



Annual Accomplishments

January 2023

Advancing Transportation Innovation
for the Public Good



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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. (Images: U.S. DOT Volpe Center)

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January 2023

Happy New Year!

LETTER FROM
THE DIRECTOR

I am pleased to present the U.S. Department of Transportation (U.S. DOT) Volpe Center's Annual Accomplishments publication. It has been an historic, fast-paced, and impactful year and this document represents some of our best work of 2022. It also underscores our sustained support to U.S. DOT, other federal agencies, state and local government organizations, and others.

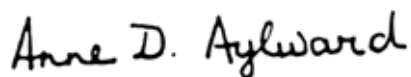
In December 2022, we had the honor of hosting U.S. Secretary of Transportation Pete Buttigieg who invested time engaging with our staff at a Town Hall and technical sessions. The Secretary challenged us to be "thoughtful, fact-driven, and imaginative," while contending with new and distinctive transportation challenges. It was the first time we convened such a large group in our auditorium since the COVID-19 pandemic hit and it was uplifting to see the room filled to capacity and staff reconnecting. The energy in the room was amazing!

The Volpe Center's multidisciplinary workforce has been hard at work advancing the nation's strategic transportation goals and objectives—safety, economic growth and global competitiveness, climate and sustainability, equity, transformation, and organizational excellence and supporting implementation of the Bipartisan Infrastructure Law—a once-in-a-generation investment in our nation's infrastructure and competitiveness.

We were excited by Secretary Buttigieg's announcement at the White House Accelerating Infrastructure Summit in October 2022 that we will be the home to a new Project Delivery Center of Excellence that is being launched to support and educate transportation infrastructure project managers in states, Tribal, local, regional, and territorial governments on project design, planning, and construction. The Center will serve as a central resource for the most innovative and effective practices and bring project managers together to learn from one another.

We look forward to collaborating with you in the year ahead in support of the Department's mission.

Wishing you a safe, happy, and healthy 2023!



Anne D. Aylward

Director

Volpe National Transportation Systems Center

U.S. Department of Transportation

Safety



U.S. DOT is working to make our transportation system safer for all people. The U.S. DOT Volpe Center supports the Department's mission to ensure our nation has the safest transportation system in the world. Our multimodal safety expertise enables us to leverage proven practices from one mode to improve safety in others.

■ HIGHWAYS

Reducing Fatalities and Severe Injuries with the National Roadway Safety Strategy

Nearly 95 percent of transportation-related deaths in the United States occur on streets, roads, and highways. In 2021, an estimated 42,915 people died in motor vehicle crashes nationwide.¹ Vehicle crashes are a leading cause of death for teenagers across the U.S., and disproportionately impact African Americans, Native Americans, and those living in rural communities.

The National Roadway Safety Strategy sets a vision of zero roadway deaths.

The National Roadway Safety Strategy (NRSS) is a collaborative effort between the Office of the Secretary for Transportation (OST) and the Operating Administrations (OAs) whose responsibilities include roadway safety.² The NRSS sets a vision of zero roadway deaths, and identified tangible Departmental actions to reduce the number of deaths each year. As part of the NRSS, the U.S. DOT adopted the Safe System Approach, which includes five elements—Safer People, Safer Roads, Safer Vehicles, Safer Speeds, and Post-Crash Care—and

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

1 Early Estimates of Motor Carrier Vehicle Traffic Fatalities and Fatality Rate by Sub-Categories in 2021; <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813298>.
2 U.S. DOT, National Roadway Safety Strategy; <https://www.transportation.gov/NRSS>.

acknowledges that humans make mistakes and are vulnerable.³ The Safe System Approach includes the following key elements:

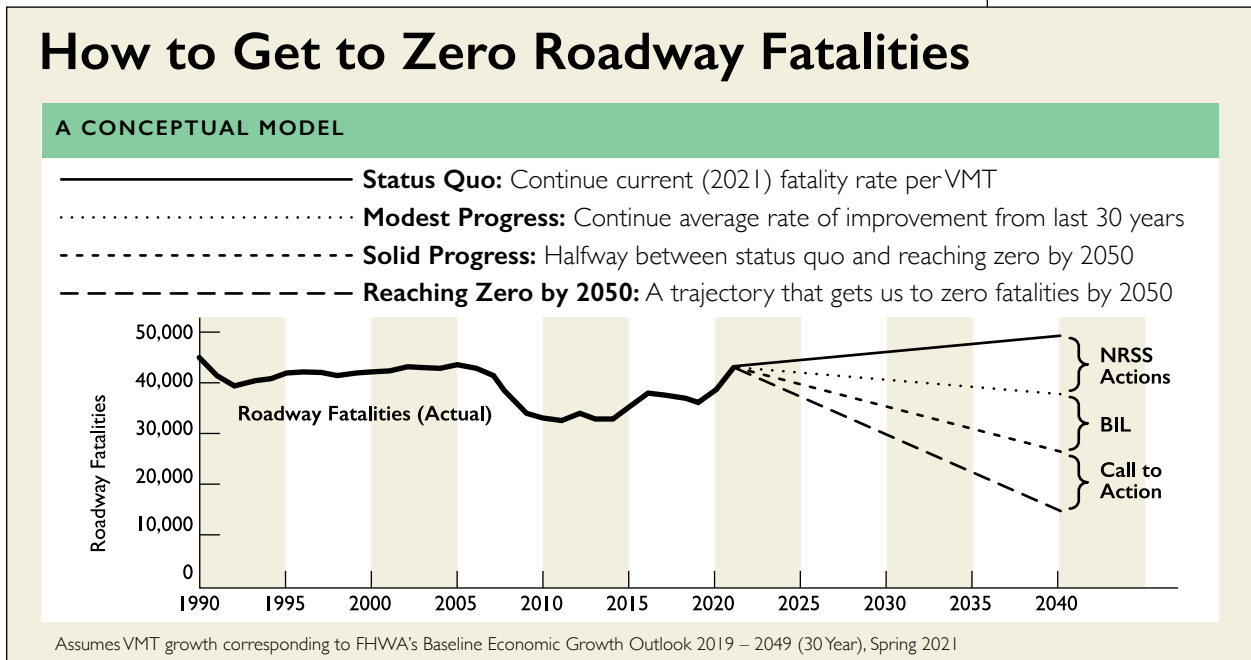
SAFETY

- **Responsibility is Shared.** All stakeholders, including every level of federal government, industry, nonprofit organizations, advocacy groups, researchers, and the general public—are essential for preventing transportation-related deaths and serious injuries.
- **Safety is Proactive.** Proactive tools should be used to identify and address transportation-related safety issues beforehand, rather than reacting after a crash has occurred.
- **Redundancy is Crucial.** Reducing risks requires strengthening every part of the transportation system, so that if one part fails, other parts are still capable of protecting people.

The NRSS seeks a sustained and concerted effort from all sectors and levels of government, the public and private sector, advocacy, and research. A U.S. Volpe Center team designed the NRSS website, created the NRSS Dashboard using Tableau software for quarterly reporting on 29 U.S. DOT actions across the five

3 What is a Safe System Approach? <https://www.transportation.gov/NRSS/SafeSystem>.

NRSS Theory of Change. (Image: U.S. DOT Volpe Center)



elements of the Safe Systems Approach, and provided analysis and policy development support to OST-P in crafting the NRSS, including substantial OA coordination. The NRSS website officially launched on January 27, 2022.

The U.S. DOT Volpe Center collaborated with the OST Office of Policy (OST-P) to hold a community forum in April 2022 to update stakeholders on progress toward executing actions outlined in the NRSS, solicit input, and promote ownership across stakeholder groups. Over 50 stakeholders participated, spanning advocacy organizations, the public and private sector, and state and local government.

The U.S. DOT's commitments to the Safe System Approach included in the NRSS are a critical first step toward reducing roadway fatalities. Combined with significant safety-focused investments provided by the Bipartisan Infrastructure Law (BIL), U.S. DOT's actions offer an approach to significantly reduce roadway deaths and serious injuries. However, including commitments from the stakeholder community is the final critical step to putting U.S. DOT on a pathway to zero fatalities by 2050. The U.S. DOT Volpe Center will support this ongoing work over the next few years. (*Sponsor: OST-P*)

■ MOTOR CARRIERS

Preventing Drug-and Alcohol-Related Commercial Motor Vehicle Injuries and Fatalities

Numerous studies have shown that driving under the influence of alcohol or drugs is dangerous for everyone on the road. Add to that, the size and weight of a commercial motor vehicle (CMV), and the risk of serious injuries and fatalities grows even higher. As a result, the Federal Motor Carrier Safety Administration (FMCSA) requires CMV drivers and their employers to follow specific rules regarding drug and alcohol testing.

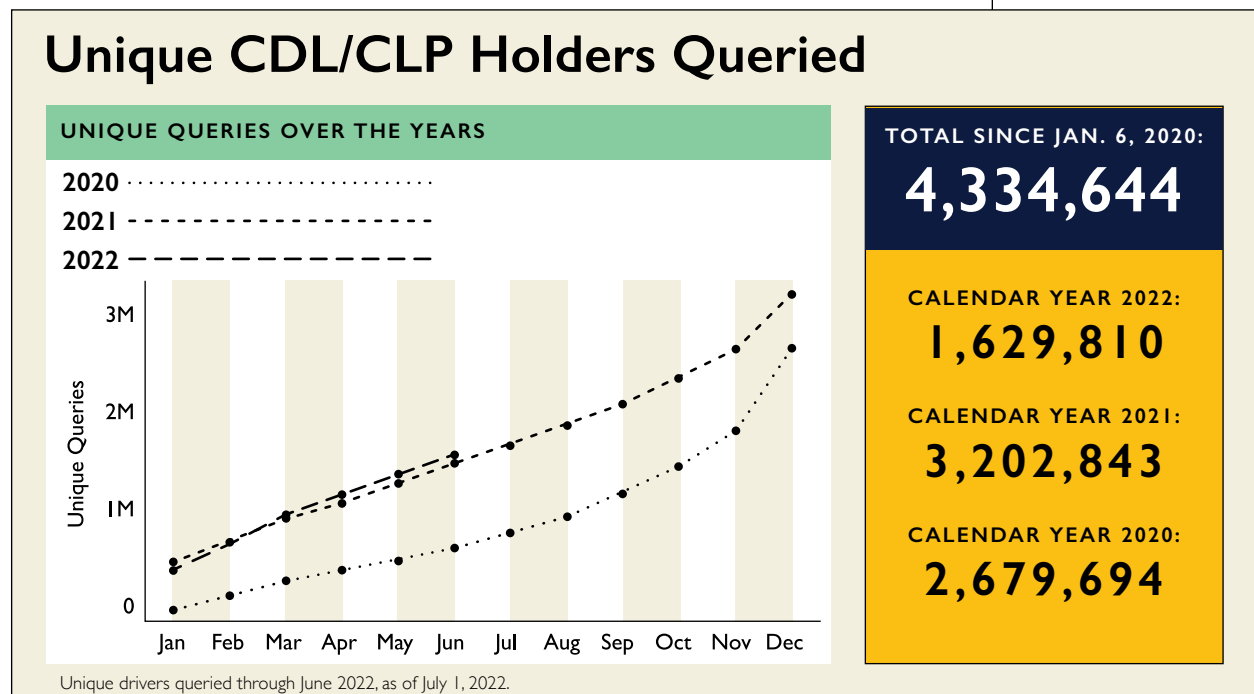
As part of this effort, FMCSA released the Commercial Driver's License (CDL) Drug and Alcohol Clearinghouse, a secure online database that centralizes records

of CMV drivers' alcohol and drug program violations. The Clearinghouse gives employers real-time access to this information, enabling them to determine which drivers to remove from operating a CMV due to drug and alcohol program violations.

SAFETY

Since the Clearinghouse's release in January 2020, employers subject to FMCSA's drug and alcohol testing policy are required to query the Clearinghouse before hiring a new driver and to annually query already employed drivers' records to ensure they are not prohibited from operating a CMV. FMCSA's next phase of the

This graph illustrates the number of CDL and CLP holders whose information has been queried by employers since the Clearinghouse launched in January 2020. (Image: U.S. DOT Volpe Center)



Clearinghouse is focused on preventing drivers who have a prohibited status in the Clearinghouse from holding a CDL. No later than November 18, 2024, before issuing, renewing, upgrading, or transferring a CDL or a commercial learner's permit (CLP) to a driver, State Driver's Licensing Agencies (SDLAs) must check the Clearinghouse; if the Clearinghouse indicates the driver is prohibited from operating a CMV, the SDLA will refuse to issue the driver a CDL. In addition, SDLAs must downgrade a CDL or CLP for drivers who currently hold such licenses.

The U.S. DOT Volpe Center supports FMCSA in designing and developing data exchange mechanisms to share Clearinghouse data with SDLAs and to educate them on the variety of options they have to request and receive driver information

from the Clearinghouse. Other areas the Volpe Center supports include program implementation planning.

SAFETY

Between January 6, 2020 and July 1, 2022, employers queried more than 4.3 million CDL holders and 151,599 drug- and alcohol-related violations were reported to the Clearinghouse. The information in the Clearinghouse allows employers and law enforcement to identify drivers who attempt to conceal alcohol and drug violations. In the future, the Clearinghouse will enable SDLAs to prevent violators from obtaining a CDL in the first place. (*Sponsor: FMCSA*)

Ensuring Consistent Level of Driver Education with the Training Provider Registry

The CMV industry is a major economic driver of the United States. Truck shipments generated \$732.3 billion in gross freight revenues in 2020, which represents 80.4 percent of U.S. freight.⁴ CMVs transport essential goods and carry thousands of passengers across the country every day. Operating a CMV comes with many responsibilities, as drivers must contend with vehicle size, weight, and numerous safety challenges—from managing wide turns and blind spots, to transporting hazardous materials. FMCSA oversees and regulates CMV operators, and works to ensure only qualified individuals drive CMVs on our nation’s roadways.

FMCSA took a significant step to set baseline training requirements for entry-level drivers.

In February 2022, FMCSA took a significant step to enforce compliance with the new Entry-Level Driver Training (ELDT) regulations, which set baseline training requirements for entry-level drivers.⁵ As of February 7, new applicants for CDLs and CDL endorsements must complete a training program before taking a CDL test. The new ELDT regulations establish the federal minimum standard for the coursework a driver must complete, as well as the requirements a provider of entry-level driver training must meet.

4 American Trucking Associations, Economics and Industry Data; <https://www.trucking.org/economics-and-industry-data>.

5 FMCSA Entry-Level Driver Training (ELDT); <https://www.fmcsa.dot.gov/registration/commercial-drivers-license/entry-level-driver-training-eldt>.



Example of a training provider search results in the Training Provider Registry, displaying fictional training providers. (Image: FMCSA Training Provider Registry)

To help stakeholders comply with the ELDT regulations, FMCSA collaborated with the U.S. DOT Volpe Center to design and implement the ELDT program. The U.S. DOT Volpe Center team provided program implementation planning expertise; engaged with stakeholders to ensure the new regulations were implemented by the February 7 deadline; developed and executed a communication and outreach plan; and facilitated education and training sessions.

To support the EDLT program, the U.S. DOT Volpe Center also supported FMCSA in designing, developing, and launching the Training Provider Registry. The Training Provider Registry is a web-based system that retains a record, submitted by training providers, of which CDL applicants have completed the required entry-level driver training. SDLAs access the Training Provider Registry before administering a CDL test to verify the applicant has completed all of the required training.

As of October 16, 2022:

- 28,055 training locations have been registered by 17,331 companies and organizations since registration opened in June 2021.
- 369,730 drivers have completed entry-level driver training and had their training certified and submitted to the Training Provider Registry by a registered training provider.

The U.S. DOT Volpe Center continues to provide post-implementation technical support for the Training Provider Registry, and will monitor the program and provide continuous evaluation and improvements.

The ELDT regulations represent a major milestone for FMCSA as they establish nationwide minimum requirements for individuals who are seeking to obtain a CDL, or certain CDL endorsements, for the first time. By standing up the Training Provider Registry to equip states with information about CDL applicants, the ELDT program brings together partners across the roadway community to ensure only qualified individuals are issued CDLs. This online system impacts all CMV operators across the United States. (*Sponsor: FMCSA*)

■ PEDESTRIANS AND BICYCLES

Improving Vehicles' Direct Vision Safety with the VIEW Blind Zone Measurement Application

While motor vehicle occupant deaths in the U.S. have trended downward since 2010, fatalities involving non-occupant vulnerable road users (VRUs)—pedestrians, bicyclists, and children—have steadily increased. Pedestrians made up 17 percent of all traffic-related deaths in 2020, compared to 13 percent in 2010.⁶ The designs of both heavy trucks and light sport utility vehicles (SUVs) and pickup trucks create blind zones that make it difficult for drivers to view their surroundings, increasing the risk of blind-zone related fatalities and injuries. A University of Michigan analysis estimates that blind zones are involved in 25 percent of U.S. pedestrian deaths in crashes with large trucks. The increasingly large blind zones in SUVs and pickups have been associated with fatal “frontover” crashes, in which children have been run over by the drivers of slow-moving vehicles in driveways or parking lots.

⁶ New Projection: U.S. Pedestrian Fatalities Reach Highest Level in 40 Years; <https://www.ghsa.org/resources/news-releases/GHSA/Ped-Spotlight-Full-Report22#:~:text=Pedestrians%20accounted%20for%2017%25%20of,2020%20after%20years%20of%20increases>.

In 2017, the Santos Family Foundation asked the U.S. DOT Volpe Center to pursue a number of strategies to help reduce the number of these preventable crashes. This effort began as a Volpe-advised project with five students at the Olin College of Engineering to develop an application that would measure the size and location of a vehicle's blind zones. Based on the positive results achieved during the Olin project, the Santos Family Foundation asked the Volpe Center in 2019 to continue developing the application and bring it into real-world use.

With the Visibility In Elevated Wide vehicles application (VIEW), users are able to measure a vehicle's blind zones in 10 minutes using a smartphone with panoramic view capability, a tape measure, and a five-foot pole. VIEW tells the user how much of the safety-critical area directly in front of and to the right of the vehicle cannot be seen with the driver's naked eye. Critically, VIEW also quantifies how many adults, children, people in wheelchairs, and other vulnerable road users cannot be seen.

Direct vision—how much of a vehicle's surroundings its driver can directly see through the windows—strongly affects pedestrian safety. Research from the United Kingdom indicates that a driver who sees a pedestrian with the naked eye reacts 0.7 seconds faster than one who sees a pedestrian through a mirror or camera, underscoring the safety benefit of removing vision obstructions present in today's vehicles.

Since 2010, fatalities involving pedestrians, bicyclists, and children have steadily increased.

The U.S. DOT Volpe Center designed and performed a driver simulation study in 2021 to determine the effect of direct vision available to a truck driver on the risk of their running over a stranded pedestrian in a crosswalk in a typical signalized intersection. The Volpe Center team ran two video simulation studies with participants, including truck drivers. Volpe Center experts conducted the simulation 45 times with a low-vision truck model and 45 times with a high-vision truck model, based on commercially available trucks. The results, published in a 2022 Transportation Research Record paper, were striking:

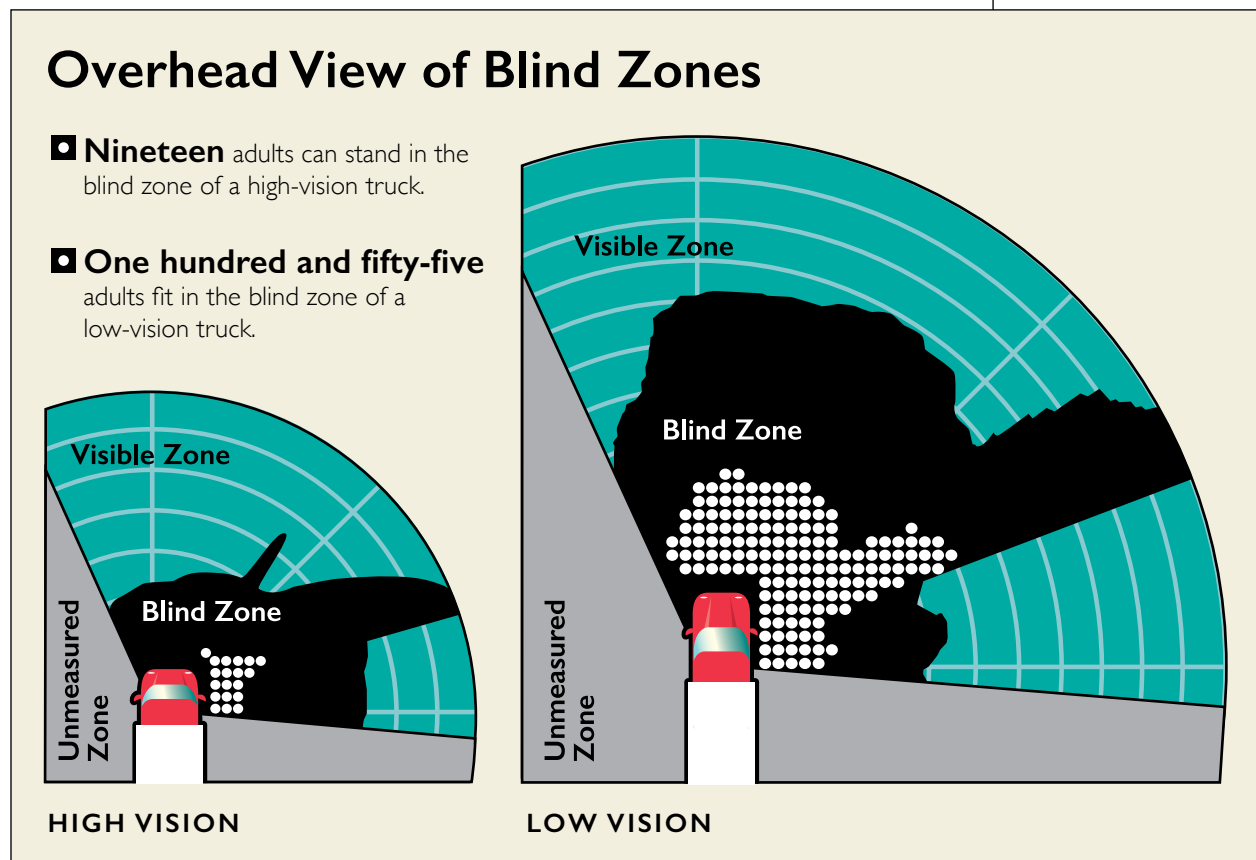
1. Participant drivers in the low-vision truck design noticed and stopped for the pedestrian in the blind zone only 6 out of 45 times—simulating a pedestrian survival rate of 13 percent.
2. Under the high-vision truck scenario, drivers detected the pedestrian in the blind zone 45 out of 45 times—simulating a 100 percent safety outcome.

These and related data suggest that increasing the availability of high-vision heavy and light trucks could significantly reduce VRU blind-zone fatalities.

SAFETY

The ultimate purpose of the VIEW app is to raise awareness about blind zones and direct vision among consumers, other researchers, and industry. The U.S. DOT Volpe Center has conducted live VIEW demonstrations for both major public and private fleets, and offered trainings to those that have adopted it, including the fleets of New York City, the city of Boston, and Republic Services, the nation's second largest waste and recycling operator.

VIEW beta app overhead blind zone visualizations of a high- and a low-vision truck, including the number of adults outside the truck whom the driver cannot see. (Image: U.S. DOT Volpe Center)



The project team participates in and hosts multiple events each year to increase awareness of the VIEW application and of human factors research on the importance of direct vision for VRU safety. Dozens of project discussions with federal as well as consumer and advocacy stakeholders have revealed a collective desire to measure and address the risk created by the large blind zones being designed into today's heavy and light trucks. (Sponsor: Santos Family Foundation)



U.S. DOT Volpe Center engineer Tatiana Mowry and NTSB investigator Dr. Turan Kayagil inspect a rolled over passenger car in Mendon, Missouri. (Image: U.S. DOT Volpe Center)

■ RAIL

Investigating Passenger Rail Accidents to Aid Railroad Safety Research

In the early afternoon of June 27, 2022, an Amtrak passenger train traveling from Los Angeles to Chicago impacted a dump truck on a grade crossing in the town of Mendon, Missouri, causing a derailment that resulted in the deaths of four people with dozens more seriously injured. During the accident investigation, U.S. DOT Volpe Center crashworthiness experts gathered key data on window glazing, side structures, and end frame and coupler performance, which have been areas of concern for Federal Railroad Administration (FRA) and National Transportation Safety Board (NTSB) officials in other major rail accidents. The FRA's Office of Safety investigates major rail accidents to provide real-world data in support of research efforts and regulatory development efforts intended to improve rail safety.

U.S. DOT Volpe Center rail crashworthiness engineers support several FRA research programs and are part of the FRA's Forensics Team, which conducts investigations on passenger train accidents and derailments across the country. This project highlighted rail accident behavior in rollover conditions, and provides data on the performance of glazing, coupler strength, and emergency egress of passengers and crew. Accident data is evaluated within FRA-Volpe

research programs and addressed through the FRA's Railroad Safety Advisory Committee to evaluate and improve existing regulations.

During a Forensics Team investigation, U.S. DOT Volpe Center engineers work with FRA staff to identify the causal mechanisms for injuries and fatalities. This includes inspecting the rail cars' interior, gathering data (e.g. measurements at the accident site, event recorder data, etc.), and conducting interviews with passengers, railroad crew, and first responders. With this information, FRA and U.S. DOT Volpe Center engineers are able to reconstruct the sequence of events that led to the injuries and fatalities involved.

Following the five-day investigation of the Mendon accident, the FRA Forensics Team shared their field notes with the NTSB's Survival Factors Investigative Party. The U.S. DOT Volpe Center team prepared an Accident Briefing Power-Point presentation for the FRA within a month of the accident and is scheduled to presents its findings to the FRA Director of Railroad Systems and Technology Office in the near future.

Accident investigations inform existing and future research and are used to develop and update existing regulations. With real-world data on these areas and other lessons learned from rail crashworthiness investigations, FRA and NTSB safety officials can be better positioned to improve rail safety across the United States. (*Sponsor: FRA*)

■ AVIATION

Moving to Multiple Airport Route Separation (MARS)—Improving Flight Efficiency Safely at High-Density Airports

Airports located close together must share critical airspace, which can lead to operational inefficiencies, congestion, and delays during takeoffs and landings. The U.S. DOT Volpe Center partnered with the FAA's NextGen Human Factors

Division to explore ways to safely improve efficiency, while getting people to their destinations faster. This project addressed multiple FAA research needs related to flight deck human factors perspectives on an emerging Next Generation Air Transportation System (NextGen) concept known as Multiple Airport Route Separation (MARS). MARS will allow two aircraft to fly under reduced separation standards when both are flying along specially designed pairs of instrument flight procedures (IFPs) in airspace with multiple high-density airports (HDAs).

As designed, the MARS IFP combinations would deconflict aircraft flying into or out of different airports in areas such as the New York metropolitan region. IFPs supporting MARS will be designed for aircraft flying with Global Positioning System (GPS) technology, ensuring they meet navigation standards associated with Performance Based Navigation (PBN). The U.S. DOT Volpe Center supported this project by examining the MARS concept from the pilot's perspective.



New York regional airports in proximity to each other with high volumes of air traffic present a challenge for coordinating arrivals and departures within the airspace. (Source: Image adapted from Julius Schorzman, CC BY-SA 2.5, <https://commons.wikimedia.org/w/index.php?curid=280246>)

This project has two broad impacts. First, the U.S. DOT Volpe Center provided recommendations to the FAA NextGen Human Factors Division that will be applied in the development of MARS. Second, the U.S. DOT Volpe Center's work will impact recommendations that are forthcoming from a government-industry working group. Some of the U.S. DOT Volpe Center's recommendations apply to the design of paths that connect arrival routes with approach paths to the runway. Routes that connect arrivals and approaches are an area of risk because pilots sometimes fly a path that was not cleared by air traffic control (ATC) or pilots can become confused about what path they should fly. This connection was identified by a previous U.S. DOT Volpe Center study and confirmed by others in industry and government.⁷

⁷ Chandra, D.C., Sparko, A., Kendra, A., & Kochan, J. (2020). "Operational Complexity in Performance-Based Navigation (PBN) Arrival and Approach Instrument Flight Procedures (IFPs)," DOT-VNTSC-FAA-20-02. U.S. DOT Volpe National Transportation Systems Center. <https://rosap.ntl.bts.gov/view/dot/43835>.

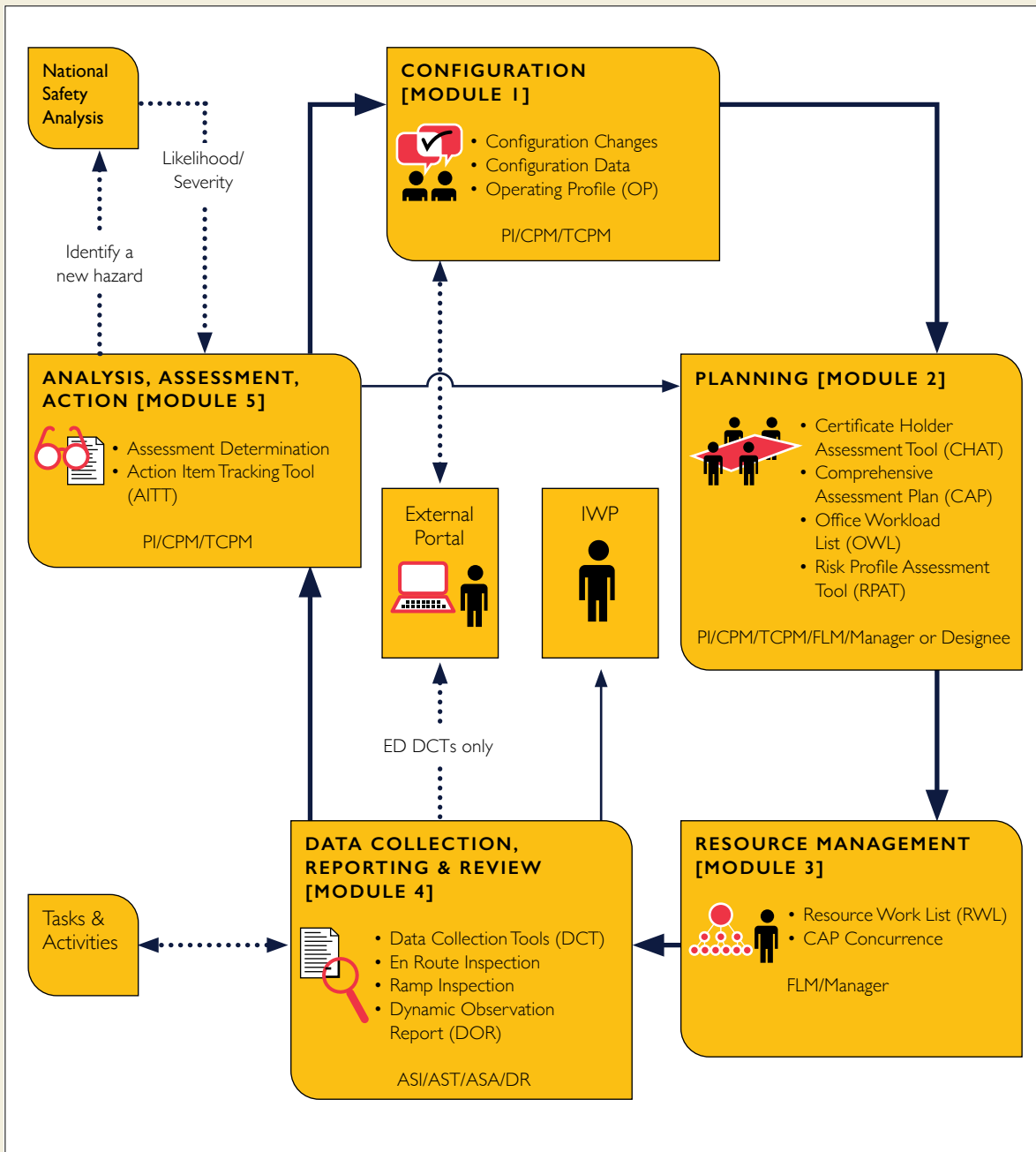
The U.S. DOT Volpe Center accomplished this project through a combination of conceptual work, data analysis, and data collection. Using a literature review as a starting point, the U.S. DOT Volpe Center team created a working definition of the construct of airspace complexity for pilots and used it to identify related events from the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS), to study pre-COVID New York flight operations. They analyzed ASRS events using a structured coding rubric to understand current operational issues in the New York region and studied resilient pilot behaviors through the New York ASRS dataset. The U.S. DOT Volpe Center team also gathered input on New York operations from airline pilots. The U.S. DOT Volpe Center also developed a method for a conceptual evaluation of a MARS application.

New York airports were used for the case study, but recommendations generated for MARS can be applied to any area of the U.S. with multiple large and small HDAs. A key deliverable for this project was the release of Flight Deck Human Factors Issues Related to Instrument Flight Procedures (IFPs) at High Density Airports (HDAs) (bts.gov), which was published in January 2022. (*Sponsor: FAA NextGen Human Factors Division ANG-C1*)

U.S. DOT Volpe Center-Developed Software Streamlines Data Capture and Identifies Trends and Issues for Safety and Organizational Assurance Review (SOAR)

The Federal Aviation Administration's (FAA) Flight Safety Standards Service (FS) is responsible for ensuring air carriers are capable of operating at the highest possible degree of safety and their safety-critical processes comply with the regulations and safety standards prescribed by the FAA. For more than a decade, FAA has relied upon the U.S. DOT Volpe Center to design, develop, and test the Safety Assurance System (SAS). Since then, U.S. DOT Volpe Center experts have modified the software in response to changing policies. Further, as the development lead on the Integrated Product Teams, the U.S. DOT Volpe Center continues to create new functionalities for integration into the existing software.

FAA Safety Assurance System (SAS)



Source: FAA's Order 8900.1 V10 ChI 52 Figure 10-1-2A.



Operated by the FAA Service's Safety Analysis & Promotion Division (AFS-900), SAS standardizes the work performed by FAA offices across the country, and improves consistency and collaboration between the agency and industry. SAS helps FAA aviation safety inspectors determine risk-based, data-supported oversight decisions, and provides the standardized protocols to evaluate whether carrier operations are in compliance with regulations.

A separate FAA FS division, Safety Risk Management (AFB-400), oversees the performance and organizational consistency of FAA's operations, using the Safety and Organizational Assurance Review (SOAR) process, to ensure consistent and equitable programs. Unlike AFS-900's automated process management, SOAR used manual, case-by-case question generation, development of checklists, and entry results using Excel. The Division's Evaluation Program Modernization Core Team concluded SAS might be the vehicle to achieve a more efficient and data-driven SOAR process.

After approaching AFS-900 managers to explore the possibility of using SAS, the AFB-400 Core Team came up against a fundamental problem: its requirements for using SAS, although similar to those for safety inspection and performance monitoring, were different. Managing inspections and their outcomes across hundreds of carriers and thousands of audits required recurring visits with a set protocol and acquiring repetitive responses to a fixed set of preprogrammed questions. Evaluating the performance and organizational consistency of offices with the same program mission might in some ways be comparable, but overall, the programs themselves would have distinctly different goals.

In July 2021, AFS-900 turned to the U.S. DOT Volpe Center to find a solution. The U.S. DOT Volpe Center was singularly equipped help solve this dilemma because of its deep domain knowledge in aviation, software programming and management, and SAS itself. As experts in the existing software, workflows, and designs, the U.S. DOT Volpe Center team could look at different aspects of the software and re-use existing code. Another important factor was the U.S. DOT Volpe Center's longstanding relationship with the customer. The established rapport and trust enabled FAA to give the U.S. DOT Volpe Center greater flexibility in trying out proposed solutions. The U.S. DOT Volpe Center team recognized

A team of U.S. DOT Volpe Center experts found that while some new code would be needed, existing code could help create the necessary utilities.

it should develop a prototype using actual case data so that FAA could perceive the prototype's potential and shortcomings in concrete terms.

For more than six months, a small team of U.S. DOT Volpe Center program management and business analysis experts met virtually with AFB-400 Core Team members and AFS-900 staff to work through the critical first step in software design. After each discussion, U.S. DOT Volpe Center participants consulted on the feasibility of proposals with its on-site developers, who originally developed SAS and continue to develop additional functionalities. The U.S. DOT Volpe Center found that, while some new code would be needed, SAS already had existing code elsewhere in the system that could be pulled in to create the necessary utilities once connecting codes were developed.

The software that will enable automated program evaluation is in final testing at the U.S. DOT Volpe Center. Electronic shipment of the program to FAA is targeted for March 2023, with final acceptance and release to AFB-400's users in April 2023.

Other offices within FAA have heard about the SAS augmentation for program evaluation. The Office of Security and Hazardous Materials Safety is undergoing a similar exercise to use SOAR for evaluating its processes. AFS-900 made a similar request, and other offices believe the streamlined SOAR process has other potential applications. (*Sponsor: FAA*)

Identification Friend or Foe (IFF) Stage 2 and Stage 3 Models Support FAA Spectrum Certification and Frequency Assignment Processes

The FAA is responsible for monitoring the 1030/1090 MHz spectrum, which is the radio frequency (RF) band used by Automatic Dependent Surveillance-Broadcast (ADS-B), Secondary Surveillance Radar (SSR), Aircraft Surveillance and Collision Avoidance Systems (ASCAS), and other safety-critical systems in the National Airspace System (NAS). Reduced spectrum bandwidth—measured

in terms of aircraft transponder occupancy, probability of transponder replies, surveillance system update rates, etc.—leads to loss of data, late transmission and/or reception of data, and other hazardous effects that can degrade pilots' and Air Traffic Control's ability to maintain aircraft separation. Accurate and timely information on the spectrum environment helps decision makers allocate spectrum and approve or reject requests to use spectrum.

The FAA and U.S. Department of Defense (DoD) requested the FAA William J. Hughes Technical Center (WJHTC) and U.S. DOT Volpe Center to develop the Stage 2 End-State and Stage 3 Automated, Validated, End-State Model software requirements, along with the models themselves, to inform spectrum certification and frequency assignment processes for the addition, modification, and removal of systems using 1030/1090 MHz; as well as DoD Identification Friend or Foe (IFF) system tests and exercises. The models, which will be hosted in FAA Cloud Services (FCS) and accessed through a public website, will be able to estimate the spectrum impact caused by adding, modifying, or removing aircraft, ground-based, and/or ship interrogators and receivers that use the 1030/1090 MHz spectrum. The Stage 2 Model is currently under development at the WJHTC and is expected to be operational in September 2023.

The U.S. DOT Volpe Center led the development of the Stage 2 Model Software Requirements Specifications (SRS) document version 1.0 (delivered in September 2021), the Stage 3 Model SRS version 1.0 (delivered in October 2022), and the Stage 3 Model Interface Control Document version 1.0 (delivered in September 2022). In addition, the U.S. DOT Volpe Center team is contributing to FCS "Authority to Operate" documentation demonstrating that the models will satisfy FAA's information systems, user authorization, user authentication, and public-facing website requirements. U.S. DOT Volpe Center's expertise in ATC, air traffic management, ADS-B, SSR, and multilateration systems contributed to the development of the Stage 2 and Stage 3 Models.

Once the Stage 2 and 3 Models are complete, they will allow U.S. government users and members of the public to evaluate the effect of adding, modifying, or removing a system on the 1030/1090 MHz spectrum environment. The models will help FAA automate its spectrum certification and frequency assignment workflows. As a result, the NAS can accommodate more aircraft using key spectrum bands while maintaining the same level of safety. (*Sponsors: U.S. DoD*)

Office of the Chief Information Officer [CIO]; FAA Spectrum Engineering Office; FAA Air Traffic Organization Cybersecurity Group [ACG] [key stakeholder]; National Telecommunications and Information Administration [NTIA] [key stakeholder]

■ MULTIMODAL

Improving Resilience and Fostering Responsible Use of Positioning, Navigation, and Timing Services

The national and economic security of the United States depends on reliable Positioning, Navigation and Timing (PNT), which is an essential component of the nation’s transportation infrastructure. The civil, commercial, and military sectors rely on PNT technology to provide critical location services in the air, on land, and at sea. On February 12, 2020, the White House issued Executive Order 13905 “Strengthening National Resilience through Responsible Use of Positioning, Navigation, and Timing Services,” with the goal of fostering the responsible application of PNT services by critical infrastructure users, owners, and operators (including the transportation industry), to strengthen national resilience. The objective of Executive Order 13905 is to ensure disrupted or manipulated PNT systems do not undermine the reliability or efficiency of critical infrastructure services by:



The USNS *Denebola* at dry dock for routine maintenance in Boston on March 25, 2021. The U.S. DOT Volpe Center team was able to tour the ship to see where PNT equipment was located and how the crew used the equipment while at sea. (Image: U.S. DOT Volpe Center/Christopher Scarpone.)

- Raising awareness of the extent to which critical infrastructure depends on PNT services;
- Ensuring critical infrastructure can withstand disruption or manipulation of PNT services; and
- Engaging the public and private sectors to promote responsible use of PNT services.

In response to the Executive Order, the Office of the Assistant Secretary for Research and Technology (OST-R) and Maritime Administration (MARAD), developed a Pilot Program Plan in August 2020 to address GPS jamming and spoofing in the maritime environment. In December 2020, U.S. DOT hosted a workshop, “GPS Jamming and Spoofing in the Maritime Environment,” which featured speakers from government, industry, and nonprofit PNT organizations. The objective of this workshop was to raise awareness of the extent to which maritime vessels depend on nonprofit PNT services among commercial vessel operators, regulators, enforcement organizations, technology providers, PNT experts, and policy agencies. In February 2021, OST-R initiated an interagency agreement with the U.S. DOT Volpe Center to support DOT Pilot Program MARAD Phase I with the primary goal of applying guidance provided in the NISTIR 8323 Foundational PNT Profile: Applying the Cybersecurity Framework for the Responsible Use of Positioning, Navigation and Timing (PNT) Services through an application-based effort.

The pilot program focused on operations in the maritime environment and provided findings and recommendations along each of the four components by:

1. Identifying specific shipboard systems on MARAD Ready Reserve Fleet (RRF) vessels that use or form PNT data—through stakeholder outreach, fleet inventories, and individual ship surveys.
2. Identifying both existing and alternative PNT data sources suitable for the maritime operating environment—through operational testing and data collection aboard both stationary and active ships.
3. Detecting the disruption and manipulation of PNT services in a marine environment—through successful testing of shipboard PNT equipment in

both laboratory and real-world operational settings, under normal and disrupted/manipulated conditions.

4. Providing MARAD with a framework to manage the associated risks to the shipboard systems, networks, and assets that depend on PNT services—by identifying equipment that provides protection (i.e., shields and/or defeats manipulation of PNT) and augmentation (i.e., utilizes alternative PNT signals), and sharing that information with key stakeholders.

The U.S. DOT Volpe Center managed the pilot project from start to finish by utilizing its expertise in PNT and leveraging critical contractor support. Major project work was conducted at the U.S. DOT Volpe Center in Cambridge, Massachusetts with field testing completed in Fairfax, Virginia. The impact of this project is specific to MARAD's RRF. A final report was completed in December 2022, and the U.S. DOT Volpe Center is working on releasing a version to the public.

The success of DOT Pilot Program MARAD Phase I has led to DOT Pilot Program MARAD Phase II to conduct additional testing and further MARAD's efforts to adopt resilient PNT solutions, as well as a similar pilot program for FRA. U.S. DOT Volpe Center engineers will support FRA by conducting vulnerability testing and identifying existing and complementary PNT data sources suitable for rail applications through operational testing and data collection aboard stationary and active trains. *(Sponsor: OST-R, with input and coordination from MARAD)*

Volpe Center Experts Serve as U.S. DOT's GPS Liaisons to the U.S. Space Force

After the launch of Sputnik in 1957, the White House assigned the U.S. Department of Defense (DoD) the responsibility for development and operation of satellite navigation technologies, which at the time were exclusively military. In the wake of the downing of Korean Air Lines Flight 007 by the Soviet Union in 1983, the Reagan administration announced it would make GPS available worldwide to provide precise location determination services for civilian use.

The U.S. Department of Transportation (U.S. DOT) became the lead agency within the U.S. government on issues of GPS-related civil (non-military) requirements and use beginning in 1986 with the creation of the Civil GPS Service Interface Committee (CGSIC). Because of the significance of U.S. DOT's GPS responsibilities, the U.S. DOT Office of the Assistant Secretary for Research and Technology (OST-R) is directly responsible for interfacing with other federal agencies on their civil GPS needs.

In 1992, the FAA approved GPS receivers for civilian flight operations, but the first flights were not authorized until GPS Initial Operational Capability was declared in 1993. With the removal of the intentional degradation of GPS accuracy by the military in 2000, the civil sector was granted full access.

GPS has irreversibly changed the face of military operations.

Today, GPS is an integral part of everyday life, and tends to be taken for granted by the American public. GPS services are critical not only for the safe and efficient use across all modes of transportation, it is utilized for numerous applications including network synchronization, surveying, precision agriculture, machine control, earthquake detection, and scientific applications. Freely accessible by anyone with a GPS receiver, it has irreversibly changed the face of military operations and civilian navigation and infrastructure.

To the extent the typical American understands how GPS works, they know that a signal is coming from a satellite, and their phone, car, or the plane they are riding in, receives a signal to tell them where they are. Hidden from the typical American's conscious awareness is that something, or someone, is making sure the system does what it is supposed to, and without fail.

National policies and interagency agreements ensure an effective, coordinated working relationship between DoD and U.S. DOT in this arena. Per U.S. National Space-Based Positioning, Navigation, and Timing (PNT) policy, also known as Space Policy Directive 7 (SPD-7), U.S. DOT is responsible for representing the civil departments and agencies in the development, acquisition, management, and operation of GPS.

To fulfill this responsibility, U.S. DOT and the U.S. Space Force (USSF) have a well-established and cooperative working relationship to reliably deliver space-based PNT service to civil and military users of GPS worldwide. U.S. DOT

provides a liaison to USSF Space Systems Command (SSC) at Los Angeles Air Force Base designated as the liaison for civil GPS applications. U.S. DOT also provides a liaison to USSF Space Operations Command (SpOC) at Peterson Space Force Base designated as the liaison for civil GPS operations and sustainment in accordance with the GPS Standard Positioning Service Performance Standard. These liaison positions are filled by two U.S. DOT Volpe Center experts as requested by FAA to replace prior FAA liaisons who served in these positions and who have subsequently retired.

Three things have to happen in order for GPS to perform seamlessly in the face of advancing technologies and changing military or civilian user needs. First, is the recognition of new system requirements, and their harmonization to ensure system functionalities are not at odds with each other. Next, is the process of acquiring new hardware and software. Lastly, the hardware and/or software are installed, the modified satellite system and controls are validated, and operation proceeds.

There is an increasing need for resiliency due to threats from disruption, denial, and manipulation of the GPS signal.

As the U.S. DOT's liaison to Space Systems Command (USSF/SSC) for GPS Acquisitions, a U.S. DOT Volpe Center expert conveys civil user input to the GPS Enterprise technical baseline and reviews any GPS Enterprise technical baseline changes to identify conflicting or competing objectives.

In 2021, the U.S. DOT Volpe Center assigned a liaison to the USSF's Space Operations Command (USSF/SpOC) for Civil GPS Operations. This role represents to the USSF all civilian government departments and agencies that are PNT stakeholders. The U.S. DOT Volpe Center liaison has also collaborated with USSF/SpOC to coordinate military and civil user GPS interests and needs. The liaison has worked with the Joint Chiefs of Staff to cooperatively support the civil participation in the Joint Capabilities Integration Development System (JCIDS) and serves as a liaison to interface with the Pentagon requirements group. Further, the liaison's role has been designed to facilitate requirements review, funding strategies, and future developments.

This realignment has been timely. These changes present an opportunity for U.S. DOT to improve the methods for developing the documentation required by the JCIDS process to facilitate the entry of civil requirements into the

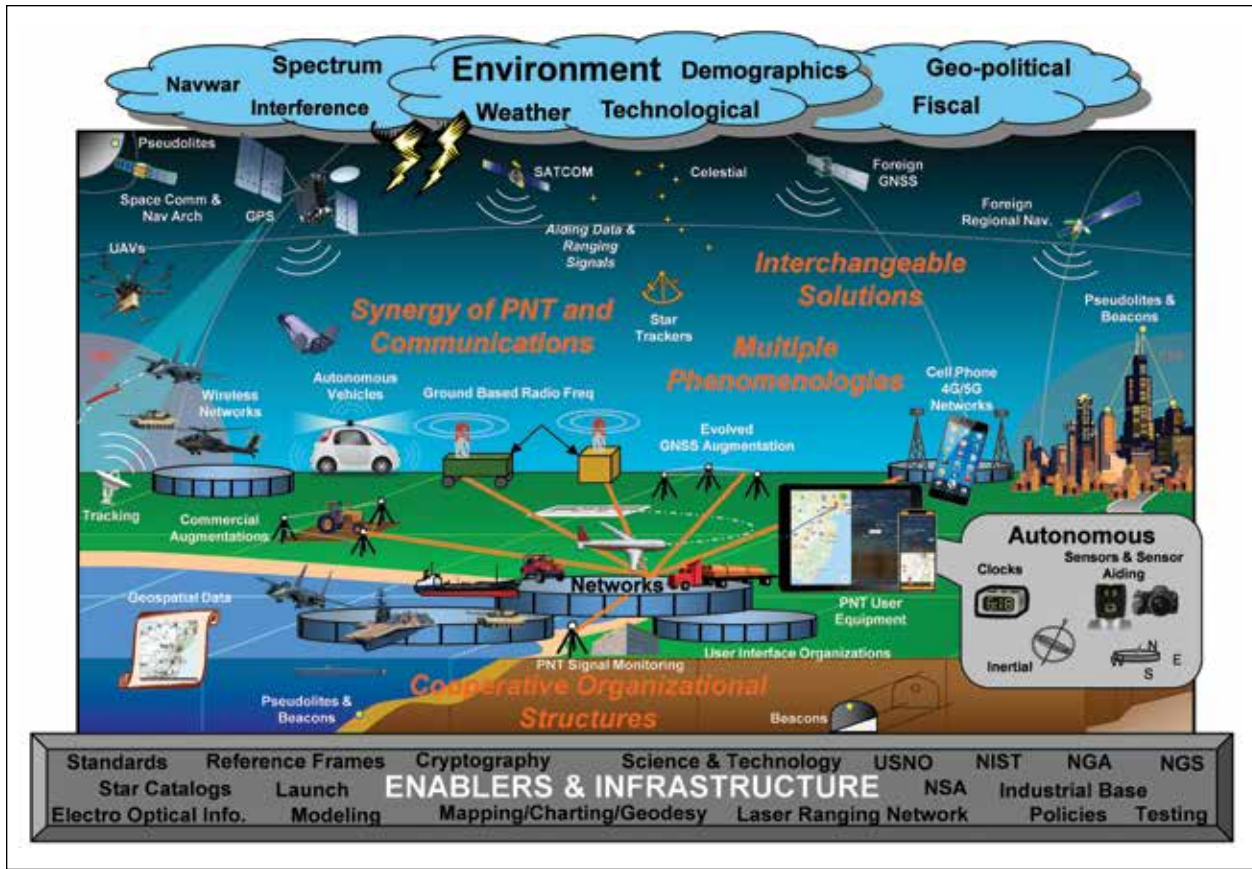
consideration process. The Interagency Forum for Operational Requirements (IFOR) is the process by which civil agencies are able to insert requirements into the JCIDS process.

To reinforce the partnership between U.S. DOT and USSF, the U.S. DOT Volpe Center supported OST-R during a joint one-day PNT summit between U.S. DOT and USSF at U.S. DOT headquarters in May 2022 co-chaired by the Deputy Secretary of Transportation and the Vice Chief of Space Operations, General David D. Thompson. The summit focused on a range of topics concerning strategic planning, operations, and implementation of PNT services. U.S. DOT and USSF recognize that GPS is the cornerstone and gold standard of global space-based PNT services, however there is an increasing need for PNT resiliency due to threats from disruption, denial, and manipulation of the GPS signal. Topics covered during the PNT Summit focused on assured PNT for safety-critical applications, PNT resiliency initiatives, PNT spectrum protection and interference detection, GPS modernization and backwards compatibility, and command and control of modernized civil GPS signals.

The PNT Summit laid the groundwork for future collaboration in PNT technology and policy, as well as in federal funding and public outreach. The U.S. DOT Volpe Center underscored the importance of the U.S. DOT liaisons it provides to the USSF for GPS acquisitions and operations, and initiated discussion of a future liaison position for GPS requirements and capabilities. (*Sponsor: OST-R and FAA*)

U.S. DOT Volpe Center Manages Development of the Federal Radionavigation Plan

The Federal Radionavigation Plan (FRP) is required by U.S. code, and is the official source of PNT policy and planning for the federal government. The FRP describes the federal government's roles, responsibilities, and policies applicable to PNT systems. It presents PNT user requirements, operating plans, and a national PNT architecture that serves as a framework for evaluating and advancing policy and planning for present and future federally provided PNT systems. The FRP is prepared jointly by the Department of Transportation (DOT),



the Department of Defense (DoD), and the Department of Homeland Security (DHS), with the assistance of other government agencies. The statute requires the FRP be revised and updated at least every two years and the document is signed by the Secretaries of Transportation, Defense, and Homeland Security.

The National PNT Architecture. (Image: The 2021 Federal Radionavigation Plan)

The FRP impacts national and global transportation systems by highlighting the importance of maintaining resilient and effective PNT systems. Resilient PNT is not only important for supporting critical infrastructure in the transportation sector, it is also essential for national, homeland, and economic security.

The 2021 FRP reflects updates to U.S. PNT policy and addresses known and emerging capability gaps, and articulates initiatives to close those gaps (or mitigate their impacts). It does this by identifying future PNT capabilities that will sustain U.S. civil, homeland and national security, and scientific activities through the mid-21st century or longer, and motivating studies, analyses, and assessments for the development, demonstration, implementation, security, and resilience of PNT technology. Finally, it provides a coordinated framework to

inform government decisions regarding common-use PNT systems (i.e., systems used by both civil and military sectors).

The U.S. DOT Volpe Center played a significant role in the formulation and submission of updates for the 2021 FRP. With guidance from the Director for PNT and Spectrum Management in the Office of the Assistant Secretary for Research and Technology (OST-R), the U.S. DOT Volpe Center acted as the lead for configuration control and management of the document, handling and incorporating all of the updates and/or submissions from government participants involved in the 2021 FRP coordination process. The U.S. DOT Volpe Center received updates and submissions from U.S. DOT, DoD, and DHS, Department of the Interior (DOI), U.S. Coast Guard (USCG), NASA, U.S. Department of Agriculture (USDA), Department of Commerce (DOC), and Department of State (DOS).

On July 26, 2022, the 2021 Federal Radionavigation Plan (FRP) was publicly released through the U.S. DOT National Transportation Library's Repository & Open Science Access Portal and may be accessed here: <https://rosap.ntl.bts.gov/view/dot/63024#tabs-2>. (*Sponsor: Office of the Assistant Secretary for Research and Technology (OST-R), Office of Positioning, Navigation and Timing (PNT) & Spectrum Management*).

■ OIL AND GAS OPERATIONS

Enabling Near-Miss Data Sharing for Offshore Oil and Gas Operations

The U.S. DOT Volpe Center's expertise in programming and web-based data visualization have helped the federal government provide assistance to oil and gas producers on the Outer Continental Shelf (OCS) to improve the safety and environmental stewardship of offshore operations.

In August 2013, the Department of the Interior's Bureau of Safety and Environmental Enforcement and the Bureau of Transportation Statistics (BTS) signed an interagency agreement to develop and implement SafeOCS, a voluntary program

for confidential reporting of accidents and near misses that occur on the OCS.⁸ Near miss reporting, an already proven tool in the aviation industry, was a key recommendation that emerged from the 2010 Deepwater Horizon disaster.

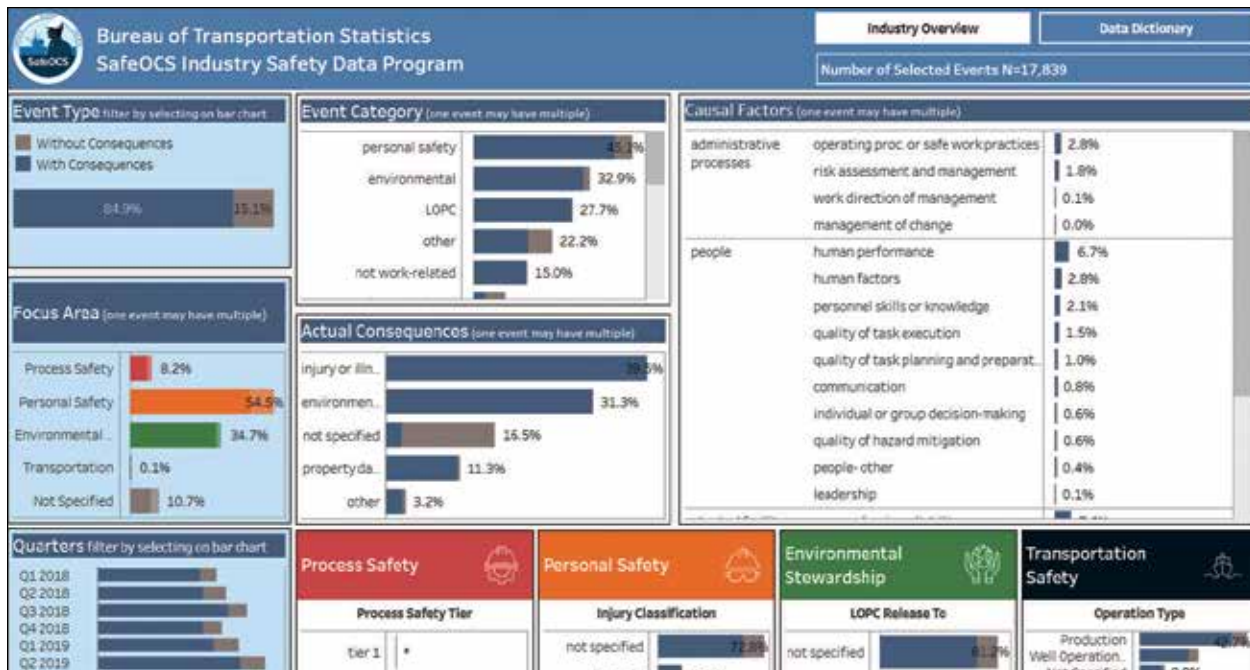
The intent of SafeOCS is to enable offshore oil and gas companies to learn collectively and individually from one another's mistakes—through a discrete and anonymous system. Each company wanted the capability to evaluate its performance against the rest of the industry, and maintaining confidentiality of shared data on near miss and hazardous events was critical for this need. While the principle of aggregating data to assure anonymity was sound, obfuscating the data to conceal companies' identities presented significant challenges.

In 2013, the idea of companies voluntarily sharing confidential information on near misses and potential hazards was novel within the highly competitive oil and gas industry. Over the next five years, BTS worked with industry members, encouraging participation by enabling companies to avoid the legal and commercial obstacles that would otherwise prevent sharing of safety data.

BTS asked a team of U.S. DOT Volpe Center programmers to develop a process that could overcome the challenges of collecting, aggregating, and disseminating safety data from disparate company databases. The near-miss data were in different formats, spanned different years, and included different geographic regions. To solve this problem, a U.S. DOT Volpe Center team developed a mapcode for each company to accommodate its peculiar data structure, translated and guided the data to the appropriate field in the BTS database, and created each record. Additional programming enabled data aggregation and the creation of sets of export files for dissemination.

On the user interface side, the U.S. DOT Volpe Center's web-based data visualization experts developed the front-end analysis framework using Tableau software, and designed the company and public-facing dashboards on the BTS website. The second phase of the project took place virtually due to COVID-19; the U.S. DOT Volpe Center relied on BTS and its subject matter experts to communicate the participant-defined requirements and vision in a clear, implementable way. Dashboard conceptual development and design proceeded iteratively via Microsoft Teams.

8 About the SafeOCS Reporting System; <https://www.safeocs.gov/>.



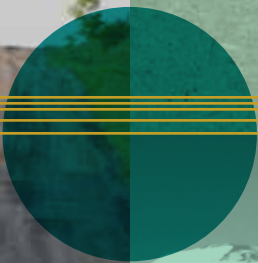
It was during this process the U.S. DOT Volpe Center team solved the data obfuscation problem. The team also overcame the challenge of visualizing data that fell into multiple, overlapping categories without divulging confidential company data.

Screenshot of the Industry Safety Data Public Dashboard released on June 3, 2022. (Image: Bureau of Transportation Statistics)

For the public dashboard, BTS initially wanted nearly 96 different hardcoded data views. The U.S. DOT Volpe Center quickly recognized that updates, maintenance, and quality control multiple times per year would be far too cumbersome. Furthermore, static data views would not necessarily enable the user to look at what was of particular interest to them. As an interactive and powerful alternative, the U.S. DOT Volpe Center discovered a way to create a more abstract version of the data, which users could control with a filter to select primary and secondary axes, enabling users to view any of the possible data permutations.

In March 2022, SafeOCS achieved a major milestone when BTS released initial versions of the secure, company-specific dashboard to each of the participants, and the Industry Safety Data Public Dashboard to the public. The dashboards are a work in progress, and the U.S. DOT Volpe Center will monitor their performance and make necessary adjustments over time. The U.S. DOT Volpe Center team will update both dashboards on a quarterly basis. (*Sponsor: Bureau of Transportation Statistics*).

Infrastructure, Economic Strength, and Global Competitiveness



With its broad range of multimodal, multidisciplinary expertise from engineering to economic analysis, the U.S. DOT Volpe Center works across modes and federal agencies to support critical transportation modernization programs and initiatives focused on growing an inclusive and sustainable economy.

INFRASTRUCTURE,
ECONOMIC STRENGTH,
AND GLOBAL
COMPETITIVENESS

■ MULTIMODAL

U.S. DOT Volpe Center Supports Essential Grant Programs to Help Modernize the U.S. Transportation System

The U.S. DOT provides discretionary funds to state and local governments, Tribes, federal transportation agencies, metropolitan planning organizations, as well as urban and rural transportation organizations to build and maintain a safe, efficient, accessible, and convenient transportation system for every American. President Biden's Bipartisan Infrastructure Law (BIL) introduced a once-in-a-lifetime opportunity for federal investment in the nation's infrastructure. BIL established many new grant programs to rebuild the United States' infrastructure, roads, bridges, ports, waterways, and public transportation and provides opportunities for communities across the country to apply for federal funds. Before BIL was established, the U.S. DOT Volpe Center supported 14 grant programs. Since BIL's passage, not only has the number of active grants doubled, but existing grant programs also expanded in terms of dollars and staff needed to support them.

Some of the new BIL-supported programs include Strengthening Mobility and Revolutionizing Transportation (SMART), Safe Streets and Roads for All,

The U.S. DOT Volpe Center supports the Department's goal of improving public safety and climate resilience, creating jobs across the country, and delivering a more equitable future for all Americans.
(Images: Adobe Stock [Seattle harbor] and U.S. DOT Volpe Center)

Railroad Crossing Elimination Grant Program, Culvert Aquatic Organism Passage Program, Reconnecting Communities Pilot Program, Rural Surface Transportation Grant, the Mega Grant Program, and many others.⁹ U.S. DOT Volpe Center staff were asked to help establish these new programs, and to provide support to existing programs such as the Consolidated Rail Infrastructure and Safety Improvements (CRISI) and the Federal-State Partnership for State of Good Repair Grant Program. To assist this effort, an internal working group was established for project managers to share resources on how to establish new programs and lessons learned, and internal training was created and made available to U.S. DOT Volpe Center staff to provide baseline knowledge on the Volpe Center’s role in supporting discretionary grant programs.

U.S. DOT Volpe Center technical experts have been engaged across topic areas to help design new programs, serve on technical review panels, and support project delivery of grants post-award. For example, the first discretionary funds to flow from BIL were the 2022 Rebuilding American Infrastructure with Sustainability and Equity (RAISE) and Infrastructure for Rebuilding America (INFRA) grant awards. Both programs were supported by U.S. DOT Volpe Center staff who served on technical review panels, performed benefit cost analyses, and conducted project readiness activities. U.S. DOT Volpe Center engineers are also supporting RAISE awardees in the construction phase.

U.S. DOT Volpe Center staff have supported the Safe Streets and Roads for All program in publishing the Notice of Funding Opportunity, providing technical assistance to applicants, reviewing applications, and holding senior review team meetings; those awards are expected soon as well.

U.S. DOT Volpe Center involvement provides a solid and consistent structure to these new or expanded discretionary programs. Based on decades of grant program experience, U.S. DOT Volpe Center staff possess a knowledge base to start creating new programs quickly. Internal coordination at the U.S. DOT Volpe Center helped streamline processes for OST and modal sponsors, and a coordinated approach to staffing review panels helped ensure all programs had the staff needed to meet the BIL requirements. (*Sponsor: OST, OST-P, and OST-R*).

⁹ Bipartisan Infrastructure Law Grant Programs; <https://www.transportation.gov/bipartisan-infrastructure-law/bipartisan-infrastructure-law-grant-programs>.

Benefit-Cost Analyses Help U.S. DOT Select Cost-Effective Transportation Projects

INFRASTRUCTURE,
ECONOMIC STRENGTH,
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COMPETITIVENESS

In November 2021, President Biden signed the Bipartisan Infrastructure Law (BIL), or Infrastructure Investment and Jobs Act, into law. BIL provides \$550 billion in investment in infrastructure, including roads, bridges, mass transit, water infrastructure, resilience, and broadband improvements. Many new competitive grant programs established by BIL, as well as existing programs, require a benefit-cost analysis (BCA) as part of the evaluation process. BCA results will help U.S. DOT determine which infrastructure projects will be a cost-effective use of federal funding.

As a trusted expert in BCAs, the U.S. DOT Volpe Center was asked to support the OST, Federal Highway Administration (FHWA), Maritime Administration (MARAD), and FRA in evaluating project proposals, developing BCA and program guidance, planning, and other technical support. A team of U.S. DOT Volpe Center economists assisted FHWA in developing a BIL-mandated spreadsheet template that will allow future applicants to more easily submit BCAs for bridge-related projects.

Many new competitive grant programs, as well as existing programs, require a benefit-cost analysis.

While BIL provides significant investment in grant programs, previous legislation has also supported infrastructure projects and related activities. The reviews for two grant programs—FRA’s Consolidated Rail Infrastructure and Safety Improvements (CRISI) and the Federal-State Partnerships for a State of Good Repair—have been completed. The selections for CRISI were announced by U.S. DOT in June 2022, and the selections for the Federal-State Partnerships for a State of Good Repair were announced in September 2022. These programs were funded through the Consolidated Appropriations Act of 2021, with related funding provided through the Consolidated Appropriations Act of 2019. BIL will continue to support these competitive grant programs in coming years, while U.S. DOT Volpe Center economists review BCAs and provide guidance to U.S. DOT planners and decision makers.

The BCA reviews for OST’s Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program were completed and awarded in September 2022. This year’s grant allocations provide more than \$2.2 billion to help urban

and rural communities move forward on infrastructure projects that will modernize roads, bridges, transit, rail, ports, and intermodal transportation. Projects were evaluated based on several criteria, including safety, environmental sustainability, quality of life improvements, economic competitiveness and opportunity, innovation, and state of good repair.

Grant proposals come from communities across the country, and there are more project requests coming in than there is available funding. As an example, CRISI was able to fund 46 projects at \$368.6 million out of a requested \$1.1 billion. All projects meeting criteria for programs that require a BCA are evaluated for their cost-effectiveness. The U.S. DOT Volpe Center's BCA work helps U.S. DOT narrow down the plethora of project applications to make the best use of BIL funding to invest in infrastructure. (*Sponsor: OST, FWHA, MARAD, and FRA*).

■ AVIATION

Maintaining Safe Air Traffic Operations with the Sustainable Tower Design Initiative

The FAA's Air Traffic Organization (ATO) manages 45,000 flights a day with 5,400 aircraft in the air during peak flight operations. The ATO oversees a vast airspace system of more than 29 million square miles and provides service to 1.6 million passengers every day.¹⁰ To maintain critical safety of both aircraft and passengers, the FAA relies on a network of 520 airport traffic control towers (ATCTs) and Terminal Radar Approach Control (TRACON) facilities across the U.S. The FAA initiated the ATO Terminal Facilities Investigation Project to upgrade aging ATCTs and TRACONs including their related equipment in order to provide continued safe, efficient, and resilient flight operations across the National Airspace System (NAS).

Conducted at various ATCT and TRACON facilities across the nation, the ATO Terminal Facilities Investigation Project provided FAA with essential aviation

¹⁰ Air Traffic by the Numbers; https://www.faa.gov/sites/faa.gov/files/air_traffic/by_the_numbers/Air_Traffic_by_the_Numbers_2022.pdf.



INFRASTRUCTURE,
ECONOMIC STRENGTH,
AND GLOBAL
COMPETITIVENESS

The FAA's Airport Traffic Control Tower Design Initiative seeks innovative design and streamlined construction approaches to quickly build ATCTs at regional and municipal airports across the United States. (Image: U.S. DOT FAA)

facility analysis and planning support, including economic models; cost analysis algorithms; business plans; project management; project cost planning; operations research/engineering analysis and disposition; project implementation management; and program planning budget development. The project is responsible for establishing, replacing, and modernizing terminal ATC facilities to ensure safe, efficient, and cost-effective infrastructure is in place for terminal operations in the NAS. Replacement and refurbished facilities support the NAS modernization strategy to achieve efficient ATC systems and operations.

The U.S. DOT Volpe Center provided management and subject matter expertise to the FAA ATC Facilities and Engineering Services (AJW-2) and Facilities Group (AJW-24) to help identify and mitigate operations and maintainability issues related to aging facilities and legacy system architectures. The U.S. DOT Volpe Center team developed project cost models, which provided FAA decision makers with critical information for prioritizing task activities and resources. The U.S. DOT Volpe Center's principal project activities included enhancing ATC facility sustainability and resiliency; providing technical subject matter expertise to FAA managers and project engineers, which included leading facility implementation efforts; conducting operational analysis assessments; developing budget and cost analyses; and performing site inspections and surveys.

With funding provided through the Bipartisan Infrastructure Law, the FAA is planning to replace large number of aging ATCTs across the United States,

primarily located at regional and municipal airports. To enable the cost-efficient and rapid deployment of these towers across the United States, the FAA has launched the Sustainable Tower Design Initiative,¹¹ which will develop a new standard tower design. The U.S. DOT Volpe Center has been acting in an advisory role to the FAA for this ongoing solicitation. This project will successfully continue the work of modernizing ATC facilities, enhancing the safety and efficiency of the NAS, and supporting the implementation of NextGen. (*Sponsor: FAA ATC Facilities*).

INFRASTRUCTURE,
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COMPETITIVENESS

■ HIGHWAYS

Estimating Long-Term Effects of the Pandemic on Vehicle Hours Traveled

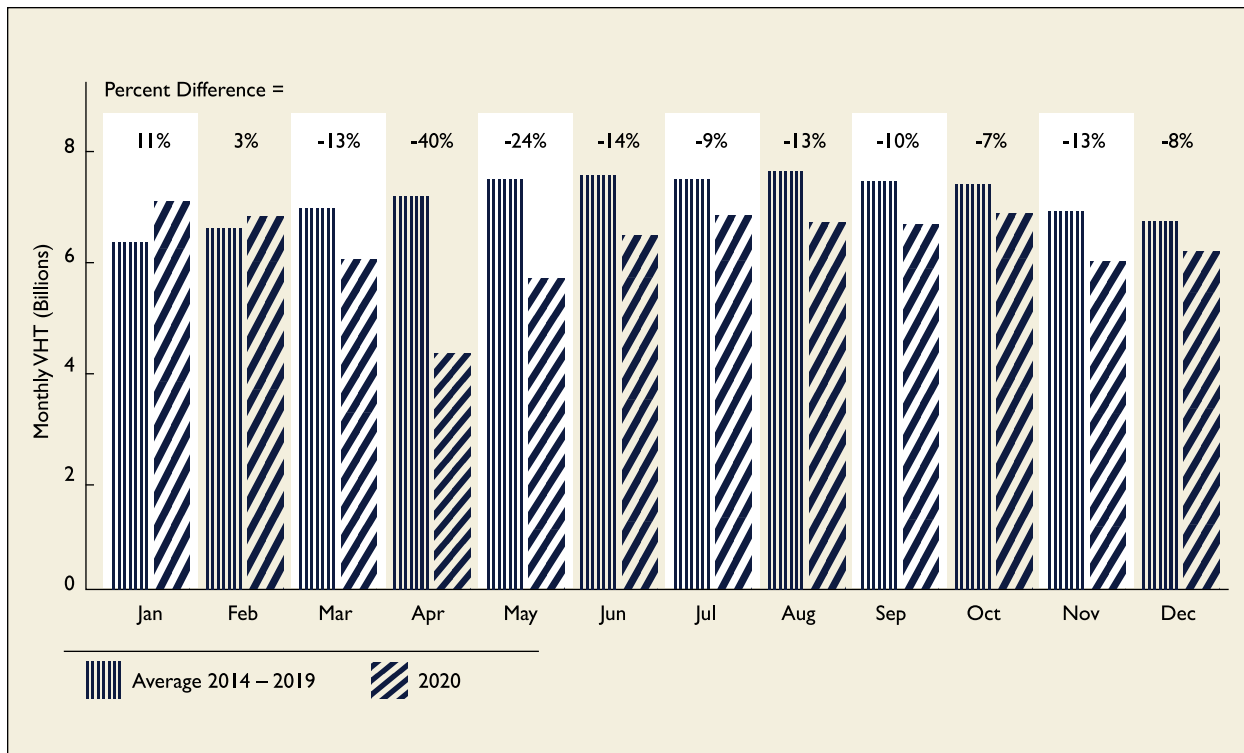
Since 2015, the U.S. DOT Volpe Center has produced annual and monthly estimates of total travel time on the nation's roadways for the FHWA Office of Highway Policy Information. These estimates are reported separately by hour of day, vehicle class, type of roadway, and in any combination of those attributes.

In 2021, the seventh year of estimates was provided to FHWA. In support of an exploratory study associated with FHWA's Traveler Analysis Framework, U.S. DOT Volpe Center experts used analytical methods developed for the annual estimates to reveal the effect of the pandemic on travel activity (vehicle hours traveled [VHT]) at national and local levels during 2020.

The U.S. DOT Volpe Center's VHT estimation procedures integrate traffic volume data and roadway characteristics from FHWA's Highway Performance Monitoring System (HPMS), detailed hourly counts by vehicle class from FHWA's Continuous Counting Station (CCS) database, and travel speeds for different vehicle types from the National Performance Management Research

At the height of the pandemic in April 2020, VMT was down 41 percent relative to the January 2020 total.

11 Sustainable Tower Design Initiative; <https://www.faa.gov/tower-design>.



Data Set (NPMRDS). By comparing traffic patterns during 2020 to historic trends, the U.S. DOT Volpe Center team analyzed the pandemic’s impact on total travel time, the geographic and time-of-day distribution of travel activity, the composition of travel by vehicle type, and different types of roadway.

The U.S. DOT Volpe Center found that motor vehicle travel in the U.S. totaled 75.7 billion hours during 2020—a 13.5 percent decline from 2019. At the height of the pandemic in April 2020, vehicles miles traveled (VMT) was down 41 percent relative to the January 2020 total. National VMT remained below the January 2020 baseline through March 2022.

Analysis of travel demand revealed that changes in hourly traffic patterns during the pandemic also persisted through December 2020. The morning peak had a smaller share of daily hourly traffic than in prior years, and the afternoon peak share spread out, starting earlier in the day and with greater volume.

Additionally, the U.S. DOT Volpe Center separately estimated travel time for 27 urban areas that were selected to reflect the broad array of driving patterns across the nation. In this sample, the average daily VHT in a passenger vehicle in 2020

This chart compares the total vehicle hours traveled per month in 2020 with the monthly total on average between 2014 and 2019. Source: U.S. DOT Volpe Center (Image: Adobe Stock)

ranged from 1 hour 20 minutes per auto commuter in Birmingham, Alabama, to 37 minutes in Honolulu, Hawaii. The extra daily travel time caused by congestion, construction, or other traffic incidents ranged from 26 minutes on average per auto commuter in Boise, Idaho, to 7 minutes in Tulsa, Oklahoma.

Although it is unclear whether any of these pandemic-related changes in national traffic patterns will become permanent, the ability to observe the extent of the changes in travel behavior and how they are evolving will be instructive for transportation policy makers and analysts.

U.S. DOT Volpe Center economists presented the results of the pandemic impact assessment on national VHT and the localized urban travel time analysis at the 2022 NatMEC Conference in June. (*Sponsor: FHWA Office of Highway Policy Information*).

■ PUBLIC LANDS

Improving the Forest Service's Annual Deferred Maintenance Cost Estimates

Since 2012, the U.S. DOT Volpe Center's technical assistance to the U.S. Department of Agriculture (USDA) Forest Service has enabled it to meet federal requirements for annually reporting deferred maintenance costs on its 65,000-mile passenger-car road network. In the past year, U.S. DOT Volpe Center economics and transportation planning experts have successfully proposed an alternative approach to the challenge, applying an innovative statistical technique to improve the precision of the cost estimates.

Surveying the condition of this entire network is infeasible. Instead, the Forest Service draws a sample from its database of passenger road segments using a U.S. DOT Volpe Center-developed algorithm; agency field staff assess the condition of each sample segment, estimate the cost of repairs to bring the segment into a state of good repair, and record the estimate in a central database. The U.S. DOT Volpe Center then analyzes the cost data to produce an estimated

per-mile deferred maintenance cost for Forest Service passenger-car roads, both nationally and for each of the Forest Service’s nine regions.

INFRASTRUCTURE,
ECONOMIC STRENGTH,
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COMPETITIVENESS

The U.S. DOT Volpe Center has worked to refine this method over the years in order to improve the accuracy of the annual cost estimate, achieving a precision of +/- 12 to 15 percent. Recently, the Forest Service asked the U.S. DOT Volpe Center for a way to calculate more precise estimates.

The U.S. DOT Volpe Center has proposed to increase the precision of the estimates by “stacking” data over multiple years, adapting a method used by the U.S. Census American Community Survey. Stacking the data increases the sample size, which improves Volpe’s ability to increase estimate precision. The U.S. DOT Volpe Center projects a precision of +/- 5 percent by 2024 once three years of data are collected and stacked, a substantial improvement.

The Forest Service has accepted the proposed change in methodology. Going forward, the U.S. DOT Volpe Center will provide the agency with both the one-year and three-year stacked deferred maintenance cost estimates. This will allow the Forest Service to have a better understanding of year-over-year trends in deferred maintenance, and the impact of funding allocations on their passenger-car road network. *(Sponsor: USDA Forest Service).*



This photo shows Tripoli Road and a Civilian Conservation Corps-era bridge in the White Mountains National Forest located in Maine and New Hampshire.

(Image: U.S. DOT Volpe Center)

■ DEFENSE INFRASTRUCTURE

INFRASTRUCTURE,
ECONOMIC STRENGTH,
AND GLOBAL
COMPETITIVENESS

U.S. Navy and Marine Corps Far East Infrastructure Support Program

A major challenge facing the United States Department of Defense (DoD) at overseas installations of U.S.-owned/operated infrastructure is they may comply with host nation specifications, but the sites may not comply with U.S. requirements. For example, fuel storage tanks constructed through the Japan Facilities Improvement Program may include fewer vents than are required by the fire code applicable to U.S. installations in the Far East. To solve this problem, the Naval Facilities Engineering Systems Command (NAVFAC) asked the U.S. DOT Volpe Center to support DoD in modernizing U.S.-owned/operated infrastructure throughout Japan and Diego Garcia.

U.S. DOT Volpe Center environmental engineers provide technical support and expertise in the areas of water treatment and fuel system design, operation, and maintenance. They identify critical system faults and provide detailed technical recommendations and solutions based on industry standards, best practice research, and first-hand knowledge. Rather than simply pointing out problems, U.S. DOT Volpe Center engineers also spend considerable time researching and developing solutions to address issues based on location needs and environmental requirements.

U.S. DOT Volpe Center engineers assessed the compliance posture at U.S. installations and proposed comprehensive, cost-effective solutions to address these challenges. This work included performing thorough on-site inspections of fuel and water system infrastructure;



U.S. DOT Volpe Center Engineer, Richard Reiss, P.E., inspecting an aboveground fuel storage tank overfill prevention system component at Combined Arms Training Center Camp Fuji in Gotemba, Japan. (Image: U.S. DOT Volpe Center/ Richard Reiss)

researching engineering and industry standards and regional governing standards and policy requirements; identifying opportunities to transform infrastructure to meet present and future logistics, operations, and compliance needs; proposing detailed technical plans of action to upgrade infrastructure; and providing on-the-job and classroom training to NAVFAC design engineers, operators, inspectors, emergency response, financial management, maintenance, and asset management personnel. The U.S. DOT Volpe Center team's experience in NAVFAC funding, asset management, and environmental management systems provided the necessary insight into the development of plans and strategies to obtain funding for infrastructure upgrades.

During site visits at more than 15 locations throughout Diego Garcia, British Indian Ocean Territory, and Okinawa and Gotemba, Japan, the U.S. DOT Volpe Center inspected 145 fuel and oil storage tanks and 242 potential slug sites—or locations where unintended batch discharges enter wastewater treatment systems—and collected more than 30,000 pieces of information. These inspections informed the contents of the Slug Prevention Plans (SPPs) and Fuel Storage Tank Management Plans (TMPs). The U.S. DOT Volpe Center also provided formal training at Naval Support Facility Diego Garcia (NSFDG) in March 2022, in which participants learned fuel system design and installation requirements and best practices and how to perform their own monthly inspections of fuel system infrastructure and improve safety, operational efficiency, and environmental protection practices.

The final NSFDG SPP was submitted in September 2022 and the draft Commander, Fleet Activities Okinawa (CFAO) SPP was submitted in October 2022. Two final TMPs were submitted in July and September 2022 and a third draft TMP was submitted in October 2022. Other deliverables included tank inspection summary documents, summaries of noncompliance findings, and Summaries of Plans of Action to Repair, Replace, or Retrofit Fuel Storage Tanks. The U.S. DOT Volpe Center's deliverables and on-the-job and classroom training informed stakeholders of the applicable requirements included in myriad industry standards and practices. This work aligns with DoD priorities and will help DoD comply with infrastructure-related requirements included in Japan and Diego Garcia final governing standards. *(Sponsor: NAVFAC Pacific and NAVFAC Far East. NAVFAC Pacific and Far East provided technical and logistical support to Volpe before, during, and after infrastructure assessments.)*

Resilience, Climate, and Sustainability



U.S. DOT is tackling the climate crisis by ensuring that transportation plays a central role in the solution. The U.S. DOT Volpe Center is a proven leader in helping the nation address its most pressing transportation-related energy and environmental challenges.

RESILIENCE, CLIMATE,
AND SUSTAINABILITY

■ HIGHWAYS

Developing Electric Vehicle Charging Infrastructure

The transportation sector is the largest source of carbon dioxide emissions in the U.S. and is increasingly vulnerable to climate change. One of the goals of the Bipartisan Infrastructure Law (BIL) is to invest in electric vehicle (EV) charging infrastructure; \$7.5 billion of BIL funding is dedicated to making EVs accessible to all Americans for both local and long-distance trips. The U.S. DOT Volpe Center supports the development of this new EV charging infrastructure through support to the Joint Office of Energy and Transportation (the Joint Office) and through support to FHWA.

Since the inception of BIL's National Electric Vehicle Infrastructure (NEVI) formula program in 2022, the U.S. DOT Volpe Center has been supporting the Joint Office which was established by BIL to work with federal, state, and local officials, as well as private industry, to plan and promote a national network of charging/fueling stations, with a focus on filling gaps in rural, disadvantaged, and hard-to-reach locations.

The plan is to promote a national network of charging/fueling stations, with a focus on rural, disadvantaged, and hard-to-reach locations.

The U.S. DOT Volpe Center supports the Department's mission of substantially reducing greenhouse gas emissions and transportation-related pollution, and building a more resilient and sustainable transportation system that benefits every community.
(Image: Adobe Stock)

The U.S. DOT Volpe Center supports the Joint Office's work related to the NEVI program through strategic planning; program guidance development; state plan reviews/evaluations; stakeholder coordination, outreach, and resource development; technical assistance for state DOTs; geographic information systems; program evaluations; and coordination efforts with Justice40 and labor and equity workforce initiatives. In addition, the U.S. DOT Volpe Center facilitates coordination between FHWA and the Joint Office.

On June 22, 2022, FHWA published a Notice of Proposed Rulemaking (NPRM) related to minimum standards for a national network of EV chargers. The U.S. DOT Volpe Center produced the preliminary regulatory impact analysis (PRIA) of those minimum standards.¹² The PRIA covered a wide range of issues including the environmental impacts of EVs, qualifications of electricians who will install and maintain the chargers, communication protocols for the equipment, methods of payment, wattage of the equipment, equity considerations, and pricing transparency. Next, the U.S. DOT Volpe Center will work with FHWA to analyze comments on the NPRM and further refine the analysis in order to produce the final regulatory impact analysis.

On September 14 and 27, 2022, FHWA announced the approval of Electric Vehicle Infrastructure Deployment Plans for all 50 States, the District of Columbia, and Puerto Rico ahead of schedule under the NEVI Formula Program.¹³ These approvals were based on the review and recommendations of the Joint Office, for which U.S. DOT Volpe Center staff played a key role in supporting. U.S. DOT Volpe Center staff, as part of the Joint Office team, will continue to provide technical assistance to state DOTs as they begin plan implementation.



U.S. DOT Secretary Pete Buttigieg and U.S. Secretary of Energy Jennifer Granholm take a selfie together before announcing the creation of the Joint Office. (Image: twitter.com/secretarypete)

12 Biden-Harris Administration Takes Key Step Forward in Building a National Network of User-Friendly, Reliable, and Accessible Electric Vehicle Chargers; <https://highways.dot.gov/newsroom/biden-harris-administration-takes-key-step-forward-building-national-network-user-friendly>.

13 Biden-Harris Administration Announces Approval of First 35 State Plans to Build Out EV Charging Infrastructure Across 53,000 Miles of Highways; <https://highways.dot.gov/newsroom/biden-harris-administration-announces-approval-first-35-state-plans-build-out-ev-charging>, and <https://highways.dot.gov/newsroom/historic-step-all-fifty-states-plus-dc-and-puerto-rico-greenlit-move-ev-charging-networks>.

The NEVI program directly supports the Biden Administration’s vision for making transformative transportation investments to support job growth and reshape the U.S. transportation system to support a sustainable energy and climate future. Additionally, this is one of the key DOT activities supporting the Administration’s 500,000 charger goal, as well as the net-zero carbon by 2050 goal, and addresses other DOT priorities such as clean energy job creation, transformative infrastructure, and transportation equity/equitable access to opportunity. *(Sponsor: Joint Office of Energy and Transportation and FHWA)*

■ SUPPLY CHAIN

Supply Chain Assessment of the Transportation Industrial Base: Freight and Logistics Report

The economy of the United States and the well-being of its citizens depend on safe, efficient, and resilient supply chains that move important goods within and across the nation’s borders. Supply chains connect businesses and people to vital infrastructure, but they are vulnerable to many types of disruptions and failures—from severe weather and natural disasters, to cyberattacks and public health restrictions. In response to Executive Order 14017: America’s Supply Chains, the Office of the Assistant Secretary for Transportation Policy released the Supply Chain Assessment of the Transportation Industrial Base: Freight and Logistics in February 2022. The report identifies and addresses current risks and vulnerabilities to the national supply chain and recommends policies to strengthen the U.S. freight system and alleviate the effects of future disruptions.

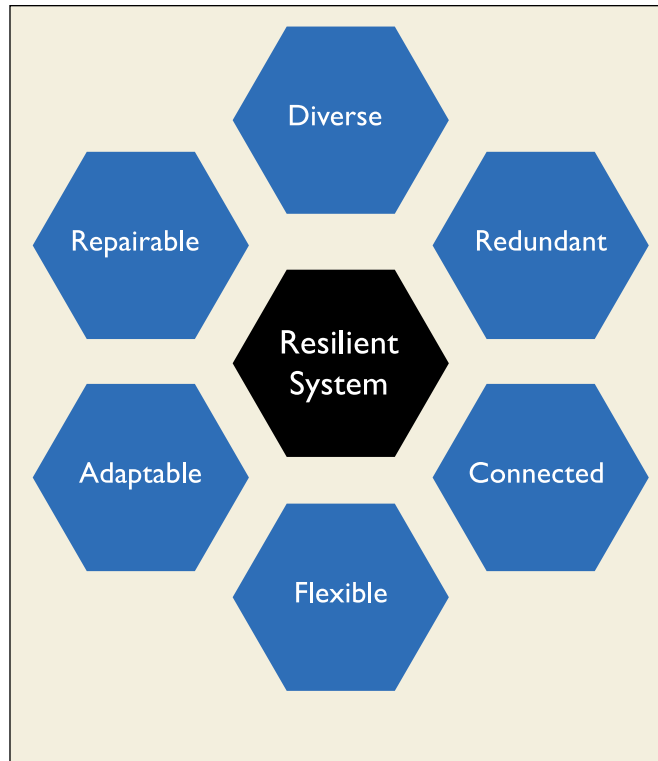
In the past, infrastructure failures, workforce challenges, natural disasters, cybersecurity breaches, changing international trade policies, and global conflicts have upset supply chains, causing price fluctuations, unfilled orders, challenges for workers and families, and lost economic productivity. The Supply Chain Assessment addresses longer-term resilience challenges facing the transportation industrial base and supply chains in the U.S. and provides recommendations to strengthen these systems. The report draws on lessons from the Administration’s current efforts as well as extensive public and private stakeholder outreach, and

highlights ways in which the Administration is leveraging new resources made available through the BIL to make significant investments in ports that will improve supply chain resilience.

A U.S. DOT Volpe Center team researched and developed the Supply Chain Assessment report, created

materials for stakeholder meetings and outreach, analyzed over 400 stakeholder comments to inform policy recommendations, coordinated with other U.S. DOT and federal agencies (e.g., Bureau of Transportation Statistics, White House) for data and input, and developed graphics and charts to visualize the information contained in the report. The assessment recommends 62 policy responses categorized under 17 policy goals and 5 federal policy roles, including infrastructure investment, planning and technical assistance, research and data, rules and regulations, and coordination and partnerships.

Demand for freight is expected to grow by about 40 percent by 2045. Air cargo (a projected 84 percent increase by tonnage), shipping by multiple modes (58 percent increase), and truck freight (42 percent) are projected to grow at the fastest rates during this time. Even as these modes grow rapidly in the coming decades, trucking is projected to remain the predominant method of shipping in the U.S., moving 66 percent of total volume in 2045. Additional statistics on freight movement and future trends are provided in the final report. *(Sponsor: FHWA Office of Freight Management and Operations; Office of the Secretary)*



RESILIENCE, CLIMATE, AND SUSTAINABILITY

Resilience refers to the ability of a system to adapt to changing conditions as well as withstand and rapidly recover from disruption. The figure illustrates the properties of a resilient supply chain system. Building the resilience of supply chains requires federal leadership to coordinate efforts across a wide range of freight and logistics stakeholders.

(Image: U.S. DOT Volpe Center)

Developing a Maritime Fuel Use and Emissions Model to Inform Alternative-Marine-Fuel Supply Chain

International maritime transport generates an estimated 3 percent of global greenhouse gas (GHG) emissions, even more than aviation.¹⁴ Nationally determined contributions to reduce carbon emissions under the Paris Agreement, along with fluctuating and increasing fossil fuel prices, have generated strong interest in biofuels for the maritime sector. Renewable biofuels that are naturally low in sulfur and have a lower life cycle carbon footprint compared to traditional fuels may help the shipping industry meet increasingly stringent carbon, sulfur, and particulate matter (PM) emissions requirements and targets set by the International Maritime Organization (IMO).

Renewable biofuels
may help the shipping
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and targets.

The United States has committed to achieving economy-wide net-zero emissions no later than 2050. To that end, the U.S. DOT Volpe Center is collaborating with the National Renewable Energy Laboratory (NREL) to evaluate demand, supply, and logistics for marine biofuels. The collaboration will produce important tools to support the decarbonization of maritime shipping.

Maritime fuel use and related GHG emissions are estimated based on fuel sales, and through required vessel reporting to IMO. In contrast, the U.S. DOT Volpe Center team is developing a bottom-up maritime fuel use and emissions model based on automatic identification system (AIS) data and vessel characteristics. The U.S. DOT Volpe Center-developed fuel and emissions model uses data available within U.S. DOT and is consistent with emissions methods developed by other federal agencies. Similar efforts have used real-time AIS data to estimate emissions at the port level using proprietary models. An advantage of the bottom-up approach is that the model can support future projections and scenario analysis of fuel use under different technology adoption rates and policies.

¹⁴ YCC Team, "Maritime Shipping Causes More Greenhouse Gases Than Airlines," Yale Climate Connections, August 2, 2021, <https://yaleclimateconnections.org/2021/08/maritime-shipping-causes-more-greenhouse-gases-than-airlines/>.



For Phase 1 of the project, the U.S. DOT Volpe Center team used Maritime Safety and Security Information System (MSSIS) location tracking data to develop a prototype maritime fuel use and emissions model for large cargo and tanker vessels. While the prototype model analysis focused on the Port of Seattle region, the model can be applied to any global shipping data where vessel characteristics and position information are available. In Phase 2, the model will be extended to assess the impacts of fuel and engine type on maritime fuel use and emissions.

In Phase 2, the U.S. DOT Volpe Center team will also apply the Freight and Fuel Transportation Optimization Tool (FTOT) to evaluate scenarios for marine biofuel deployment and distribution in the Port of Seattle region. In parallel, NREL is using a combination of detailed refinery and system dynamics models to evaluate the suite of organizational and market factors that could determine marine biofuel viability, and the types of incentives that could promote biofuel integration into the marine sector. The FTOT and NREL modeling efforts will help DOE understand the potential demand for alternative fuels at the port to support the emissions control low-sulfur requirements and explore opportunities to supply those fuels from regional agricultural, forestry, and waste supply chains. *(Sponsor: U.S. Department of Energy – Bioenergy Technologies Office [BETO] and National Renewable Energy Laboratory [NREL])*

Biofuels will have an essential role in lowering GHG emissions and moving the maritime shipping industry closer to carbon neutrality. (Image: Adobe Stock)

Reducing Aviation Noise and Greenhouse Gas Emissions

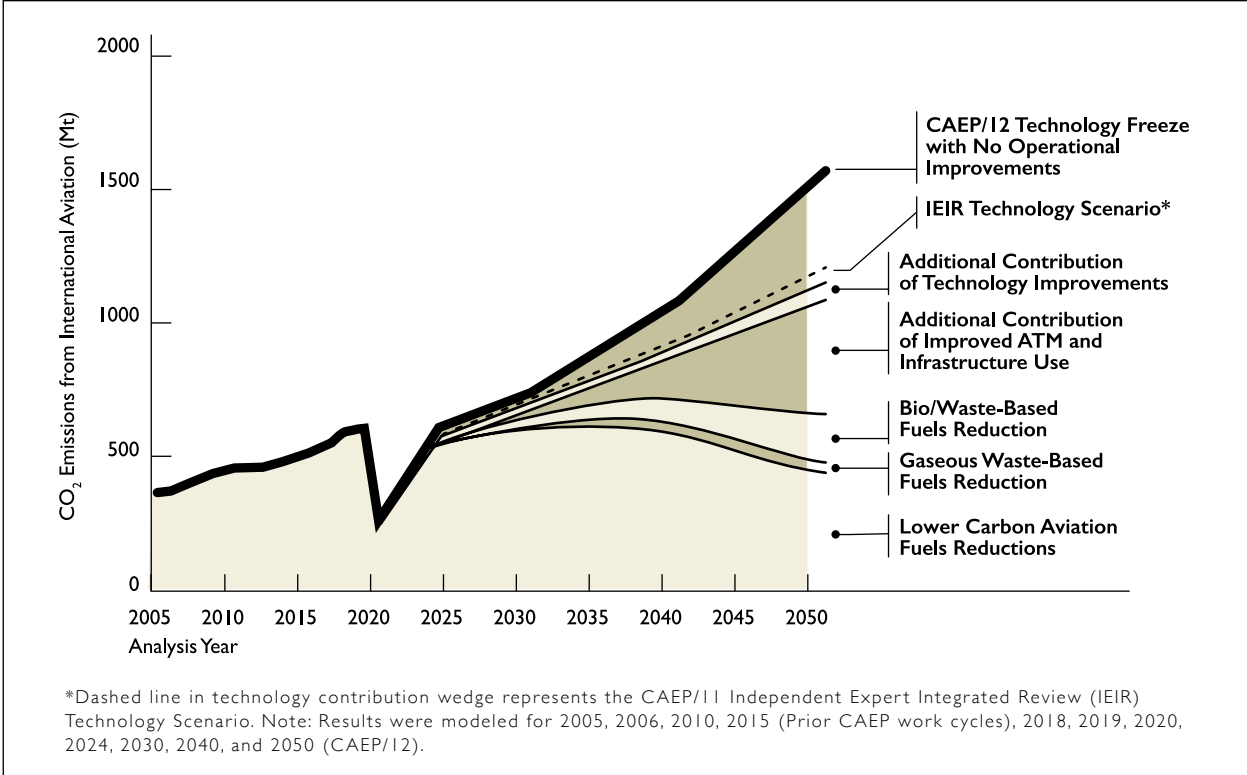
The International Civil Aviation Organization (ICAO) estimates the aviation sector generates approximately 2 percent of GHG emissions. In response, ICAO has implemented the Carbon Offsetting and Reduction Scheme for International Aviation (CORSI A), which caps carbon emissions from international aviation at 2019 levels from 2021–2035.¹⁵ On behalf of FAA’s Office of Environment and Energy, the U.S. DOT Volpe Center provides expertise to ICAO’s Committee on Aviation Environmental Protection (CAEP), which supports policies and standards to help curb aviation’s environmental impacts. CAEP activities include new noise and CO₂ emissions standards, carbon offset requirements, and methodologies for assessing sustainable and lower carbon aviation fuels.

In three-year cycles, the CAEP investigates future environmental trends in aviation—particularly aircraft noise, engine emissions, and fuel consumption—that will affect the global climate and local air quality. U.S. DOT Volpe Center staff regularly attend and contribute to working group meetings in cities of CAEP member nations. U.S. DOT Volpe Center subject matter experts lead traffic demand forecasting activity for the Forecasting and Economic Analysis Support Group (FESG), perform sustainability activity for the Fuels Task Group (FTG), deliver noise technical support (WG1), provide emissions technical support (WG3), and also serve as co-rapporteurs of the Modelling and Databases Group (MDG) and the Sustainability Certification Schemes Evaluation Group (SCSEG).

The most recently completed CAEP cycle (CAEP/12) considered the impacts of the COVID-19 pandemic on aviation traffic demands; assessed a range of technology and operational improvement scenarios for their potential to reduce noise, emissions, and fuel burn, including the potential impact of increased adoption of sustainable and lower carbon aviation fuels.

The aviation sector
generates approximately
2 percent of
GHG emissions.

¹⁵ Carbon Offsetting and Reduction Scheme for International Aviation (CORSI A); <https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx>.



U.S. DOT Volpe Center economists led the development of air traffic demand forecasts for the passenger, cargo, and business jet aviation markets from 2018 to 2050. Acknowledging the uncertainty surrounding the economic effects of the pandemic, the U.S. DOT Volpe Center team also developed a series of COVID-19 scenarios to represent a plausible range of recovery curves in terms of demand for passenger, cargo, and business jet travel. U.S. DOT Volpe Center environmental modelers employed those traffic forecasts to predict noise, emissions, and fuel burn trends in international and global aviation out to 2050 (global aviation includes both international and domestic aviation).

Net CO₂ emissions from international aviation, 2005 through 2050, including sustainable and lower carbon aviation fuels lifecycle CO₂ emissions reductions (based on 3.16 kg of CO₂ per 1 kg of fuel burn). (Image: U.S. DOT Volpe Center)

For 319 global airports that currently account for approximately 80 percent of commercial air traffic, the noise modelers developed trends in total noise contour area and population exposed to different noise levels. In 2050, the percentage increase in total affected population within the 55 decibel (day-night level) noise contour as compared with 2018 could range from 105 percent, under the baseline no-intervention scenario, to only 3 percent, assuming operational improvements and engine technology advancements are achieved. Under an advanced technology and operational improvements scenario, it is estimated the industry could experience noise-neutral growth after 2025.

The emissions analysis by U.S. DOT Volpe Center environmental modelers projected the potential of aircraft technology, and operational improvements to reduce aircraft emissions and fuel consumption. In conjunction with CAEP working groups, the U.S. DOT Volpe Center team considered current conversion technologies available to mitigate CO2 emissions during aviation fuel production, including renewable and waste-based fuels, carbon capture, and renewable hydrogen and energy use.

The U.S. DOT Volpe Center's modeling work demonstrated that if no action is taken, overall emissions produced by international aviation during full flight, landing, and takeoff will increase by 2050 to levels two to four times those in 2018. Aircraft technology advances, operational improvements, and adoption of sustainable aviation fuel could significantly curb the growth in aviation's net CO2 emissions in the longer term. In addition to the 27 percent reduction in CO2 emissions provided by technology and operational improvements in 2050, these fuels may provide an additional 56 percent reduction in net life cycle CO2 associated with international aviation. However, achieving these reductions will require significant public- and private-sector investment.

If no action is taken,
overall emissions
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The U.S. DOT Volpe Center team completed its COVID-19 forecasts and final noise, emissions, and fuel burn modeling in 2021; the summary technical reports were submitted to the CAEP/12 meeting in February 2022. The U.S. DOT Volpe Center team also submitted a final report to the ICAO Assembly and prepared the ICAO/CAEP 2022 Environmental Report, which was published in summer 2022.¹⁶ It is also worth noting that this work helped inform ICAO/CAEP's assessment of the feasibility of a long-term global aspirational goal (LTAG) for international aviation (<https://www.icao.int/environmental-protection/Pages/LTAG.aspx>).

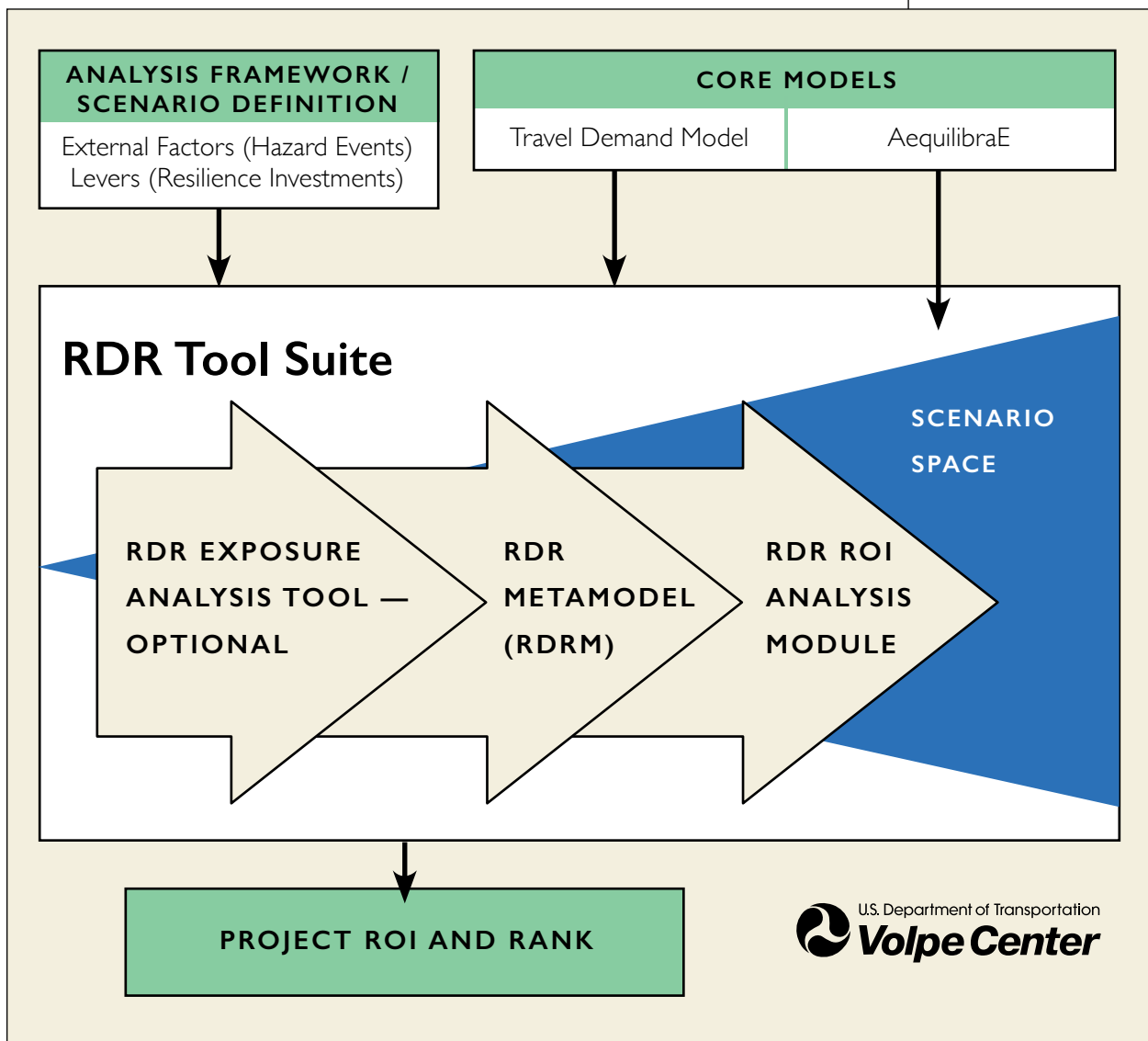
The U.S. DOT Volpe Center will continue to support the ICAO CAEP through technical contributions during CAEP/13 work cycle, which culminates in 2025. *(Sponsor: FAA Office of Environment and Energy)*

¹⁶ ICAO Environmental Report 2022; <https://www.icao.int/environmental-protection/Pages/envrep2022.aspx>.

A Tool Suite to Compare Return on Investment in Planning for Resilient Transportation Infrastructure

Private industry, federal, state, and local governments must be able to accurately assess the value of including resilience in future transportation projects. To achieve this, transportation planners need to assess the costs and benefits of building resilient assets and incorporate this information into project prioritization.

Structure of the Resilience and Disaster Recovery (RDR) Tool Suite. The scenario space increases as more potential hazard severities, durations, recovery periods, and resilience investments are assessed. (Source: U.S. DOT Volpe Center)



zation for transportation infrastructure investment decisions. Such analyses are challenging, given that future conditions and hazards are highly uncertain.

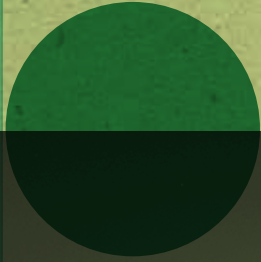
On August 1, 2022, the U.S. DOT Volpe Center released the first public version of the Resilience and Disaster Recovery (RDR) Tool Suite (V. 2022.1) for use by transportation agencies in their long-term transportation planning. This was the successful culmination of a three-year effort by the U.S. DOT Volpe Center, from the tool suite's conceptualization through implementation in support of the Office of the Assistant Secretary for Research and Technology (OST-R), and in partnership with the Federal Highway Administration.

The RDR Tool Suite is designed to enable agencies and their stakeholders to explore the scenario space for transportation disruption and mitigation, to estimate ROI of resilient infrastructure across a range of uncertain future hazards, and to rank those projects based on performance.

During development of the tool suite's beta version in Phase 1, the U.S. DOT Volpe Center coordinated a pilot study in the Hampton Roads area of Virginia, in collaboration with the Hampton Roads Transportation Planning Organization (HRTPO), the Hampton Roads Planning District Commission (HRPDC), and the Virginia Department of Transportation. In Phase 2, HRTPO and HRPDC continued with tool testing, and two additional planning agencies undertook a tech-transfer testing role: the Houston-Galveston Area Council (H-GAC), and the Hillsborough Transportation Planning Organization (TPO), in partnership with the Florida Department of Transportation. As the agencies applied the RDR tools to their particular planning situations, the U.S. DOT Volpe Center provided troubleshooting, data preparation support, and other related assistance.

Through those pilot tech-transfer tests, the U.S. DOT Volpe Center obtained invaluable feedback on the RDR Tool Suite and associated documentation, ensuring the initial public release will offer the transportation planning community a set of usable, transferable tools. HRTPO, H-GAC, and Hillsborough TPO have all expressed interest in continuing to use the RDR Tool Suite in their future long-range planning efforts. (*Sponsor: OST-R in partnership with FHWA*)

Transformation



The U.S. DOT Volpe Center works in collaboration with U.S. DOT, other federal agencies, and the broader transportation community to advance transportation innovation for the public good. By developing fresh approaches and new solutions, Volpe works to ensure innovation and technology create a safer, more sustainable and accessible transportation future.

■ AVIATION

The U.S. DOT Volpe Center Advances UAS Integration in the National Airspace System

Wake turbulence is the rotational movement of air created behind any aircraft under lift generation. The U.S. DOT Volpe Center's measurements and analyses of wake turbulence on behalf of the FAA have been instrumental in enabling the FAA to make positive operational changes in the National Airspace System (NAS). The result has been improved wake turbulence safety, reduced airport delays, shortened final approaches to airports, and reduced fuel burn and greenhouse gas emissions.

FAA's long-term goal is to fully integrate unmanned aircraft systems (UAS) into the NAS. From a wake turbulence perspective, the full scope of UAS integration of any sizes has been a continuing topic of discussion and research between FAA and various stakeholders. However, the question of how to integrate larger UAS into the NAS when they require air traffic control (ATC) services presented immediate and near-term challenges to air traffic controllers, because no UAS had yet received a categorical wake turbulence designation.

No unmanned aircraft systems had received a categorical wake turbulence designation.

Previous page: Melbourne, Florida, USA, January 06, 2020: SpaceX launch of Falcon 9 - Starlink 2 rocket seen from the beach; White self-driving passenger drone takeoff and landing on the helipad. 3D rendering image; Mount Denali (Images: Adobe Stock)

For example, the General Atomics Q9 is a large, fixed-wing UAS the Department of Defense (DoD) currently operates in airspace with mixed civilian and military traffic. FAA guidance recommends that until an aircraft receives a categorical wake turbulence designation, it receives a NOWGT (no weight) designation, which requires controllers to place 10 nautical miles (NM) between the Q9 and another aircraft—both in front and behind the aircraft being assessed. In 2021, the FAA NextGen Wake Turbulence Research and Development Program (WTRDP) asked the U.S. DOT Volpe Center to evaluate the wake turbulence separation requirement for the Q9 as a specific integration scenario.

Mission, performance, aerodynamic design requirements, and operating procedures of any UAS can be significantly different from those of commercial aircraft. For this reason, the U.S. DOT Volpe Center first needed to examine the details of the current wake turbulence separation assessment in order to determine its extendibility and necessary revisions with respect to the Q9. Ultimately, U.S. DOT Volpe Center's analysis included wake parameters such as speed profile, weight, wingspan, roll resistance, and roll performance of the Q9. The assessment employed a dynamic wake encounter model developed by the WTRDP along with other data-driven tools; in combination, these could provide conservative estimates of the wake strength evolution of the Q9. Additionally, the U.S. DOT Volpe Center team used aircraft performance characteristics provided by the airframe manufacturer and operational experience input from Q9 subject matter experts to develop the recommended wake separation.

The U.S. DOT Volpe Center's analysis demonstrated the wake separation minima for all variants of the Q9 can be safely reduced below 10 NM. Moreover, the Q9 could be safely designated to one of the FAA's wake turbulence categorical schemes already in use. The WTRDP and FAA Chief Scientist and Technical Advisor for Wake Turbulence, upon reviewing the analysis from the U.S. DOT Volpe Center as well as factoring in other perspectives, made a joint recommendation for the Q9 wake separation minima to the FAA ATO in late 2021. The minima were published and operationalized in FAA JO 7360.1G, issued April 8, 2022.

The Q9 is the first UAS in the NAS to receive a categorical wake turbulence designation. The designation is specific to the Q9 and cannot be generalized to any other UAS aircraft. However, the U.S. DOT Volpe Center's work has yielded both a valuable case study and initiated what may eventually become a repeatable

process for developing recommended minima, both for other DoD large fixed-wing UAS operating in the NAS, and for future aircraft entrants (including other UAS designs as well as Urban Air Mobility)—a significant step toward achieving FAA’s long-term goal of integrating UAS into the NAS. This achievement has implications for both safety and economic competitiveness. *(Sponsor: FAA NextGen Wake Turbulence Research and Development Program [WTR&DP])*

Market Analysis for NASA’s SUSAN Aircraft Concept

In the United States, aviation’s contribution to overall greenhouse gas (GHG) emissions reached 2.7 percent in 2019. Without substantial technological innovations, the International Civil Aviation Organization (ICAO) forecasts this percentage will grow significantly by 2050. To reduce aviation’s environmental impacts in the U.S., NASA is applying innovative technologies to create sustainable regional-transport aircraft. The U.S. DOT Volpe Center has supported this effort with NASA since 2021.



An artist rendering of the NASA SUSAN aircraft concept. (Source: NASA)

Currently in the concept stage, NASA’s narrow-body, subsonic, single-aft-engine (SUSAN) electrofan is an advanced hybrid-electric design. SUSAN seeks to find a configuration that will reduce GHG emission levels by 50 percent for narrow body aircraft. Additionally, SUSAN’s novel engine and airframe design has the potential to improve fuel efficiency and reduce energy consumption while retaining the speed, size, and range capabilities of current conventional aircraft.

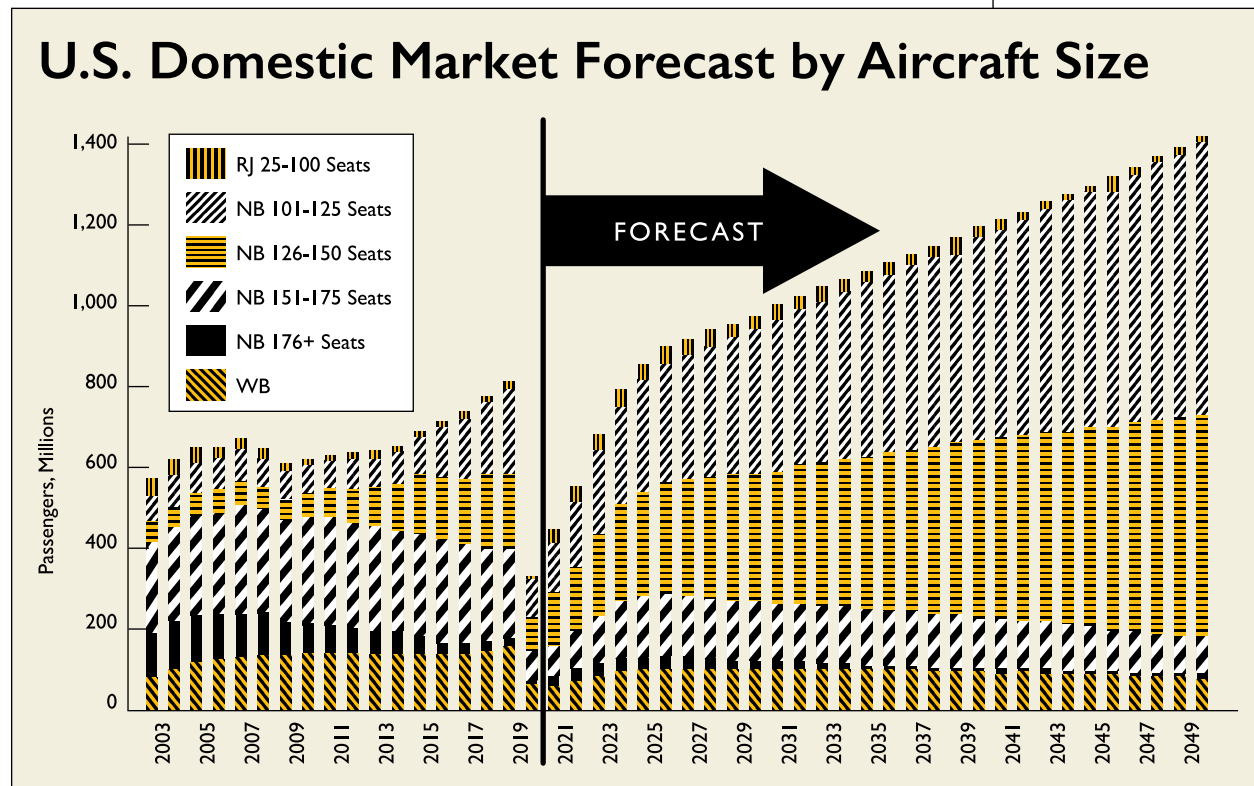
Determining SUSAN’s market viability will help NASA determine whether to move forward with the concept aircraft. In early 2021, a team of U.S. DOT Volpe Center economists provided NASA with an analysis of current trends in the commercial domestic aviation market, presenting the data at the Convergent Aeronautics Solutions (CAS) X1 Workshop for Electrification of Regional Transport Aircraft. In August 2021, NASA asked the U.S. DOT Volpe Center to project the

size of the future market, and the potential impact of SUSAN’s introduction to the aviation industry.

The U.S. DOT Volpe Center’s work had three segments. In the first segment, using publicly available data from the FAA and the Bureau of Transportation Statistics, the U.S. DOT Volpe Center projected a detailed fleet forecast of the U.S. domestic aviation market to be used as the baseline demand forecast for measuring the impacts of introducing the SUSAN aircraft. The SUSAN aircraft is expected to compete in the two largest narrow-body market categories; employing a multinomial logit discrete choice model, the U.S. DOT Volpe Center forecasted significant increases in demand in terms of revenue passenger miles (RPMs) in the two relevant markets, with the share of total RPMs increasing from 60 percent in 2019 to 83 percent by 2050.

In the second segment, the U.S. DOT Volpe Center developed a model to predict potential changes in the direct costs of fleet operation under a range of scenarios with and without the inclusion of SUSAN aircraft. Preliminary results from the scenarios that included the SUSAN aircraft saw significant declines in fleet fuel costs by 2050 relative to the baseline.

U.S. domestic market forecast by aircraft size category: (Source: U.S. DOT Volpe Center)



In the third segment, the U.S. DOT Volpe Center modeled the impacts of the possible increase in maintenance and acquisition costs of the SUSAN design by performing a break-even analysis. This was done to determine up to what balance of cost savings from fuel burn reductions and increased operating expenses SUSAN could remain competitive. The results showed that SUSAN would retain a competitive advantage over alternative aircraft even at moderate levels of increased maintenance and capital-acquisition costs because of the extent of savings in fuel burn.

The U.S. DOT Volpe Center's economic analysis experts will present a conference paper detailing the market demand forecast, operational cost modeling, and break-even analysis for the SUSAN concept at the American Institute of Aeronautics and Astronautics (AIAA) SciTech Forum held in January 2023. (*NASA Aeronautic Research Mission Directorate [ARMD]*)

The U.S. DOT Volpe Center Explores Space-Based Automatic Dependent Surveillance-Broadcast

Space-Based Automatic Dependent Surveillance-Broadcast (ADS-B), also known as SBA, is a new technology that uses satellites instead of ground stations to receive aircraft ADS-B broadcast position information. ADS-B is an integral part of the aviation industry that provides real-time, precise, shared situational awareness and advanced applications for both pilots and controllers. Since SBA satellites are in a Low Earth Orbit constellation, they cover every part of the earth's airspace, all the way to the ground in most locations.

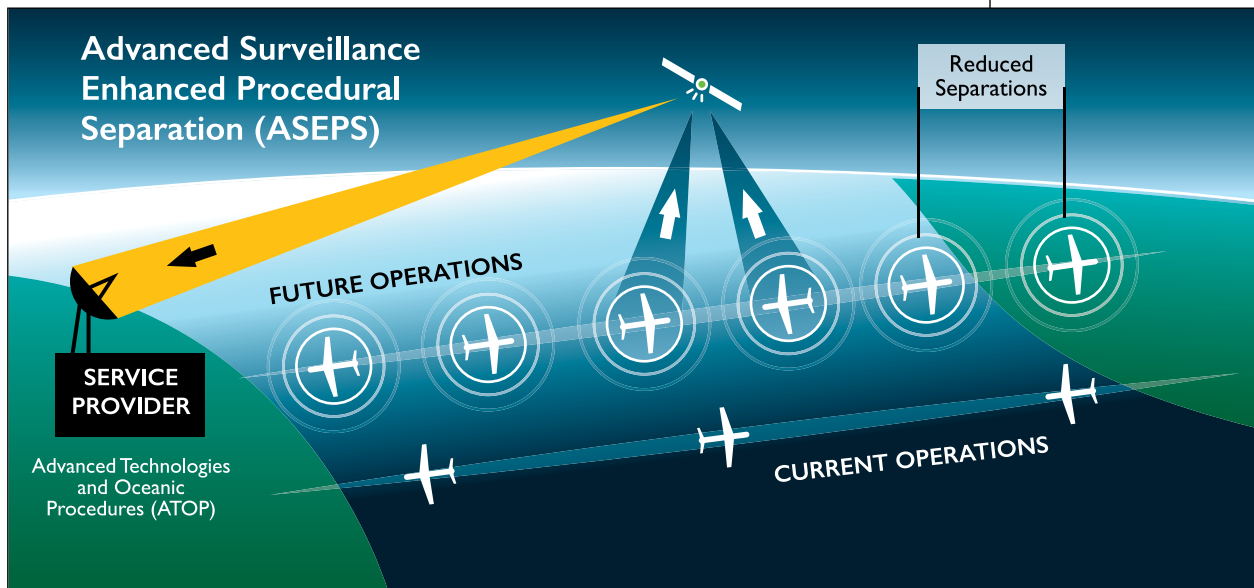
Since 2017, FAA's Advanced Surveillance Enhanced Procedural Separation (ASEPS) program has been rigorously evaluating space-based ADS-B (SBA) under the agency's Acquisition Management System (AMS).¹⁷ During this time, FAA assessed SBA capabilities in various airspace domains for air traffic control (ATC) and also looked at the benefits this technology may offer for non-operational use cases (e.g., air traffic management (ATM) and analysis functions).

¹⁷ ADS-B; https://www.faa.gov/air_traffic/technology/adsb/atc/aseps.

Through the ASEPS program, FAA purchased non-operational (not used in any operational settings) SBA data from Aireon for a one-year evaluation from September 2020 through August 2021. The SBA data purchase was later extended through January 2022. The goal of the evaluation was to identify potential applications and associated benefits of SBA data to inform FAA investment decisions. The U.S. DOT Volpe Center led the evaluation and provided key support to FAA, from inception to delivery of the evaluation final report in January 2022. A total of 20 FAA organizations participated in the one-year evaluation across multiple FAA Lines of Business. The report contains descriptions of the potential applications, evaluation results, and benefits, which support the FAA in future procurement decision making on SBA data.

In 2019, the ASEPS program planned to conduct an Operational Evaluation of SBA data in the Miami Air Route Traffic Control Center (ZMA) Caribbean airspace to assess the capability of SBA to provide ATC separation services and to estimate operational benefits. An SBA performance analysis was conducted in preparation for the Operational Evaluation, which revealed the FAA’s requirements for SBA performance necessary to maintain five nautical miles separation were not met in the ZMA airspace. Therefore, the ASEPS program declined to initiate the Operational Evaluation. Details of the SBA performance assessment through analysis of the SBA data are provided in the SBA Caribbean Operational Evaluation final report. In May 2022, the U.S. DOT Volpe Center delivered the final report to the ASEPS program. The U.S. DOT Volpe

This illustration shows current aircraft separation standards under Automatic Dependent Surveillance-Contract (ADS-C) and future separation standards using Space-Based ADS-B. (Source: U.S. DOT FAA)



Center led the input coordination of the final report, which includes benefits, safety, performance, and ATC operational acceptability assessments from multiple FAA organizations.

In September 2022, FAA's Joint Resources Council (JRC) considered the SBA Investment Analysis Readiness Decision (IARD) package and materials; some of the materials included were a Concept of Operations (CONOPS), functional analysis, shortfall analysis, and preliminary program requirements. The specific types of applications for each airspace domain were defined in the CONOPS document. The U.S. DOT Volpe Center led and coordinated with other FAA organizations to develop, write, review, edit, and facilitate the final signatory process of the CONOPS for the ASEPS IARD. The U.S. DOT Volpe Center also contributed to other materials that were part of the IARD package. As a result of the ASEPS assessments of SBA, the JRC decided to suspend ongoing and planned investment activities associated with the effort. SBA may have the potential to provide some marginal benefits for various applications evaluated (including ATC and ATM); however, the currently available SBA system is not sufficiently mature to warrant entry into AMS Investment Analysis. SBA fails to meet FAA's technical requirements and does not deliver sufficient benefits to justify its costs compared to the available benefits. The FAA will re-focus its resources on industry engagement around this technology to reassess market capabilities and determine if other implementation approaches are viable for future investment considerations. *(Sponsor: FAA)*

■ MOTOR CARRIERS

Improving the Safety of Commercial Motor Vehicle Operations with In-Motion Roadside Inspections

Under the FMCSA roadside inspection program, inspectors assess motor carrier compliance with federal safety regulations. The resulting data enable the agency to prioritize carriers most in need of intervention.

The U.S. DOT Volpe Center is supporting FMCSA in developing and implementing the Level VIII Inspection Program Operational Test, which will apply new technologies to improve the efficiency and effectiveness of roadside enforcement while mitigating the current process's climate impacts and minimizing supply chain disruptions.

FMCSA has a finite number of federal and state safety officials available to conduct inspections; due to the increasing number of CMVs on the road, only a fraction of them can be inspected. Additionally, roadside inspections often occur in the middle of a driver's trip, when they may be conveying time-sensitive goods from one point to the next. The repeated acceleration, deceleration, and idling involved when a CMV waits in an inspection queue produces undesirable greenhouse gas emissions.

As envisioned, Level VIII inspections would be conducted wirelessly while the CMV is in motion, without direct interaction with a roadside inspector. The in-motion inspection results would be entered into the carrier's safety record. Carriers identified by the wireless inspection as higher risk would be required to stop for a conventional inspection. Electronic data would be pre-populated in the inspection report, reducing both the amount of time the vehicle spent off-road and the potential for manual entry errors. Carriers would participate using existing mobile-connected devices.

Among Level VIII inspection's potential benefits are a tenfold increase in the total number of vehicle inspection data collected annually, while enabling better decisions about which carriers to prioritize for inspection. Additionally, greenhouse gas emissions would be proportionally reduced as would delays and supply chain disruptions compared to a conventional vehicle inspection.

Bringing the federal government, state partners, technology experts, and motor carriers together, FMCSA will design and implement a multi-state operational test of Level VIII inspections to measure the feasibility and potential impact of nationwide adoption. The effort will define the IT requirements for wirelessly collecting the Level VIII inspection data; assess how these data would be integrated into FMCSA's policies and procedures; and evaluate the impacts of these in-motion inspections on companies, FMCSA, and the environment.

The U.S. DOT Volpe Center will provide program management, communications, data analysis, and stakeholder engagement support before, during, and after the operational test.

The U.S. DOT Volpe Center has a long relationship with FMCSA, continuously improving safety management systems. The U.S. DOT Volpe Center team is uniquely equipped to provide the support to propose an operational test design, and to estimate the safety, environmental, and efficiency benefits of a fully implemented Level VIII inspection program. Similarly, expertise in measuring motor carrier safety enables the U.S. DOT Volpe Center to support FMCSA in understanding how best to incorporate the wireless inspection data into their safety programs including the Safety Measurement System (SMS) workload prioritization tool, which FMCSA uses to identify carriers with potential safety problems for intervention.

The U.S. DOT Volpe Center's IT expertise will help FMCSA gather and document requirements for an application programming interface that will enable technology vendors to collect the data necessary for Level VIII inspections.

A kick-off meeting to launch the planning stage of the operational test was held in May 2022; the project, with the U.S. DOT Volpe Center's continuing involvement, will be a multi-year effort that will continue through at least May 2024. (*Sponsor: FMCSA*)

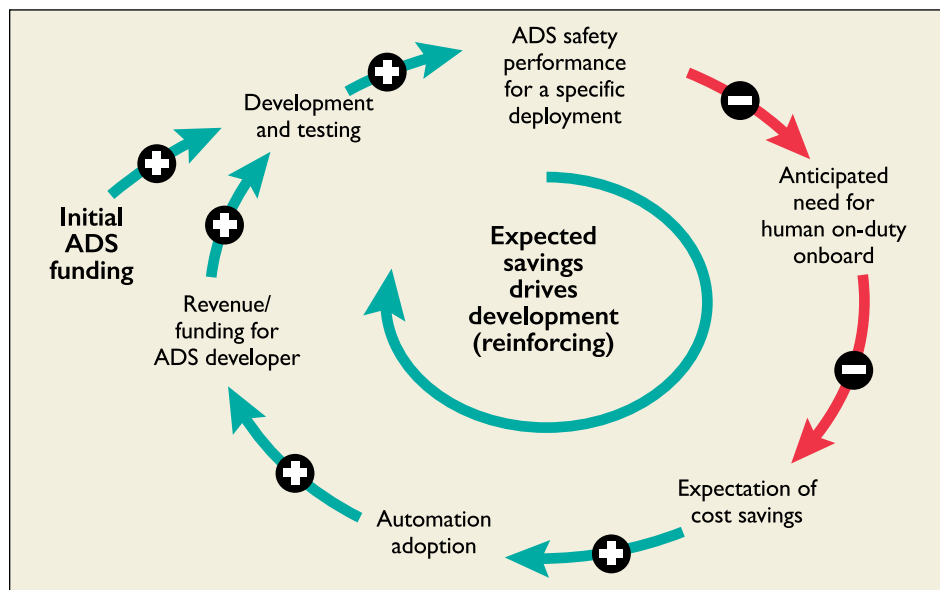
Using Systems Modeling to Help FMCSA Prepare for Automated Driving Systems

U.S. technology companies, truck manufacturers, and motor carriers are developing and testing automated driving systems (ADS) for use in large trucks that haul freight in interstate commerce. Automation offers an opportunity to improve the safety and efficiency of the motor carrier industry. FMCSA wishes to understand the opportunities and risks automation may provide, so it can conduct appropriate research to support future policy decisions. The agency wants to think broadly and use new analytical tools to consider how technology providers, carriers, consumers, and regulators interact with each other; how that

might change with the introduction of new technologies; what new business models might emerge; and how FMCSA might respond to these developments. In 2021, FMCSA asked the U.S. DOT Volpe Center to use a systems modeling approach to help it explore how ADS may change business models and shipping patterns in the trucking industry, and possible implications on safety, the role of drivers, and FMCSA business practices.

The results of this project will help FMCSA identify priorities for research in order to anticipate the policy and regulatory ramifications of the trucking business models that could emerge with the widespread adoption of ADS. In modeling the potential effects of ADS on trucking, this innovative project represents a new application of the U.S. DOT Volpe Center’s capability in system dynamics and systems modeling.

From May to September 2021, the U.S. DOT Volpe Center team acquired a rich, diverse set of qualitative data to ground its modeling effort. First, the U.S. DOT Volpe Center conducted a literature review to document the trucking industry’s competitive structure and the current state of development of automated CMVs. The team then inventoried current relevant safety regulations and FMCSA’s past regulatory actions related to automation. With these data, the U.S. DOT Volpe Center built a preliminary causal loop model of the trucking business ecosystem, exploring industry dynamics related to development and deployment of ADS. This model became the baseline for a discussion of how automated driving



One loop in the initial causal loop model, representing a part of the interaction between technology developers and motor carriers. (Source: U.S. DOT Volpe Center)

systems could potentially change not just the competitive trucking landscape, but also the respective roles and responsibilities in maintaining safety of carriers, CMV operators, FMCSA field personnel, and state partners.

In October 2021, the U.S. DOT Volpe Center convened a two-session virtual workshop involving staff from FMCSA research, policy, analysis, and enforcement groups, at headquarters and in the field. Participants began identifying how potential future situations might interact with current safety regulations and agency procedures. The U.S. DOT Volpe Center then revised the causal loop model, summarizing the group's observations about possible dynamics of deployment scenarios and interactions between ADS and existing regulations and enforcement activities. A guided discussion began refining related FMCSA research needs.

After further enriching the systems model and considering the implications of possible ADS scenarios in more depth, the U.S. DOT Volpe Center delivered a final technical memo in February 2022. FMCSA highlighted the work at its annual public Analysis, Research, and Technology (ART) Forum in March. *(Sponsor: FMCSA)*

■ MULTIMODAL

Prototyping New Ideas with the Volpe Innovation Accelerator

Since its launch in August 2020, the Volpe Innovation Accelerator (VIA) has spurred innovation by inviting employees to propose ideas, recruit teams, and develop prototypes and concept papers. In the process, it encourages collaboration, develops skillsets, and strengthens cross-divisional professional networks. Increasing employees' capacity for innovation will help solve important transportation challenges, especially those aligned with U.S. DOT priorities.

To date, 22 projects have been evaluated and funded in a total of three sprints, with several projects being deployed to solve pressing transportation challenges.

For example, one Sprint 1 team created a machine learning algorithm to identify when driving study participants look at single or multiple operations while operating a vehicle—a tool that has reduced labor costs, improved R&D approaches, and provided benefits to other agencies that may sponsor future work with the U.S. DOT Volpe Center.

Another Sprint 1 team developed an Urban Air Mobility (UAM) case study to identify Boston-area locations where vertiports and UAM routes could be located. The team performed an economic analysis of door-to-door commute options to address questions on mode shift, time, cost, environmental impacts, and equity. The team's paper titled Urban Air Mobility (UAM) and Total Mobility Innovation Framework and Analysis Case Study: Boston Area Digital Twin and Economic Analysis received the Best of Session award at the Digital Avionics System Conference in September 2022.



Five Sprint 2 projects were selected to receive additional funding:

- **Using Virtual Reality to Study Vehicle Operational Safety near Vulnerable Road Users:** This project examines the use of virtual reality (VR) headsets to study a variety of transportation and safety problems, including unintended consequences of automation, vehicle and infrastructure design, and driver training. This project created a virtual world using VR headsets to allow researchers to assess options for mitigating blind zones in heavy trucks to protect bicyclists and pedestrians.
- **Truck Parking Status Using Drones:** Insufficient truck parking leads to truck drivers parking on highway ramps and other unsafe places. This innovative solution uses drone video to capture available parking spaces and machine vision technology and artificial intelligence to determine parking lot status. Key advantages of this approach are lower costs compared to previously tested alternatives, and faster notification of available parking to truck drivers via smartphone, changeable message signs, variable message signs, and in-vehicle displays.
- **Inclusive Demographic Data Collection Handbook:** Demographic data is essential for measuring and advancing transportation equity; however, many federal datasets are not disaggregated by key demographic variables. A comprehensive approach to advancing equity for all requires an accurate

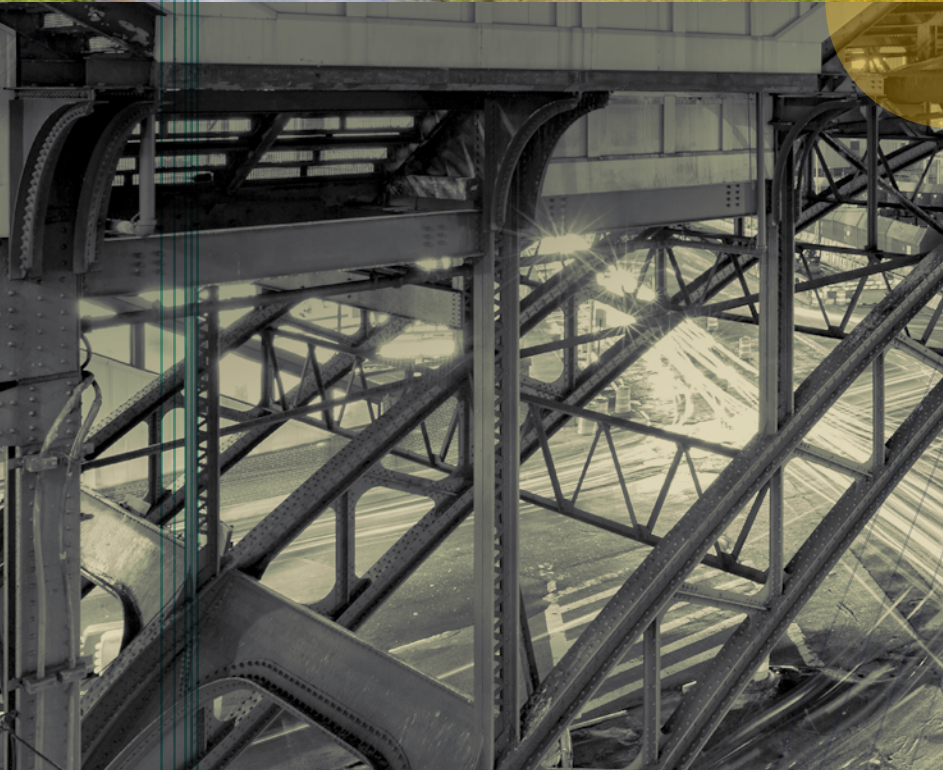
demographic assessment of race, ethnicity, religion, income, geography, gender identify, sexual orientation, and disabilities. This project developed a handbook to help U.S. DOT Volpe Center staff decide which demographics and level of detail are needed for specific analyses. The handbook will guide staff when they design inclusive demographic questions or surveys or undertake other data collection efforts, enabling staff to better support sponsors' transportation equity priorities.

- **Creating a Climate Change Toolkit for the Volpe Center:** Climate change presents a significant and growing risk to the nation's transportation infrastructure, the communities it serves, and the people who rely on it. This guide will help U.S. DOT Volpe Center staff discuss climate risks with project sponsors and how those risks could be addressed in project development, scoping, and closeout. The toolkit presents lessons learned from interviews with U.S. DOT Volpe Center subject matter experts and leadership, presents case studies of projects that work toward greenhouse gas mitigation and climate change resiliency strategies, and references internal and external climate resources.
- **Environmental Justice Impact Lifecycle:** Historically, infrastructure investments have not considered the impacts to communities and the disproportionate effects to specific populations of people. Many communities are not fully engaged in the decision-making process, and some projects lack accountability to ensure investments are made that benefit short- and long-term environmental justice goals. This project created an evaluation tool that state DOTs, metropolitan planning organizations, and local agencies can use to analyze infrastructure projects at different stages, enabling communities to define priorities and shifting decision-making power to a broader, more equal group of people.

Sprint 3 ran in 2022 with an expanded scope, including concepts focused on internal processes. VIA continues to experiment and adapt to help ensure employees are engaged and pressing challenges are addressed. (*Sponsor: U.S. DOT Volpe Center – Steve Popkin*)

Equity

The U.S. DOT is committed to advancing equity, civil rights, racial justice, environmental justice, and equal opportunity. The U.S. DOT Volpe Center has been working to support programs to reduce inequities and promote safe, affordable, accessible, and multimodal access to opportunities and services.



U.S. DOT Volpe Center Supports the Department’s Ongoing Plan to Provide an Equitable and Inclusive Workplace

U.S. DOT aims to cultivate a workforce that reflects the communities it serves and provides a safe, inclusive workplace so that all employees can bring their full selves to work. In August 2022, U.S. DOT issued the 2022-2026 Diversity, Equity, Inclusion, and Accessibility (DEIA) strategic plan in accordance with EO 14035 (Advancing Diversity, Equity, Inclusion, and Accessibility (DEIA) in the Federal Workforce). The plan outlines U.S. DOT’s strategic direction for continued development and implementation of programs, policies, procedures, and activities that will advance DEIA goals across the Department over the next four fiscal years. A primary operating principle for DEIA at U.S. DOT is to use data to support evidence-based decision making and policy development. In support of this operating principle, the Departmental Office of Civil Rights (DOCR) and the Departmental Office of Human Resources (DOHRM) are collaborating with the U.S. DOT Volpe Center to support statistical analysis of workforce data that can be used to inform programs and policies.

All employees can bring their full selves to work.

The U.S. DOT Volpe Center is conducting a detailed assessment to establish a baseline understanding of U.S. DOT employment demographics through an employee life cycle and identify key levers to advance equity throughout the U.S. DOT workforce. The team is applying statistical models to determine if there are significant differences in hiring, salary, stasis and promotions, and separations by sex and by race or ethnicity. The project will also evaluate potential barriers for persons with an identified disability in the hiring process or for existing staff. The findings will inform actions U.S. DOT will take as part of its DEIA strategic plan to improve diversity, equity, inclusion, and accessibility of the U.S. DOT workforce. *(Sponsor: Departmental Office of Civil Rights Project: DOT workforce equity [OS40])*

The U.S. DOT Volpe Center’s mission is to advance transportation innovation for the public good—which requires work informed by a deep understanding of impacted communities’ needs.
(Images: Adobe Stock [New York City] and U.S. DOT Volpe Center)

Organizational Excellence



The U.S. DOT Volpe Center team helps to advance the U.S. DOT's mission by supporting transportation planning initiatives and helping to responsibly steward the public's resources.

ORGANIZATIONAL
EXCELLENCE

■ AVIATION

Supporting FAA Requirements Management Efforts with Subject Matter Expertise

Requirements management (RqM) is a key process area for the FAA. When implemented properly, RqM helps FAA Program Management Organization (PMO) programs deliver stakeholders' needs on time and within budget. The FAA's Technical Management and Integration Team (AJM-132) accomplishes this by collaborating with PMO programs and delivering requirements management governance and best practices, lifecycle support, and knowledge sharing. In October 2020, AJM-132 asked the U.S. DOT Volpe Center to provide subject matter expertise to complete their business plan goals related to RqM activities.

A team of U.S. DOT Volpe Center experts facilitated webinars on requirements management, configuration management, and risk management in May 2022; delivered a full-day RqM workshop, during which PMO programs learned about governance practices and how to use a prescribed template to develop a RqM Plan (RqMP); and conducted ongoing RqM health metrics to determine a program's state and recommended improvement activities. The U.S. DOT Volpe

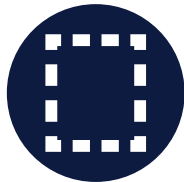
Program Management
Organization programs
are better positioned to
cost-effectively meet
stakeholders' needs as
defined and within scope

The U.S. DOT Volpe Center provides innovative solutions and subject matter expertise to help deliver key transportation projects efficiently, cost effectively, and within scope.
(Images: Adobe Stock)

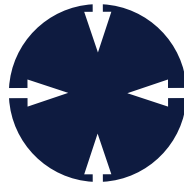
FAA Team’s Business Plan Incorporates “Requirements Management” Activities

ACCOMPLISHED BY AJM-132 THROUGH COLLABORATION WITH PMO PROGRAMS

The **Federal Aviation Administration’s (FAA) Technical Management and Integration Team** asked the **U.S. DOT Volpe Center** to help complete their business plan in such a way that its goals centered on “requirements management” activities. **Requirements management** is a key process area that aids PMO programs in delivering the stakeholder’s needs:



As Defined



Within Scope, and



Under Budget.

5-LEVEL MATURITY INDICATOR

The follow-on requirements health metrics activity developed a 5-level maturity indicator to identify program adherence to requirements management governance, where the **first 3 levels are in place** and **the next 2 are future goals**.

- Level 1 Program process not documented
- Level 2 Program has an approved process that is not in compliance with the latest governance
- Level 3 Program has an approved process and follows the latest governance
- Level 4 Program adherence to defined process verified with assessment **(Future Goal)**
- Level 5 Program metrics, process quality and performance optimized **(Future Goal)**

10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100%

87% of PMO programs have a defined Requirements Management Plan (RqMP).

13% are at Level 1

45% are at Level 2

and 42% are at Level 3



Center held a follow-up RqM workshop in August 2022 and continued to support the AJM-132 team as they rolled out new configuration management tools across FAA in September 2022. The U.S. DOT Volpe Center's expertise with RqM made the team uniquely qualified to contribute to the development of recommendations to improve compliance of requirements management for PMO programs.

A program self-assessment survey determined that 87 percent of PMO programs have a defined RqMP. The requirements health metrics activity developed a 5-level maturity indicator to identify program adherence to RqM governance, in which Levels 1-3 are in place and Levels 4-5 are future goals. This activity found that 13 percent of PMO programs are at Level 1 (program process not documented), 45 percent are at Level 2 (program has an approved process that is not in compliance with the latest governance), and 42 percent are at Level 3 (program has an approved process and follows the latest governance).

The RqM project provides PMO programs with the knowledge and tools to efficiently manage program requirements. Through its work developing workshops, reviewing RqMPs, and creating metrics, and with the U.S. DOT Volpe Center's detail-oriented and results-driven approach in evaluating RqM plans and practices, PMO programs are better positioned to cost-effectively meet stakeholders' needs as defined and within scope. (*Sponsor: AJM-132 under the PMO within FAA*).

Small Business Innovation Research



The U.S. DOT Volpe Center administers the Department's Small Business Innovation Research (SBIR) Program on behalf of the Office of the Secretary of Transportation. Small businesses that participate in the Department's SBIR Program have developed numerous new and innovated technologies that have benefitted the Department and the public, and helped small businesses grow.

SMALL BUSINESS
INNOVATION RESEARCH

The U.S. DOT Volpe Center Provides Key Support and Expertise to Multiple SBIR Projects

The U.S. DOT's Small Business Innovation Research (SBIR) program awards over \$10 million annually to small businesses to enable research on and development of innovative solutions to our nation's transportation challenges. The highly competitive program encourages small businesses to explore their technological potential and provides the incentive to profit from its commercialization. Small businesses that participate in the SBIR program have developed numerous new and innovative technologies that have benefitted the U.S. DOT and the public, while providing a basis for growth for small businesses. The U.S. DOT Volpe Center administers the SBIR program on behalf of the U.S. DOT, partnering with funding operating administrations and small businesses alike in working toward a successful outcome that can benefit the nation's transportation system.

The following are four SBIR success stories—two projects on intersection safety, sponsored by FHWA, and two projects on rail crossings, sponsored by FRA.

The program encourages small businesses to explore their technological potential.

The U.S. DOT's highly competitive SBIR program awards contracts to U.S. small businesses to pursue research on and develop innovative solutions to our nation's transportation challenges. (Image: Adobe Stock)

Low-Cost, Modular Mini-Roundabouts Help Improve Small-Intersection Safety and Reduce Congestion

In roundabouts at small, but critical intersections across the United States, safety and congestion can be a challenge. Mini-roundabouts, which are small-scale versions of modern roundabouts with a traversable center island, were created to address these issues. FHWA became interested in looking into opportunities to improve mini-roundabouts' design, functionality, and processes. Through Phase I, II, and IIB SBIR awards, ZKxKZ, LLC developed a design for low-cost, easily installed mini-roundabouts made from recycled plastic.

There are 10 commercial installations of mini-roundabouts, including one at a site in Silver Spring, MD. Three more sites are planned for Richmond, VA. The success of these installations and potential for other future infrastructure-related improvements have led FHWA to invest further into the development of the system through the SBIR Phase IIB award. Some of those developments include load transfer mechanisms to distribute vehicle impact loads to neighboring boards and anchors.

Not only are mini-roundabouts beneficial because they are inexpensive, but they can also fit into existing intersection rights-of-way and have shown potential to be used in other road features. Furthermore, the success of the installation of mini-roundabouts has led the Department of Defense to contribute funding to the U.S. DOT contract for defense-specific systems development. *(Sponsor: FHWA)*

Mini-roundabout, street-level view. (Source: U.S. DOT FHWA)



Dilemma Zone Warning System: Addressing High-Speed Crashes at Lighted Intersections

The “dilemma zone” is a term for the predicament drivers face when a traffic light suddenly turns yellow, requiring either an abrupt stop or rapid acceleration through the intersection. The dilemma zone has caused high-speed, rear-end, and side-impact crashes at lighted intersections. To help solve this problem, FHWA sponsored an SBIR project to create, develop, and implement a multi-technological approach to alert drivers in advance of being caught in a dilemma zone.

Intelligent Automation, Inc. and the Delaware Department of Transportation (DelDOT) tested this technology at two intersections and collected data over three years and observed some informal patterns. At the completion of Phase II, Intelligent Automation wanted to continue to work with FHWA and DelDOT to implement this technology at 10 additional intersections and planned to improve the system to make it more advanced. DelDOT decided to use state funds to continue improving the technology and implement the technology at those 10 additional intersections.



Intelligent transportation system in place at intersecting roadways.
(Source: U.S. DOT FHWA)

The willingness of DelDOT to invest its own funds, to continue the tests and research activities, and to upgrade the system shows that there is promise to this approach and that Intelligent Automation’s innovations are opening new doors for intersection safety that will only grow as the adoption of its technology becomes more widespread. By creating an integrated warning system that alerts drivers of the dilemma zone, this work increases safety by reducing crashes at lighted intersections. In the future, these systems can be integrated into the vehicle-to-infrastructure communication environment that the federal government is developing in coordination with state DOTs, private industry, and international partners. *(Sponsor: FHWA)*

Improving Highway-Rail Grade Crossing Inspections with Drone Technology

Highway-rail incidents contribute to hundreds of fatalities a year, according to FRA data.¹⁸ Roadway maintenance and vegetation growth can change road conditions at highway-rail grade crossings, affecting the visibility of trains for drivers. Inspecting crossings more frequently would improve data on whether and how highway-rail conditions have changed over time and help prioritize needed maintenance.

In 2020, FRA sponsored two SBIR projects to improve highway-rail grade crossing inspection systems to more efficiently and frequently assess the safety of crossings. VisioStack was awarded SBIR funding to develop the Aerial Crossing Inspection System (AXIS), which uses drones to perform inspections and identify risk factors, such as limited lines of sight, enabling rail authorities to prioritize maintenance activities that will improve safety. VisioStack also developed a stand-alone mobile app that will enable users to perform the entire inspection process, including planning drone flights, collecting images, and analyzing conditions at crossings.



AXIS analyzes the profile of a crossing, determines lines of sight, and searches for relevant crossing inventory signage. (Source: VisioStack)

AXIS can also be paired with VisioStack’s mobile Field Inspection app to help users inspect a variety of rail asset types and automatically update the FRA Grade Crossing Inventory, which will help ensure compliance with grade crossing inspection requirements. In the future, VisioStack may enhance the technology for specific use cases, such as allowing the inspection of multiple crossings during a single drone flight and improving object detection models to determine the presence of key signage more accurately. *(Sponsor: FRA)*

¹⁸ Federal Railroad Administration Office of Safety Analysis; <https://safetydata.fra.dot.gov/OfficeofSafety/default.aspx>.

Michigan Tech Research Institute (MTRI, Inc.) partnered with Michigan Technological University to develop the Crossing-i system, which uses cost-effective 3D drone sensing to identify and assess the safety of crossings through an easily deployable, automated system. Crossing-i identifies areas to improve technical insufficiencies and automatically identifies needed signage, which will help ensure grade crossings comply with FRA inspection requirements. MTRI, Inc. demonstrated this technology at highway-rail crossings in Illinois, Indiana, Michigan, Minnesota, and Wisconsin. The technology has been tested with new drones and is ready for deployment. Next, the Crossing-i team will partner with agencies and organizations interested in providing commercial operation of Crossing-i.

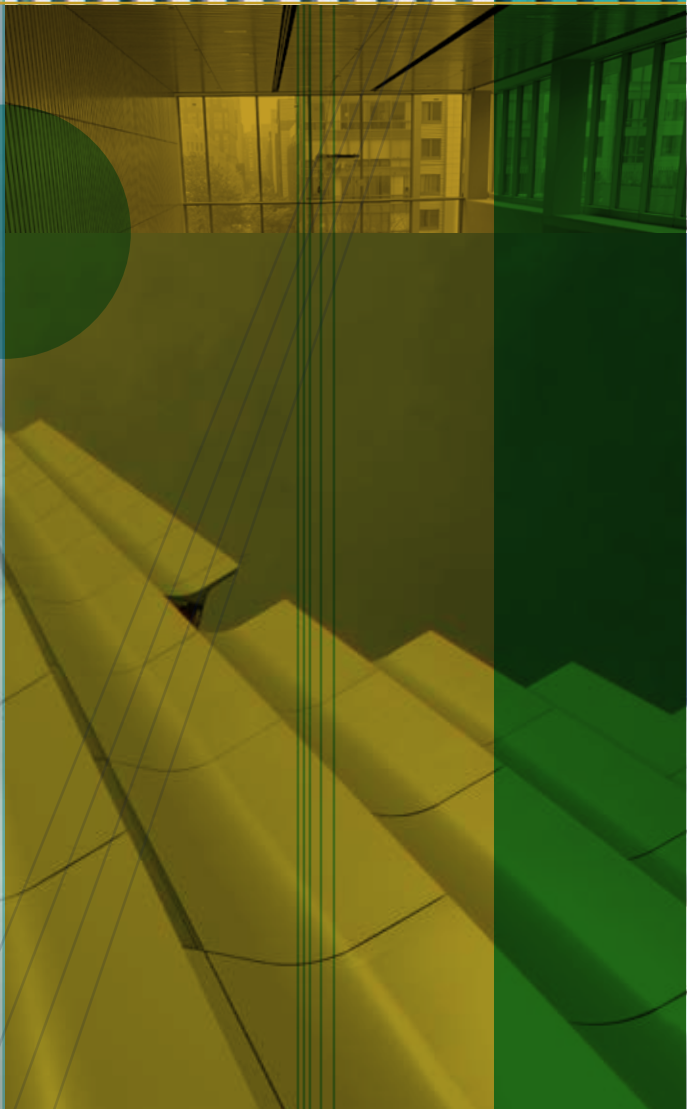
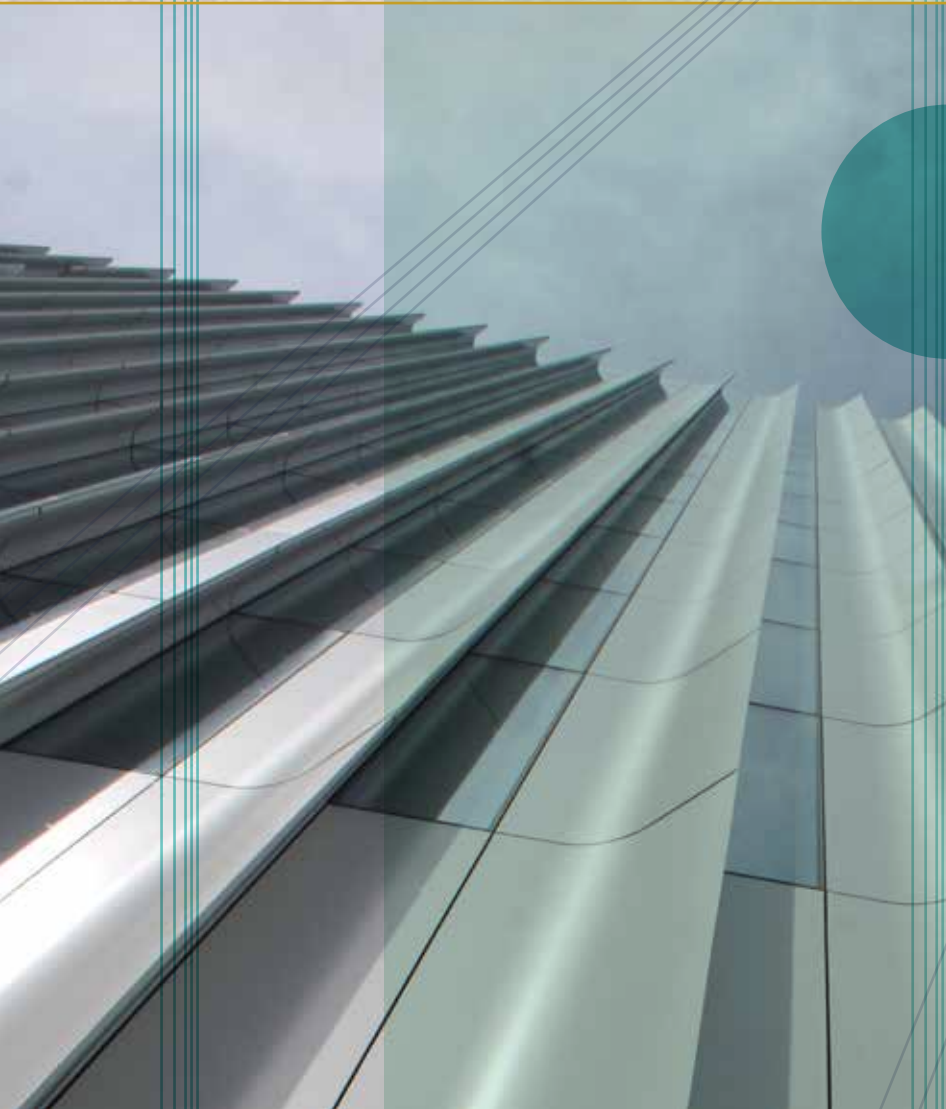
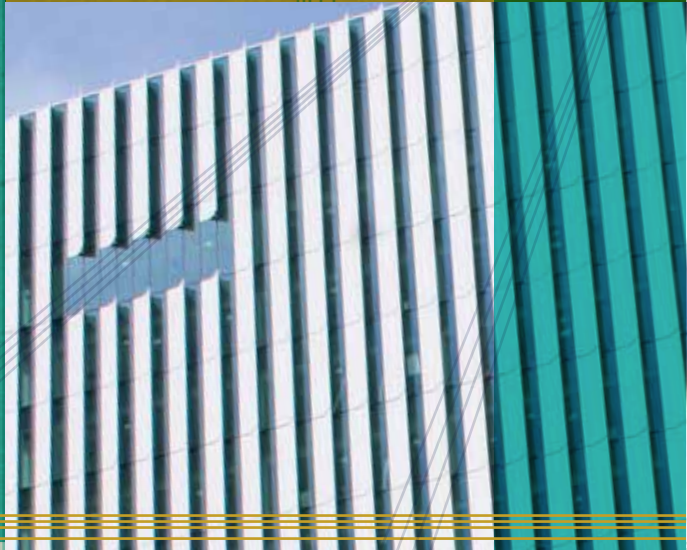
This innovative technology could help improve the safety of approximately 212,000 highway-rail grade crossings in the United States by rail agencies, commerce commissions, and FRA through an easily deployable, rapid system that takes advantage of cost-effective 3D drone sensing. This technology will help rail companies responsible for managing crossings save money and target safety improvements at specific rail crossings where problems exist.

The innovative work accomplished through these projects, including the FHWA-sponsored projects on mini-roundabouts and dilemma zone warning systems, furthers the SBIR program's initiative to help small businesses participate in federal research and development, while also fostering the commercialization potential of such novel technology. *(Sponsor: FRA)*



A MTRI technician prepares to launch a drone for a highway-rail grade crossing inspection.
(Source: MTRI, Inc.)

Your New U.S. DOT Volpe Center



In fall 2023, U.S. DOT will open its doors to our new facility at 220 Binney Street, Kendall Square, Cambridge, Massachusetts. The U.S. DOT first broke ground on the new building in October 2019, and it is now 95 percent complete.

YOUR NEW VOLPE CENTER

New U.S. DOT Volpe Center Facility to Open in Fall 2023

The state-of-the-art building sits on four acres of land in the heart of Kendall Square, Cambridge, a premier location known as “the most innovative square mile on the planet.” The new building was designed with very high levels of sustainability and resilience in mind and is expected to receive a Leadership in Energy and Environmental Design (LEED) Gold V4 certification from the U.S. Green Building Council.

The 400,000-square-foot space boasts approximately 26,000 square feet of laboratories and approximately 38,000 square feet of conference and meeting areas, and is designed to enhance innovation, collaboration, flexibility, and partnerships while embracing the emerging transportation needs of the future. The innovative, accessible lab space allows researchers to test theoretical concepts in real-world simulations and put research to work to advance transportation innovation for the public good.

The Binney Street building is built with open floor plans and collaboration space, designed to facilitate safety and teamwork. With training and conference areas that can accommodate up to 800 people, the U.S. DOT Volpe Center can invite more participants to experience its renowned expertise and expand its programming to meet the needs of the rapidly evolving transportation enterprise.

The U.S. DOT Volpe Center’s new state-of-the-art facility will officially open in fall 2023, and will continue to provide groundbreaking innovations and solutions for the Department’s most pressing transportation challenges. (Images: U.S. DOT Volpe Center)

Thanks to a unique, first-of-its-kind property exchange partnership between the General Services Administration, U.S. DOT, city of Cambridge, and the Massachusetts Institute of Technology, the new U.S. DOT Volpe Center facility will be financed without requiring appropriated funds.

YOUR NEW VOLPE CENTER

Our new home at 220 Binney Street brings together world-class transportation expertise in one building—the U.S. DOT Volpe Center, U.S. DOT Office of the Secretary of Research and Technology, and regional U.S. DOT offices—allowing for connections, efficiencies, and scalability to benefit the traveling public.



The new U.S. DOT Volpe Center. (Images: U.S. DOT Volpe Center)





Top left: View of the main entrance. Above: Project Director, David Duncan, Office of Volpe Center Director for Operations leads a tour of the office space. Left: The distinctive pattern of the new building's southeast wall. (Images: U.S. DOT Volpe Center)

Secretary Pete Buttigieg Visits the Volpe Center



U.S. Secretary of Transportation Pete Buttigieg Talks about the Future of Transportation at the U.S. DOT Volpe Center

The U.S. DOT Volpe Center welcomed U.S. Secretary of Transportation Pete Buttigieg on December 14, 2022. The Secretary challenged us to be “thoughtful, fact-driven, and imaginative,” while contending with new and distinctive transportation challenges during a standing-room-only Town Hall with U.S. DOT Volpe Center and U.S. DOT Region 1 staff. Robert Hampshire, PhD, Deputy Assistant Secretary for Research and Technology and Chief Science Officer, U.S. DOT, welcomed the Secretary, and Anne Aylward, U.S. DOT Volpe Center Director, moderated the event. NHTSA Acting Administrator Ann Carlson was also in attendance.

“The moment that we’re in right now ... is one of unprecedented opportunity and unprecedented challenge,” said the Secretary. “We are faced with ... the most multiple and sustained set of problems and disruptions to transportation since

U.S. Secretary of Transportation Pete Buttigieg speaks at the Volpe Center Town Hall. The Secretary and U.S. DOT Volpe Center Director Anne Aylward engaged in an interactive Town Hall. (Images: U.S. DOT Volpe Center)

the founding of the Center, or even the Department. It's also the case ... that right now, we see this extraordinary moment opening up in front of us with the most resources ever being made available for federal investment in transportation since the founding of this Department and this Center.”

SECRETARY PETE BUTTIGIEG VISITS THE VOLPE CENTER

Secretary Buttigieg fielded questions on a range of topics related to the Bipartisan Infrastructure Law, safety, transportation modernization, innovation, and the role of transportation in enabling wealth creation in underserved communities and project delivery.

The Secretary visited our NextGen and Global Maritime Domain Awareness laboratories to discuss work underway to improve the safety and efficiency of the NAS, Advanced Air Mobility, and recent advancements in maritime domain awareness systems used by 80 nations.

Secretary Buttigieg toured the new U.S. DOT Volpe Center facility, currently under construction and scheduled to open in fall 2023.

U.S. Secretary of Transportation Pete Buttigieg spoke with U.S. DOT Volpe Center staff on work underway on Advanced Air Mobility. (Image: U.S. DOT Volpe Center)



The Secretary's visit culminated in a tour of the U.S. DOT Volpe Center's new facility at 220 Binney Street in Kendall Square designed to enhance innovation, collaboration, and flexibility, enabling U.S. DOT to embrace the emerging transportation needs of the future.

Secretary Buttigieg recognized the facility's uniquely sustainable features designed to equip researchers with the space and equipment necessary to continue the U.S. DOT Volpe Center's mission to advance transportation innovation for the public good.

Before touring the new building, Secretary Buttigieg referenced the original U.S. DOT Volpe Center's historical origins and roots in public service: "It's fitting that this building came about during the NASA days, and I think that was the moment, this call to serve, that motivated so many people...to be part of this enterprise," said the Secretary.

"Now is a moment that is ripe for that same call. There is a generation, or generations of Americans who can find meaning...through their involvement in propelling America to the next level."

"Now is a moment that is ripe for that same call. There is a generation, or generations of Americans who can find meaning ... through their involvement in propelling America to the next level."



Dr. Robert Hampshire, U.S. DOT Deputy Assistant Secretary for Research and Technology and Chief Scientist speaks with Director Anne Aylward. Both were on hand to introduce Secretary Buttigieg. (Image: U.S. DOT Volpe Center)



Above: The Secretary and Director Aylward at the Town Hall. Left: Secretary Buttigieg, Deputy Assistant Secretary for Research and Technology Dr. Robert Hampshire, and Acting NHTSA Administrator Ann Carlson met with the Volpe Center; DOT Region I and local National Association of Government Employees leadership teams. (Images: U.S. DOT Volpe Center)

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