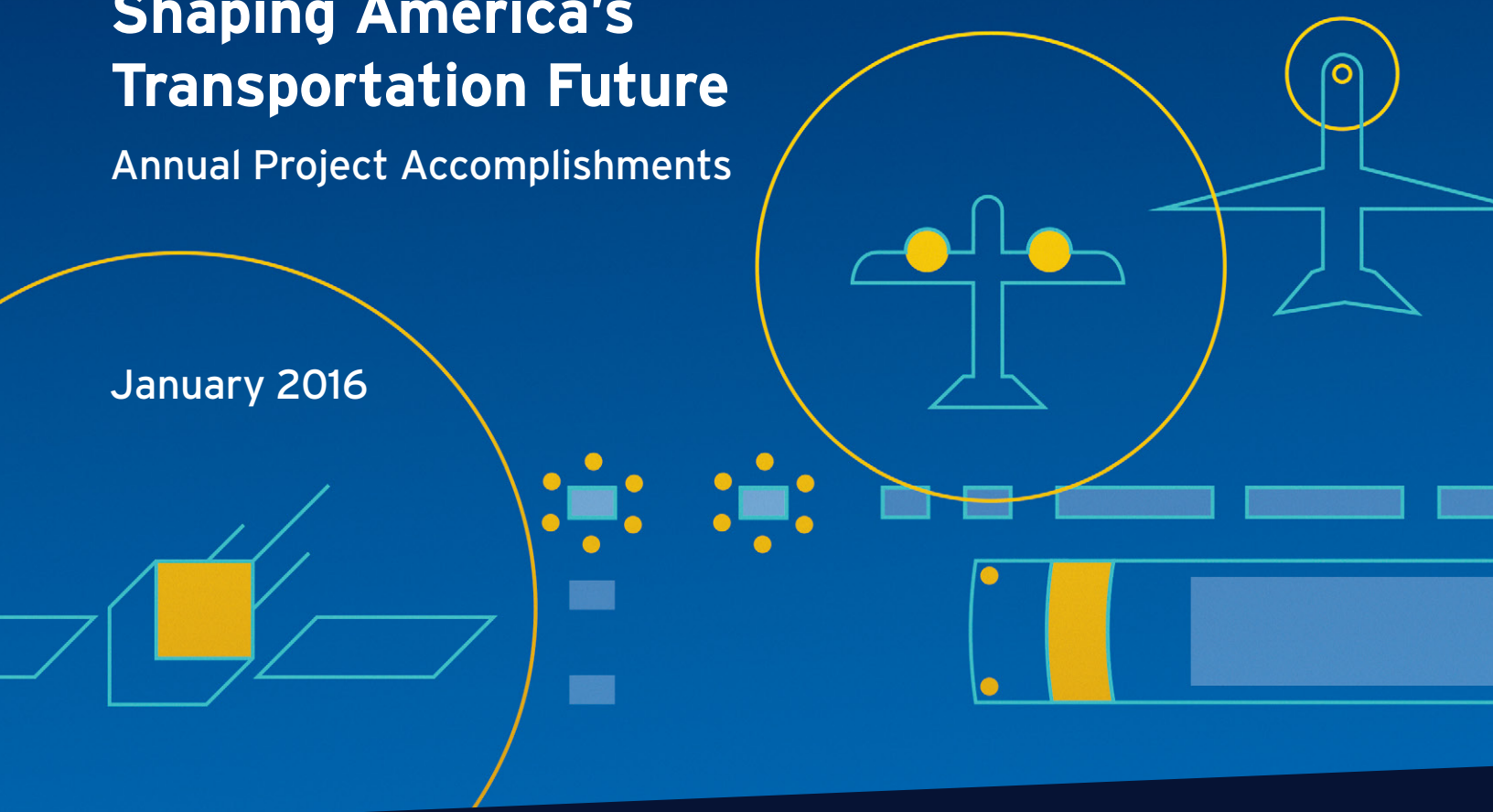




Shaping America's Transportation Future

Annual Project Accomplishments

January 2016



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

Volpe



Advancing transportation innovation for the public good.

For more than 45 years, Volpe has served as a beacon of insight for a transportation community navigating its most challenging problems.

Shaping America's Transportation Future highlights Volpe's best work of 2015. The major project milestones, achievements, and thought leadership initiatives showcased here are helping to guide America's current and future transportation system.

Opposite: Our Cambridge, Massachusetts campus in Kendall Square, a premier global technology hub, fosters a dynamic atmosphere of intellectual excitement and professional ingenuity that enriches our staff and infuses our work. Source: U.S. DOT/Volpe

As the National Transportation Systems Center, our mission is to improve the transportation system by anticipating emerging issues and advancing technical, operational, and institutional innovations.

Part of the U.S. Department of Transportation, Volpe is a unique federal agency that is 100-percent funded by sponsor projects. We partner with public and private organizations to assess the needs of the transportation community, evaluate research and development endeavors, assist in the deployment of state-of-the-art transportation technologies, and inform decision and policy making through comprehensive analyses.

Home to renowned multidisciplinary expertise in all modes of transportation, we serve our sponsors with advanced technologies, research, and programs to ensure a fast, safe, efficient, accessible, and convenient transportation system that enhances the quality of life for the traveling public, today and into the future.

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SAFETY

Volpe 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

First Real-World Evaluation of Connected Vehicle Safety Applications

Connected vehicles offer improvements in safety, mobility, and the environment. Volpe provided independent evaluations of crash warning

Opposite: Connected vehicles can communicate with each other, with drivers and pedestrians, and with the infrastructure. Source: ©iStockPhoto.com/Pglam

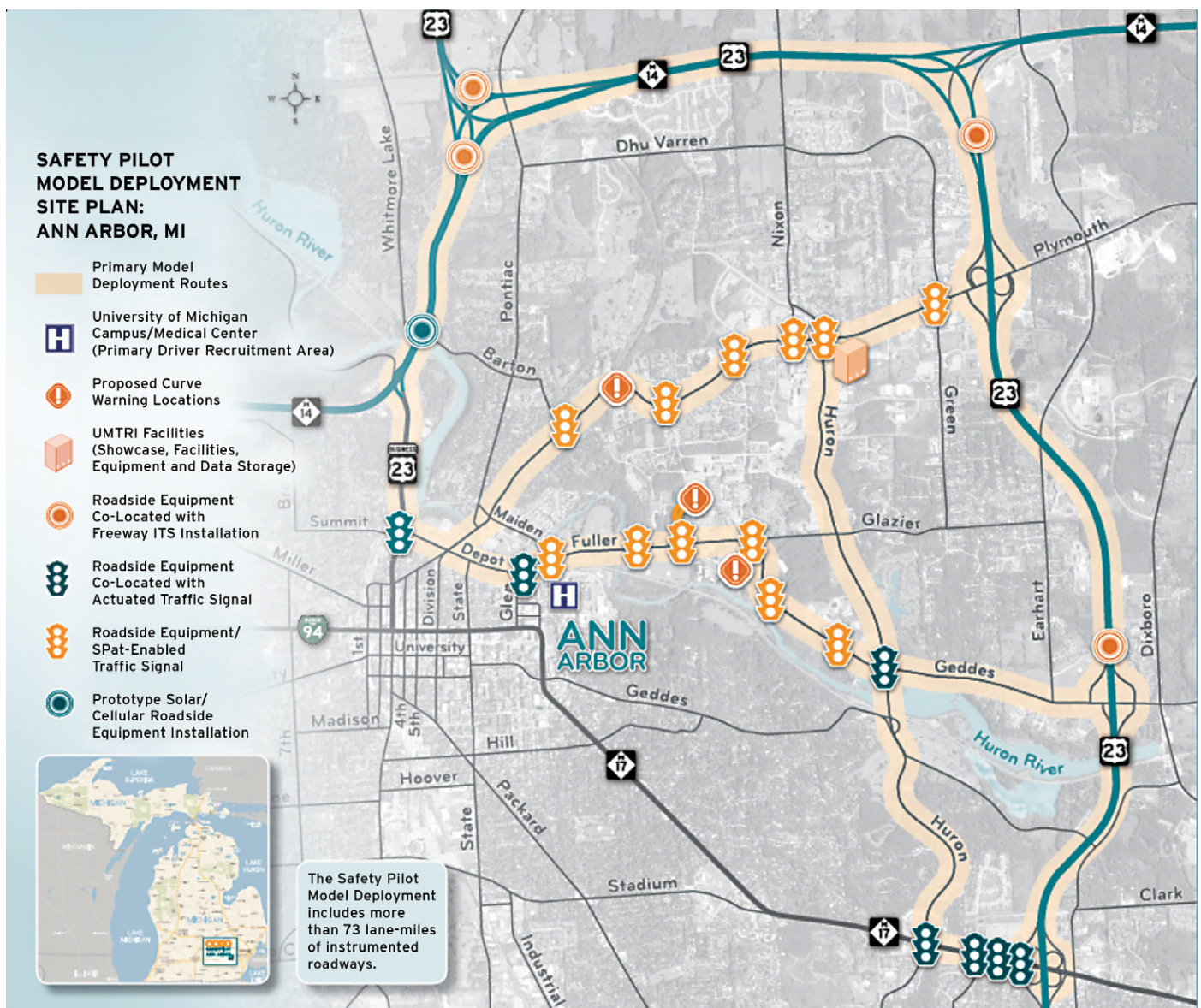
applications based on vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technologies for passenger vehicles, heavy trucks, and transit buses. It was the first time ever that connected vehicles were deployed and tested in the real world, on a large scale. Volpe estimates that V2V and V2I crash warning technologies have the potential to reduce motor vehicle crashes involving unimpaired drivers by 80 percent.

Connected vehicles communicate and exchange safety data to enable crash warning applications and vehicle automation. For example, intelligent vehicles include automated emergency braking that prevents crashes without driver intervention, and adaptive cruise control that automatically adjusts the speed and maintains constant distance to the vehicle in front. Volpe supports the National Highway Traffic Safety Administration (NHTSA), Federal Transit Administration (FTA), and ITS Joint Program Office (JPO) in research to generate data from V2V and V2I technologies in field operational tests.

Volpe's advanced vehicle technology experts and engineers provided support to the Safety Pilot Model Deployment, a real-world driving operational environment located in Ann Arbor, Michigan, which tested 2,800 vehicles equipped with communication-based V2V and V2I technology. The test area included 73 lane-miles of roadway equipped with measuring instruments. Evaluation goals assessed the V2V and V2I safety application's capability, unintended consequences, and driver acceptance. Aggressive deadlines presented challenges to analyzing test

results that produced large, complex driving data sets; some by project partners using different data acquisition systems.

Volpe provided NHTSA, FTA, and ITS JPO with complete analysis and reporting. NHTSA was able to make informed decisions and met its target deadline for important advanced notice for proposed rulemaking on V2V technology and safety applications. The Safety Pilot Model Deployment advances this technology—improving safety and opportunities to address traffic



Safety Pilot Model Deployment site, Ann Arbor, Michigan. Source: University of Michigan Transportation Research Institute

The Front Line of Crash Avoidance Technology

With **vehicle-to-vehicle (V2V)** technology, vehicles within range communicate wirelessly to exchange information such as speed and location to help drivers avoid catastrophic crashes.



Vehicle-to-infrastructure (V2I) is a wireless info-swap between vehicles and roadside fixtures, such as traffic signals and signs.



If completely effective, V2V and V2I warning systems could potentially address about

80 percent

of all vehicle crashes involving unimpaired drivers.

Source: U.S. DOT/Volpe

congestion. Real-time transportation data transmission keeps traffic flow moving, providing travelers with options to change routes and avoid traffic jams. This reduces the cost of fuel spent while sitting in traffic and reduces emissions.

Volpe collaborated with other modal administrations including the Federal Highway Administration (FHWA), as well as external partners such as vehicle manufacturers and academic affiliations. The results of the Safety Pilot Model Deployment helped transportation objectives shift its focus from helping people survive crashes to helping people avoid crashes. (Sponsored by NHTSA, ITS JPO, and FTA)

CONNECTED VEHICLES

The Power of Connected Vehicle Data to Transform Transportation Systems

Preparation is under way for the coming wave of connected vehicle data. Volpe has been supporting the ITS JPO Connected Vehicle Real-Time Data Capture and Management (DCM) program's efforts to ensure

transportation agencies are ready to obtain and use data generated by connected vehicles.

DCM technologies collect real-time data from a variety of sources, integrate it across transportation modes, and make it available for a wide range of uses that could lead to improved safety and mobility and reduced environmental impacts. Knowing how to use connected vehicle data is becoming increasingly important. This effort helped transportation agencies and private partners better understand how DCM technologies can help solve transportation problems like traffic congestion.

Volpe published a white paper on "Big Data's Implications for Transportation Operations," expanding the understanding of advanced data approaches for transportation operations, the value it could provide, and implications for the future direction of the DCM program.

Advanced data management and analytics are needed to contend with the coming volume of connected vehicle and traveler data, to enable a wide range of new transportation strategies, and reduce the need for traditional data collection mechanisms. (Sponsored by ITS JPO)

Improving Cybersecurity in Automobiles

Modern day automobiles are extremely complex, containing up to 100 embedded electronic control units, a wide range of infotainment/telematics networks to support these units, and an ever-increasing number of wired and wireless interfaces. With increased connectivity comes a higher risk of cyber vulnerabilities. Volpe, in partnership with the Department of Homeland Security (DHS) Science and Technology cyber security division, has developed the Automotive Cybersecurity Industry Consortium (ACIC). Over a five-year period, Volpe and DHS will work with major automotive original equipment manufacturers (OEMs) to develop technologies and infrastructure to reduce the risk of automotive threats and vulnerabilities that cybercriminals might exploit.

The voluntary public and private partnership provides OEMs with a framework to leverage government resources and conduct “pre-competitive research” (PCR) to develop technologies that dramatically improve the level of cybersecurity in automobiles. ACIC is funded by member OEMs with matching funds from DHS. Volpe and DHS have already identified several PCR projects to reduce this risk, including hacker motivational database/threat assessment and incident response algorithms.

In 2015, during the first year of the program, Volpe and DHS produced an ACIC Program Plan for member OEM technical staff and management, describing the proposed ACIC organizational structure and project summaries. Legal agreements are being developed, including the Master Participation Agreement and the ACIC “Hub” organization to oversee day-to-day operations between member companies.

Volpe has extensive experience in cybersecurity expertise and innovation. Prior collaboration with DHS includes reducing the success and severity of cyberattacks against critical infrastructure control systems. When the program ends in 2019, automotive cybersecurity operations will transition to industry, with DHS and the U.S. DOT serving in an advisory role as liaison members to the consortium. (Sponsored by DHS)

MOTOR CARRIERS

Compliance, Safety, Accountability Continuous Improvement Study

Compliance, Safety, Accountability (CSA) is the Federal Motor Carrier Safety Administration’s (FMCSA) program to improve large truck and bus safety. CSA allows FMCSA and its state partners to identify at-risk motor carriers and help them get safe, or get them off the road—before crashes occur.

Since 2010, CSA has been fully implemented in a number of states, leading to significant improvements in the safety of commercial motor vehicle operations on our nation’s highways. Volpe has supported FMCSA by designing a continuous improvement effort to review and analyze elements of the program—to determine if they are working and whether modifications are needed prior to full national implementation.

The Continuous Improvement Study’s primary focus has been on FMCSA’s intervention and prioritization processes. The study resulted in a number of recommendations planned for implementation. They were finalized and are designed to: enhance the intervention process, ensuring better use of procedures and techniques by field staff; and modify prioritization algorithms and processes to



FMCSA has enhanced the CSA intervention process to make better use of field staff. Source: FMCSA

ensure FMCSA focuses its resources to maximize safety outcomes. The new prioritization algorithm will allow FMCSA to more effectively identify and prioritize motor carriers that pose the greatest safety risk for interventions, such as investigations. It will also allow FMCSA to pinpoint carriers that will require close monitoring over time. The FMCSA Administrator approved the recommendations.

The effort builds on FMCSA's commitment to continuous improvement and lays the groundwork for ongoing evaluation of the CSA program.

These improvements will increase the effectiveness and efficiency of CSA, making the roads safer for everyone. (Sponsored by FMCSA)

MOTOR CARRIERS

New Entrant Motor Carrier Safety Audit Program

New motor carrier companies first interact with FMCSA through the agency's New Entrant Program. FMCSA and state partners provide new entrants with educational materials and conduct safety audits to assess their understanding of federal regulations covering motor carriers.

FMCSA created the program to ensure that new carriers operate safely, that they understand and follow regulations, and to remove carriers that operate unsafely. While the program consistently meets those

goals, a number of fundamental challenges have emerged over the last several years.

Resources to administer the New Entrant Program have remained constant while the number of new entrants has steadily risen. Federal legislation has also reduced the time allowed to conduct safety audits from 18 months to 12 months for motor carriers and from 9 months to 120 days for passenger carriers with motorcoaches.

Volpe, in support of FMCSA, develops, tests, refines, and implements offsite safety audits as one of several solutions designed to improve the efficiency and effectiveness of the New Entrant Program. In an effort to conduct more audits and address safety compliance issues sooner, the Offsite Safety Audit enables auditors to remotely evaluate a new entrant motor carrier's basic safety management controls. It does not replace the Onsite Safety Audit, but provides states with a way to conduct audits more efficiently for carriers that have not been identified as having a known safety issue.

Carriers submit documentation and auditors determine if carriers have sufficient safety management practices in place. Offsite safety audits are completed in a fraction of the time and cost of onsite audits while still meeting regulatory requirements, allowing auditors to focus onsite audits on higher-risk carriers.

From July 2013 to December 2014, Volpe conducted six pilot tests of the offsite safety audit program in Alaska, California, Florida, Illinois, Montana, and New York. The pilot states reduced overall travel costs related to safety audits by 58 percent, and by conducting 60 percent of audits offsite, states reduced overall time spent on audits by 33 percent.

In January 2015, Volpe and FMCSA began planning for a phased national roll-out of the offsite safety audit

program, which will be completed over the next three years. Thirteen states implemented the program in summer 2015. (Sponsored by FMCSA)

MOTOR CARRIERS

Making Motor Carrier Enforcement More Efficient and Effective

Volpe supported FMCSA's efforts to bring greater efficiency and effectiveness to their overall enforcement program—Compliance, Safety, Accountability. The CSA program brought about new business processes that realized the efficiency and effectiveness of the overall enforcement program.

FMCSA's workforce faced new challenges and requirements with the advent of these new processes, and identified the need to introduce a new program analyst (PA) role. Volpe conducted a workforce analysis that showcased how the position could be designed and successfully implemented in the field division offices, and the overall gains that could result.

After initial success with implementing the PA role in 9 states, Volpe expanded the program to 21 state division offices, supporting the hiring, onboarding, and training of new PAs to support the day-to-day operations in FMCSA division offices as well as informing CSA program design.

The PA program is a model of efficiency. It boosts the FMCSA workforce and supports business process redesign. Relying on Volpe to analyze the current workforce structure and identify ways to maximize efficiency and effectiveness is critical to the overall success of the CSA program. The implementation of the PA role into the field effectively frees up safety

investigators and division management to focus their expertise on identifying and removing unsafe bus and truck companies, vehicles, and drivers, ensuring everyone’s safety. (Sponsored by FMCSA)

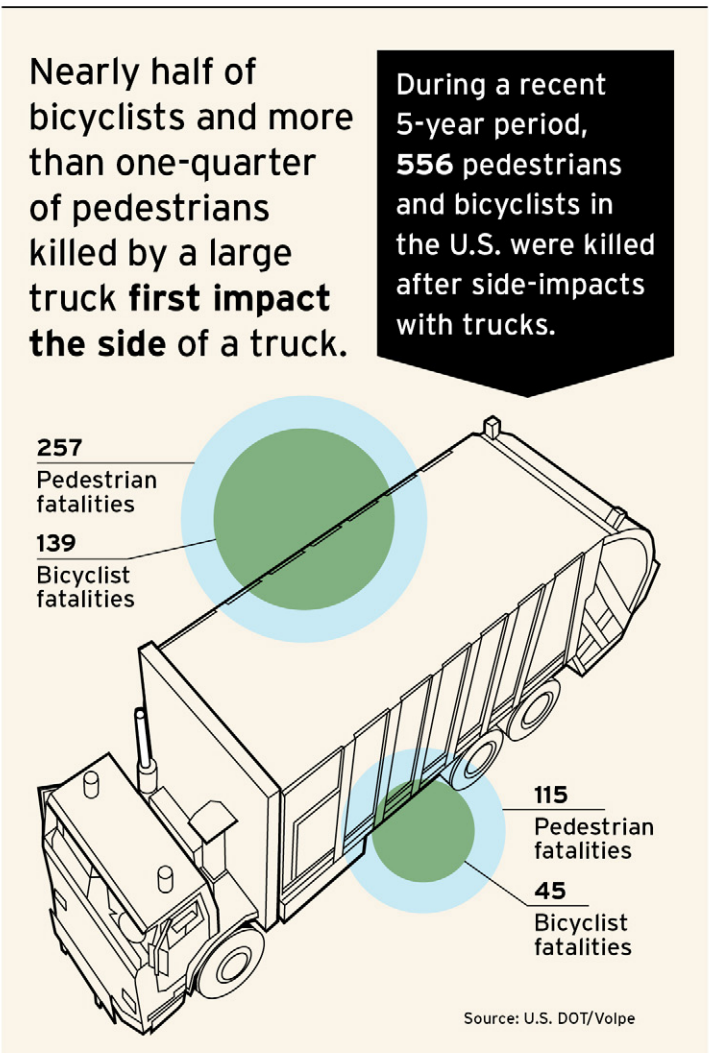
PEDESTRIANS AND BICYCLISTS

From Research to Reality,
Volpe Brings Side Guards to
Large Trucks

Side guards save lives. That’s not hyperbole—Volpe’s research showed it.

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 physically cover that open space.

Volpe’s research coalesced years of international analysis on side guards. The United Kingdom, for



Above: Side guards help keep pedestrians and bicyclists from falling between axles. Source: City of Boston

instance, enacted a side guard requirement in the 1980s. After the requirement was implemented, bicyclist fatalities decreased 61 percent, and pedestrian fatalities decreased 20 percent for side impacts with large trucks. Through presentations at conferences and consultations with elected officials and transportation agencies, Volpe is helping bring side guards to the United States.

In 2014, the city of Boston asked Volpe to help expand its truck side guard pilot—which was informed by Volpe research—and to craft the nation’s first side guard ordinance for private truck fleets. The ordinance took effect in May 2015.

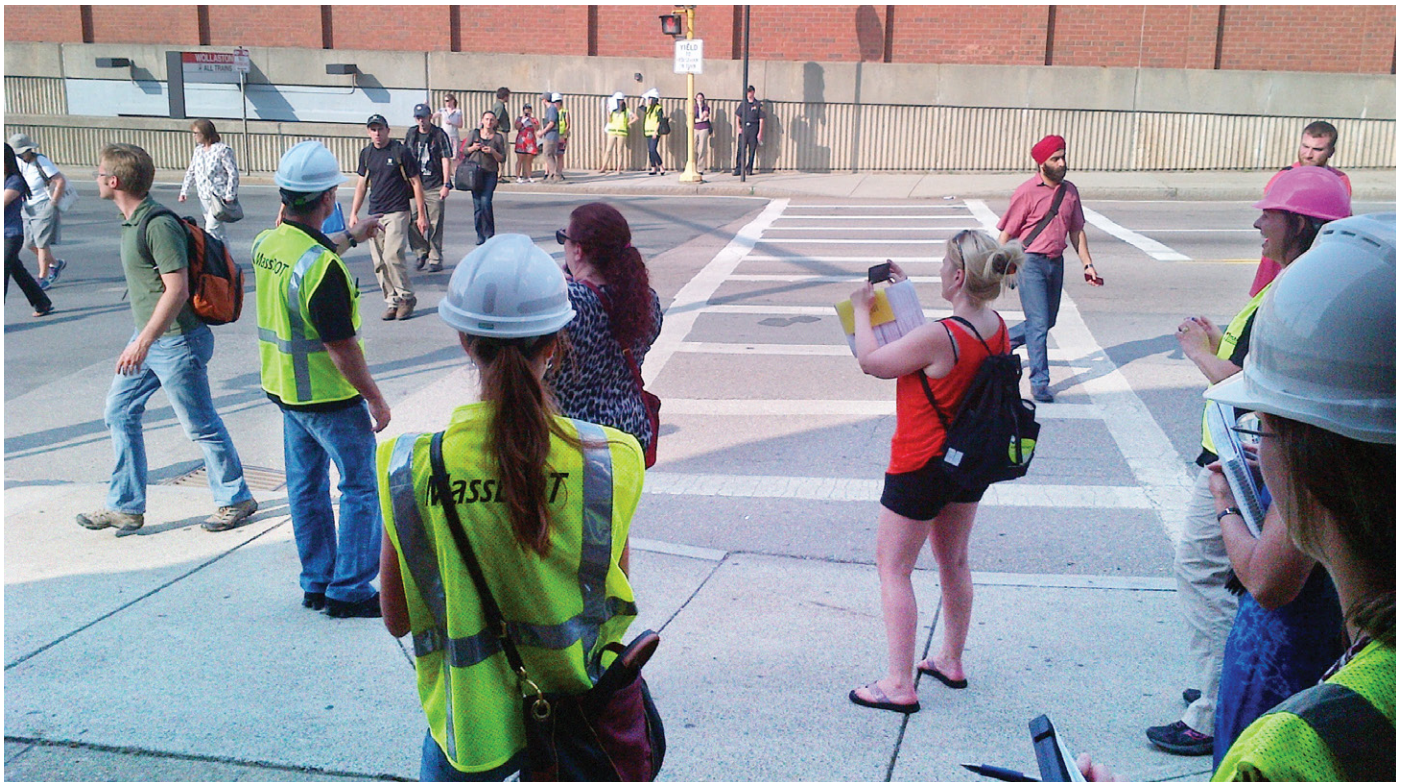
New York City also asked Volpe to study and develop a pilot truck side guard program for its largest-in-the-nation municipal truck fleet. In June 2015, New York unanimously passed a Volpe-advised law requiring side guards on 10,000 city-owned and regulated trucks

by 2024. With New York’s truck fleet fully equipped with side guards, the city can expect to see several lives saved and dozens of serious injuries avoided per year. (Sponsored by the cities of Boston, New York, and Cambridge; and Tetra Tech)

PEDESTRIANS AND BICYCLISTS

Safer People, Safer Streets

Over the past few years, more people have been walking and bicycling farther than ever before. At the same time, pedestrian and bicyclist injuries have steadily increased. Since spring 2014, Volpe has supported the Office of the Secretary of Transportation (OST) on the Safer People, Safer Streets Pedestrian and Bicycle Safety Initiative. The initiative uses a combination of strategies targeted at improving infrastructure, policies, research,



The Pedestrian Assessment Group, made up of Volpe staff and MassDOT personnel, observe pedestrian access to and from the Wollaston MBTA station in Quincy, MA. Source: U.S. DOT/Volpe

and multidisciplinary relationships to reverse this troubling trend.

Partnering with FTA, NHTSA, FMCSA, FHWA, and the Federal Railroad Administration (FRA), Volpe developed internal materials to support U.S. DOT field staff in planning and conducting local safety assessments. Between July 2014 and June 2015, U.S. DOT modal field offices in all 50 states, Washington, D.C., and Puerto Rico led pedestrian and bicycle safety assessments. The assessments identified issues related to safe walking and bicycling, and barriers related to infrastructure, policy, funding, and coordination. They provided an opportunity for education and collaboration, and in some cases will lead directly to site-specific project improvements.

In January 2015, Secretary Anthony Foxx kicked off the Mayors' Challenge for Safer People, Safer Streets, encouraging mayors and other elected city officials to advance safety and accessibility goals in their communities. Volpe assisted in scoping, planning, conducting, and documenting the national summit for the Challenge, held in March. To date, 237 communities have signed up to be part of the Challenge.

More recently, Volpe developed a summary report for OST on the national assessments effort; it highlights experiences, lessons learned, and common themes from all 52 assessments around the country. Volpe staff are helping to shape the agenda for the next phase of the initiative in order to address non-motorized safety issues and help communities create safer, better connected bicycling and walking networks. (Sponsored by OST)

RAIL

Increasing the Safety of Crude Oil and Ethanol Rail Shipments

A surge in crude oil and ethanol production has resulted in an equivalent increase in the volume of these materials being transported by rail. In 2013, freight railroads were estimated to have carried 435,000 carloads of crude oil, roughly equivalent to more than 300 million barrels, compared with 9,500 carloads in 2008. Ethanol shipments by rail have also risen sharply, but the increase is not as dramatic as that of crude oil. The



Tank car shell puncture from the Lac-Mégantic, Quebec, rail disaster in July 2013. Source: NTSB

increase in rail shipments has raised safety and environmental concerns, underscored by a spate of recent rail accidents in the U.S. and Canada.

On the basis of available information, roughly half of the more than 330 derailed hazmat rail cars released dangerous material in 19 accidents. Of the derailed cars, at least 281 were DOT111 general-purpose tank cars. Damage to derailed tank cars is typically characterized as: head puncture, shell puncture, failures to valves and fittings, thermal failures, stub sill failures, loss of containment volume, and energetic ruptures.

Volpe has been providing technical support to FRA related to rail and tank car safety since the 1970s. The most recent research accomplishments include conducting two full-scale shell puncture tests—one on a general-purpose tank car and the other on a DOT112 tank car, which has a thicker tank—to examine structural behavior and crashworthiness performance under a generalized shell impact scenario.

This full-scale testing effort was done in tandem with computational modeling, comparing calculations from finite element analyses conducted by Volpe engineers with test data for both tank cars. Ultimately, results from FRA and Volpe collaborative research will be used to create innovative designs and to develop regulations for safer tank cars. (Sponsored by FRA)

RAIL

Stressing Safety in the Short Line Railroad Industry

In early 2014, the American Short Line and Regional Railroad Association (ASLRRA) committed to the Secretary of Transportation that it would take specific

voluntary actions to improve the safety of transporting crude oil by rail. Among those actions is the creation of the Short Line Safety Institute to strengthen safety culture and improve safety practices on short line and regional railroads across the country. ASLRRA's vision is for the short line and regional railroad industry to be recognized as one of the safest in the world.

The Institute intends to offer member railroads a voluntary safety-culture assessment, involving an online survey and site visit to review safety documents, observe work practices, and interview staff. An assessment will be given to senior railroad management with findings related to the strength of safety culture, while providing much-needed education for managers and employees. This activity supports the Institute's mission: to build a strong and sustainable safety culture in the short line industry through non-punitive and voluntary partnerships.

Experts from Volpe facilitated and provided critical, necessary feedback to help foster the Institute's growth by analyzing its design and assessing its influence. Volpe is also summarizing the preliminary utility and potential sustainability of the new organization for affecting industry-wide safety culture change.

Since the program's inception, Volpe has observed seven pilot site assessments, and has supported FRA on writing three published Research Results. Volpe has systematically led activities to investigate, measure, and assess key aspects of the pilot project. Interviews are now being conducted with key project stakeholders to help inform the Institute's growth and development.

Volpe will continue to provide assistance with the goal of improving safety culture, safety conformance and, ultimately, safety performance for participating short line railroads through the end of the pilot period. (Sponsored by FRA)



Security footage of three individuals trespassing along a rail ROW with cautionary signage prominently displayed.

Source: U.S. DOT/Volpe

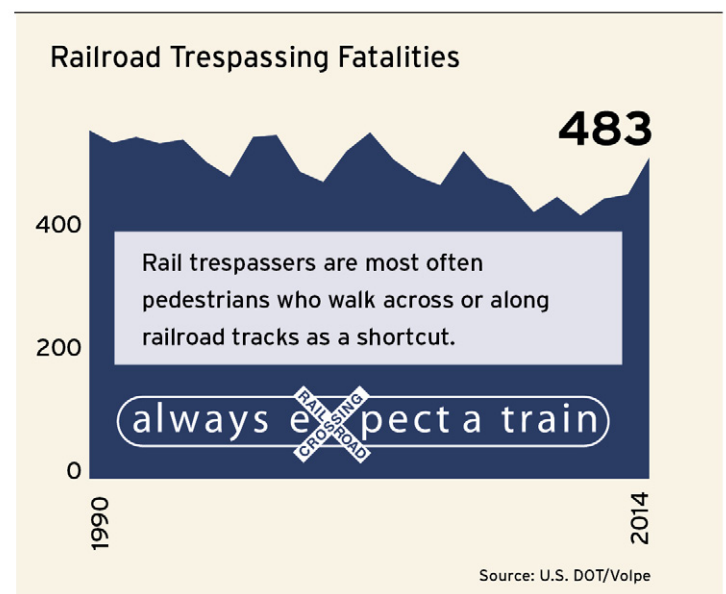
RAIL

Addressing Trespass-Related Fatalities on Rail Right-of-Way

Trespassing on active railroad tracks is the leading cause of rail-related deaths in the U.S., resulting in 483 fatalities in 2014 alone. Preventing these types of deaths is a primary concern of U.S. DOT, FRA, railroad companies, and the communities through which trains operate.

Beginning in October 2009, Volpe partnered with FRA to conduct research and develop guidelines for preventing trespass-related fatalities on rail rights-of-way (ROWs). The project demonstrated FRA's rail trespass prevention guidance known as Community, Analysis, Response, Evaluation—or CARE—and

evaluated specific intervention strategies implemented using the model. The main objective of the research was to develop national recommendations to significantly reduce trespass-related incidents and deaths.



A trespass prevention case study was conducted in West Palm Beach, Florida to show the benefits of using CARE to bring together multiple participants, perform robust data analysis, and develop and put into practice good mitigation strategies. The study leveraged collective resources, increased stakeholder collaboration, and strengthened the community-based effort to reduce trespassing on the city's railroad ROWs. The project was successful, which led to additional research at another location prone to high trespass risk.

Volpe mechanical engineers and analysts partnered with FRA personnel and agency staff from Florida DOT, Florida Operation Lifesaver, TriRail, Amtrak, and Florida East Coast Railway to develop best practices and lessons learned. This provided critical guidance on how to best implement the CARE model and demonstrated effective trespass mitigation strategies. These strategies are being implemented by FRA and railroads throughout the U.S. to make the nation's rail network safer for people and communities near active rail networks. (Sponsored by FRA)

RAIL

Preventing Stop Signal Violations in Passenger Railroad Terminals

Trains passing stop signals (PASS) is a nationwide issue. It occurs when a locomotive engineer does not stop the train prior to a stop signal. Passing a stop signal without proper authorization from the railroad has resulted in train collisions where multiple fatalities have occurred and has at times caused the release of hazardous materials. The National Transportation Safety Board has identified Positive Train Control (PTC) technology as a way to prevent PASS.

PTC systems are integrated command, control, communications, and information systems for control-

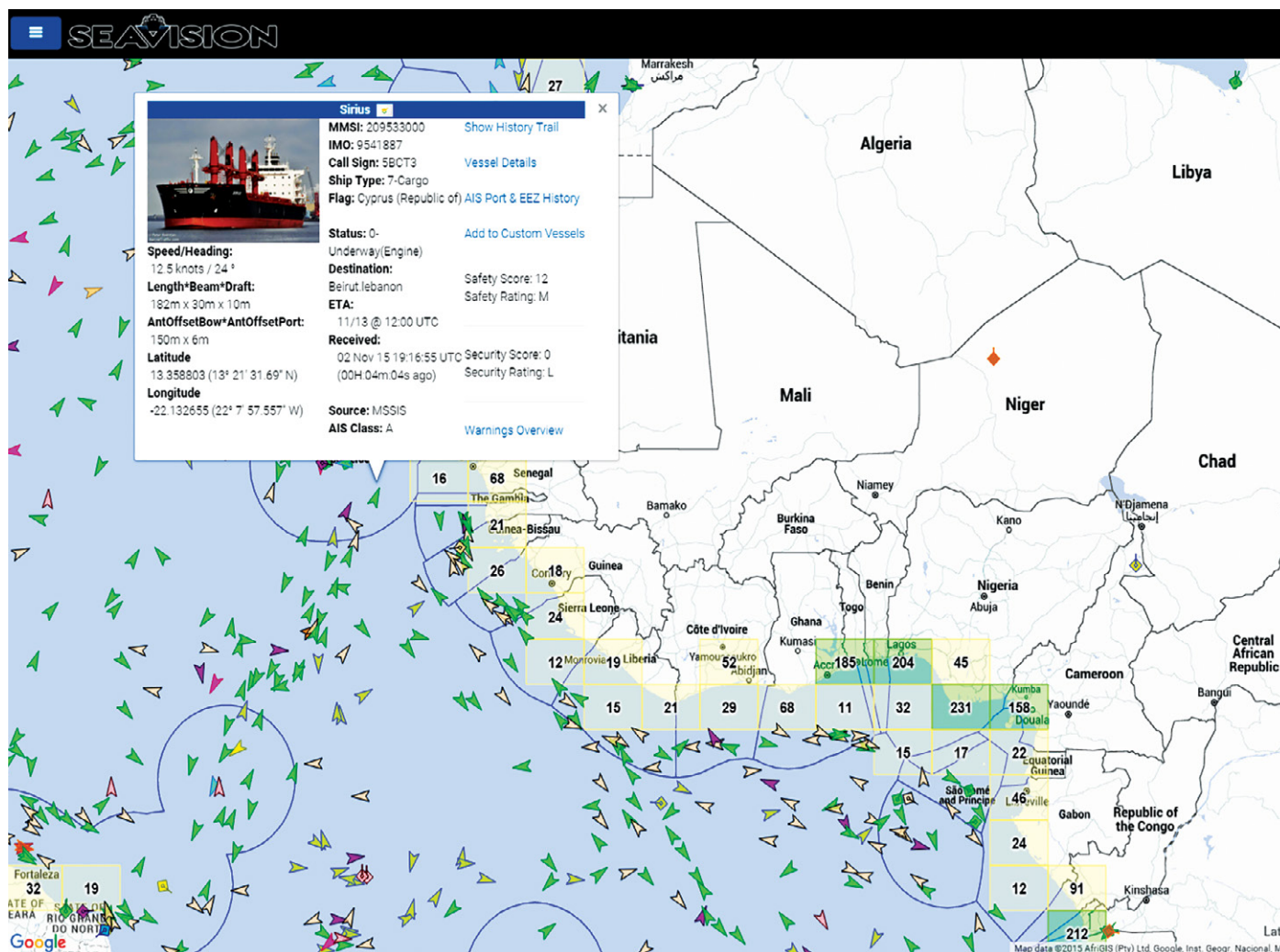
ling train movements safely, securely, precisely, and efficiently. The Rail Safety Improvement Act of 2008 mandated PTC to be implemented across most of the nation's rail industry. Identifying how and why trains pass stop signals can provide railroads with an expanded set of tools to prevent PASS from occurring, particularly in areas where PTC is not in place.

FRA turned to Volpe with its more than 20 years of rail human factors expertise to work closely with a passenger railroad in identifying why train crews pass stop signals and the corrective actions to prevent or limit PASS from occurring in the future.

Volpe developed corrective actions to address the source of the railroad's PASS and briefed the railroad on factors contributing to PASS events. Volpe also



Railroad stop signals are placed near rail ROWs. Photo composite source: 123RF.com/Richard Semik/Mark Winfrey



SeaVision enables users to view and track vessels on a map, anywhere in the world. Source: U.S. DOT/Volpe

provided FRA with a report, listing recommendations for resolving these events. Volpe’s research on PASS is the first to be sponsored by FRA. Researchers outside the United States have conducted all previous research on this topic.

Volpe’s findings show how the design and operation of railroad systems produce unsafe conditions, such as PASS events. Significant strides have been made in understanding why PASS occurs at individual railroads. By understanding underlying causes at all levels of the organization, the railroad can reduce the likelihood of these incidents from occurring and FRA can share this new knowledge with the wider railroad community. (Sponsored by FRA)

MARITIME

SeaVision Shines Light on the Global Seas

SeaVision is an evolving maritime domain awareness (MDA) tool originally developed by Volpe for the U.S. Naval Forces Africa (NAF). SeaVision was created to help countries on the western coast of Africa improve vessel traffic management and navigation safety; increase maritime situational awareness and security; reduce illegal fishing, illicit trading, human smuggling, and piracy; provide improved data for search-and-rescue operations; facilitate commerce; and enable disaster-recovery efforts.

SeaVision displays Automatic Identification System (AIS) data from the Volpe-developed Maritime Safety and Security Information System (MSSIS) network on a Google map. AIS allows the automatic exchange of real-time ship-to-ship, ship-to-shore, and shore-to-ship vessel information, including vessel identity, characteristics, position, course, speed, and heading. SeaVision provides a historical and current view of MSSIS data that can be used to analyze vessel movements.

In 2015, SeaVision was used in three naval exercises including participation from 23 African countries and their respective Maritime Operation Centers (MOCs). On behalf of the U.S. Africa Command, Volpe recently hosted its second annual on-site and multi-week MDA Administrator and Technician Training Workshop, training African government officials on SeaVision and additional MDA tools with the goal of “training-the-trainer” for in-country system sustainment.

SeaVision is making a difference: Cabo Verde recently noted a significant improvement in the fight against illegal maritime activities after joining the system. The Cabo Verdean maritime police—in collaboration with the Senegalese MOC—were able to identify and intercept a foreign-flagged vessel illegally fishing both on and near the respective borders of each country, within their territorial waters.

Because SeaVision provides unclassified data, it is readily available to other countries, and its use has now spread well beyond Africa. Many countries use SeaVision to track vessel movements within their exclusive economic zones and waterways, and the system has enabled maritime safety and security professionals around the world to better track, analyze, and monitor vessel movements. (Sponsored by U.S. Naval Forces Africa)

AVIATION

Flight Standards Safety Assurance System

Safety is the most important element of the Federal Aviation Administration’s (FAA’s) mission. Volpe, in collaboration with the FAA Flight Standards Service System Approach for Safety Oversight Program, began an extensive initiative in late 2010 to address safety standard challenges. Volpe successfully designed and developed the Safety Assurance System (SAS), which is currently operational in more than 90 FAA offices nationwide.

SAS integrates aviation safety oversight into a unified framework and national standard based on Safety Management System (SMS) principles. SAS now provides FAA with a more refined understanding of safety by applying thousands of automated business rules to connect regulations and safety hazards to the operating characteristics of each air carrier and repair station.

Establishing a national aviation safety standard, SAS incorporates International Civil Aviation Organization critical elements for SMS-based safety oversight systems. These include specific operating regulations and technical training, surveillance obligations, and resolution of safety concerns. In addition, SAS assists inspectors in performing assessments and identifying hazards by branching through a hierarchy of smart questions. The system currently encompasses 129 master lists of functions supported by 800 separate data collection tools and a library of nearly 10,000 safety oversight questions. By scoping oversight to reflect only applicable functions, a significant amount of wasteful effort is eliminated for FAA field employees.

Developed at Volpe, SAS now resides at the Mike Monroney Aeronautical Center in Oklahoma City.

After key site testing, Volpe's project team moved the system to production in September 2014. Ninety FAA offices had converted to the new system by the fall of this year. Efforts are underway to deploy the system to all sites. (Sponsored by FAA)

AVIATION

Identification Friend or Foe System Simulation and Test Support

Safety in the national airspace system (NAS) relies heavily on the moment-to-moment ability of FAA air traffic controllers to track and manage the identity, location, speed, and direction of aircraft using information gathered by Secondary Surveillance Radar (SSR), Multilateration, and Automatic Dependent Surveillance–Broadcast systems. As a last line of defense, pilots use the Traffic Collision Avoidance System (TCAS) to detect nearby aircraft and prevent airborne collisions. Together, these systems are called the Aeronautical Surveillance and Collision Avoidance Systems (ASCAS) and share use of the 1030 and 1090 MHz bands, owned and controlled by FAA, to accomplish their surveillance missions.

There is a risk that an aircraft may go temporarily undetected by ASCAS if there are too many signals on the 1030 or 1090 MHz bands. If spectrum congestion were allowed to exist beyond what ASCAS could handle, FAA Air Traffic Control (ATC) may not be able to safely separate aircraft. As a result, airborne collision avoidance warnings may be delayed beyond the critical amount of time needed for a pilot to avoid an impending collision.

FAA is the agency that grants permission to operate in and around the 1030 and 1090 MHz bands. In times

of conflict, the U.S. Navy must be able to distinguish friendly aircraft from unfriendly aircraft, and uses civilian waveforms in addition to encrypted military protocols on the bands to accomplish this via ship-borne SSRs. While FAA has granted the U.S. Navy permission to use these bands to accomplish their mission, FAA has limited the peace-time physical operational zones in which U.S. Navy ships can operate their ATC and combat system SSRs. This prevents interference that would affect ASCAS operation. These limitations did not allow the U.S. Navy to meet their training requirements.

Volpe was called upon by the U.S. Navy and FAA to lead a test effort to collect data on the performance of ASCAS during use of the U.S. Navy's SSRs to identify a safe level of joint usage of the bands. After 15 months of planning, Volpe led a major test event in the Chesapeake Bay that required coordination among key stakeholders, including FAA ATC, the FAA William J. Hughes Technical Center, the FAA Spectrum Engineering Services office, and the U.S. Navy. The findings indicated that degradation of ASCAS during the operation of four Navy SSR platforms, adequately separated in distance from the next four SSR platforms, was within acceptable limits. A final report was produced in fall 2015.

To support live testing, Volpe used its 1030/1090 MHz Interference Simulator to model the existing ASCAS environment with the additional U.S. Navy SSRs that would be under test. Pulling aircraft, transponder, and ASCAS data from many sources, Volpe ran simulations to evaluate the possible effects on ASCAS systems before the test was approved to ensure no surveillance system would see unacceptable performance degradation from the U.S. Navy SSRs. After the test, the live data collected was used to validate and fine-tune the simulator to better represent transponder and ASCAS performance. (Sponsored by U.S. Navy)

Algorithm to Test How Pilots Access Complex Flight Decks

Aircraft use Automatic Dependent Surveillance-Broadcast (ADS-B) to display traffic data on Cockpit Displays of Traffic Information (CDTIs). Modern flight decks are extremely complex, showing pilots massive amounts of data on multiple displays. In addition, new Next Generation Air Transportation System (Next-Gen) flight procedures, such as the In-Trail Procedure (ITP), have the potential to be far more complex than their predecessors. Flight data must be accessible to pilots so they can perform defined self-separation procedures, such as ITP.

Accessibility refers to finding data on a visual display and looking directly at the data. There are several issues with ADS-B data accessibility: CDTIs can be located outside of the crew's primary field of view; data may be shown in different places on the screen based on the CDTI design; and CDTIs may be configured differently based on the type of ADS-B application.

Volpe's aviation experts—with extensive knowledge in addressing human factors issues related to Next-Gen implementation—have proposed an algorithm for identifying the accessibility of data used by pilots for ADS-B flight deck procedures. The basis for the algorithm is that more frequently used—or more urgently needed—data should be more easily accessible. Volpe researched the concepts, interviewed subject matter



Commercial pilots must constantly watch the flight deck instrument panel and process complex data on multiple displays.

Source: carlosphotos/www.123rf.com

experts to determine the importance of various data types being considered for CDTIs, developed the algorithm on ITPs, and published the results.

The result is a novel approach to deciding where a new piece of data should be displayed on the flight deck—based on the data’s importance to the pilot during a given task or procedure—to ensure its optimum accessibility and usefulness. Additional work is needed before the algorithm and the recommendations based on it can be used in practice. This work includes validating that the algorithm produces correct recommendations from correct inputs.

The same methodology could be applied to other modes displaying large amounts of data to an operator such as a car or truck dashboard, a train engineer’s cab, or a ship’s helm. (Sponsored by FAA)



NEXT GENERATION AIR TRANSPORTATION SYSTEM

A wide-ranging transformation and modernization of the nation's air traffic system is underway. 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.

Opposite: As air traffic continues to grow, FAA's NextGen will help commercial airports meet demand for expanded capacity, safely and efficiently. Source: Robert

Adams/Creative Commons

Modernizing the National Airspace System for Future Growth

Air traffic demand is predicted to increase by 2 to 3 percent per year over the next 20 years, and the number of revenue passenger miles is expected to nearly double by 2032. As a result, new technologies and procedures are critically needed to accommodate this growth, safely and efficiently.

If left unchanged, this demand will lead to increased delays, fuel costs, noise pollution, and greenhouse gas (GHG) emissions. The National Aeronautics and Space Administration (NASA) is collaborating with FAA and other industry partners to develop

advanced technologies and automation tools to meet these changes.

Terminal Sequencing and Spacing (TSAS) is a decision-support tool for terminal air traffic controllers that extends the concept of Time-Based Flow Management (TBFM) into the Terminal Radar Approach Control (TRACON) facility. NASA developed an early concept for TSAS, including a prototype of the capability for use in a simulated ATC environment. As TSAS matured, a joint National Air Traffic Controllers Association (NATCA)/NASA team conducted an Operational Integration Assessment (OIA) as risk mitigation toward investment and operational deployment prior to transitioning TSAS from the laboratory to the NAS.

Volpe was called upon to serve as project manager for the effort, an operational assessment of en route and terminal air traffic control performance-based arrival operations supported with TSAS. An FAA/NASA team integrated TSAS with technologies FAA expects it to leverage when TSAS becomes operational, including the Standard Terminal Automation Replacement System, the En Route Automation Modernization platform, and newer TBFM capabilities, such as Extended Metering and Ground-Based Interval Management for Spacing. NATCA controllers and traffic management coordinators participated in the OIA, which took place at the FAA's William J. Hughes Technical Center in May 2015.

Volpe evaluated the impact of TSAS-supported operations on terminal and en route ATC operations, and the dependencies of efficient and safe TSAS support operations on en route ATC operations management. Evaluation factors included: automation performance, existing and future policies and procedures, training effectiveness, and TSAS computer-human interface considerations.

The knowledge gained during the assessment will influence the design and deployment of this capability to the NAS. Most recently, FAA achieved a final investment decision to develop and deploy TSAS. An initial operating capability of TSAS is targeted for 2019. (Sponsored by FAA)

Improving Data Sharing Across the Aviation Community

FAA is a data-rich organization, but historically has not had a standard mechanism in place for sharing its data between programs and with aviation stakeholders. This has limited the benefits that can be derived from existing data sources. Data sharing improves transportation efficiency and reduces delays by providing common situational awareness and improved planning capabilities. By standardizing delivery methods and building data delivery into the FAA infrastructure, data-sharing costs are greatly reduced and secure data-sharing options are maximized.

The objective of the System Wide Information Management (SWIM) Program is to improve data sharing across the aviation community using defined, standardized, secure, flexible, and scalable connections. SWIM provides information, when and where it is needed, within FAA and between FAA and its stakeholders, including air carriers, general aviation, and the military. Airlines no longer need to scour numerous sources to access weather and surface operations information. Private industry can also capitalize on SWIM-distributed air traffic control data to develop new software products that serve the aviation community.

Volpe is FAA's developer for the SWIM Terminal Data Distribution System (STDDS), which distributes airport data; the SWIM Visualization Tool (SVT), which

displays airport surface traffic; and the SWIM Flight Data Publication Service (SFDPS), which distributes flight data. In 2015, Volpe accomplished three major project objectives:

- STDDS Release 3.1 was completed in February, several weeks ahead of schedule.
- SVT was completed and the system installed at 11 FAA sites in March.
- By making flight data available through SFDPS as an operational capability in July, Volpe met a major SWIM final investment—an objective of the FAA Administrator.

Volpe has a continuing role providing enhancements for these three solutions. (Sponsored by FAA)

Volpe-Developed Software is FAA's Eye in the Sky

The NAS is made up of a complex network of facilities, systems, procedures, aircraft, and people. For travelers and goods to consistently get to their destinations safely and efficiently, each part of the system needs to be in sync. FAA relies on Volpe to support their mission pertaining to smooth operation of the NAS.

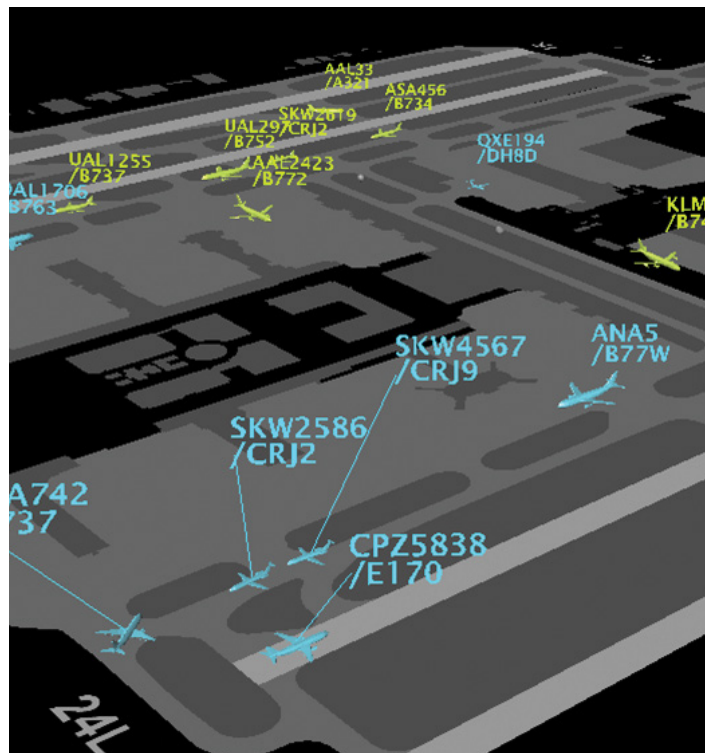
FAA uses the National Airspace System Performance Analysis System (NASPAS) to track interruptions to facilities and services needed to keep the NAS running smoothly. Numerous databases populate NASPAS, including aircraft registries, airport schedules, and equipment descriptions. Data analysts use this information to detect trends and evaluate field maintenance programs.

FAA tapped into Volpe's software and data expertise to develop NASPAS 4.0, which makes that data available in near real-time. Now, NASPAS users can access

up-to-date data, and data is reviewed for accuracy as it streams into the system. Under past versions of NASPAS software, batches of facilities and service data were checked for anomalies and accuracy. It could take up to six weeks for data to reach NASPAS users.

For this major software update, Volpe engineers analyzed requirements and managed budgets, schedules, designs, development, and testing procedures. Volpe also managed software requirements for new servers that run NASPAS software, and purchased and installed a new server at Volpe.

The Volpe and FAA servers are mirrored to ensure NASPAS functionalities and software loaded at Volpe also work at FAA headquarters. With the linked servers, Volpe staff perform updates, fix bugs, and add enhancements to NASPAS at both locations simultaneously. This dramatically reduces the time and cost of improving the software.



Pictured is a screenshot of the SWIM Visualization Tool.

Source: FAA

As a result of this two-year project, FAA air traffic controllers can now be confident they have the most up-to-date information and a full view of the complex network that keeps the NAS operating safely and efficiently. (Sponsored by FAA)

Wake Turbulence Analysis Leads to Increased Airport Efficiency

For 40 years, Volpe has collected and analyzed aircraft wake turbulence data at airports, providing FAA with recommended changes to improve terminal air traffic safety and increase efficiency. Volpe engineers provide critical analyses to help FAA achieve operational changes, among them are enabling aircraft to land on closely spaced parallel runways (CSPRs) under

instrument approaches, as well as revision of the single runway wake turbulence separation minima.

FAA has achieved several significant milestones through Volpe's support, including approval of the Safety Risk Management Document for Wake Turbulence Mitigation for Arrivals-Procedural (WTMA-P) for Philadelphia International and Detroit Metropolitan Wayne County airports. This procedure enables airports to use dependent dual-arrival traffic streams on CSPRs with reduced diagonal separation under instrument conditions, where previously the two runways had to be treated as a single runway in less than good visual weather conditions.

Additionally, FAA developed Wake Turbulence Recategorization or RECAT, which revises aircraft single runway spacing defined in the early implemen-

Wake Turbulence

Most FedEx aircraft can now be separated by **2.5 to 3.5 nautical miles (NM)** instead of the previously required **4 NM**.

14 extra planes per hour

One Hour of Air Traffic in Memphis

Before Fall 2012

After RECAT

3 minutes:
The average amount cut from aircraft taxi time.

56

70

Across the nation, other airports may see an average capacity increase of **7-10%** depending on the mix of aircraft.

Delta Airlines has reported a range of 0.5-2 minute shorter taxi times for departures, and 0.5-1 minute shorter descent times for arriving aircraft. Delta estimates annual operational cost savings of \$14.8 to \$38.1 million.

Louisville International Airport became the second airport to use the RECAT standards. As a result, UPS and others now benefit from the implementation of new wake RECAT.

The new separation standards in Memphis are saving FedEx

\$1.8 million a month in fuel costs.

Plus, less time waiting on the tarmac results in a reduction in gas emissions.

Source: U.S. DOT/Volpe

tation of RECAT I. This new wake turbulence separation minima integrates RECAT with earlier CSPR solutions developed under the framework of wake separation specified in 7110.65, and others; further reducing separations for certain aircraft pairs since the first RECAT implementation.

RECAT was implemented at Hartsfield-Jackson Atlanta International Airport, where it had a very positive impact. The new standards allow tighter arrival and departure sequences, resulting in improved flight efficiency as well as surface movements—especially during peak operation periods. As a result, Delta Airlines has reported a range of 0.5 to 2 minute shorter taxi times for departures, and 0.5 to 1 minute shorter descent times for arriving aircraft. Delta estimates annual operational cost savings of \$14.8 to \$38.1 million.

Volpe has collected, processed, and analyzed wake turbulence data to support various FAA and NextGen objectives, as exemplified by RECAT and WTMA-P. (Sponsored by FAA)

Departure Clearance Trials Demonstrate Reduced Takeoff Times

Data communication is a key component of FAA's NextGen program. It plays a vital role in issuing route revisions by air traffic control (ATC) and acceptance of the revision by the Flight Deck–Data Communications Departure Clearance (DCL) system and flight crew. Quicker takeoff times and reduced departure delays due to faster route revision by ATC and DCL acceptance will improve how Future Air Navigation Services (FANS)-equipped aircraft receive and process initial and revised departure clearances.

Prototype automation systems that issue DCLs are being tested at the Memphis, Tennessee and Newark, New Jersey ATC towers. Volpe technical experts have been instrumental in leading both trials, partnering with the FAA Data Communications Program Office, Thales Group–Trials Automation System, and Harris Corporation–Trials Communications to conduct the tests. DCL trials at both airports seek to refine requirements, reduce risk, identify benefits, develop lessons learned, and stimulate airline and avionics community interest in data communications. These are key steps prior to FAA's formal implementation of DCL services at more than 56 airports through January 2016.

Current FAA ATC departure clearance must issue all route revisions via voice over VHF radio. With the DCL program, a flight crew receives initial and revised route clearances through a VHF data link. The program transmits complex instructions and route information directly into the flight management system of the aircraft through FANS Integrated Avionics. This is a much faster and more efficient method of data transmission. The DCL system was successfully field tested at Memphis and Newark airports using FedEx, United Airlines, United Parcel Service, Scandinavian Airlines, and British Airways aircraft.

The DCL data communications program has demonstrated reduced takeoff times for aircraft equipped with DCL services. These trials will continue into 2016, at which time DCL service at Memphis and Newark will be replaced with a permanent Terminal Data Link Services (TDLS) data communications upgrade. TDLS was added to the NAS to reduce frequency congestion, aircrew and controller workload, and to enhance overall safety at airports. (Sponsored by FAA)

Global Positioning System Adjacent-Band Compatibility Program

Over the past 10 years, wireless telecommunications use has grown exponentially. As a result, the demand for increased use of the radio spectrum has surged, including those frequencies adjacent to the bands used for Global Positioning System (GPS) navigation.

The GPS Adjacent Band Compatibility Program aims to develop GPS spectrum interference protection criteria to inform proposals for commercial use of frequencies operating next to GPS/Global Navigation Satellite Systems (GNSS) signals. These criteria will help inform future applications of power levels that can operate in adjacent bands without compromising current and future space-based Positioning, Navigation, and Timing (PNT) services essential to economic, public safety, scientific, and national security needs.

According to National Space-Based PNT Policy, U.S. DOT serves as the lead federal agency for all civilian uses of GPS. In addition to transportation applications, GPS is essential for first responders, search and rescue operations, weather forecasting, earthquake monitoring, surveying and mapping, precision agriculture, telecommunications, and financial transactions.

Volpe engineers coordinated with and received input from U.S. DOT, FAA, U.S. Air Force (USAF), and other federal partner departments and agencies regarding their use of GPS/GNSS receivers and corresponding use cases and categories. Volpe also hosted four public workshops, taking a planned approach by asking GPS manufacturers and other industry stakeholder attendees to identify GPS/GNSS



The DCL system was field tested using FedEx and UPS aircraft. Source: 123RF.com/tomxox

receiver use cases and categories, and to participate in a test program. Volpe received feedback from attendees on the test plan development and possible test environments.

Protecting GPS/GNSS receivers will ensure existing and future uses of space-based PNT services are not adversely impacted, including those applications that provide critical support to all transportation modes. Volpe will continue to work with federal partners to develop a GPS receiver test plan and procedures, and establish a program to evaluate GPS/GNSS adjacent band transmit power limit criteria. (Sponsored by OST and FAA)

Sense and Avoid Technology Assists Remotely Piloted Aircraft Operators

In recent years, remotely piloted aircraft (RPAs) have proven invaluable for applications such as environmental monitoring, law enforcement, and humanitarian aid. The U.S. military has an increasing number of critical mission needs requiring the use of RPAs, here and abroad. The USAF is especially interested in finding ways for RPAs to safely operate alongside manned aircraft in the NAS.

The strength of the U.S. economy depends on the ability of the transportation enterprise to adapt to ever-changing technologies and capabilities. With RPA applications potentially supporting up to 100,000 new jobs by the end of 2025, it is critical that the nation's aviation infrastructure quickly evolves to accommodate the routine and safe operation of RPAs in the NAS.

Without a pilot onboard an RPA, a remote operator has very few approved options for visualizing neighboring aircraft. In response to this challenge, Volpe worked closely with USAF to develop a low-cost automated solution which enables RPA operators to “sense and avoid” other aircraft. This Ground-Based Sense and Avoid (GBSAA) capability leverages existing NAS terminal automation and radar assets to provide RPA operators with a real-time display of aircraft movement in the airspace surrounding the RPA.

Since 2011, Volpe engineers and analysts have provided technical expertise to the GBSAA initiative in the areas of hardware configuration, software testing, system architecture analysis, and post-demonstration data analysis. Recent successes in demonstrating GBSAA led FAA to grant a certificate of authorization to USAF permitting unimpeded, daily RPA operations at

Cannon Air Force Base (AFB) in New Mexico using the GBSAA automated solution. USAF is now considering expanding the number of GBSAA installation sites to include Wilmington Air Park in Ohio and Beale AFB in California.

Enabling the U.S. military to operate RPAs with increased safety, frequency, and regularity will significantly reduce the need for restricting NAS airspace to accommodate RPA operations. The transportation enterprise will immediately benefit from the increased ability of civil aircraft to fly more direct routes, resulting in less time and distance flown, along with a decrease in overall aviation fuel emissions. (Sponsored by U.S. Air Force)



A typical remotely piloted aircraft used by the U.S. military for critical operations in the NAS. Source: 123RF.com/

Sergey Soldatov



HIGH-PERFORMANCE PASSENGER RAIL

A cross-center, multidisciplinary Volpe team is lending key support to the Department of Transportation's efforts to advance high performance and intercity passenger rail in the United States.

Ensuring Future Investments in the Northeast Corridor

The Northeast Corridor (NEC) is a 457-mile rail spine running from Washington, D.C., to Boston, transporting more than 750,000 passengers daily, as well as valuable material and goods. The NEC FUTURE program is a comprehensive planning effort led by FRA to define, evaluate, and prioritize future passenger rail investments in the NEC.

Opposite: A high-speed Acela train crosses a bridge in Stonington, CT. Source: U.S. DOT/Volpe

Decisions resulting from the NEC FUTURE program could have far-reaching effects on transportation in the Northeast, potentially reducing travel times, increasing service frequency, and adding new stations. The national economy could be affected by these changes as 20 percent of the nation's gross domestic product originates from areas within the NEC FUTURE Study Area.

The NEC increasingly faces constraints, including inadequate track capacity, speed restrictions, aging rail infrastructure, and overall service reliability. Additionally, any improvements to the NEC require coordination and agreement with multiple regional stakeholders, as the rail corridor intersects eight states and the District of Columbia. The NEC FUTURE program will upgrade aging infrastructure and improve the reliability, capacity, connectivity, performance, and resiliency of passenger rail service in the NEC for intercity and regional trips, while promoting environmental stability and economic growth.

The program achieved a number of major milestones during 2015. Accomplishments include the development of 25 environmental resource methodologies, a draft programmatic agreement in accordance with Section 106 of the National Historic Preservation Act, and a new ridership model that captured traveler behavior and modal preference and release of the Tier 1 Draft Environmental Impact Statement.

Ten Volpe staff members from five divisions currently support FRA's oversight and development of the NEC FUTURE program, providing technical guidance and environmental support. Volpe manages all of the technical work; oversees public and stakeholder engagement, including resource and regulatory agency coordination; assists with ridership model development and application; and participates in government-to-government consultation. Volpe staff serve as FRA's Deputy Program Manager, Environmental Lead, and Ridership Lead for the NEC FUTURE program.

Losing the NEC for one day could result in nearly \$100 million in transportation-related losses, according to studies from the Northeast Corridor Infrastructure and Operations Advisory Commission. Volpe's support of the NEC FUTURE program will address critical mobility issues through rail and infrastructure improvements to this important and heavily traveled rail corridor. (Sponsored by FRA)

Amtrak Performance Tracking System Development and Implementation Support

Accurate financial information on operating costs has helped Amtrak manage its business while helping set passenger rail goals and increasing transportation efficiency. In 2005, Volpe and Amtrak jointly developed a managerial accounting tool to monitor costs and

allocations—the Amtrak Performance Tracking (APT) System. Amtrak uses APT for internal management, reporting financial data to FRA and Congress, and managing passenger rail service contracts in 19 states.

Several years after it was developed, the APT system documentation was in critical need of updates. Current APT documentation was confusing to users and stakeholders, providing inconsistent financial data and solutions. Volpe economists worked with Amtrak and FRA to rewrite the entire system documentation and define current implementation to users on how the system works. This boosted stakeholder confidence in the answers APT provided. By cleaning up the outdated documentation describing key system components and how they work together, external stakeholders have a better understanding of the system as a whole.

Volpe collaborated with FRA and Amtrak to develop the underlying methodology and logic for the cost accounting structure and allocation rules within APT. Volpe developed a new set of reports for state-supported services, and updated the 2009 Report to Congress—offering a look at the current state of the system, which was submitted to FRA.

Volpe assisted FRA with recommendations in response to a Department of Transportation Inspector General audit, adding information improvements to APT where possible. In addition, Volpe provides ongoing technical assistance to cost or allocation-related queries for the states' mediation with the Federal Mediation and Conciliation Service on Amtrak's billing methodology.

At its core, APT was designed to provide internal and external stakeholders with accurate data on Amtrak's operating and capital costs. Accurate cost information will help stakeholders manage Amtrak's assets more efficiently. Volpe will continue to provide support on the APT initiative. (Sponsored by FRA)

Program Oversight Keeps Rail Projects on Track

FRA administers grant and loan programs to assist states and other eligible entities in the planning, acquisition, design, construction, and operational readiness of high-speed and intercity passenger rail projects and freight rail projects. FRA provides stewardship of taxpayers' dollars and conducts due diligence as a federal grant-making agency.

The number and amount of grants and loans FRA administers have dramatically increased over the last several years. The agency's Monitoring and Technical Assistance Program (MTAP) is currently responsible for overseeing more than \$13 billion worth of transportation investments in 175 projects throughout the U.S. MTAP covers projects funded through grants and cooperative agreements. Volpe and FRA work together to oversee recipients' efforts on high-speed and intercity passenger rail projects, the U.S. DOT Transportation Investment Generating Economic Recovery (TIGER) grants, and Amtrak capital and operating activities.

The objective of Volpe's oversight role is to identify risks and recommend corrective actions to keep the projects on schedule and on budget, with the objective of ensuring they are delivered successfully, provide public benefits, and meet federal requirements. The Volpe MTAP team has conducted over 70 monitoring site reviews and 150 technical reviews to assist grantees in successful project execution. For example, Volpe performed 25 design reviews and 11 site reviews for Amtrak's Accessible Station Design Program to identify areas where proposed, designed, or completed work was not in compliance with Americans with Disabilities Act standards. This oversight activity resulted in corrections that improved station accessibility, providing a direct benefit to the traveling public.

FRA wants to develop a sense of community and partnership to encourage learning. To this purpose, the Volpe MTAP team coordinated a national meeting that was attended by FRA, grant and loan recipients, members of the railroad industry, and others to share best practices, discuss lessons learned, and provide educational briefings. The team also developed and delivered a technical assistance webinar on understanding and complying with Buy America requirements.

Through its work under MTAP, Volpe is helping FRA fulfill its mission of promoting safe, environmentally sound, successful rail transportation to meet the needs of customers today and tomorrow. (Sponsored by FRA)



FRA and Volpe staff monitor work at the Muldraugh Bridges for a TIGER project near West Point, KY. Source:

U.S. DOT/Volpe



ENVIRONMENT & ENERGY

Whether it's assessing the costs and benefits of national fuel economy standards or informing policy makers on the environmental impacts resulting from decisions on aircraft operations around the world, Volpe is a proven leader in helping the nation address its most pressing transportation-related energy and environmental challenges.

Analytical Expertise Supports Medium- and Heavy-Duty Fuel Consumption Standards

Title I of the 2007 Energy Independence and Security Act (EISA) of 2007 required NHTSA to

Opposite: U.S. DOT is undertaking efforts to mitigate the impact of transportation on the environment. Pictured is the Logan Pass Visitor Center parking area in Glacier National Park, MT. Source: U.S. DOT/Volpe

establish the first fuel efficiency standards for medium- and heavy-duty commercial vehicles. The stated purpose of EISA is, "to move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes."

As with any kind of regulatory action, NHTSA must consider a range of alternatives and present results of its analysis of the potential impacts of each alternative. NHTSA asked Volpe to provide analyses the agency needed in order to develop and defend the new fuel standards. The project was conducted jointly with the U.S. Environmental Protection Agency and the California Air Resources Board.

Volpe solved several challenging problems, including developing detailed estimates of future vehicle

production and selecting and applying appropriate methods for estimating the technological, economic, energy, and environmental impacts of alternative potential standards for heavy-duty pickup trucks and vans. Additionally, Volpe made significant contributions to the language and critical supporting documentation comprising the Notice of Proposed Rulemaking (NPRM) package.

The NPRM was issued in the Federal Register in July 2015. If it is finalized as proposed, the standards developed with Volpe's support are projected to lead to significant fuel savings after 2020. Volpe's support of NHTSA's fuel efficiency work is ongoing. (Sponsored by NHTSA)

Informing Safety Requirements in Electric Vehicles

Performance is a big deal when it comes to rechargeable energy storage systems (RESS) in electric and hybrid-electric vehicles. A RESS-equipped vehicle stores electrical energy and kinetic energy usually lost during braking, and uses that energy to power its engine.

Safety is as important as performance when new technologies are introduced into our everyday transportation lives. Volpe spent nearly three years researching the safety risks to operators and occupants in vehicles with RESS compared to vehicles with internal combustion engines. This work supported NHTSA safety goals, with input from NASA, academic partners, and the U.S. military.

Volpe engineers examined the safety implications of RESS-equipped cars and light trucks during several typical and atypical scenarios: charging when parked,

RESS discharging, normal driving, crashes, post-crashes, emergency response, and disposal.

In their final report for NHTSA, Volpe engineers applied analytical methods to identify:

- RESS-related hazards and their severity levels.
- Safety requirements and constraints.
- RESS control diagnostics, event data loggers, and prognostics.
- Critical safety information and effective methods to communicate that information to operators, first and second responders, and service technicians.

Volpe also identified several diagnostic elements beyond the current standard for monitoring the safety of RESS vehicles. This work adds to the body of knowledge on the safety of RESS-equipped vehicles and will inform safety requirements for electrical systems in road vehicles. Motor vehicles with RESS conserve energy, reduce harmful emissions, and preserve a healthy environment—and, with a full understanding of the potential hazards, they can be as safe to operate as traditional internal combustion vehicles. (Sponsored by NHTSA)

Evaluating Aircraft Fuel Burn, Emissions, and Noise

FAA relies on innovative tools and analyses to predict the effects of aviation operations on the environment. Until recently, FAA used separate processes to model noise and emissions of aircraft. Now, the agency is implementing a scalable process that combines noise, emissions, and fuel burn estimates into one tool.

The Aviation Environmental Design Tool (AEDT) is software that models aircraft operations in space and time to evaluate the impacts of fuel consumption, emis-

sions, noise, and air quality. The software enables environmental review activities that are required under the National Environmental Policy Act (NEPA) by coalescing the modeling of these environmental impacts into one package.

Released in May 2015, AEDT version 2b is FAA's NextGen environmental interdependencies tool. It replaces five older methods, integrating their capabilities into one model. AEDT 2b performs aviation fuel burn, noise, and emissions analysis, and supports the development of a global policy—including a novel CO₂ mandate currently being adopted by the International Civil Aviation Organization.

At its core, AEDT 2b enables analysts to understand the environmental interrelationships of aviation operations. The program is scalable, meaning it can perform analyses at a single runway, an entire airport, and within regional, domestic, and global environments. It can also integrate with other NextGen tools such as Terminal Area Route Generation, Evaluation, and Target Simulation and System-Wide Analysis Capability. AEDT 2b can be paired with modern software tools, including geospatial analysis and relational databases.

Volpe engineers, physical scientists, and analysts provided key technical support to this project from the beginning. Volpe was the lead developer and system architect for AEDT, and served as the fuel burn, noise, emissions, and aircraft performance domain lead for the project.

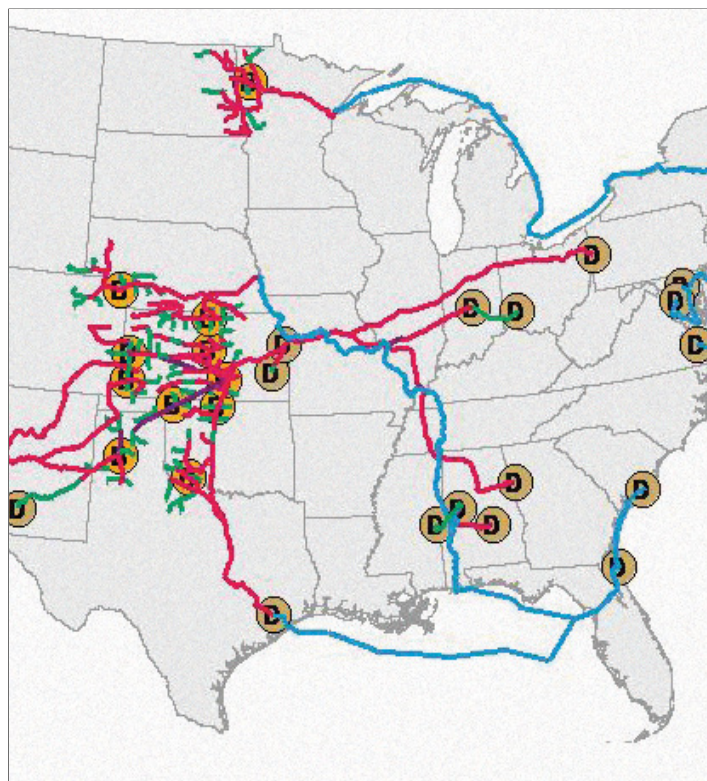
Several partners were involved in early testing and development. NASA analyzed alpha and beta versions of the software, conducting climate change investigations and researching the integration of advanced vehicle concepts into the NAS. A design review group worked with Volpe and FAA throughout the development process, including the initial generation of

requirements, stakeholder engagement, and quality assurance and testing of the final product.

AEDT will better inform policymakers on the environmental impacts resulting from decisions on aircraft operations around major national and international airports where noise, emissions, and fuel use are ongoing concerns. (Sponsored by FAA)

Aviation Industry Alternative Fuel Transportation Optimization Tool

The aviation industry is a significant consumer of petroleum-based fuels. FAA has a strong need for reliable supplies of sustainable alternative aviation



A sample map from the Alternative Fuel Transportation Optimization Tool showing the movement of wheat straw to biorefinery locations selected using the tool. Source: U.S.

DOT/Volpe

fuels that can be efficiently distributed throughout the U.S.

To improve its understanding of the implications of future fuel scenarios, Volpe developed the Alternative Fuel Transportation Optimization Tool (AFTOT) for FAA's Office of Environment and Energy, and the Department of the Navy's Office of Naval Research. Alternative fuels have the potential to help mitigate climate change, enhance energy security, and reduce fuel prices.

For the aviation sector, alternative fuels are part of the solution to achieving carbon-neutral growth in international aviation starting in 2020. A successful launch of the emerging alternative jet fuels industry requires appropriate transportation planning to accommodate shifts in energy transportation patterns and movement of biofuel stocks. The AFTOT model is a flexible, geographic information system (GIS) and optimizer-based scenario-testing tool that identifies the lowest cost routing of commodities associated with scenarios for fuel and raw material collection, processing, and distribution within the U.S. AFTOT generates and selects among candidate processing locations and calculates transportation-related costs, carbon dioxide emissions, vehicle miles traveled, network usage, and other performance metrics.

In the past year, the Volpe AFTOT team completed Phase 2 of tool development, expanding analytical capabilities to include:

- Transport of raw materials in solid or liquid form.
- Seasonality of movements.
- Incorporation of barges and pipelines into a unique multimodal, flowable GIS network.
- Ability to handle multiple processing pathways for conversion of raw material.

AFTOT will be used to analyze supply chain scenarios generated by the U.S. 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.

Volpe began Phase 3 of AFTOT tool development in late summer 2015. (Sponsored by FAA and DOE)

Marine Hydrokinetic Technology Harvests Low-Carbon Energy

Hydrokinetic technologies convert the energy of ocean waves, tides, and river and ocean currents into electricity. Volpe is providing expertise to the Advanced Research Project Agency–Energy (ARPA-E) by evaluating the environmental challenges and benefits of a hydrokinetic energy harvesting device currently being developed at Brown University.

The proposed technology will generate low-carbon energy that can be used to power port and marine facilities, island homes and businesses, and other coastal facilities. The power can also be fed back into the electrical grid to power vehicles, ships, and utilities. Ports are interested in this type of renewable energy to reduce emissions and improve facilities through port electrification, instead of relying solely on diesel-generated onboard power sources.

One drawback is that these tidal projects are often installed within environmentally sensitive areas, like river beds and tidal basins. This presents serious implications for shipping lanes and other marine activity. Structures placed in or near the coastline could alter water flow and sedimentation, affecting shoreline scour and infrastructure such as bridges.

In January 2015, Volpe delivered a draft report describing potential environmental impacts of hydrokinetic energy projects. The report looked specifically at the effects unique to hydrofoil-type power conversion devices currently being developed. Key contributions of the report included a comparison of modeled wake structures for turbine and hydrofoil designs, with an analysis of potential repercussions for wildlife.

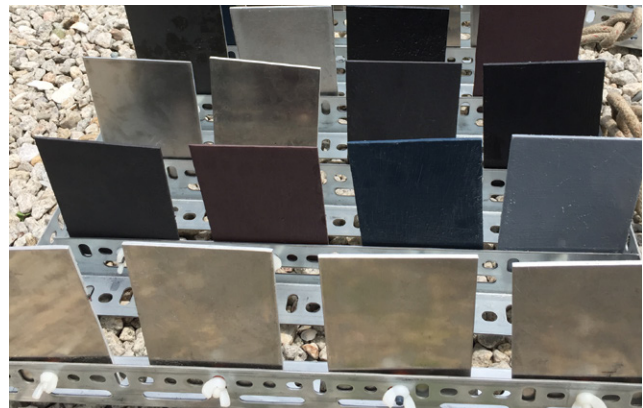
In addition to evaluating device specifications, Volpe environmental specialists worked with a Brown University research team to deploy a materials testing experiment. The goal was to measure growth rates of marine life on prospective device materials with different paint coatings. Mollusks, algae, and other organisms are likely to attach and grow on hydrokinetic devices deployed in a marine envi-

ronment. These experiments will inform researchers in selecting suitable device materials and assessing environmental effects of larger-scale installations.

Volpe participated in meetings in Rhode Island related to permitting needs for the testing phase of this project. This work included reviewing available site-specific environmental data for the proposed test site at the Sakonnet River Bridge, and developing questions for a meeting with the Rhode Island Department of Environmental Management, Division of Fish and Wildlife.

Environmental assessment of hydrokinetic harvesting devices is ongoing, and Volpe's support of ARPA-E on this project will continue through November 2016.

(Sponsored by ARPA-E)



Pictured above are experiments to compare how quickly marine life grows on potential hydrokinetic device materials with different paint coatings. Testing frames were secured to a 17-point road dock, and large numbers of marine organisms were observed on the submerged surfaces of the dock. Source: U.S. DOT/Volpe

Developing a National Framework for Addressing Naturally Occurring Asbestos

Natural Occurring Asbestos (NOA) refers to asbestos that is naturally present in soil and rock, as opposed to asbestos that was commercially mined and applied to building materials. NOA is found across the country; however, many federal and state agencies lack awareness of its occurrence and methods for assessing and mitigating its potential adverse effects. NOA is an emerging issue, which currently isn't addressed within federal regulations, such as under NEPA, nor state regulations with the exclusion of California.

In response, Volpe environmental engineers and NEPA practitioners were engaged by the FHWA office of Project Development and Environmental Review (HEPE) to develop a recommended framework as a national resource to help FHWA division offices address the challenges of NOA during the planning, development, construction, and operation of proposed transportation projects.

This guidance is very much needed, as evidenced by the FHWA Nevada Division Office's (FHWA-NV) 2014 request for technical assistance in evaluating the presence and impact of NOA at the Nevada Boulder City Bypass (BCB) site. One of Nevada's largest, high-profile construction projects, the BCB was halted when a research study raised questions about the possible presence of NOA within many local communities, including the BCB site. Volpe acted quickly to aid FHWA in minimizing impacts to construction plans that were years in the making. Volpe's support included organizing and leading a voluntary multi-disciplinary committee of government and private subject matter experts to further inform the BCB and development of the framework.

Volpe's technical guidance to the BCB project helped FHWA complete a NEPA reevaluation and establish mitigation plans for protecting workers and the public from possible NOA exposure. Volpe's expertise was instrumental in restarting the BCB project, which will relieve congestion, improve safety, and enhance travel and commerce between Arizona and Nevada.

The BCB project has served as a pilot study to inform the development of the national NOA framework. Lessons learned from the BCB project are currently being used in collaboration with FHWA staff to develop the framework. (Sponsored by FHWA)

Controlling Invasive Species through Ballast Water Management

Invasive aquatic organisms from around the world find their way to the U.S. through the ballast water of ships transiting our nation's coastal waterways. The potential environmental and economic impact caused by invasive species is severe, and the United States Coast Guard (USCG) is looking at innovative methods to mitigate these waterborne nuisances.

The European green crab, zebra mussel, hydrilla plant, and Eurasian watermilfoil are just some of the invasive species that have entered U.S. territorial waters via ballast water discharge. To address these invasives, the USCG initiated a Ballast Water Management (BWM) program to promote marine safety and environmental stewardship. The BWM program applies to all vessels equipped with ballast water tanks that navigate the U.S. Exclusive Economic Zone bound for ports or places in the U.S.



Experimental BWM system enrolled in STEP. In support of USCG, Volpe engineers and marine biologists conduct shipboard visits to observe the BWM system and execution of biological treatment performance experiments.

Source: U.S. DOT/Volpe

Volpe engineers and marine biologists directly support the USCG Environmental Standards Division by evaluating experimental BWM systems enrolled in the Shipboard Technology Evaluation Program (STEP).

Under STEP, USCG allows applicants to use an experimental BWM system that satisfies stringent environmental requirements. Acceptance into the program involves a rigorous examination of the prototype and its ability to successfully treat ballast water based on a review of the science and technology.

Volpe is currently reviewing Alternate Management System (AMS) applications submitted by vendors with foreign type-approved BWM systems. The objective is to assess current BWM technology in this area, develop USCG program policy and implementation tools, and review available commercial BWM systems. Volpe has completed biological reviews of 53 AMS applications of prototype BWM systems, reported on scaling calculations in accordance with G8 guidance, and evaluated alternate filter designs.

Lessons learned from vessels enrolled in STEP has resulted in the development of USCG's Final Rule, Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters (Federal Register Vol. 7, No.57; March 23, 2012). As the Final Rule goes into effect in phases, the USCG expects most ships to meet the discharge standard by employing effective treatment technologies.

The Aquatic Nuisance Species program started at Volpe in 2000 and has been an ongoing effort. USGG considers Volpe an essential partner in evaluating new ballast water treatment technologies that will prevent invasive organisms from entering U.S. waters. (Sponsored by USCG)



INFRASTRUCTURE MODERNIZATION

With its broad range of expertise, from engineering to acquisition management, Volpe works across modes and federal agencies to support critical transportation infrastructure modernization programs and initiatives.

Volpe Helps Make the Case for New Maritime Training Vessels

The U.S. Maritime Administration (MARAD) maintains a fleet of six U.S. government-owned vessels to train merchant marine officer candidates and

Opposite: The Training Ship *Golden Bear* is owned by MARAD and serves as the primary training platform for Cal Maritime cadets. Source: California State University Maritime Academy

support other federal agencies in humanitarian assistance and disaster relief efforts. These training ships (TS) are on loan to and operated by the state maritime academies of California, Maine, Massachusetts, Michigan, New York, and Texas.

The current fleet ranges considerably in age, size, mission capability, and material condition. The two training ships with the greatest student capacity—the TS *Empire State*, with capacity for over 650 cadets, and the TS *Kennedy*, with capacity for 600 cadets—were built roughly 50 years ago. The potential loss of one or both of these vessels would have a devastating ripple effect across the nation's state maritime academy training programs.

As more and more cadets enroll in the state maritime academy programs, MARAD needs to increase capacity and modernize the capabilities of its training fleet.



The Training Ship *State of Maine* is the flagship of the Maine Maritime Academy fleet, offering midshipmen important hands-on experience at sea. Source: Snavely Associates Photo, Courtesy of Maine Maritime Academy

In January 2015, MARAD asked Volpe to help produce a business case analysis report capturing the inventory of existing vessel designs that meet basic training requirements and support federal humanitarian response efforts. This report included an analysis of various recapitalization options to extend the fleet's overall service life to 50 years.

Volpe's maritime experts assembled a highly capable team, bringing together expertise in marine engineering, economic analysis, mariner education and train-

ing, and maritime policy. Volpe and MARAD worked closely to develop and refine recapitalization options, scenarios, and strategies.

Based on Volpe's business case, MARAD concluded that three ships will no longer be operational if no action is taken by 2025. The loss of these ships would have long-term negative impacts on national security, reducing the number of credentialed mariners available to operate U.S. vessels during war, national emergencies, and for domestic and international commerce.

Based on Volpe's analysis, MARAD is now exploring the costs and benefits of a long-term recapitalization program. Constructing five new vessels would have the lowest total estimated lifecycle costs, according to the analysis, and would provide vessels ready for a range of missions for 50 years. (Sponsored by MARAD)

Modernizing Key Air Traffic Control Facilities

FAA is responsible for the upkeep of nearly 300 air traffic control towers (ATCTs) and terminal radar approach control (TRACON) facilities. The agency maintains and modernizes these facilities to ensure they meet evolving air traffic operational needs and airport expansion requirements.

Identifying ATCTs and TRACONs that cannot meet present day operational requirements is a large part of this effort. Additionally, FAA is exploring the costs and operational benefits of TRACONs with common boundaries.

A Volpe team of engineers and operations research analysts have provided key technical expertise to this critical project. Volpe's support has enhanced ATC sustainability and resiliency, providing technical subject

matter expertise to FAA in a number of areas, including: leading facility implementation efforts, conducting operational analysis assessments, developing budget and cost models, performing site inspections and surveys, and mitigating operations and maintainability issues for aging facilities and legacy system architectures. In addition, project cost models developed by Volpe provided FAA decisionmakers with critical information for prioritizing task activities and resources.

Most recently, a new project cost model and assessment tool and failure mode criticality analysis report on the Potomac TRACON Chiller were developed and demonstrated. Volpe has been key to supporting FAA's



Volpe engineer Roni Rostom inspects a global positioning system surge suppressor installation high above the Mountain Home AFB in Idaho. Source: U.S. DOT/Volpe

ambitious, decades-long plan to upgrade its air traffic facilities and support its NextGen objectives.

(Sponsored by FAA)

Enhancing the Department of Defense's National Airspace

Legacy ATC systems often do not meet the needs of today's fast-moving aviation environment. For every advance in airplane technology there is a ripple effect that reaches all the associated ATC technologies needed to fly within the NAS.

Since 1999, the Department of Defense (DoD) has been replacing antiquated equipment in radar approach control tower facilities that it owns and operates. These upgrades are compatible with FAA equipment and standards and provide infrastructure to support FAA's NextGen program.

In 2015, Volpe engineers completed their 45th and last installation of a modern radar—called Airport Surveillance Radar: Model 11—providing state-of-the-art surveillance capability to the entire DoD. The U.S. Air Force's ATC automation equipment is also now integrated with the ATC systems of the Republic of Korea and Japan, eliminating the need for voice communications in those countries.

Throughout the upgrade process, Volpe engineers have worked closely with DoD to install new air surveillance equipment. Much has been accomplished, including the replacement of all analog voice switching equipment at 177 military locations worldwide. The Volpe team installed the Airfield Automation System, which replaces paper checklists, hand-written weather reports, maps, and instrument approach procedures with a touch-screen display.

Volpe staff also perform site surveys and site preparation for all Standard Terminal Automation Replacement System installations, which automatically process air traffic and weather data critical to a safe NAS. In addition, Volpe staff served as lead engineers on several of the systems.

While the initial objective of the program was to update aging systems that were difficult to maintain, the program has significantly evolved to provide dozens of new capabilities, including the integration of the GPS-based ADS-B, and the transponder-based Mode Select (Mode S). These capabilities reduce maintenance and logistics costs and allow new technologies to be easily integrated as new requirements develop. The benefits do not belong solely to the military, as civil and commercial flights transit military airspace and can use these improved ATC technologies and processes. (Sponsored by U.S. Air Force, AFLCMC/HBAG)

Modernizing Rail and Locomotives for the Department of Defense

The DoD rail fleet contains more than 110 locomotives with an average life span of 50 years. This fleet is in critical need of new, modern equipment to increase the efficiency, reliability, and safety of operations on U.S. Army installations and U.S. Navy facilities.

An aging rail fleet means increased toxic emissions and poor operational readiness, as well as high maintenance costs and the need for replacement parts for older trains. In support of DoD efforts to lower the age of the locomotive fleet, Volpe is reducing harmful emissions and creating a safer work place.

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



Pictured is an Ultra-Low Emitting Locomotive-U.S. Army locomotive USAX 6523 Source: U.S. Army

- Identifies requirements.
- Develops technical specifications.
- Provides technical and cost analyses.
- Conducts engineering and safety compliance inspections.
- Performs quality assurance inspections.
- Ensures proper integration of new equipment with existing DoD railway infrastructure.
- Provides acquisitions expertise.
- Oversees delivery and final acceptance of railroad rolling stock for DoD.

This modernization program is a priority for DoD, requiring the involvement of numerous commands; introducing a new kind of locomotive into an aging fleet; and creating the need for additional communication channels. Volpe established a successful teleconference forum to support end-users, maintenance personnel, and others affiliated with the equipment.

The program has replaced 29 conventional locomotives with Ultra-Low Emitting multi-engine GenSet

locomotives, which are quieter, more reliable, emit fewer pollutants, and require less fuel. GenSet technology offers many benefits over conventional diesel-electric motive power for the type of operations they support. A multi-engine GenSet locomotive, depending on the design, uses two or three engines to equal the power of a conventional single-engine locomotive. For example, instead of a conventional switcher locomotive offering a 2,000-horsepower engine, 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.

A significant recent milestone for Volpe was introducing state-of-the-art, EPA TIER 4-compliant road switcher locomotives two years before the regulation started being enforced. The new locomotives are high-tech and produce significantly cleaner emissions than earlier engines. (Sponsored by 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)



PLANNING & PROFESSIONAL CAPACITY BUILDING

Volpe develops and advances transportation-planning and professional capacity building initiatives at the local, state, national, and international levels.

Scenario Planning for Climate Change Mitigation and Resilience

The Albuquerque, New Mexico, region is projected to grow by more than 50 percent over the next 25 years to approximately 1.4 million people. This presents a challenge to the area as local planners

Opposite: Severe flooding struck downtown Albuquerque, NM, in August 2014 after record-setting rainfall in the region. Source: Roberto E. Rosales

strive to accommodate growth while meeting community goals for the environment, the economy, and preserving the character of surrounding cities and towns.

The Central New Mexico Climate Change Scenario Planning Project (CCSP) relied on a process to create a multiagency transportation- and land use-focused development plan for the Albuquerque area. This approach aims to reduce future GHG emissions and prepare for the potential impacts of climate change on the region.

The Mid-Region Council of Governments (MRCOG) provides metropolitan and rural transportation planning for Bernalillo, Sandoval, Valencia, and Tarrant counties. With Volpe assistance, MRCOG undertook a scenario planning effort to test the impact of different transportation and land-use scenarios on community goals. Federal grant fund-

ing and technical assistance allowed for integration and analysis of methods to reduce GHG emissions and improve resilience to climate change effects, like flash flooding, water shortages, and wildfires.

A diverse group of stakeholders collaborated during this project to address climate change adaptation and mitigation in a region of the U.S. that had no previous climate change discussions in the context of its transportation system. As a result of this effort, Volpe published a handbook titled *Integrating Climate Change in Transportation and Land Use Scenario Planning: An Example from Central New Mexico* as a guide for regional planners and environmental specialists.

Volpe experts successfully integrated climate change considerations into the Albuquerque region's long-range transportation plan, managed a diverse group

of stakeholders, and developed several interim and final deliverables. Funding partners included the FHWA, U.S. Fish and Wildlife Service, Bureau of Land Management, and the National Park Service (NPS). More than a dozen other federal, state, regional, and local agencies were also involved in the scenario planning project.

The Central New Mexico CCSP successfully met its goals and objectives and helped generate meaningful dialog about climate change in the region. Several key takeaways included: invite federal land management and resource agencies to take part in the planning process; plan for climate change beyond traditional planning time frames; where appropriate, make wild-fire and flooding risk analysis part of metropolitan transportation planning; and examine the effect of different land-use patterns on water consumption.

(Sponsored by FHWA, USFWS, BLM, and NPS)



A severe wildfire burned 290,000 acres of land in Gila National Forest, NM, on June 6, 2012. Scientists calculate that high fire years like 2012 will likely occur two to four times per decade by mid-century, instead of once per decade under current climate conditions. Source: Kari

Greer/USFS Gila National Forest

Transition to a Transportation Performance Management Framework

Data-driven decisions lead to improved performance management. Volpe is supporting FHWA's Transportation Performance Management (TPM) initiative to successfully transition the nation's highway agency and its partners to a more performance-based transportation system.

This effort relies on critical information to make data-driven investments and policy decisions to achieve national transportation goals. The shift to a data-driven decision-making process will improve public transparency, fiscal accountability, and investment decisions affecting the safety, condition, and performance of the nation's surface transportation system.

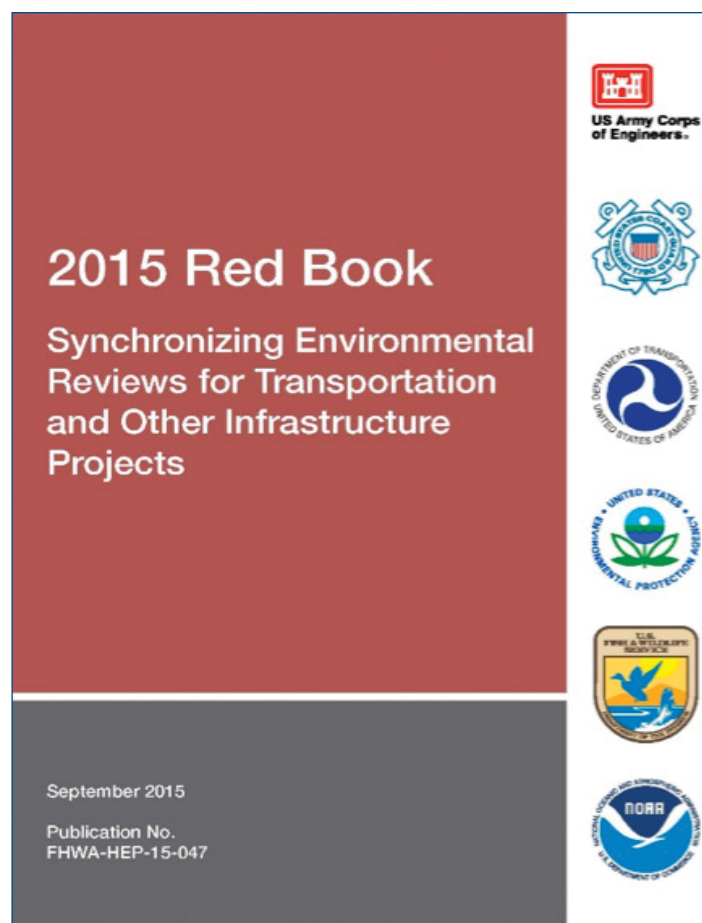
A team of Volpe planners conducted over 40 webinars on rules and other TPM-related topics to inform FHWA staff and state and local partners on performance management practices. A suite of nine training courses was developed to support the new regulations. Noteworthy practices were documented on tools, as well as on state and metropolitan planning organizations' initial efforts to implement performance management.

In addition, Volpe supported NPRM on performance management for safety, planning, asset management, bridges, and pavements, implementing Moving Ahead for Progress in the 21st Century Act (MAP-21) requirements. Volpe also launched an Institutional Capacity Development Program—which developed a strategic vision and plan, and a Technical Assistance Program—to support the extensive change required among FHWA and state and local agencies. Volpe partnered with key staff from FHWA's Office of Infrastructure and the Office of Transportation Performance Management to initiate this work.

Volpe will continue to support coordination efforts between FHWA's headquarters and field offices to inform staff and partner agencies on performance management tools and methods. This will ensure that data-driven decisionmaking becomes standard practice. (Sponsored by FHWA)

Synchronizing Environmental Reviews for Infrastructure Projects

The Red Book is a key resource for federal agencies that review permit applications, and federal, state, and local agencies that fund or develop major transportation and other infrastructure projects. Volpe supported



The 2015 Red Book will assist agencies that review permit applications or fund or develop transportation and infrastructure projects. Source: U.S. DOT/Volpe

the FHWA Office of Project Development and Environmental Review in developing and publishing a 2015 update of the 1988 handbook, *Applying the Section 404 Permit Process to Federal-Aid Highway Projects*, more commonly known as the Red Book. It is important to note the project was highlighted in the Implementation Plan for the Presidential Memorandum on Modernizing Infrastructure Permitting, and will be recognized as a successful outcome of this key White House initiative.

Transportation and infrastructure projects often require multiple federal permits and reviews—including NEPA review—to ensure projects are built safely and responsibly, and that adverse impacts to the

environment and communities are avoided, minimized, and mitigated. The ultimate goal of the handbook is to provide a practical ‘how-to’ guide that will increase the use of review synchronization, which will result in projects with reduced impacts to the environment as well as savings of time and money.

Updating the Red Book was a collaborative effort among six agencies: the U.S. Army Corps of Engineers, USCG, FHWA, FRA, FTA, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration. (Sponsored by FHWA)

U.S. DOT's National Freight Strategic Plan

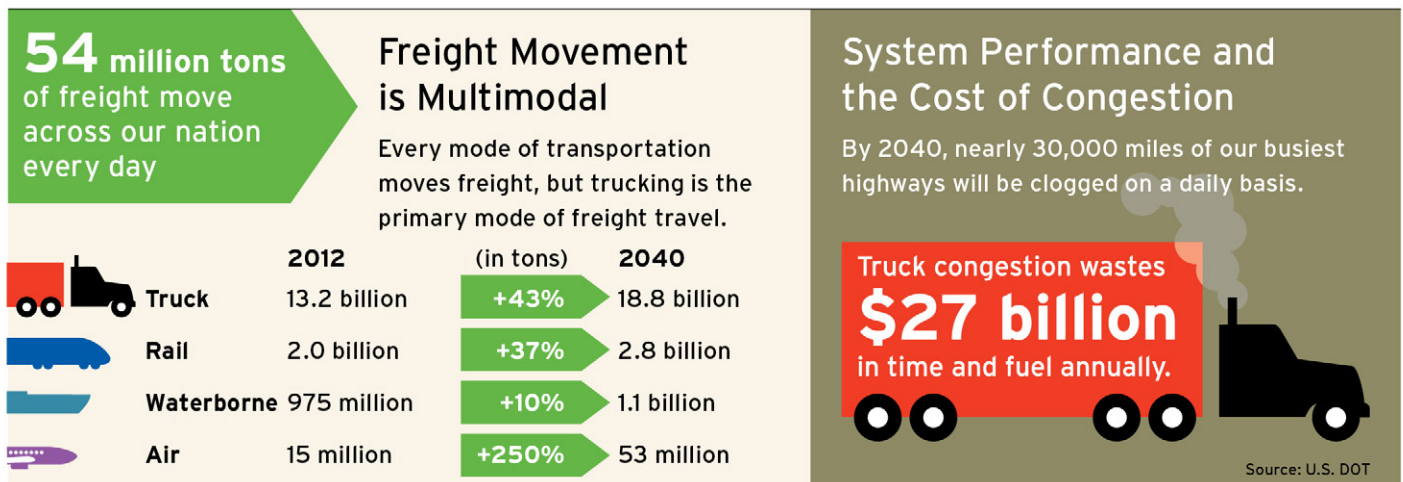
In October 2015, U.S. DOT released its first draft National Freight Strategic Plan (NFSP), with the goal of directing resources toward improved system performance for efficient movement of freight across the country.

The first-of-its-kind project is one result of MAP-21, aimed at transforming the policy and programmatic framework for investments in the transportation sector to guide the system's growth and development.

Though freight transportation is much safer than in past decades, the growing demands placed on an aging infrastructure have put a significant strain on the nation's freight system. A relatively outdated system is helping to shoulder a growing population, increased demand for goods, and abrupt changes in commodities and movement patterns—even as it must continue to maintain its effectiveness in an increasingly complex global marketplace. Increased responsibility coupled with the lack of financial attention on freight-specific transportation needs has left the freight system struggling to keep pace with America's growing economy.

The NFSP proposes ideas that will lead to solutions and strategies to facilitate efficient movement of goods by addressing infrastructure, institutional, and financial bottlenecks. In order to best advance freight transportation, the NFSP identified several programs already in place that would improve freight planning and investment.

Volpe has worked collaboratively with the Office of the Secretary, and modal contributors and reviewers to complete a draft for public comment. The project team leads also drew on recommendations from the National Freight Advisory Council and other stakeholders. (Sponsored by OST)





Ranger III, Isle Royale National Park's primary passenger and freight vessel. Source: U.S. DOT/Volpe

Studying Future Transportation System Needs at Isle Royale National Park

The Isle Royale National Park transportation study analyzed current and future transportation system needs at this remote archipelago located in western Lake Superior, 14 miles from the closest mainland and 60 miles from the park's headquarters in Houghton, Michigan. Visitors treasure the park's pristine environment and solitude, but Isle Royale has the highest cost per visitor (\$170) of any unit in the National Park System due to the cost of transporting visitors to the park and its operation in such a remote location.

Isle Royale currently spends about \$1 million annually on operation and maintenance of its transportation system. Additionally, the park's primary passenger and freight vessel, *Ranger III*, is reaching the end of its useful life. Volpe staff identified and evaluated alternative

vessels and service models to meet park needs, as well as measures to streamline and reduce operating costs.

The study included four central analyses: missions, visitation, options, and alternatives, identifying four transportation alternatives that meet current transportation demand and one option that meets park needs for a high-visitation scenario. This included considering the use of a crew boat or tug and barge for cargo and a concessions-operated high-speed passenger ferry service—in addition to extending the life of *Ranger III* and building an equivalent *Ranger IV*. The report provides recommendations for identifying sources for capital and annual operating costs plus the required steps to implement each alternative, with costs ranging from \$7.3 to \$26.8 million.

The Isle Royale transportation study provided background information for park management to explore vessel upgrade or replacement alternatives, as well as possible strategies to achieve its key missions. It also

defines required transportation activities to operate the park, the impact of potential changes in visitation on these activities, and whether alternatives exist for current ways of completing those missions. The report provided the NPS with the necessary data to conduct a value analysis workshop to select a preferred alternative. (Sponsored by NPS, Midwest Region Office)

Documenting Winter's Impact on Public Transportation

Over a three-week period beginning in late January 2015, Boston and the surrounding region were battered by four back-to-back winter storms. The storms broke records for snowfall rates and accumulation. Along with extreme, extended cold temperatures, the unprecedented winter weather in 2015 led to major service disruptions for the Massachusetts Bay Transportation Authority (MBTA) public transportation system.

By early March, walls of snow astride rail lines and streets were slowly receding. MBTA tapped Volpe to document challenges the agency faced while operating a multimodal transit agency during and after punishing winter weather events. The documentation was created in large part to set down an historical account for future MBTA managers and staff.

Through interviews with MBTA personnel and reviews of weather data, MBTA communications materials, and media accounts, Volpe delivered two timeline reports and one report based on a roundtable of chief executive officers of major transit agencies.

The MBTA 2015 Winter Event Timeline report summarizes the weather events, service responses, and response actions that MBTA launched. *The MBTA Communications Winter 2015 Timeline* report pro-



Unprecedented snowfall severely disrupted trains across the MBTA service area. Source: MBTA

vides an overview of communications and outreach efforts MBTA and other Massachusetts agencies undertook to keep the public informed about transit service, over the period immediately before the first storm to roughly two weeks after the fourth storm.

A Transit CEO Roundtable featured insights on lessons learned from high-level executives from peer transit agencies. Panelists included CEOs, presidents, or general managers from the following transit agencies: Chicago Transit Authority, Chicago Regional Transportation Authority's Metra, New Jersey Transit, the Metropolitan Transportation Authority of New York and New York City Transit, Southeastern Pennsylvania Transportation Authority, and the Toronto Transit Commission. Volpe produced the CEO Roundtable Event Summary Report as the final deliverable for this project.

The reports provide a comprehensive and objective understanding of the conditions MBTA faced in its response and recovery following the unprecedented weather events that affected the Boston area during winter 2015. (Sponsored by MBTA)

Transportation Planning and Policy Support to the Millennium Challenge Corporation

Freight movement is inherently multimodal. Vessels bring goods to trucks and vice versa as people move raw materials and finished products terrific distances. If any part of the logistics chain is weak or broken, the system shuts down. Economies—and citizens—suffer in turn.

Nowhere is this truer than in developing nations like Liberia. The Millennium Challenge Corporation (MCC), an innovative, independent U.S. foreign aid agency, has used Volpe's research and advisory services, and a Volpe-led traffic study, to provide inputs as it works with the Government of Liberia to develop a five-year investment strategy for transportation.

Just over a decade after the conclusion of a civil war, Liberia is working to rebuild its infrastructure and strengthen its government institutions. Many of its roads regularly flood, and the government lacks the capacity to maintain them adequately. Liberia's economic growth is hindered by a lack of mobility options in part due to these deficiencies. As part of the development of its compact with Liberia, MCC worked with Liberian

officials to identify projects in the areas of road planning, maintenance, and transportation capacity building. Volpe has provided comprehensive transportation expertise as MCC considers transportation investments in Liberia.

In the spring of 2015, Volpe researchers traveled to the Liberian capital, Monrovia, and tallied motorcycles, buses and taxis, cars, and commercial trucks along the two roads leading out of the city's main port. MCC used traffic data from this study in considering its investment options.

Volpe is now discussing with MCC several paths forward to improve Liberia's transportation. One track will complete a national inventory of road system conditions. Inventory data will inform a national asset management plan, which will provide systematic, transparent, predictable decisionmaking for road maintenance, and promote consistent funding for maintenance.

At the end of MCC's five-year investment program, the overall goal is for Liberia to be closer to having the planning processes, technology, and skills to carry out a sustainable, systematic, and predictable road maintenance practice into the future.



Traffic congestion in Monrovia, Liberia, is an ongoing problem. Source: U.S. DOT/Volpe

Late in 2015, Volpe began supporting additional MCC projects in Nepal and in Côte d'Ivoire. Those projects are in the concept development phase. Volpe's work with MCC is enhancing its expertise in innovative transportation project planning and its experience in the international sphere. (Sponsored by MCC)

PROFESSIONAL CAPACITY BUILDING

Educating the Next Generation of Transportation Professionals

Innovation and creative problem solving are the cornerstones of a modern transportation system. To make sure America's transportation workforce is qualified and highly skilled, U.S. DOT offers the Intelligent Transportation Systems Professional Capacity Building (ITS PCB) Program, which increases ITS and connected vehicle knowledge, skills, and abilities for transportation professionals.

Every year, a Volpe team supports ITS PCB objectives of expanding its outreach to new audiences and broadening the ITS workforce. The ITS PCB team at Volpe provides a variety of support, including:

- Leading coordination with academia to develop and expand ITS and connected vehicle curricula at educational institutions.
- Managing and producing ITS webinars.
- Managing the ITS PCB website.
- Coordinating with professional associations to develop and deliver ITS training.
- Responding quickly to short-term needs of those planning and deploying established ITS technologies and applications.
- Working to ensure appropriate levels of awareness and technical training for current and future transportation professionals.

Over the past year, the Volpe ITS PCB team has spearheaded several programs to enrich the transportation workforce. To expand interest in ITS and connected vehicles among students seeking engineering and computer science degrees, the Volpe ITS PCB team is overseeing the development of a number of case studies that professors will incorporate within their curricula.

The Volpe team continues to work with the Institute of Transportation Engineers to develop ITS transit standards training modules. This information makes it easier for transit agencies to more smoothly apply ITS technology standards. The Volpe team also leads development of ITS and connected vehicle curricula for middle schools, high schools, community colleges, and trade schools.

In 2015, the ITS PCB Program is expected to reach more than 36,000 participants through 255 live and on-demand educational offerings. (Sponsored by the ITS JPO)

PROFESSIONAL CAPACITY BUILDING

Volpe Leads Workshop for South Africa's Future Transportation Leaders

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 promote careers for women in transportation. Their first initiative, Tomorrow's Transportation Leaders, connects emerging transportation professionals with established experts. The kick-off event was a Volpe-led workshop held in June 2015 in Johannesburg.

South Africa faces significant transportation challenges, including increasing dependence on automobile



U.S. Secretary of Transportation Anthony Foxx and South Africa's Minister of Transport Dipuo Peters sign a new memorandum of cooperation, supporting more women as they find careers in transportation. Source: US DOT

travel (which can be costly and can have negative environmental impacts); lack of mobility alternatives, particularly for low-income populations without access to cars; security concerns; and the need for new investments to stimulate economic growth and employment. The Johannesburg workshop brought together 30 young African transportation professionals, many of them women, from policy, road, rail, transit, aviation, and environment offices. Students exchanged ideas and perspectives with expert instructors from Volpe and from the South Africa Department of Transport.

Volpe transportation planners spent three months designing the workshop and are providing follow-up technical assistance. Instructors discussed how the U.S. and South Africa address transportation policy and planning and several other critical topics, including:

- Asset management.
- Major trends and emerging issues in transportation planning.
- New technologies affecting transportation systems.

- Planning for accessibility and healthy communities.
- Transit management and performance.

Students and Volpe instructors discussed how the above themes fit into frameworks of national transportation strategies, institutional roles and responsibilities, long-range and vision planning, smart cities, and safety, among others. In one exercise, teams used data benchmarks on transit performance to diagnose inefficient operations practices and to communicate with policymakers and the public on transit's potential to address regional mobility needs. Students also had the opportunity to present their ideas, spurred by the emerging issues they learned during the course.

Secretary Foxx participated in the workshop wrap-up, leading discussions with participants on challenges shaping Africa's transportation future. The workshop was the first component of a multi-year agreement with the Office of the Secretary, engaging further Volpe support in Africa, Brazil, India, and other countries. (Sponsored by OST)

How will we move?

Population Increase

2015: **320 million people**
2045: **390 million people**

In 30 years our population is expected to grow by about

70 million

... that's more than the current populations of



Bumper-to-Bumper

On average, we spend

over 40 hours

stuck in traffic each year

The annual financial cost of congestion is

\$121 billion



Older Americans — Redefining Longevity

By 2045, the number of Americans over age 65 will increase by

77%

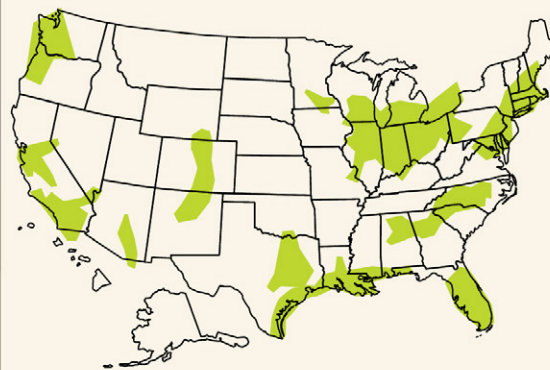


About **one-third of people over 65** have a disability that limits mobility. Their access to critical services will be more important than ever.

Millennials — Shaped by Technology

There are **73 million Millennials** aged 18 to 34. They are the first to have access to the internet during their formative years and will be an important engine of our future economy.

Millennials are driving less. By the end of the 2000s, they drove over **20% fewer** miles than at the start of the decade.



Income Inequality

10% of the population takes home **one-third** of our national income.

Transportation is the **second-largest** expense for U.S. households.



Megaregions and Shifts in Population Centers

11 megaregions are linked by transportation, economics, and other factors.

They represent over **75%** of our population and employment.

In 2014, **365,000** people moved to the South—up **25%** from 2013—and moves to the West doubled.

THOUGHT LEADERSHIP

Volpe is U.S. DOT's go-to source for strategic thinking that pushes the nation's transportation system toward a safer and ever-more efficient future.

Beyond Traffic 2045: Trends and Choices

In the enabling legislation that created the U.S. DOT, the Secretary of Transportation is charged with reporting on current and future conditions of the nation's transportation system. At a time when America's transportation infrastructure is in disre-

Opposite: Trends in personal mobility from U.S. DOT's *Beyond Traffic* report. Source: U.S. DOT

pair, *Beyond Traffic 2045: Trends and Choices* is a comprehensive overview of major forces impacting the national transportation system.

Secretary Anthony R. Foxx considers *Beyond Traffic* to be his signature initiative. It is intended to start a national conversation about our country's true transportation needs and the big decisions that will be needed for us to move forward. It provides not only a sobering account of the current state of affairs, but also serves as a call to action to policy-makers and citizens alike.

U.S. DOT assembled a team of internal and external experts to conduct a comprehensive examination of our nation's transportation system. This team shared key findings and solicited feedback in six public webinar sessions that drew 1,300

participants. The participants included engineers, researchers, transportation planners, pilots, truck drivers, transit operators, and safety and disability-rights advocates, among others.

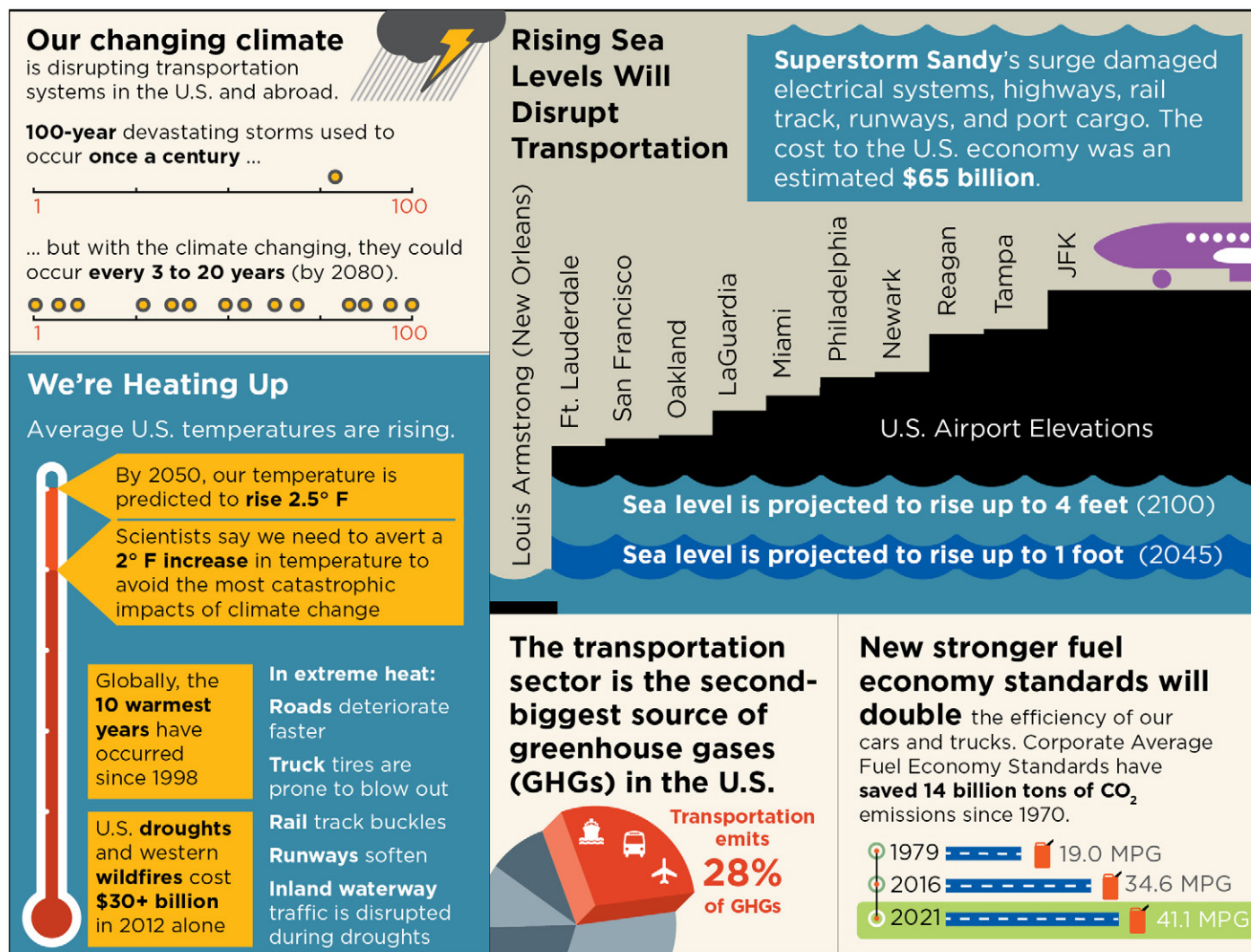
As part of the Office of the Assistant Secretary for Research and Technology (OST-R), Volpe was asked to be the primary technical author and a key contributor on the *Beyond Traffic* report, in conjunction with the Office of the Secretary of Transportation-Policy. In just a matter of months, Volpe drafted over 300 pages of original content, created dozens of graphics and infographics, and produced a series

of short videos that introduced key stakeholders to the report.

Beyond Traffic contributes to national objectives and priorities by focusing on five key issue areas:

1. Personal Mobility—*How We Move*
2. Freight—*How We Move Things*
3. Technology and Data—*How We Move Better*
4. Climate Change—*How We Adapt*
5. Revenue and Finance—*How We Align Decisions and Dollars*

How will we adapt?



Source: U.S. DOT

To compete in the global economy,

the U.S. needs a world-class transportation system. Some of our most critical transportation infrastructure is crumbling.

65% of U.S. roads are in **less than good condition**



25% of U.S. bridges **need significant repair** or can't handle today's traffic



50% of locks and chambers are **more than 50 years old**



Source: U.S. DOT

Real-time Travelers

Mobile access to everything from **traffic data** to **transit schedules** informs our travel choices.

90% of American adults own a mobile phone.

20% use their phones for **up-to-the-minute** traffic or transit information.



Big data is all around us.

Global data generated is projected to grow by **40% annually**.

Data enables innovative transportation options, such as **car-sharing**, **ride-sharing**, and **pop-up bus services**, and more **rapid delivery of goods**.



Source: U.S. DOT

Based on initial feedback, additional content is being developed on the pressing issues of income inequality and workforce development.

The draft report was launched in February 2015 at a Google Town Hall by Secretary Foxx and Google's

Executive Chairman, Eric Schmidt; the event was live-streamed around the world. The report, videos, and supporting materials have been downloaded and/or viewed hundreds of thousands of times, and have been widely recognized in the field. (Sponsored by OST)



Reimagining Transportation

A Thought Leadership Speaker Series at Volpe

Volpe continued its long tradition of providing a forum for transportation leaders to share insights with key stakeholders and to tackle emerging transportation issues. The Beyond Traffic speaker series informed the national conversation on advances in connected automation, navigation, communication, robotics, and smart cities.

The series explored new innovations that are changing how we think about transportation.

“Beyond Traffic is more than a document. We want it to be part of a national conversation about transportation and the choices we need to make in the 21st century. This Volpe speaker series is a valuable part of that conversation.”

Anthony Foxx
U.S. Transportation Secretary

“I can’t think of any corner of the economy that is going to be immune from this very deep question: Will technology assist and augment us, or will it take over things we are very used to doing ourselves?”



Andrew McAfee, PhD
Principal Research Scientist
Co-founder, Initiative on the Digital Economy
Massachusetts Institute of Technology

“Transportation is special in its energy needs in that the propulsion systems are almost all internal combustion engines today, and they fit what we want remarkably well, except that their impacts are very unattractive and we’ve got to change those impacts.”

John Heywood, PhD
Professor of Mechanical Engineering
Sun Jae Professor, Emeritus
Massachusetts Institute of Technology



"When we go back and think about our mission of improving people's lives by transforming mobility, we decided to go and really solve the problem deeply. Turns out it's a tough problem. As we were thinking about cars that are going to drive themselves, that means you don't have to drive it anymore, so the experience in the vehicle should be different. You effectively are moving people from being the helmsman to the captain of the ship."

Chris Urmson
Director, Self-Driving Car Program
Google

"Any story about the future falls into one of four archetypes. It's either a story about growth, chugging into the future unimpeded. It's a collapse story, where favorable conditions deteriorate, and that causes some critical failures. It could be a constraint story in which there's a key resource that limits growth. Or, a transformation story. This is really the Silicon Valley narrative of disruptive change."



"What we're seeing is just kind of a whole reinventing of the whole idea of what the vehicle may mean to a person. So, we're going from a model of a vehicle is something I go out and buy every so often, to a vehicle is something I can use to get me from point A to point B, and I don't necessarily have to own it."

Harry Lightsey
Executive Director of Global Connected Customer Experience
General Motors



Anthony Townsend, PhD
Senior Research Scientist
New York University
Fellow, Data and Society
Research Institute



"Today we have the largest controlled, safest, most diverse, most complex airspace on planet Earth—but it's not a birthright. You've got to fight to keep it. We cannot handle the capacity that we're going to have in 20 years doing what we're doing today."

"Being able to define the concept space and the way in which we drive technology is, to me, surprisingly, the biggest challenge we've had to address. [Aeronautics] is a field that is evolving so quickly—what is the state of the art right now and how fast can we expect it to go?"

John Cavoletsky, PhD
Director, Airspace Operations and Safety Program
NASA Aeronautics Research Mission Directorate



"There's not just one marriage: there are going to be many, many, many marriages in the future ... Marriages between autonomous, semi-autonomous, and non-autonomous vehicles, along with marriages between the driver, the pedestrian, and the bicyclist."

Donald Fisher, PhD
Principal Technical Advisor
Volpe, The National Transportation Systems Center



Edward Bolton
Assistant Administrator for NextGen
Federal Aviation Administration



"You've got to move fast. Having spent time in the government and in the private sector, there is always a tendency to slow down for whatever reason. And it's really important to move fast. Teams go away, opportunities go away, people leave—and they are a vital part of making things happen."

Ken Gabriel, PhD
President and CEO
Draper



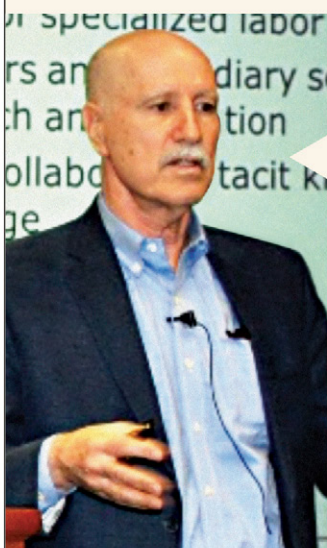
TRANSPORTATION and the **ECONOMY**

**Leading Globally
Succeeding Locally**

Volpe's 2014-2015 thought leadership speaker series considered emerging and future issues crucial to the U.S. transportation system's ability to move people and goods and remain competitive in today's economy.

"The United States must embrace research, technology, and data and do what's necessary to leverage 21st-century progress to make transportation safer and better for Americans and our enterprises."

Gregory D. Winfree
Assistant Secretary for Research and Technology
U.S. Department of Transportation



"In transportation, what happens is the following: as the cluster grows, transportation costs go down, because you can start using larger conveyances which are on a per ton mile route and less expensive."

Yossi Sheffi, PhD
Elisha Gray II Professor of
Engineering Systems
Massachusetts Institute
of Technology

"In the global economy, the megaregion has supplanted the metropolitan area as the appropriate economic unit of scale."

Catherine L. Ross, PhD
Director, Center for Quality Growth and Regional Development
Georgia Institute of Technology



"It doesn't take a village. It takes a multijurisdictional stakeholder coalition. You can't get projects done without identifying multiple stakeholders and including them from the beginning."

Rosabeth Moss Kanter, PhD
Chair and Director
Harvard University
Advanced Leadership
Initiative



"All involved in transportation are fully aware of the significant economic benefits and bang for the buck that investment in infrastructure creates."



Kurt Nagle
President and CEO
American Association of
Port Authorities

"Two-thirds of small- and medium-sized companies don't have any participation in the international marketplace whatsoever, and they should."



Rich McArdle
Managing Director for Global Operations Policy
UPS

Transportation and the Economy

By 2045, the U.S. economy is forecast to grow by **115%** to **\$36.7 trillion**—and the transportation sector will represent about

\$1.6 trillion

of total Gross Domestic Product.

Major gains
in freight
movement are
predicted
by 2040

By 2040, U.S.
freight volume
will grow to
29 billion tons—
an increase of
45%.



Source: U.S. DOT



"In the last number of years, something really has happened around intermodal transportation—and particularly around federal support for freight issues. This new attention has come from both the legislative and executive branches of the federal government, and also from the private sector."

Anne Aylward
Deputy Director for Research and Technology
Volpe, The National Transportation Systems Center

"There is a huge amount of data—on weather, on traffic, on routings—that is not really networked. We're building that into a network, into a centralized hub system, so that data can be shared by all users—by airlines, airports, pilots—really anyone in the system."



Michael G. Whitaker
Deputy Administrator
Federal Aviation Administration

"The city of the future is one where consumers choose from an array of different options to meet their mobility needs of the moment."

John Moavenzadeh
Senior Director, Head of Mobility Industries
World Economic Forum, USA

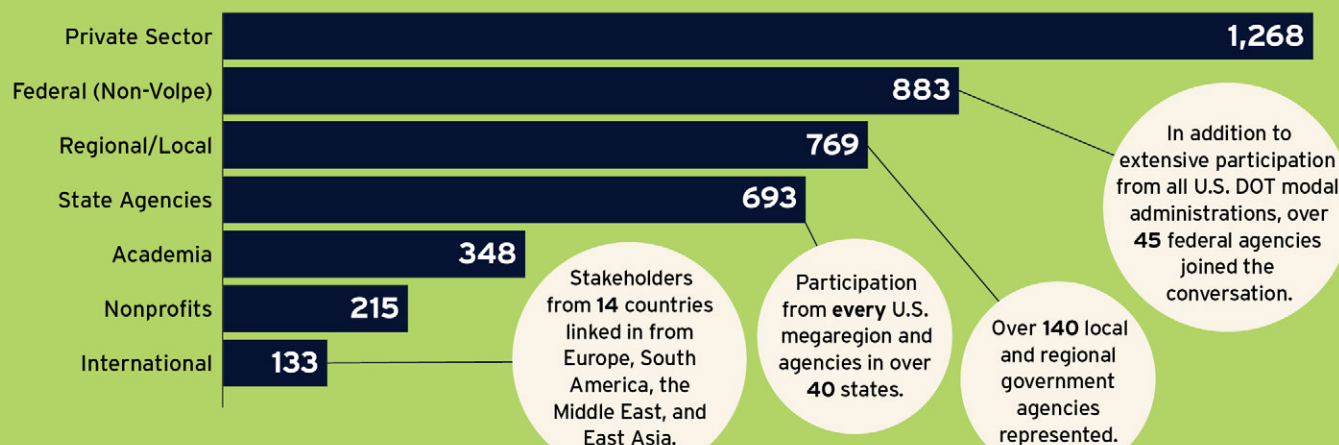


Volpe is engaging a broad range of stakeholders in an important dialogue about the future of the global transportation system.

Over **4,700** registrations, and **1,200** seats filled.

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 two recent speaker series—**Beyond Traffic 2045: 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 4,700 online registrations over the course of both series. The infographic below provides a snapshot of levels of engagement by sector.



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