

Ahead of testing for the second, larger prototype, a Volpe Center team led efforts to characterize the tidal resource at the Cape Cod Canal test site, and monitored certain environmental effects during testing. These data will provide key information that will help the Volpe Center team understand how the device may alter water flow and sedimentation, potentially affecting shoreline scour and transportation infrastructure such as bridges. Data provided by the Volpe Center will shape the final assessments of the prototype performance and inform the selection of future testing sites.

(Sponsored by ARPA-E)

Photograph of the M/V *Ranger* at Massachusetts Maritime Academy, showing the equipment used to measure water current speed at the location where the Leading Edge team will test the second prototype device. Photo: U.S. DOT/Volpe Center.

Transportation Management and Planning

The Volpe Center develops and advances transportation management and planning initiatives at local, state, national, and international levels.

Building a Long-Range Transportation Plan for America's National Parks

Tourists, conservationists, educators, students—a long list of people travel to and through our national parks. National parks see more than 300 million visitors each year, a figure roughly equivalent to 90 percent of the U.S. population. The transportation network across more than 400 national park units includes 5,500 miles of paved roads, 120 million square feet of paved parking, more than 1,400 bridges and tunnels, and 130 transit systems.

That vast network requires planning, construction, operations, and maintenance to keep it in good, safe condition, but the National Park Service (NPS) faces major transportation funding shortfalls. To ensure safe and efficient access to and through national parks for all Americans, the NPS called on Volpe Center planners to help develop the first-ever NPS Long-Range Transportation Plan.

Together, the Volpe Center and the National Park Service's Denver Service Center co-managed development of the plan and facilitated the participation of over 80 subject matter experts from throughout NPS. The result is a plan that considers transportation from the perspectives of asset management, finance, resource protection, visitor experience, and safety, and presents a strategy to coordinate over 15 fund programs and sources that align transportation investment priorities with mission-driven needs.

Targeted for release in early 2017, the draft plan identifies:

- Five nationally strategic goal areas;
- Over 50 implementation strategies to meet those goals;
- Fourteen performance measures to determine the impacts of strategies and objectives; and
- A national, coordinated strategy for investing in the NPS transportation system.

Opposite: The National Park Service celebrated its 100th birthday in 2016. The Volpe Center's federal lands and noise management teams have conducted research at Mount Rushmore National Memorial and other NPS locations. Photo: NPS.

Pictured is the George Washington Memorial Parkway, one of five major parkways in the Washington, DC metropolitan area managed by the NPS. Photo: NPS.

The plan's financial analysis shows how NPS has funded transportation investments, provides a baseline for strategic decision making, and identifies ways to improve data collection and management. The plan also makes it easier for NPS to communicate the scale of its transportation-funding shortfall and how it impacts transportation at national parks.

(Sponsored by NPS)

Transition to a Performance-Based Transportation System

The Transportation Performance Management (TPM) project supports the U.S. DOT's initiative to transition FHWA and its federal-aid partners toward a performance-based transportation system. TPM is a strategic approach that uses system information in making data-driven investment and policy decisions to meet national performance goals.

Moving Ahead for Progress in the 21st Century Act (MAP-21) marked the shift to a performance- and outcome-based transportation program for federal-aid funding. State and local transportation agencies must invest resources in projects to meet individual targets that will collectively help meet national goals. The FHWA Office of TPM is working with agencies to help them meet MAP-21 requirements, regardless of resource constraints.

The Volpe Center has extensive expertise working with federal, state, and local transit agencies to integrate performance management into various programs. FHWA turned to the Volpe Center for guidance and support in issuing all TPM-related rulemakings. Recent examples include:

- Notice of Proposed Rulemaking (NPRM) for System Performance of the National Highway System, Freight Movement on the Interstate System, and the Congestion Mitigation and Air Quality Improvement Program.
- Final rules for the Highway Safety Improvement Program (HSIP) to establish performance measures for state departments of transportation to implement

the HSIP; and the Safety Performance Management Measures (Safety PM) to track safety progress at the national level.

The rulemaking effort to implement performance management requirements was started under MAP-21, and continues under the Fixing America's Surface Transportation (FAST) Act. With a strong background in professional capacity building, the Volpe Center also developed materials for the NPRM roll out that would be easily understood by stakeholders.

Since October 2015, the Volpe Center has conducted over 40 TPM webinars on NPRMs, final rules, and other performance management-related topics. Over 4,000 participants have linked in for the TPM sessions. The Volpe Center also facilitated meetings between FHWA and FTA and used feedback to support development of TPM training courses on the new regulations. Based on interviews with states and Metropolitan Planning Organizations (MPOs), the Volpe Center also captured noteworthy practices for implementing performance management on what worked well in those organizations.

TPM will improve public transparency, fiscal accountability, and investment decisions affecting the safety, condition, and performance of the nation's surface transportation system. It will also help explain the impact of investment decisions and improve communication between decision makers, stakeholders, and the public.

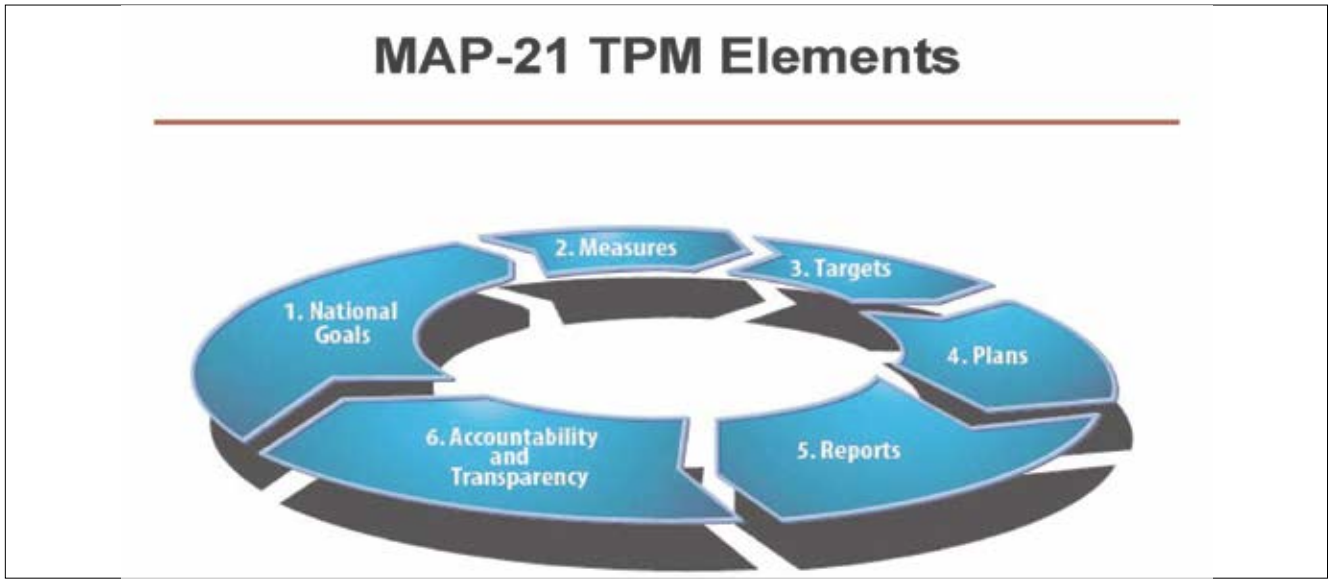
(Sponsored by FHWA)

Volpe Expertise Helps FHWA Evaluate Research and Technology Goals

The FHWA Research and Technology (R&T) Agenda addresses six of the nation's highway challenges. By applying a collaborative and strategic approach to conducting research, the agency is focused on getting innovative technologies into the hands of states, MPOs, and the private sector. The Volpe Center worked with FHWA to organize the agency's agenda and continues to showcase its research on the web and through other communications channels.

Six National Highway Challenges

- Advancing safety
- Improving mobility
- Maintaining infrastructure integrity
- Enhancing performance
- Promoting sustainability
- Preparing for the future



The MAP-21 TPM framework consists of six interrelated elements which form a feedback loop. Source: FHWA.

FHWA has since asked the Volpe Center to assess how well the research offices and programs are meeting the goals and objectives set in the R&T Agenda, and to provide useful data to inform future project selections. The R&T evaluations are intended to improve the quality of information about the outcomes and impacts of research activities.

The Volpe Center is evaluating 17 separate and distinct research projects. Some evaluations are focused on completed projects, while others are prospective and extend out as far as 2021. Due to the extensive nature of the task, the Volpe Center performed a scoping process to assess the resources and timeline prior to performing the evaluations in order to manage costs, ensure timely delivery, and produce high-quality findings. Understanding the cause-effect chain that leads from ideas to impacts will enable FHWA management to pinpoint specific activities that assist or hinder successful project implementation.

The results of the scoping process enabled the Volpe Center to identify key performance metrics and develop a preliminary project timeline. Tasks for qualitative and quantitative data collection, their respective analyses, and report generation were scored as low, medium, or high in complexity and required-skill level. These scores determined staff needs by level. Only then was it possible to derive costs and develop the overall project budget. Finally, specific Volpe Center personnel and other resources were allocated to the 17 evaluation efforts.

The cost estimates developed through the scoping process proved to be reasonably accurate. Having these evaluations performed by the Volpe Center adds value because it demonstrates to research practitioners how to bring evaluation thinking into their future practice.

As of November 2016, six retrospective evaluations were completed with final draft reports in review. Five additional reports will be completed in FY 2017, and all remaining projects are in the data-collection stage. Thorough scoping to assure maximum efficiency and excellent quality represents the high level of professionalism in project management and performance the Volpe Center brings to its customers.

(Sponsored by FHWA)

Sustainable Transportation Solutions Address Challenges of a National Wildlife Refuge

Kilauea Point National Wildlife Refuge is a popular destination for both residents and visitors to Hawaii, drawing more than 500,000 people annually to its scenic overlooks and ocean views. A recent influx of visitors and increased congestion throughout the refuge prompted the U.S. Fish and Wildlife Service to find solutions to ease ongoing traffic-related problems.

Traffic congestion on roads and in parking lots has caused safety concerns for refuge visitors, staff, and wildlife alike. Additionally, the refuge shortened its operating hours due to budget constraints, further exacerbating congestion as overall visitation remained the same. Having undergone a number of transportation planning studies in the past, the refuge was eager to move forward with implementing strategies to solve these issues.

The Volpe Center served as the primary project manager in an effort to evaluate the feasibility of transportation solutions included in the Kilauea Point National Wildlife Refuge's Comprehensive Conservation Plan (CCP). The CCP contains strategies related to a visitor shuttle service, improved visitor information, fee change/structures, parking management, temporary traffic control measures, ITS, and non-motorized access to the refuge.

Volpe Center staff and the FHWA Central Federal Lands Highway Division (CFLHD) carefully studied these options and recommended a set of short-, medium-, and long-term actions for implementation. They also led several on-site stakeholder meetings and participated in four public meetings in the county. The recommended actions are included in a final report that draws upon the feedback of refuge staff and visitors to create sustainable transportation solutions. The final report was released in 2016.

Current parking lot management techniques at Kilauea Point include some cones and staff directing incoming vehicles to turn around and come back later when the lot is not full.

Photo: U.S. DOT/Volpe Center.

The Volpe Center completed a final draft of the shuttle feasibility section of the report, in which it explored three potential business models: contracting with the county as it expands its public transit service on the island; partnering with a local private, nonprofit, or public shuttle service provider; and implementing a timed entry or reservation-based system for private vehicles. The study examines potential implementation costs, shuttle service routes, vehicle types, and funding opportunities.

Through the planning process, Volpe Center staff assisted the refuge in creating ties with county-planned activities related to transit and helped solidify a relationship with the local government and local developers in the area.

(Sponsored by U.S. Fish and Wildlife and FHWA Central Federal Lands Highway Division)

Addressing Challenges through Regional Models of Cooperation

Transportation planning agencies face a number of issues, such as air quality, freight movement, and traffic congestion that often extend beyond their planning jurisdiction. Moreover, as metropolitan regions continue to expand and new MPOs are created, the geographic extent of urban areas do not match planning agency boundaries. Given these trends, cooperation among transportation agencies has become more important. Agencies can better optimize decision making about investments and identify and prioritize regionwide needs by operating across jurisdictional boundaries.

The FHWA Office of Planning and FTA Office of Planning and Environment's Regional Models of Cooperation initiative supports transportation planning agencies in addressing regional-scale challenges. It also provides examples of how regions have enhanced effective communication across state DOTs, MPOs, transit authorities, and other planning organizations. The Volpe Center has provided support to FHWA and FTA on the program's peer exchange workshops, webinars, case studies, and a new handbook on notable practices in regional cooperation.

The Regional Models of Cooperation initiative has hosted four peer exchange workshops in North Carolina, Ohio, Utah, and Indiana, as well as one virtual peer exchange for agencies in Alaska. These workshops provide technical assistance to a host agency aiming to improve cooperation on any number of topics including regional freight planning, environmental justice, statewide transportation planning, connecting bike/ped and transit networks, and performance-based planning and programming. The Volpe

Center lent support to developing and conducting the workshops.

Volpe Center experts have also supported FHWA and FTA in hosting several national webinars featuring notable practices in cooperation on transportation planning. Topic areas have included statewide transportation planning, air quality planning, congestion management, public transportation planning, data systems and tools, freight planning, and safety planning. The webinars have each drawn between 100 and 250 participants representing state DOTs, MPOs, transit agencies, local governments, consultants, and researchers. They are available for viewing on the FHWA website.

The initiative has also produced 20 case studies highlighting successful and notable practices in multijurisdictional planning and cooperation. The case-study series serves as a resource for regions working to improve transportation-planning coordination and is the basis for a handbook providing guidance on regional cooperation. The Volpe Center is supporting the development of the case studies and the handbook.

The Regional Models of Cooperation initiative continues to raise awareness of effective techniques for collaboration, and has elevated the visibility and importance of regional transportation planning.

(Sponsored by FHWA)

Exchanging Innovative Approaches in South Africa

Bridging the gap between transportation research and real-life applications of that research takes strong connections between stakeholders in the U.S. and around the world.

In 2015, U.S. Secretary of Transportation Anthony Foxx and South Africa's Minister of Transport Dipuo Peters signed a Memorandum of Cooperation establishing a mutual commitment to address common transportation challenges.

Under that memorandum, in 2016 the Volpe Center supported the Office of the Secretary (OST) with planning and delivery of a regional connectivity workshop that will serve as a jumping-off point for future collaboration with the South Africa Department of Transportation (DOT) and other transportation agencies in South Africa. At the workshop, Volpe Center transportation planners joined U.S. DOT colleagues to discuss with South African transportation professionals:

- Barriers to economic development that can be lowered by improving regional trade and making border crossings more efficient.
- Potential solutions to South Africa's transportation challenges based on U.S. policies, planning processes and programs, and technologies.
- Opportunities to improve regional trade and border crossings in South Africa.

Participants left the workshop with innovative approaches to plan and manage multimodal transportation, and to improve regional connectivity and cross-border trade.

To put the workshop together, Volpe Center planners researched the national transportation context in southern Africa, with a focus on cross-border transportation. They also supported OST by organizing and facilitating the workshop, identified opportunities for future collaboration, gave presentations on multimodal planning, and shared innovative approaches to transportation challenges.

In addition to the South Africa DOT, which served as co-organizer and host along with the U.S. Embassy in South Africa, participating agencies included the South Africa Cross-Border Transport Agency, the South African National Roads Agency Limited, South African Revenue Service, and the South African maritime and aviation authorities.

The Volpe Center is supporting the U.S. DOT Office of the Secretary to establish follow-up goals and activities with the South Africa DOT. The workshop was part of ongoing Volpe Center support to OST to conduct workshops in South Africa, India, and Brazil on a range of transportation topics relevant to the host countries and U.S. DOT.

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

Assessing Transportation Investment in Nepal and Côte d'Ivoire

The Millennium Challenge Corporation (MCC) is an independent U.S. government foreign aid agency helping to lead the fight against global poverty through economic growth. MCC provides developing countries committed to good governance, economic freedom, and citizen investment with large-scale grants that fund country-led solutions for solving constraints to economic growth. These investments span various sectors, including transportation—roads, bridges, public transportation infrastructure, and ports.

The high cost of transporting people and goods is a constraint to economic growth in many predominantly agricultural countries that are rapidly urbanizing. For example, the quality and quantity of Nepal's transportation infrastructure does not meet its current needs. MCC has concluded that Nepal's transportation sector is a binding constraint for the country's economic growth.

In Côte d'Ivoire, households spend more of their budget on transportation compared to other countries. Trucking prices are also high, limiting the international attractiveness of the port of Abidjan, a major driver for the economy of the nation's key commercial city. At the same time, public transport is limited, traffic congestion in Abidjan is significant, and many truckers earn low wages.

The Volpe Center has a strong record of helping national and international government and industry decision makers analyze complex issues and develop strategies to deliver world-class transportation solutions. MCC turned to the Volpe Center to provide on-site assessments of potential high-priority transportation investments in Nepal and Côte

Many rural bridges and roads in Nepal are undermaintained, contributing to transportation delays. Photo: U.S. DOT/Volpe Center.

d'Ivoire as well as professional capacity building expertise in Côte d'Ivoire, targeting urban planning improvements and road asset management.

In Nepal, the Volpe Center worked with MCC to identify potential high-priority projects for investment. In Côte d'Ivoire, the Volpe Center identified key factors leading to high-transport costs and helped MCC recognize potential projects for investment. Using these assessments, MCC will assist the government of Côte d'Ivoire in pursuing smart urbanization, including developing industrial zones and improving trucking efficiency and options for affordable transportation.

The projects MCC selects for investment are designed to address key constraints to economic growth in developing countries. The Volpe Center is now working with MCC to create a vehicle-operating cost model to compare the expense of operating vehicles in Nepal and elsewhere with that of developed countries.

(Sponsored by the Millennium Challenge Corporation)

Supporting the Port Performance Freight Statistics Program

Our nation's coastal, inland, and Great Lakes ports form critical links in the U.S. freight transportation system, moving an estimated 55 million tons of cargo valued at more than $49 billion each day over seven million miles of highways, local roads, railways, navigable waterways, and pipelines. Collectively, they are a vital engine for our national economy and way of life. In some form or another, these ports handle almost everything that we as a nation consume or use—from merchandise and foodstuffs to petroleum and fuel products.

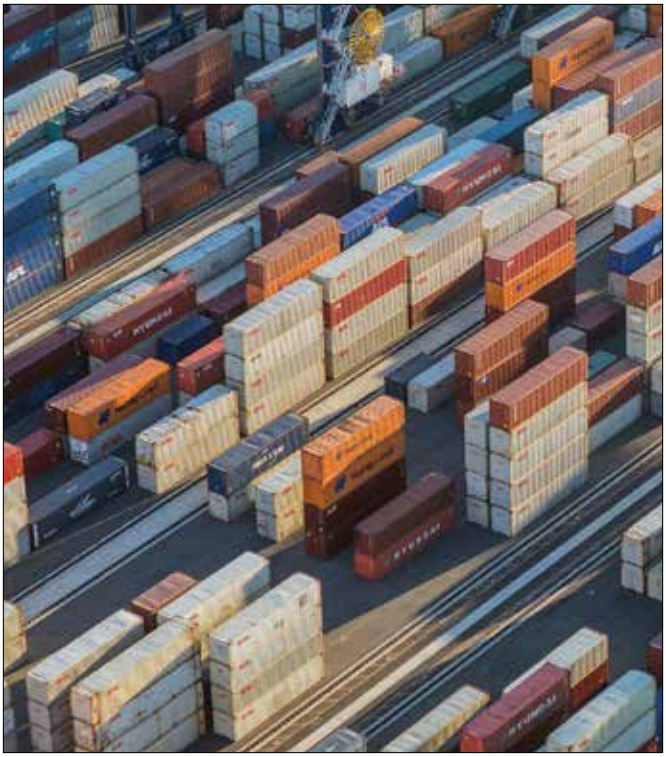
Maintaining safe, well-functioning, and highly performing ports is essential to the nation's overall economic health. Assessing port performance at the national level can help provide policy and decision makers with a better understanding of ports' roles in the national transportation network and their contributions to the nation's economy.

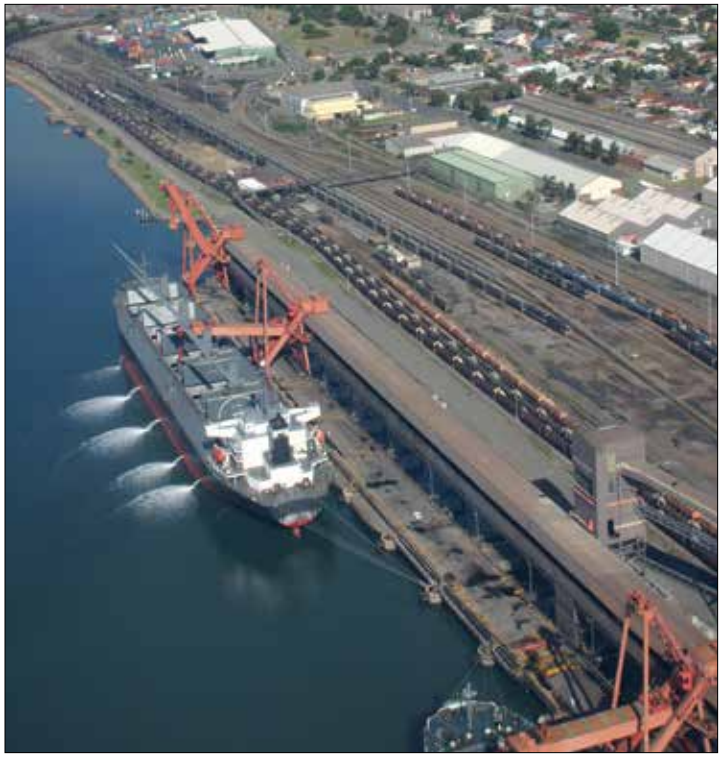
The U.S. DOT's Bureau of Transportation Statistics (BTS), one of the principal federal statistical agencies, reached out to the Volpe Center's technical and policy experts for help in taking a national-level look at port performance. This effort was spurred by the FAST Act, Section 6018, which requires BTS to develop a new program, known as the Port Performance Freight Statistics Program (PPFSP).

As part of this program, BTS is required to identify and report to Congress annually on nationally consistent measures of port performance (capacity and throughput) for the nation's top 25 ports in terms of containers moved, overall tonnage, and dry-bulk tonnage. Section 6018 also requires a working group to convene, representing a range of stakeholders (including representatives of federal agencies, a port authority, labor organizations, and industry associations, among others) to provide recommendations to BTS on nationally consistent port performance measures and a process for collecting data.

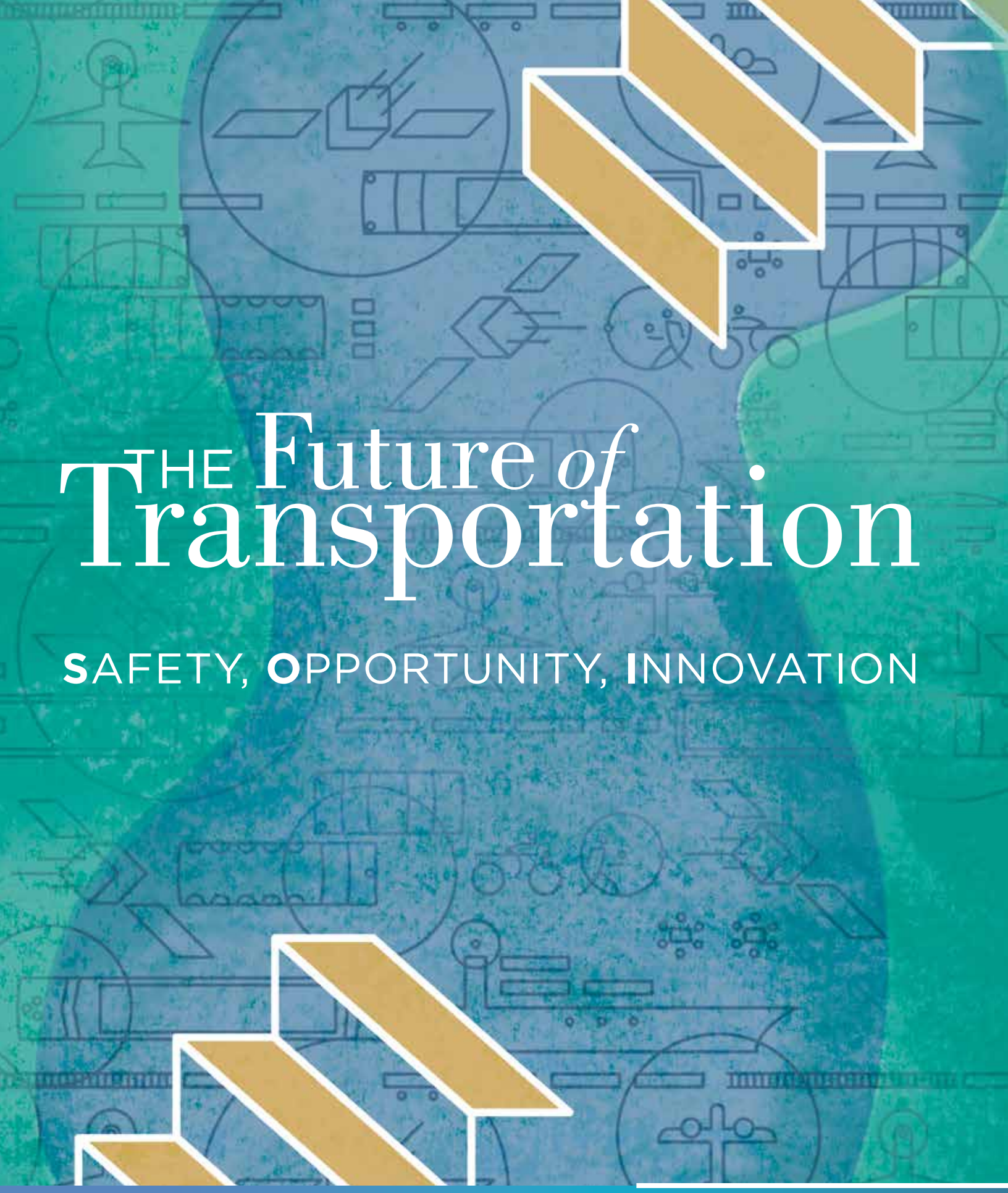
In support of the PPFSP, a Volpe Center team, in coordination with external subject matter experts, compiled and analyzed information from multiple sources to identify nationally consistent capacity and throughput metrics and the lists of top 25 ports, as required by FAST Act Section 6018. The team also planned, designed, facilitated, and documented the working group's meetings. The team is now developing the PPFSP's first annual Report to Congress. The team anticipates that this initial report will help provide a strong foundation for BTS to build on in subsequent years through the PPFSP.

(Sponsored by BTS)





These images illustrate different types of cargo (dry bulk, liquid bulk [one component of "other tonnage"], and containerized cargo) discussed in the PPFSP's annual Report to Congress and some of the different types of vessels and equipment used to handle this cargo. Photos: Top left: 123rf.com/hxdyl, Top right: iStock.com/JANIFEST, Bottom: iStock.com/bjeayes.



THE Future *of* Transportation

SAFETY, OPPORTUNITY, INNOVATION

Thought Leadership

The Volpe Center is U.S. DOT's go-to source for strategic thinking that moves the nation's transportation system toward a safer, economically competitive, and resilient future.

Transportation innovation is happening at an unprecedented pace. From driverless cars to unmanned deliveries to smart cities, innovation and new technologies are key to the future of a safe, reliable transportation system that helps more Americans reach economic opportunity and helps the nation be more economically competitive.

The 2016 *Future of Transportation* series continued the Volpe Center's tradition of convening thought leaders, decision makers, and stakeholders from across the global transportation enterprise to anticipate future transportation issues, generate fresh approaches to emerging issues, anticipate transportation trends, and inform decision making.

The series brought together leading thinkers in transportation and addressed three key themes: safety, opportunity, and innovation.

"We're facing a tsunami of change in transportation. We have population growth—70 million more people over the next 30 years," said U.S. Transportation Secretary Foxx at the standing-room-only *Future of Transportation* speaker series kickoff held on June 27, 2016. "We have changes where those people are coalescing… That [demands] **tremendous rethinking of how we deliver transportation."** Photo: U.S. DOT/Volpe Center.

Photo: U.S. DOT/Volpe Center

Robin Chase
Co-founder of Veniam, co-founder and former CEO of Zipcar

"The way people are thinking about autonomous vehicles today is so focused on safety and regulation and maybe they are thinking it'll be shared or multimodal or we're going to make it electric. **We're not going to get this job done if we don't deal with so many other things.** The transportation infrastructure revenue piece, land use and urban planning – **we've got to decide, what are our community priorities right now.**"

"**What we're confronting ahead is this 20-year period of automation.** It's primarily about reinventing the automobile. It's involving a massive amount of private investment, and I don't think we really have an urban lens yet. I think it's key to understand **there's nothing inevitable about the direction this goes**. It's really up to us to design the outcome and to influence that through policy... An ideal policy framework for cities preparing to manage an influx of automated vehicles would address safety, economics, and land use."

Photos: U.S. DOT/Volpe Center

Anthony Townsend
Senior Research Scientist, New York University

Dr. Austin Brown (far left), Assistant Director for Clean Energy and Transportation at the Office of Science and Technology Policy in the Executive Office of the President facilitated the panel discussion on urban mobility with **Robin Chase** and **Dr. Anthony Townsend**.

Photo: U.S. DOT/Volpe Center

Daniel L. Doctoroff
Chairman and CEO, Sidewalk Labs and
former deputy mayor of New York City

"When you imagine a city from the Internet up, you get **a place that is personalized for our needs and desires.** A place that is adaptable, constantly evolving, with changing demands, technologies, and tastes. A place that feels like a city, but functions like a community."

"I firmly believe that most of us own and drive vehicles that we do not really need. I think **the future is one that is based on a different model of mobility**: shared mobility, shared vehicles."

Photos: U.S. DOT/Volpe Center

Emilio Frazzoli
Massachusetts Institute of Technology,
co-founder of nuTonomy

Photo: U.S. DOT/Volpe Center

J. Christian Gerdes
U.S. DOT Chief Innovation Officer

"What could we do if all vehicles could communicate with each other? That's a big-picture dream, and getting every vehicle on the road to communicate with every other vehicle and every pedestrian is a huge challenge. There's a temptation in light of those challenges to say well, that looks too hard. **So how do you get people to understand this concept? How do you get to move towards that? It's through prototyping.**"

"...if we think about the past hundred years or the past 2,000 years we can think very much of a world in which there are centrifugal technologies which enable us to spread out and centripetal technologies that draw us in. And the futures of cities will be shaped by these technologies, and we're certainly in an era in which technology is changing quickly and has the capacity to change cities quickly as well.... I think we're going to see in the next year a big push towards increasing transportation spending. **And this can be a very good thing if it is done well and a very unwise thing if it is done poorly.**"

Photo: U.S. DOT/Volpe Center

Edward Glaeser
Professor of Economics in the Faculty of Arts and Sciences, Harvard University

Photo: U.S. DOT/Volpe Center

Ben Hecht
President and CEO, Living Cities

"How do we build a new urban practice that will get dramatically better results? If you actually believe that these problems are so complex, and you need to bring people together differently **then we actually have to help places bring the right people together differently.** If it's the public sector, the private sector, philanthropy, nonprofit sector—the right people to get to the results have to be at the table."

"**The street is probably our most prized public asset.** Can streets actually be the great equalizer to address some of the issues we have in society? If so, it would demand for us to take off our different departmental heads and begin to talk about how we collaborate...People-centric design can have real, positive impacts on a city's residents. Things like residential density, intersection density, public transport density, and number of parks, **these physical elements can invite a certain type of behavior:** Up to about 90 minutes more physical activity."

Photo: U.S. DOT/Volpe Center

Jeff Risom
Partner and Managing Director
Gehl Studio

"How do you wake up and **have no lives lost on our roadways?** What would be the actions and milestones along that 30-year path to get us to zero? What's really exciting about that is you could be relatively new to being a safety professional and in your career **you could wake up one morning and that's the world you live in.**"

Photos: U.S. DOT/Volpe Center

Mark Rosekind, PhD
Administrator, National Highway Traffic Safety Administration

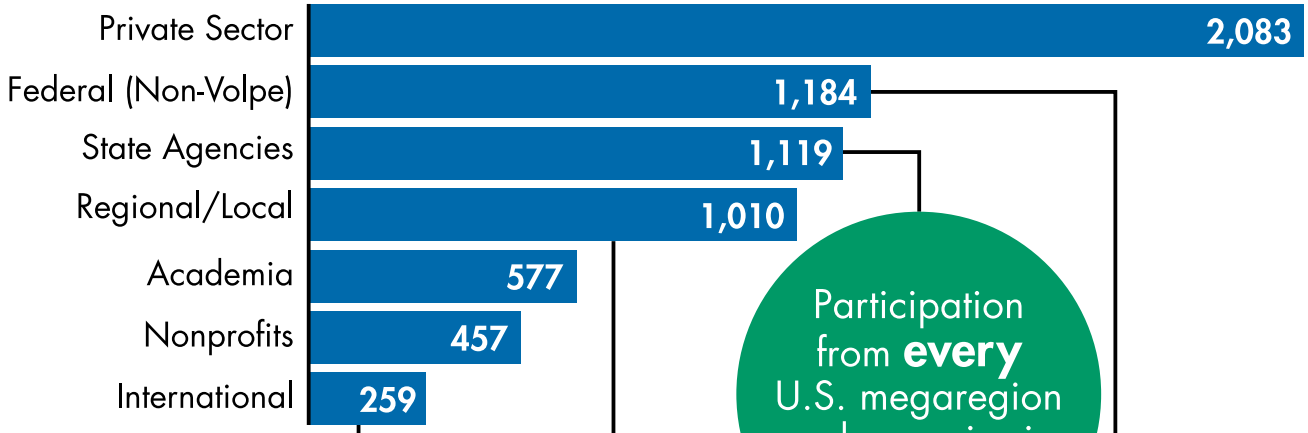
The Volpe Center is engaging a broad range of stakeholders in an important dialogue about the future of the global transportation system.

Volpe continues to engage a broad range of stakeholders in an important dialogue about the future of the global transportation system. Volpe's thought leadership initiative has wide-ranging appeal among key transportation stakeholders in government, industry, academia, and non-profit organizations. The extensive reach of our three recent speaker series—*The Future of Transportation, Reimagining Transportation,* and *Transportation and the Economy*—reflects Volpe's impact on how the transportation enterprise thinks about and plans for the global transportation system of the future.

In addition to a standing-room-only audience for many events, online stakeholder registration continues to grow. There were more than 7,800 online registrations over the course of the series. The infographic on the following page provides a snapshot of levels of engagement by sector.

Stakeholder participation in the Volpe Center's *Future of Transportation, Reimagining Transportation,* and *Transportation and the Economy* series.

Over **7,800** registrations, and **2,100** seats filled.



Participation from **every** U.S. megaregion and agencies in all **50** states.

Over **400** local and regional government agencies represented.

Stakeholders from **24 countries** linked in from Europe, South America, the Middle East, and East Asia.

In addition to extensive participation from all U.S. DOT modal administrations, over **45 federal agencies** joined the conversation.

To see video highlights of our speakers, visit www.volpe.dot.gov/our-work/thought-leadership

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- Saint Lawrence Seaway Development Corporation
- Office of the Secretary of Transportation

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Prepared by the Office of Strategic Initiatives for Research and Innovation in collaboration with the Centers for Safety Management and Human Factors; Policy, Planning & Environment; Infrastructure Systems and Technology; and Air Traffic Systems and Operations at the U.S. DOT/Volpe Center.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2017	Final Report

4. TITLE AND SUBTITLE
Annual Accomplishments – January 2017

5a. FUNDING NUMBERS

6. AUTHOR(S)
Prepared by the Volpe Center's Office of Strategic Initiatives for Research and Innovation in collaboration with the leadership and staff of the Centers for Safety Management and Human Factors; Policy, Planning and Environment; Infrastructure Systems and Technology; and Air Traffic Systems and Operations at the U.S. DOT/Volpe Center. Nathan Grace, Philip Thornton, Jacqueline Johnson, Kathy Blythe, Cassandra Oxley, Andrew MacDougall, Clark Merrefield, Sara Forni, Ingrid Bartinique, and Dan Morin provided contractor support on document design and production.

5b. CONTRACT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Office of Strategic Initiatives for Research and Innovation
U.S. Department of Transportation
John A. Volpe National Transportation Systems Center
55 Broadway
Cambridge, MA 02142-1093

8. PERFORMING ORGANIZATION REPORT NUMBER
DOT-VNTSC-17-02

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
John A. Volpe National Transportation Systems Center
55 Broadway
Cambridge, MA 02142-1093

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Prepared under the direction of Ellen Bell, Director of Strategic Initiatives for Research and Innovation, Volpe Center; Nathan Grace served as publication coordinator.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
This document is available to the public on the Volpe website: https://www.volpe.dot.gov.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
This Annual Accomplishments booklet highlights the Volpe Center's best work of 2016 and illustrates the sustained impact of the Center in making the transportation system safer, more efficient, globally competitive, connected, and resilient. The Volpe Center develops fresh approaches and new solutions that have successfully addressed some of the most complex national and global transportation challenges. This booklet also highlights some key messages and quotes from the successful 2016 thought leadership speaker series, *Future of Transportation: Safety, Opportunity, and Innovation.*

14. SUBJECT TERMS
Volpe Center, 2016 annual accomplishments, unmanned aircraft systems, NextGen, connected vehicles, wake turbulence, pedestrian and bicycle safety, maritime safety, rail trespass prevention, motor carriers, automation, data quality, maritime domain awareness, resilience, transportation planning, smart cities, wearable sensors, multimodal payments, port performance, thought leadership, fuel standards, energy and environment.

15. NUMBER OF PAGES
80

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

U.S. Department of Transportation
Volpe, The National Transportation Systems Center

Volpe