FY21 ACHIEVEMENTS IN AEROSPACE AND TRANSPORTATION

CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT
THE MITRE CORPORATION

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Photography included within this document shows images of people that were taken prior to the COVID pandemic or during a period when mask mandates were lifted in 2021. Safety protocols at both MITRE and the FAA were fully enforced in 2021, requiring all individuals in any MITRE or FAA facility to show proof of vaccination and follow all required mandates. No FAA personnel appear unmasked in any photos taken between 2020 and 2021.

CAASD
Annual Report

FY 2021

CONTENTS

Letter from Gregg Leone

As 2021 ended, the world continued to face significant challenges with the COVID pandemic. Despite the numerous hurdles COVID still poses, it is also a time for innovation and growth. Today's complex challenges offer the chance to be bold, and we are ready to seize the moment, working across the Federal Aviation Administration (FAA) as well as with international aerospace stakeholders and industry.

Since the Center for Advanced Aviation System Development (CAASD) was established as the FAA's federally funded research and development center (FFRDC), we have worked to improve the safety, security, efficiency, and resiliency of the global transportation system. For over 60 years, our work has helped to ensure the FAA continues to provide the safest, most efficient aerospace system in the world, and we are proud to be the FAA's mission partner.

While this report is a retrospective of FY21 accomplishments, it also offers a view of what's to come in the years ahead: advancing the National Airspace System (NAS) future vision, optimizing safe and efficient transportation operations, and defining the next level of safety across the transportation domain.

The year 2021 also marked the FAA's reaffirmation of CAASD as its FFRDC, and we are humbled to continue our partnership with the FAA and are inspired by their confidence in our work.

As described in the new contract and Sponsoring Agreement: *CAASD's primary focus is to partner with the FAA and other transportation stakeholders to develop innovative strategies, concepts, and technology applications, and to facilitate their transfer into operational changes that improve the safety, efficiency, and resiliency of the global transportation system.* **To fulfill our mission, we serve in four critical roles: Strategic Advisor, Innovation Partner, Integrator, and System-of-Systems Engineer.**

Aligned with FAA mission and priorities, we will continue to drive transformative innovation across the global aerospace community through our work, our cutting-edge research, our partnerships, our advocacy, and our public service mission. We look forward to an exciting year ahead!

Gregg Leone

Vice President and Director, Center for Advanced Aviation System Development (CAASD)

The MITRE Corporation

INTRODUCTION

In 1990, the Federal Aviation Administration (FAA) established its federally funded research and development center (FFRDC) to perform the advanced research and development needed to modernize the National Airspace System (NAS). As an FFRDC, the Center for Advanced Aviation System Development (CAASD) provides the FAA with advanced scientific and engineering technical capabilities in areas such as systems engineering, mathematics, and computer science, while applying in-depth aviation domain knowledge of Air Traffic Management (ATM), airspace operations, and aviation stakeholders relevant to the NAS and global aerospace operations.

To meet this need, the FAA has invested in the unique laboratories, modeling, simulations, and analytic capabilities at CAASD that are used to evaluate concepts and improvements to current and future systems and operations. These assets help the FAA and aviation stakeholders agree on changes and envision future integrated operations.

As an independent organization, CAASD provides objective analyses and recommendations. It is an essential FAA resource because of its in-depth ATM operational knowledge, institutional memory, and extensive analysis capabilities developed over many years of FAA support. Such long-term relationships are a hallmark of FFRDCs—enabling extensive knowledge and capability development that could not be as effectively created or applied through competitive procurement. This combined knowledge and capability enables CAASD to address difficult issues that require multiple disciplines, special studies, and functional specialties and that are too broad or complex for other organizations to address in a manner as timely or as cost-effectively.

FFRDCs are owned by the federal government but operated by contractors, universities, non-profit organizations, and industrial firms. CAASD is operated by The MITRE Corporation, a not-for-profit company that operates multiple FFRDCs serving both public and national security sectors. MITRE has worked continuously with the FAA since 1959 to improve the United States (U.S.) and global air transportation system.

With the approval and support of the FAA, CAASD also collaborates with the Department of Transportation on surface transportation safety; MITRE's Department of Defense FFRDC partners on civil-military integration; and with international civil aviation authorities—all of which face similar challenges in the areas of safety, security, and efficiency. CAASD's relationships with these organizations are encouraged by the FAA to increase and share knowledge of best practices across the transportation domain.

As aerospace and transportation evolve and expand to include multiple modes on the surface and into space, CAASD has expanded its capabilities to prepare for these future challenges. From commercial space launch, new entrant integration, surface transportation systems safety, and civil-military integration, CAASD works in conjunction with other MITRE FFRDCs to bring knowledge and sponsor relationships to bear on the toughest cross-domain, cross-government challenges.

The next sections outline CAASD's Fiscal Year 2021 (FY21) mission accomplishments, provide an overview of plans for FY22, and offer a longer-term outlook for the years ahead. The sections are organized by outcomes, as outlined in the Product Based Work Plan that the FAA and CAASD create each fiscal year:

- Outcome 1: NAS Concept of Operations, Architecture, and Integration
- Outcome 2: ATM Operational Evolution
- Outcome 3: Airspace and Performance-Based Navigation
- Outcome 4: Safety and Training
- Outcome 5: Communications, Navigation, Surveillance, and Cybersecurity Infrastructure
- Outcome 6: Unmanned Aircraft Systems
- Outcome 7: Special Studies, Laboratory, and Data Enhancements
- Outcome 8: Mission-Oriented Investigation and Experimentation.

Subsequent sections provide details on CAASD innovations and push for acceleration as well as governance and operations of the FFRDC.

FY21 MISSION ACCOMPLISHMENTS, PLANS, OUTLOOK

OUTCOME 01

NAS CONCEPT OF OPERATIONS, ARCHITECTURE, AND INTEGRATION

FAA Outcome Manager: Mr. Steve Bradford

CAASD Outcome Leader: Emily Stelzer

Outcome Statement: A transformed NAS and Next Generation Air Transportation System (NextGen) that:

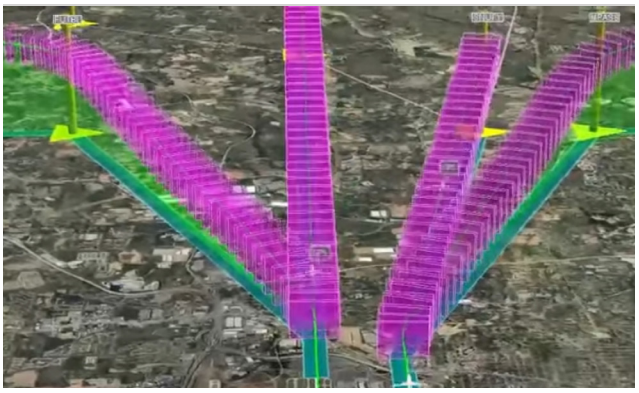
- Meets national goals for the safe and efficient delivery of air transportation services.
- Maximizes operational and cost efficiencies for the government, its customers, and its stakeholders.
- Positions U.S. aviation to meet national objectives and new entrant challenges and aligns government priorities and investments.

Highlighted Accomplishments

Florida NextGen Test Bed Demonstrations

The FAA's Florida Nextgen Test Bed (FTB) provides an industry-accessible laboratory environment to experiment with future NAS technologies. The FTB enables the FAA and partners, including CAASD, to experiment with implementing potential future concepts related to Trajectory-Based Operations (TBO) and flight information management, such as Flight and Flow Information for a Collaborative Environment (FF-ICE). The FAA and partners use these demonstrations to influence relevant International Civil Aviation Organization (ICAO) guidance and FAA system development activities. CAASD specifically develops and maintains software protype systems to provide core flight planning and filing information capabilities at the FTB, necessary for demonstrating future concepts.

FY21 ACCOMPLISHMENTS: CAASD collaborated with the FAA and partners—including Embry-Riddle Aeronautical University (ERAU), Boeing, L3Harris, Leidos, Mosaic ATM, LS Technologies, and numerous other industry and support companies—to conduct a series of experiments and demonstrations. The Multi-Regional TBO demonstration in June 2021 included the participation of several international partners with the FAA, including equivalent organizations from Canada, Japan, Singapore, and Thailand. This activity led to the development and refinement of a new Flow Information Exchange Model (FLXM), which CAASD reviewed and implemented at FTB. CAASD feedback to the FLXM development team resulted in several improvements that will now be used by additional countries in upcoming demonstrations.



Earlier in the year, the FTB concluded the Four-Dimensional Trajectories Live Flight Demo (4DTLFD). CAASD provided ground-based Traffic Flow Management (TFM) tools, which were used to perform constraint avoidance calculations for a live flight operated by the Boeing ecoDemonstrator program. These calculations were provided to the aircraft and acted upon by the flight crew.

FY22 PLANS: CAASD will continue collaborating with the FAA and partners to conduct a second Multi-Regional TBO demonstration in spring 2022. This demonstration will expand on the activities completed in FY21 with a strong emphasis on researching more complex information exchange scenarios involving multiple countries and varying information exchange capability levels. Specifically, CAASD will complete updates to software that will enable improved integration with oceanic automation systems to support an expanding emphasis on better understanding future global harmonization of flight information. In addition, CAASD will help the FAA develop a Simulated TBO capability to enable fast-time simulation of demonstration scenarios to complement the ongoing lab activities.

FY23–25 LOOK-AHEAD: CAASD will continue collaborating with the FAA and partners across a range of demonstrations. The lessons learned and overall outputs from these activities will influence ICAO implementation guidance for related concepts such as FF-ICE and be used to inform FAA planning for their TBO implementation activities.

Remote Tower Camera Visibility Toolkit and Siting Analysis

The FAA is assessing the viability of providing remote tower services using a video camera system in lieu of a conventional tower cab. Remote tower services have the potential to lower the FAA's cost to provide tower services at medium and small towered airports. A key challenge for approval of remote towers is determining whether a video camera-based system gives tower controllers sufficient visibility to maintain safety. Past CAASD work involved a collaboration with the U.S. Army to tailor CAASD's analytical models to support remote tower visibility assessment. CAASD is working closely with the FAA on two remote tower research efforts at non-towered airports in Leesburg, Virginia and Fort Collins, Colorado.

FY21 ACCOMPLISHMENTS: CAASD refined its tower visibility toolkit to include modeling of expanded lighting scenarios, updated metrics, and improved usability. CAASD also formulated performance-based guidance for remote towers and coordinated it with FAA stakeholders. This guidance included the likelihood of an observer detecting a specified object, the vertical angle between the observer's view of a distant object and the airport surface, and the lateral separation angle at distant key locations. Together, the expanded tower visibility toolkit and siting guidance will verify that vendor-proposed remote towers give satisfactory visibility and reduce the testing needed to approve a remote tower.

FY22 PLANS: CAASD is finalizing visibility models and tech transferring the toolkit to the FAA so that the public can access it on the web. CAASD is also

examining FAA Order 6480.4, Airport Traffic Control Tower Siting, to identify changes that will be needed to support remote tower operations. This will include safety analyses and demonstrations of remote tower visibility performance. CAASD will coordinate these proposed changes across FAA lines of business and incorporate stakeholder feedback, producing inputs for a siting order that addresses remote towers. Together with the toolkit and siting guidance, a remote tower siting order will establish a repeatable and evidence-based approach for ensuring visibility that integrates well with other aspects of the remote tower approval process.

FY23–25 LOOK-AHEAD: CAASD envisions the tower visibility toolkit being broadly used by a variety of remote tower stakeholders. CAASD also envisions the FAA publishing a remote tower siting order based on the provided inputs. These activities, combined with the overall remote tower approval process, will facilitate faster remote tower deployment to additional sites, enabling lower-cost tower services at more airports.

Mobile Applications for Pre-Departure Information Exchange

As the FAA draws closer to deploying the Terminal Flight Data Manager (TFDM) platform and increases the application of time-based management, it is imperative that all flight operators provide accurate departure intent data to the NAS.

Today, most airlines are providing updated intent information to the Traffic Flow Management System (TFMS) through the FAA's System Wide Information Management (SWIM) service. However, the ability for General and Business Aviation (GA/BA) flight operators to submit the same departure intent data to TFMS is not readily available. CAASD has been using the Pacer prototype mobile app to demonstrate how GA/BA pilots can use their personal mobile devices to keep FAA scheduling systems, like TFMS, updated on their departure plans. Additionally, CAASD has been exploring how providing arrival and departure demand information through a mobile app can provide pilots improved situation awareness and help them with planning.

FY21 ACCOMPLISHMENTS: In FY21, CAASD deployed Pacer to eight airports in Colorado ski country. During last winter's ski season, pilots were able to monitor arrival and departure demand at each airport and submit their departure plans days or hours in advance of their trip. Pilots reported that the information in Pacer provided improved situation awareness regarding how busy or congested the airports would be around the time of their arrival or departure.

During the year, CAASD also connected Pacer to NASA's Airspace Technology Demonstration–2 (ATD-2) surface scheduler at Charlotte Douglas International Airport (CLT). This connection allowed participating

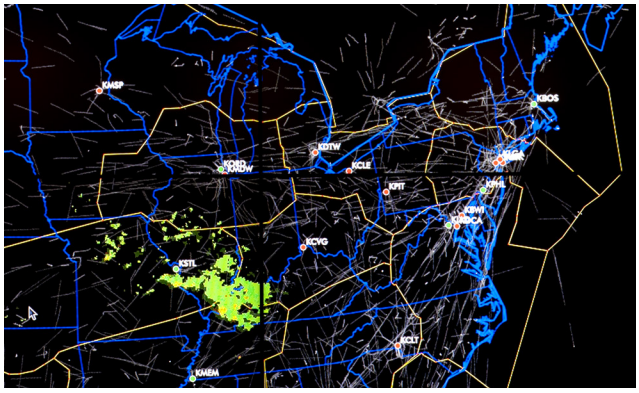
pilots to see expected departure demand and receive information back from the surface scheduler. This information included their expected departure runway, the scheduler's computed time their flight would be airborne, and any traffic management delays associated with their flight. Pilots expressed that this information is very helpful for situation awareness and planning.

Finally, in May 2021, CAASD conducted two industry forums with representatives from the GA/BA flight plan service provider and app provider community. In collaboration with the National Business Aviation Association (NBAA) and the General Aviation Manufacturers Association (GAMA), CAASD and FAA team members presented information on CAASD's mobile technology work and the FAA's plans for modernizing flight management and deployment of the TFDM surface metering capability. CAASD is engaging with companies who are interested in exploring how Pacer functions could be integrated into their flight-planning applications.

FY22 PLAN: The FAA has directed CAASD to initiate a technology transfer of Pacer functionality to industry during FY22. The technology transfer plan includes engaging with industry partners and licensing Pacer functionality to interested companies. To enable the evaluation, the CAASD team provides an Application Programming Interface (API) to Pacer, with appropriate security measures in place, so that app providers can explore how the capabilities could integrate with their app.

For the remainder of this fiscal year, the CAASD team will be preparing technology transfer materials so that interested app providers can fully implement Pacer functions on their computing infrastructure. CAASD is also working with the Collaborative Decision Making (CDM) community and TFMS Program Office to ensure they are aware of how Pacer functions will be implemented on a broader scale and how they will connect to FAA systems to enable pre-departure information exchange.

FY23–25 LOOK-AHEAD: Although Pacer prototype research will no longer be actively conducted after



FY22, Pacer's functionality will be transitioning to industry applications where it will be made available to a broader population of flight operators. CAASD will continue to encourage and support the proliferation of information exchange between the FAA and GA/BA flight operators. The experience and expertise of the CAASD team will be an excellent resource for broadening the participation of GA/BA flight operators in the emerging time-based management NAS using mobile technology.

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OUTCOME 02

ATM OPERATIONAL EVOLUTION

FAA Outcome Manager: Mr. Rob Hunt and Ms. Rebecca Guy

CAASD Outcome Leader: John Mayo

Outcome Statement: Evolve ATM into an efficient, collaborative, and cost-effective operation that over the next five to ten years:

- Improves operational safety, efficiency predictability, and productivity in the NAS, benefiting the FAA, all NAS operators, and the flying public.
- Enables more effective utilization, maintenance, and enhancement of system resources and capabilities (e.g., reduces the cost of ownership for FAA infrastructure and reduces controller workload).
- Improves the overall provision of air traffic services to users, accommodating access and flexibility under current and projected traffic volume, and integrates new entrants (e.g., commercial space vehicles, Unmanned Aircraft Systems [UAS], and balloons).
- Promotes the integration of the modernized TFM system with the evolution of en route modernization plans, terminal systems, and NAS-wide operations while increasing common situational awareness and collaborative decision making with ATM stakeholders.
- Leverages research and development advancements in aircraft and aviation technologies with particular focus on flight-deck advancements.
- Improves airspace access and national security.
- Demonstrates international leadership by promoting seamless operations around the globe.

Highlighted Accomplishments

NAS Architecture Modernization

The FAA is challenged with reducing the costs of developing, operating, and sustaining NAS automation platforms. At the same time, to support its future vision for the NAS, the FAA must address new mission needs, technology opportunities, growing cybersecurity threats, and the scalability of information management capabilities. As a result, the FAA is seeking an approach that reduces the time to develop, integrate, and deploy new capabilities.

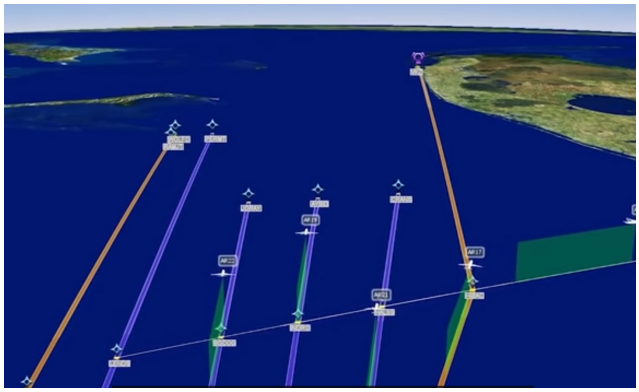
To address this challenge, CAASD, working with FAA leadership, has defined an Automation Evolution Strategy (AES) that envisions a Service-Based Architecture.

FY21 ACCOMPLISHMENTS: In collaboration with the FAA, CAASD defined an initial AES reference architecture that described the major components of the future service-based architecture. Based on this service-based approach, CAASD also defined a Concept of Use (ConUse) for the future architecture, including an industry engagement strategy, transition opportunities for automation capabilities, and necessary change management efforts to realize the AES.

CAASD also deployed a test application from MITRE's Application Based Capability Development software platform onto the FAA's Platform Elroy capability to demonstrate how a third party could deploy new applications onto an FAA operational platform. This effort successfully demonstrated how the FAA can accommodate industry vendors that contribute to the FAA's software platform capabilities.

FY22 PLANS: For FY22, CAASD will collaborate with the FAA to establish a risk-reduction software platform environment that will address key challenges associated with developing, acquiring, implementing, and sustaining the platform at an enterprise level. CAASD will also work with the TFM and Separation Management programs to define an overall enterprise transition strategy. In addition, CAASD will support the FAA in engaging with industry to improve their AES awareness. CAASD will also update the reference architecture and ConUse to reflect the outputs from above.

FY23–25 LOOK-AHEAD: Follow-on efforts will include establishing the needed AES enterprise infrastructure for programs to develop their applications and services as well as working with decision support programs to develop, acquire, and implement these capabilities utilizing this enterprise infrastructure.



ADS-B In Applications

Improvements in communication, navigation, and surveillance systems in the NAS have led to the development of multiple concepts to improve efficiency and capacity and enhance safety. These include the deployment of Automatic Dependent Surveillance–Broadcast (ADS-B) and expanded use of TBO.

These are key components of NextGen and will help mitigate the growth in NAS-wide delay and projected airport capacity shortfalls. Some ADS-B In applications, including Cockpit Display of Traffic Information (CDTI)-Assisted Separation (CAS) and Interval Management (IM), are designed to help maintain capacity and realize TBO objectives.

The CAS application will mitigate the loss of throughput that occurs when visual separation cannot be applied by enabling the CDTI to be used for visual-like separation in weather conditions that limit forward visibility, such as haze, city light glare, or flying in a cloud layer. The IM application will enable improved inter-aircraft spacing precision and allow aircraft to be consistently spaced closer to the separation standard or metering constraints, thus increasing throughput in capacity-constrained airspace. Additionally, greater precision in inter-aircraft spacing reduces controller reliance on vectors off the published procedures, resulting in shorter distances flown and lower fuel burns.

FY21 ACCOMPLISHMENTS: CAASD performed technical analyses and developed interactive lab demonstrations for multiple near-term applications. CAASD also helped mature the IM and CAS operational descriptions, including maturation of the use of CAS during departure operations, as part of the American Airlines/FAA ADS-B In Retrofit Spacing (AIRS) evaluation team. This activity involves the use of current-day ground systems to initiate and monitor ADS-B In operations and the flight-deck systems to conduct the applications. CAASD used tools and data sources such as *runway*Simulator and the Transportation Data Platform (TDP) to evaluate facility challenges and potential benefits and helped the FAA confirm Dallas/Fort Worth International Airport (DFW) as a CAS demonstration site. These efforts informed ground automation requirements and helped the FAA determine which applications should be included in upcoming investment and deployment plans.

CAASD also completed a Human-in-the-Loop (HITL) simulation examining IM operations to dependent parallel runways to inform concept documents and validate RTCA and EUROCAE requirements. In parallel, CAASD participated in FAA/industry forums, such as the NextGen Advisory Committee ADS-B In Task Group, and provided technical briefings and assistance with industry data collection and reporting. These forums identified industry priorities and barriers to equipage such that the FAA can focus on high-impact activities to motivate equipage.

FY22 PLANS: The current focus is on maturing and deploying nearer-term ADS-B In applications. This includes examining how to leverage standardized avionics applications to enable operational benefits in new environments, such as applying CAS to departure operations. CAASD is working with the systems engineering team to develop application use cases and to define validation activities in the Integration

Demonstration and Experimentation for Aeronautics (IDEA) Lab. CAASD is also supporting the AIRS evaluation by helping to define the strategy to collect flight crew human factors and application benefits data. In addition, CAASD continues to work within RTCA and EUROCAE to provide technical inputs to industry and lead an update to ADS-B In data communications message requirements. Finally, CAASD is addressing industry integration questions, such as performing research to harmonize IM and Required Time of Arrival (RTA) operations and interfaces.

FY23–25 LOOK-AHEAD: CAASD will continue to play a role on the FAA ADS-B In team, making key contributions toward concept maturation, testing, and collecting and analyzing data gathered during simulations and field evaluations. The AIRS operational evaluation will demonstrate ADS-B In benefits in the field and spur more widespread application deployments in the NAS. As part of this, CAASD will contribute to the data collection strategy, execution, and analysis. In parallel, CAASD will simulate nearer-term applications in the IDEA Lab to engage and inform stakeholders, mature ground automation requirements, and reduce deployment risk. In the midterm, CAASD will perform research to help the FAA prepare for more complex applications that will be more fully integrated into a TBO environment.

CAASD continues to work within RTCA and EUROCAE to provide technical inputs to industry and lead an update to ADS-B In data communications message requirements.

Separation Management

The FAA is maturing emerging NextGen separation management capabilities to assist controllers in maintaining aircraft separation in all domains, while optimizing the use of airspace system capacity. This effort is termed Separation Automation System Engineering (SASE) and will inform automation enhancements in both the near term and in the future. In the near term, SASE is supporting the development of enhancements to the FAA's En Route Automation Modernization (ERAM) system: ERAM Enhancement 3 (EE3). In its Separation Services Engineering (SSE) sub-project, SASE is supporting further-term NextGen operational improvements and the transition to the FAA's emerging vision for the NAS.

One area of focus in SSE is supporting the development of the emerging AES, which is a service-based approach for the delivery of automation capabilities to reduce cost and enable a more rapid, agile deployment of capabilities. A second focus area is the application to separation management of innovative technologies such as Artificial Intelligence (AI), Machine Learning (ML), and Automated Speech Recognition (ASR).

FY21 ACCOMPLISHMENTS: CAASD FY21 accomplishments in separation management included the following:

1. Investment decision analysis for the EE3 acquisition, in which concepts were refined and the development of preliminary program requirements was initiated.
2. Definition of service capabilities to support AES, which examined the feasibility of deploying ERAM's Conflict Alert and Conflict Probe functions as independent services that could be applied to not only En Route but to other domains (e.g., terminal, oceanic, offshore). These analyses included the initial development of algorithms for performance-based extensions of the ERAM Conflict Probe to the oceanic domain.
3. Investigation into the application of emerging technologies in AI, ML, and ASR, including the assessment of relevant technical developments and ongoing projects in the U.S. and international Air Navigation Service Providers (ANSP). Specific recommendations from this investigation included further investigations into the application of recent AI/ML breakthroughs in sequence-to-sequence modeling and ASR applications which build on these models.

FY22 PLANS: In FY22, investment decision analysis will continue for the EE3 acquisition with concept refinement, requirements development, and the preparation of acquisition artifacts needed for an EE3 Investment Analysis Readiness Decision (IARD). In accordance with the goals of the NAS Future Vision that seek to leverage technological advancements and agile services, the FY22 efforts are expected to include the development of service prototypes of selected SASE-related capabilities (e.g., Conflict Probe). This effort will evaluate their feasibility as independent services and support for separation management in a diverse ATM environment.

FY23–25 LOOK-AHEAD: CAASD separation management work in the FY23–25 timeframe is expected to include the provision of technical and operational inputs to complete the EE3 IARD and Final Investment Decision (FID) milestones. Following this, subsequent post-FID requirements definition and detailed design review activities are anticipated. Initial preparation for follow-on ERAM enhancements is also expected, to begin the definition and prioritization of en route separation management capabilities needed to support the FAA's future vision for the NAS.

Work is also expected to continue with service-based analyses of various separation management capabilities, combined with an assessment of needs and opportunities throughout the En Route, terminal, and oceanic domains. A key goal of this activity will be to define a common, core set of services that can be used across domains to enable reduced cost, increased flexibility, and enhanced capabilities.

The FY22 efforts are expected to include the development of service prototypes of selected SASE-related capabilities.

Advanced Surveillance Enhanced Procedural Separation (ASEPS) and Future of the Ocean 2035

The FAA's Advanced Surveillance – Enhanced Procedural Separation (ASEPS) project has been investigating the use of Space-Based ADS-B (SBA) to increase operational efficiencies in oceanic airspace managed by the FAA. The FAA is also addressing the evolution of oceanic ATM operations through 2035 via the Future of the Ocean 2035 (FOTO35) strategic initiative.

FY21 ACCOMPLISHMENTS: CAASD led the development of eight concepts for air traffic control capabilities enabled by SBA using the Concept Definition process from CAASD's Concept Maturity Framework. The SBA concepts developed focus on providing additional oceanic operational efficiencies by leveraging enhanced surveillance. Consensus on these concepts was reached over a series of meetings in summer 2021 and October 2021 with an FAA cross-organizational team that included the FOTO35 team (representatives from ATO International, Operational Policy and Implementation, and Strategy), National Air Traffic Controllers Association (NATCA), Airline Training Orientation Program (Oceanic and Offshore Automation), and ASEPS systems engineers (Surveillance and Broadcast Services).

CAASD analyzed the performance of SBA reporting in FAA oceanic and offshore airspaces, primarily by measuring the probability of update interval against

the relevant requirements. CAASD also assessed the ADS-B and antenna configuration equipage levels of aircraft in these airspaces.

CAASD analyzed and assessed many different aspects of future oceanic ATM operations as input to the FOTO35 strategic initiative. Topics included the development of concept vignettes to illustrate various concept elements; analysis of separation procedures enabled by enhanced surveillance or communications; qualitative analysis of operational shortfalls in the oceanic environment; assessment of new communications and surveillance technologies; analysis of a better-performing, better-served policy; options for collecting oceanic user fees; functional description of future oceanic trajectory models; and identification of and information needed from internal and external stakeholders to FOTO35.

CAASD developed an enterprise level Concept of Operations (ConOps) for the FOTO35 strategic initiative, including the operations envisioned for the near, mid, and far term, as well as a description of the operational shortfalls to be addressed and the opportunities to be leveraged to provide benefits to airspace users.

FY22 PLANS: CAASD will be involved in the development of an ASEPS ConOps that will describe the SBA capabilities proposed for FAA implementation; the ASEPS ConOps will be an artifact for the ASEPS IARD in September 2022. CAASD will also continue to assess SBA performance and perform a detailed investigation of aircraft that do not meet update interval requirements.

CAASD will perform additional analysis in support of the FOTO35 strategic initiative, including the identification of FOTO35 performance metrics and the establishment of a performance baseline.

FY23–25 LOOK-AHEAD: CAASD will continue to leverage extensive oceanic operational and systems engineering knowledge while providing data-driven analyses to the ASEPS and FOTO35 projects at the FAA.

TFM Operational Planning and NAS Performance Analysis

Currently, FAA personnel involved in the NAS planning and execution processes must utilize a suite of tools and descriptive data products to develop next-day plans for Traffic Management Initiatives (TMI), execute day-of traffic management decisions, and review prior TMI performance. To plan for an evolving operational condition, the individuals must mentally integrate data from various sources in various formats (numeric, textual, or graphical) and constantly make projections of TMI effectiveness and NAS states. To address the need to leverage advanced data analytics for improving TFM operations, CAASD has been supporting the FAA in advancing near-real-time and post-event performance assessment capabilities.

In FY21, CAASD's research focused on using information for better decision collaboration, proactive TFM actions, and operations insight discovery. In alignment with the FAA's Flight Plan 21 initiatives, CAASD developed the process and automation for using timely information sharing to address regional collaboration needs and began applying modern AI and ML methods to predict system performance and enable more proactive TFM actions. In addition, to strengthen NAS post-event review ability, CAASD proposed and developed an objective method to assess TMI performance when compared to other days for the same airport and weather impact. Furthermore, to support the operational transition to TBO, CAASD worked with the FAA's Air Traffic Control System Command Center (ATCSCC) to develop a systematic approach to understand the conditions of when and where active Time-Based Flow Management (TBFM) scheduling and metering should be used in conjunction with other TMIs. As the FAA is rapidly enhancing and expanding data analytics to better support TFM operations and post-event performance analysis, CAASD's research and development activities are expected to help accelerate FAA's evolution into the world's foremost data-driven ANSP.

FY21 ACCOMPLISHMENTS: In FY21, to improve the efficiency of information sharing between the FAA and industry partners in a tactical timeframe, CAASD developed a streamlined process and new collaboration capabilities on the NAS Operations Dashboard (NOD) to address regional departure fix demand balancing needs. Working with the participants designated by the CDM Stakeholders Group (CSG), CAASD conducted field trials in July and August 2021 to observe the utilities of timely flight routing collaboration using the NOD platform. The observation results indicated that the proposed process was considered useful for flight operations to express their routing preferences, despite the additional workload induced. The scenario-based benefit analysis suggested that a marginally increased practice of proactively routing out of overloaded fixes would save flight delays significantly.

To increase the use of predictive analytics, CAASD identified a set of suitable research problems and developed AI/ML-based solutions to perform prediction tasks for TFM planning and execution, such as predicting regional delay trends and airport-specific disruptive events. Advanced deep learning architectures and training methods (e.g., convolutional neural network, attention-based neural network) were used to learn from historical data the complex spatial and temporal dynamics between the operational features and the system performance metrics. The initial testing results showed promise for further operationalization. CAASD also adopted the best practice to establish the AI/ML development pipeline for model extensibility and scalability.

To bring more objectivity to TMI performance review, CAASD in FY21 completed an initial scorecard

capability for Ground Delay Programs (GDP) and proposed a technical approach to construct the daily weather group and all the metrics used in the scorecard for each airport and day. The scorecard capability consolidated the presentation of metrics, enabling an understanding of airport weather severity, TMI application, and arrival/surface operations for use in diagnosing performance. The capability is expected to provide operational insights and a TMI performance ranking method to improve shared post-event analyses.

To understand various regional TBFM uses' implications to NAS planning, CAASD scoped the necessary work with ATCSCC and started data preparation and exploration. This work is expected to answer various TBFM timing questions, such as when TBFM should be modified or replaced by alternative control measures due to constraints disrupting the operations, and when TBFM should resume after recovery from these constraints.

FY22 PLANS: CAASD will pursue the following activities in FY22:

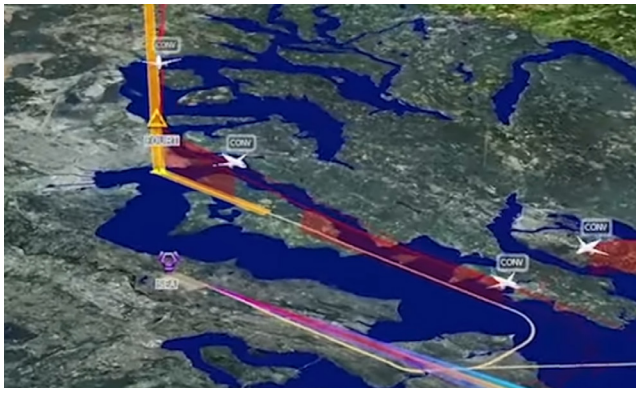
- To demonstrate the adoption of TFM predictive analytics, CAASD will deploy the trained AI/ML models in a live environment (e.g., ingesting real-time data, making predictions, getting real-time feedback from operational personnel) for testing the model performance as well as understanding the requirements needed to complete the lifecycle of an AI application. CAASD will conduct an initial operational acceptance evaluation of AI-enabled predictive analytics and address the consideration of human-machine teaming to build the trust of TFM personnel on AI results.
- To continuously address NAS efficiency challenges, CAASD will leverage both data-driven processes and collaborative procedures for identifying, measuring, prioritizing, and addressing critical inefficiencies in the air traffic system. CAASD will develop prototype reporting on system constraints, TFM actions, assessment of TFM actions, and system impacts. For instance, this effort might include expanding the TMI scorecard

capability and methodology to cover additional TMI types such as the En Route Airspace Flow Program (AFP) to support operations insight discovery of post-event analysis. Also, CAASD will seek opportunities to expand the practice, field trials, and benefit observations of FAA-industry collaboration using NOD with additional regions (e.g., Miami/Palm Beach, Dallas/Fort Worth) for better understanding region-specific collaboration challenges and data gaps to enable timely actions.

- For TBFM timing research, CAASD will propose an objective methodology to evaluate the current practice of regional TBFM operational use by combining simulation with historical event analyses. The research will provide guidelines for conditions when TBFM should be active, modulated, relieved, and resumed to maximize air traffic efficiency, based on demonstrated findings from data analytics and fast-time modeling. CAASD will collaborate with ATCSCC to apply TBFM timing evaluation findings to develop initial, strategic planning guidance for optimizing TBFM usage, alternative TFM support, and recovery to effectively meet the performance needs and priorities of the air traffic operation.

FY23–25 LOOK-AHEAD: CAASD plans to pursue the following activities for FY23–FY25:

- To continue expanding the use of TFM predictive analytics, CAASD will identify the research opportunities and develop data-driven, learning-based automation capabilities to address NAS efficiency challenges and planning needs. In addition to continuous development, CAASD will propose the technology transfer requirements for the FAA to acquire, operate, and sustain AI-enabled capabilities. The research of predictive analytics is expected to evolve the current TFM planning and execution operations from relying on descriptive analytics to utilizing more predictive analytics to enable TFM personnel to proactively act on mitigation actions for weather-induced delays or system disruptions.
- To target and address prioritized NAS efficiency challenges, CAASD will research and formalize

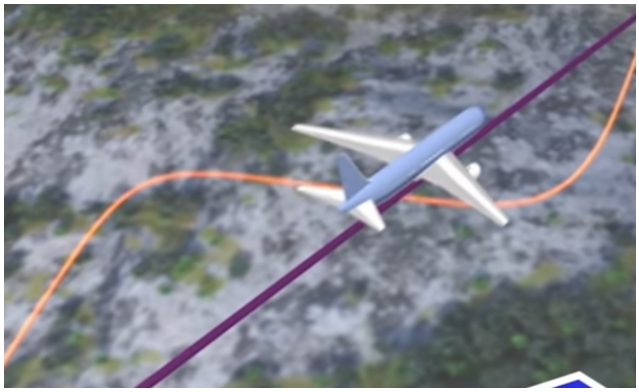


the methods and measures for identifying (then anticipating or predicting) defined efficiency "tipping points" representing significant resource or system performance degradation. Analytics, modeling and simulation tools, and collaboration tools/platforms that contribute to potential solutions/mitigations of these challenges will be developed.

- To incorporate the research findings and recommendations of NAS-wide TBFM timing research, CAASD will propose changes in ATCSCC's planning and decision-making processes on when and where the strategic operation should proactively plan for TBFM usage, assistance or relief, and recovery so that metering is more optimally timed to better meet the air traffic system's objectives of improved delay distribution, throughput, and procedure compliance. CAASD will continue engaging cognizant FAA organizations and other NAS stakeholders to identify future research and analysis needs based on the findings from this analysis to further improve strategic and tactical flow management decisions and enable improved efficiency planning of NAS resources.

Trajectory Based Operations

The FAA is evolving the NAS toward TBO to make flight operations more efficient and predictable, while maintaining operational flexibility. A key component of TBO is Time-Based Management (TBM), an ATM technique for scheduling aircraft through constraint points in the NAS. The FAA is evolving several decision support systems and related capabilities that enable TBM concepts for improved arrival and departure management.



Initial TBO Risk Reduction Analyses and Implementation Planning

The first step toward TBO is referred to as initial TBO (iTBO), which consists of the integrated use of existing and planned automation; iTBO sets the foundation for additional investments that will be needed to implement more advanced TBO evolution phases over the next several years. CAASD is engaging across the FAA to methodically address a diverse set of iTBO implementation risk areas via data, modeling, simulation, prototyping, and application of innovation. CAASD is also providing systems engineering for the refinement of new systems and capabilities and for readying the workforce and operators for the desired operational changes.

FY21 ACCOMPLISHMENTS: CAASD completed historical data analysis, fast-time simulation analysis, and lab-based HITL interoperability assessments to identify and mitigate risks and to inform the implementation of and transition to iTBO. CAASD also developed tools and analysis capabilities that were used to assess the effectiveness of TBM designs, such as modeling the predicted delay distribution and scheduling performance given a wide range of operational considerations, and to enable post-operations measurement of the overall performance of new iTBO capabilities as they are implemented. CAASD continued to support the execution of the FAA's iTBO change strategy to ensure the agency's workforce and industry are prepared for the operational changes that are coming; this was done through the development of a training and education roadmap, along with updates to orders and training content. CAASD developed comprehensive communication artifacts and conducted planning to enable impactful FAA stakeholder engagement events such as the TBO Summit and the TBO Industry Day.

To help achieve integration among Performance-Based Navigation (PBN) procedure design and TBM adaptation design, CAASD further matured the Integrated PBN and TBM Design capability by incorporating departure and coupled metering design and fast-time evaluation functionality. The changes enable more rigorous evaluations of integrated design candidates prior to deployment by allowing the FAA to explore system performance across a range of environmental conditions and traffic scenarios. CAASD also expanded the Integrated Design Guidance to aid PBN procedure designers in developing procedures that support TBM to help achieve TBO objectives.

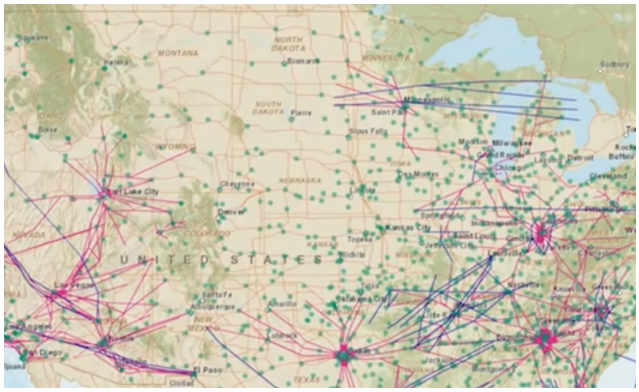
To help enable more integrated TFM decisions, CAASD developed a lightweight, scalable proof-of-concept prototype that forecasts TBM delay allocation on a

multi-facility basis to help traffic management personnel make improved decisions in the strategic timeframe about effects that will manifest in the tactical environment. That proof-of-concept prototype leverages a digital twin scheduling component and applies predictive metrics modules in a microservices application architecture to address a known iTBO shortfall.

Finally, CAASD provided analyses and technical contributions to support the pending implementation of a key iTBO system—TFDM—in the NAS. CAASD continued providing subject matter expertise in surface TFM, surface metering, and TFM system integration requirements for TFDM system design and development. To reduce implementation and operational acceptance risk, CAASD also contributed this knowledge to the development and verification of system test procedures. Additionally, CAASD aided the FAA's industry engagement efforts to increase awareness of the TFDM system, surface metering, and associated benefits.

FY22 PLANS: CAASD will continue to provide analysis to identify and mitigate risks related to iTBO implementation and will perform analyses related to post-implementation impacts of new implementation and use of iTBO capabilities. CAASD will support the successful operational transition of iTBO into the field by employing the TBO Change Strategy to continue mobilizing leadership at headquarters and in the field, providing consistent and timely communication to all stakeholders, and engaging the workforce within TBO Operating Areas and at the ATCSCC.

Additionally, CAASD will further mature development of a post-operations assessment platform to integrate additional iTBO success criteria and metrics, for the purpose of providing a clear understanding of the operational changes and their benefits. CAASD will also continue working with Air Traffic Operations (ATO) stakeholders on expanding use of the Integrated PBN and TBM Design capability and design guidance to reduce the time and resources needed to develop TBFM adaptation and validate the integration with PBN procedure designs at key sites in the NAS.



As the FAA continues to prepare for TFDM implementation in 2022, CAASD will continue to provide surface TFM subject matter expertise to further refine system design and inform operational expectations. CAASD's risk mitigation role for TFDM will focus on improving system test development and execution, as well as informing system implementation plans and activities to ensure successful site deployments. CAASD will aid in the planning and execution of a TFDM site collaboration activity, which will establish Surface Collaborative Decision Making processes, procedures, and policies in preparation for the deployment of TFDM's surface metering capability at that site.

Finally, new in FY22, CAASD will explore options to introduce needed iTBO capabilities to users using agile development concepts to support the operation, gain early acceptance, and validate required functionality. CAASD will also identify strategies to sunset legacy TFM capabilities that will be modernized as part of iTBO implementation.

FY23–25 LOOK-AHEAD: CAASD will continue to be the FAA's partner in iTBO transition and implementation across the NAS, providing subject matter expertise on iTBO technologies and their operational impact. CAASD will continue to address specific operating area implementation considerations, mitigate remaining risks, and identify opportunities for additional improvements and efficiencies based on iTBO implementation lessons learned.

Research and Planning for TBO Evolution

In parallel with iTBO implementation, the FAA is defining the vision and strategy for the future of integrated TFM, termed Future Flow Management (FFM), wherein TBO is a cornerstone. The FFM effort aligns FAA strategic initiatives detailing a comprehensive plan to progress iTBO to Full and Dynamic TBO evolution phases, including extending use of forecast trajectories to integrate diverse and new entrant operations into the NAS.

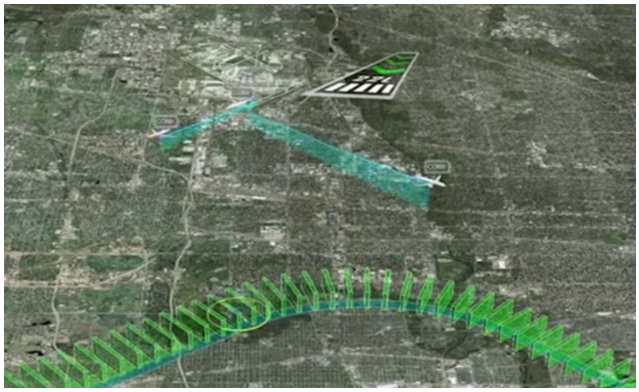
FY21 ACCOMPLISHMENTS: CAASD continued to support the enhancements research, development, and planning for critical decision support components of the TBO vision. This involved the TFDM program, integrating across available TBM-enabling systems and capabilities, and planning for the Flow Management Data and Services (FMDS) program, which will replace the aging infrastructure and capabilities of TFMS. CAASD completed systems engineering and investment analyses and provided acquisition inputs to inform the FMDS program.

Additionally, in September 2021 CAASD delivered Version 1.0 of the ATO FFM Corporate Plan to the FAA, satisfying an FY21 agency Business Plan objective. The Corporate Plan provides the full blueprint for the evolution and transformation to future TFM services, identifying the desired service vision and translating that vision into a set of initiatives leading to specific actions organized in an aligned, integrated, and timely fashion.

To prepare for the future outlined by FFM, CAASD continued to research advanced TBO concepts around predictive TBM modeling and dynamic scheduling with interval management.

FY22 PLANS: CAASD will perform analyses to define predicted trajectory accuracy for a diverse set of air vehicle operations based on the provision of scaled TFM services envisioned for the NAS. CAASD will also continue to refine the FFM Corporate Plan to account for evolving challenges and prioritizations and will socialize across the FAA's Office of NextGen (ANG) and ATO service units to gain consensus and commitment to the plan. To begin the execution of the FFM Corporate Plan, CAASD will perform concept analyses to identify candidate solutions to satisfy FFM outcomes and assess their maturity. Finally, CAASD will collaborate closely with the FAA to explore acquisition and contracting options for the FMDS program to enable potential investment planning efficiencies and accelerate availability. CAASD will also identify and refine candidate FMDS enhancements based on FFM-defined service outcomes and mature conceptual solutions.

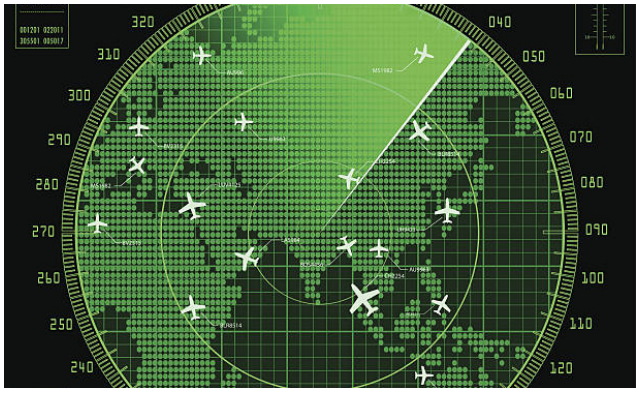
FY23–25 LOOK-AHEAD: CAASD will continue to partner with the FAA on TBO evolution by providing subject matter expertise to research, plan for, and support implementation of emerging TBO technologies. CAASD will work with the FAA to mature and execute the FFM Corporate Plan, influencing implementation strategy of policy, processes, people, and automation to resolve unaddressed traffic management shortfalls, support transition from iTBO to full and dynamic TBO, incorporate diverse users and new entrants into NAS operations, and prepare to capitalize on opportunities for the NAS Future Vision described by the Info-Centric NAS Concept of Operations. CAASD will provide analysis and influence critical investments to realize the FFM Vision and Outcomes with the implementation and integration of new capabilities, technology, and infrastructure into the NAS.



Enterprise Information Display (E-IDS)

The Enterprise Information Display System (E-IDS) will be the first FAA enterprise-level platform to support ATO in providing real-time and static secondary information. E-IDS will provide supplemental information that complements the information provided on primary displays (e.g., radar displays) to FAA operational and support personnel across the NAS. E-IDS will replace legacy Information Display Systems (IDS) with a common NAS-wide platform. It will be integrated into the FAA Service-Oriented Architecture (SOA) infrastructure using modern data exchange mechanisms, communication systems, and technological advancements to promote efficiency and NAS resiliency.

FY21 ACCOMPLISHMENTS: To ensure operational and technical alignment with requirements and concepts of operations, CAASD independently assessed the contractor's system requirements and software architecture for the Preliminary Design Review held in March 2021. CAASD also worked with the FAA's Enterprise Information Management (EIM) program to ensure that the national static data is uploaded and available to the vendor during software development, and developed software tools to test the EIM static data APIs to reduce risks to the vendor for software development and to aid in future testing of the system. CAASD provided guidance to the contractor on the development of the Computer Human Interface for both the Air Traffic, Data Administrator, and Maintenance users through our inputs to the E-IDS Human Factors Working Group and the Early User Involvement Events (EUIEs). CAASD also provided inputs into the



William J. Hughes Technical Center (WJHTC) E-IDS laboratory development of live interfaces, mockups, and setups in preparation for test and training planning and early systems integration. Finally, CAASD is helping the implementation team with site transition activities, including the development of an E-IDS Implementation Dashboard.

FY22 PLANS: As the E-IDS design contractor continues its development, CAASD will continue to provide independent assessments on the contractual deliverables and the detailed software architecture to inform the Critical Design Review (CDR) to be held in spring 2022. To allow collaborative feedback between the contractor and the FAA on the E-IDS design through direct review/analysis of their Model-Based Systems Engineering (MBSE) model, CAASD will provision an E-IDS environment on the MITRE Engineering Platform. This platform will also provide an independent environment for other purposes (e.g., independent verification and validation analysis of future enhancements). CAASD will continue providing guidance to the contractor on the development of the Computer Human Interface for both the Air Traffic, Data Administrator, and Maintenance users through our inputs to the E-IDS Human Factors Working Group and the first Risk Reduction Demonstration. CAASD will provide early assessments of the initial software development drops. In preparation for test and training planning and early systems integration, CAASD

will provide independent assessments and inputs to test and training plans, use cases, procedures, and scenario approaches. CAASD is also working with the FAA to investigate E-IDS as a pathfinder for the evolution of other enterprise automation platforms and as a platform to support wider information needs (e.g., contingency information).

FY23–25 LOOK-AHEAD: CAASD will continue providing guidance to the E-IDS design contractor on the development of the Computer Human Interface for both the Air Traffic, Data Administrator, and Maintenance users through our inputs to the E-IDS Human Factors Working Group and additional Risk Reduction Demonstrations. CAASD will continue to provide analyses and software tools to reduce risks related to the EIM platform and the SWIM-based interfaces. CAASD will continue to provide assessments of software development drops and any software fixes needed. CAASD will provide independent analyses and assessments to support the System Integration Factory Acceptance Test, Development Test, and Operational Test. CAASD will provide inputs and assessments as needed for the development of training materials. CAASD will also provide systems engineering guidance and analyses during the installation of the systems at Phase 1 sites.

CAASD will continue to provide analyses and software tools to reduce risks related to the EIM platform and the SWIM-based interfaces.

Space and Upper Class E Airspace Operations: NAS Integration of Space Launch and Reentry

Industry innovation, increased military and civil capabilities, and operations at upper altitudes are driving the need for NAS change. These diverse operations include vertical and horizontal space Launch/Reentry (L/R) vehicles, capsule and winged space reentry vehicles, balloons, high-altitude long-endurance UAS, supersonic and hypersonic aircraft, and other piloted and unpiloted vehicles. The increase in demand from the operators of these vehicles, combined with diverse vehicle performance characteristics, velocities, and unconventional operational needs, presents novel challenges for integration into the NAS.

The FAA is faced with the challenge to integrate L/R vehicle operations more efficiently into the NAS while maintaining safety. While the increasingly frequent launches of satellites from commercial vehicles have become routine, in 2022 at least three larger launch vehicles (e.g., New Glenn, Space Launch System, and Vulcan Centaur) are expected to be used operationally, and the rate of capsule reentries from space is increasing. In 2021, Americans noted significant growth in the tempo at Cape Canaveral Space Force Station. Over the next few years, there will likely be growth at other spaceports in the U.S., both coastal and inland. Transiting operations to Upper Class E/ Higher Airspace presents additional integration challenges given the diverse vehicle types and widely varying performance in vehicle characteristics, velocity, and operational endurance, as well as varying flight and float profiles with limited compatibility with most traditional NAS operations.

CAASD is collaborating with the FAA in the development of strategies to address these integration challenges and providing expertise in simulation, acquisition, risk modeling, and alternatives analysis as the FAA is proactively seeking to increase access safely and efficiently for all NAS users.

FY21 ACCOMPLISHMENTS In 2021, CAASD, as the FAA's strategic partner, collaborated with ATO to develop a corporate plan to ensure safe and efficient ATM operations for the current and expected diverse population of vehicles transiting the NAS to reach, operate at, and descend from higher altitudes. This effort is referred to as NAS Integration of Transiting and Higher Airspace Operations (NITRO). This initiative is setting the path for how the ATO will evolve to manage and integrate into the NAS a set of emerging vehicle operations that provide new services in new ways.

In the near term, ATO is proactively implementing procedures and capabilities to optimize airspace utilization for all NAS users during space L/R operations. To this end, in 2021 the ATO implemented dynamic L/R windows and time-based launch procedures to reduce the amount of time an Aircraft Hazard Area (AHA) is segregated for these operations and to strategically identify and reroute only those aircraft that will intersect an AHA while it is active during a launch. CAASD not only contributed to the development of these procedures but also developed material to facilitate their implementation across FAA facilities and external NAS stakeholders. In addition, CAASD played a key role on the implementation of the Space Data Integrator, which was deployed in 2021 as a "minimum viable product" at the ATCSCC. Building on these efforts, CAASD used operational participant feedback to validate requirements for foundational space integration capabilities to ensure the right capabilities will be provided to space operations and field facilities.

In complement to these efforts, CAASD collaborated with ATO to conduct a set of tabletop exercises to explore the feasibility of expanding the use of the Central Altitude Reservation Function (CARF) to Upper Class E airspace operations.

FY22 PLANS: In 2022, CAASD will continue to support the acquisition of future enhancements for space integration into NAS automation systems. This includes providing an operational demonstration of initial capabilities for acquisition. CAASD will also leverage the ATO Corporate Plan for NITRO and feedback from field personnel to steer development toward needed functions and procedures. As operational changes are implemented, CAASD will continue to assess operational gaps and needed services and identify opportunities to leverage existing procedures and capabilities to support space L/R and Upper Class E airspace operations.

To support the ATO in meeting future needs and expected growth, CAASD will continue to work with ATO to develop and evolve strategies to incrementally prepare the workforce and implement the procedures and automation needed to support safe integration and use of shared airspace.

FY23–25 LOOK-AHEAD: Over the next three years, determining relating to which automation enhancements to NAS systems are needed and how to implement them (both in terms of technology and how to tailor the FAA's acquisition management system to implement them in a modern, service-oriented manner) is a complex mission for the FAA and its partners.

As the forecast demand for new vehicles and operations evolves, CAASD will continue to help inform FAA decisions through data analysis, research, strategies, and interactions with potential users and stakeholders. CAASD will partner with the FAA in bringing industry and other key stakeholders together to chart a path forward for safe, secure, and efficient integration of space L/R and Upper Class E airspace operations.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OUTCOME 03

AIRSPACE AND PERFORMANCE-BASED NAVIGATION

FAA Outcome Manager: Ms. Rebecca Guy and Mr. Mark Steinbicker

CAASD Outcome Leader: Marshall Koch

Outcome Statement: A modern and effectively managed performance-based NAS that:

- Leverages the precision, reliability, predictably, and efficiencies of PBN through the application and integration of Area Navigation (RNAV) and Required Navigation Performance (RNP) capabilities.
- Effectively integrates the NextGen vision and capabilities, such as TBO.
- Increases operator safety, access, resilience, efficiency, and capacity.
- Improves controller productivity and situational awareness.
- Promotes international harmonization and seamless global operations.
- Transforms the NAS by leveraging the benefits of navigation performance with surveillance, automation, and communications.
- Implements environmentally conscious trajectories in an agile and efficient manner.
- Increases flexibility and predictability to benefit air traffic controllers and operators.
- Reduces delays and inefficient routings appropriately depending on the needs of the airspace and its users, based on measurable success criteria monitored in a rigorous, timely, and data-informed manner.
- Balances the access needs of a diverse set of aviation system users.
- Maintains the highest levels of system safety and security.

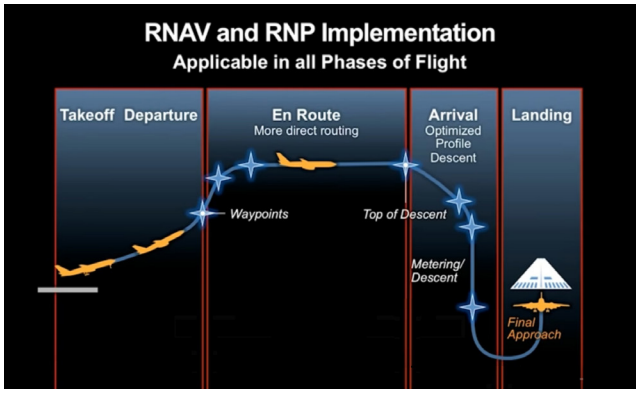
Highlighted Accomplishments

Airspace Modernization Roadmap

It has been five years since CAASD played an instrumental role in developing the FAA's 2016 PBN NAS Navigation Strategy. Many of the specific goals being tracked as part of that strategy have been fulfilled.

While the broad vision and framework laid out in the 2016 strategy still serve as a guide for the FAA, there is a need to provide additional investment and implementation details for the next several years and beyond, as well as to update and align the longer-term strategy with the evolving and emerging needs of the NAS. To that end, the FAA has partnered with CAASD to create and update relevant strategies, roadmaps, and implementation plans.

FY21 ACCOMPLISHMENTS: CAASD completed a plan and approach for transitioning the NAS to a system of PBN air traffic service routes where structure is needed across the NAS—with an emphasis in 2021 on opportunities to modernize the route structure at lower altitudes. In combination with the 2020 work, which provided the approach for high-altitude modernization, CAASD has provided the FAA with a roadmap for fulfilling a key goal in the 2016 PBN NAS Navigation Strategy. CAASD also developed a strategy, which FAA Mission Support adopted, to modernize Instrument Flight Procedure (IFP) production processes and data capture, as well as project prioritization decision-making and oversight. More broadly, CAASD reassessed the progress to date and recommended effective measures to fulfill other 2016 Strategy goals that had either stalled or needed additional definition and clarity to progress. This work forms the foundation for the FAA's Airspace Modernization Roadmap development effort, which CAASD partnered with the FAA to scope in the latter half of FY21 and continues to advance into FY22.



FY22 PLANS: CAASD will provide the key analyses, technical guidance, and strategic insights necessary to fully develop the FAA's Airspace Modernization Roadmap and begin delivering on it in FY22. Analyses will focus predominantly on identifying and prioritizing safety and efficiency needs at airports across the NAS, assessing the feasibility of addressing these needs with airspace infrastructure improvements, and efficiently scheduling projects to deliver this infrastructure, taking into consideration other initiatives or resource constraints affecting specific sites. CAASD will also develop the Airspace Modernization Playbook that synthesizes airspace project scoping and management lessons refined over the past decade during the large-scale redesign efforts of the Metroplex program. The Playbook will also align with the new Service Center-oriented execution model that the FAA is adopting.

FY23–25 LOOK-AHEAD: The Airspace Modernization Roadmap will lay out the FAA's new approach to delivering needed safety and efficiency improvements to the NAS. It will also provide an early waterfall of initial airspace project locations. As these initial projects kick off using the new approach, CAASD will partner with FAA's Mission Support Strategy Group as well as Service Center execution teams to move from needs identification and prioritization to project scoping, airspace and IFP design, systems integration planning, and ultimately project implementation. In this role, CAASD—through data-driven analysis and strategic advising—will empower the FAA to act strategically to realize the full potential of its airspace modernization efforts.

Instrument Flight Procedures, Operations, and Airspace Analysis (IOAA)

CAASD developed the IFP, Operations, and Airspace Analytics (IOAA) Tool to provide integrated metrics and analysis capabilities directly to FAA analysts. The tool supports data-driven assessment of IFP needs and procedures post-implementation, operational issues related to use of IFPs, progress toward PBN NAS Navigation Strategy goals, and separation standards safety studies.

FY21 ACCOMPLISHMENTS: CAASD built on the 2020 release of the web-based IOAA Tool by engaging with FAA Service Centers and other IOAA stakeholders to identify additional work areas that IOAA can support, including procedure implementation workflows and community engagement needs. CAASD also improved the IOAA capability by maturing data processing automation and system monitoring capabilities and integrating new data sources, including ADS-B surveillance data and flight plan information. CAASD also enabled new data-driven insights by developing and deploying new IOAA capabilities, including an approach clearance analysis module based on automated controller-pilot speech data transcriptions, an airspace usage analysis module, and a NAS-wide report for aggregate metrics on operations, equipage, PBN procedure utilization, and associated flight performance.

CAASD also developed and validated additional algorithms within MITRE's Transportation Data Platform (TDP) to track intent and flown route information, including refined procedure conformance and usage metrics, as well as identification of re-routes, shortcuts, and vectors. In collaboration with the FAA, these analytic capabilities are being used to provide additional data-driven insights for ongoing Airspace Modernization efforts and to collaboratively pursue several separation standards analyses.

FY22 PLANS: CAASD will continue pursuing ad hoc analysis, increasing automation to streamline IOAA data updates, and evolving IOAA analytic capabilities as prioritized by FAA Mission Support, Flight Standards, and other IOAA stakeholders. This work will include development of a new re-route, shortcut, and vector analysis module and additional surveillance data-based flight track visualization capabilities. CAASD will also explore integrating some IOAA capabilities into MITRE CAASD's Collaborative Research Environment (CRE) as part of development of a technology transition roadmap to integrate IOAA source data, algorithms, and source code within FAA enterprise infrastructure.

FY23–25 LOOK-AHEAD: The integrated IOAA capabilities will continue to be integrated into a variety of critical FAA work programs, including execution of the Airspace Modernization Roadmap. CAASD will continue partnering with FAA's Mission Support and Service Center execution teams to directly leverage IOAA for project scoping, airspace and IFP design, and implementation activities, streamlining project decisions using automation-enabled data-driven insights. The FAA will also leverage the advanced algorithms that drive IOAA analytics to streamline data preparation and modeling efforts for separation standard safety studies, a critical step in enabling standards that increase airport capacity and flight efficiency in the NAS.

Integrated Data and Analytic Architecture for Safety Studies

CAASD has developed integrated capabilities within a cloud-based CRE to streamline the conduct of safety studies necessary to approve new operational concepts and safety standards. With a shared environment that enables code-based access to derived data for flight analysis, traceability to source data, and shared analysis capabilities, FAA Flight Standards, the Office of NextGen, and CAASD can collaborate more effectively on safety analyses, leading to reduced implementation timeframes for new standards and procedures and a safer and more efficient NAS.

FY21 ACCOMPLISHMENTS: CAASD expanded the CRE to directly support separation standards research, releasing new capabilities with additional documentation and tutorials, and increasing data availability of derived data within MITRE's TDP. CAASD and FAA Flight Standards collaboratively developed a final approach deviation analysis that supports ongoing Multiple Airport Route Separation (MARS) concept assessment and safety analysis within the CRE, demonstrating the value of collaborative development using the same data sources, methodology, and scalable computational resources.

CAASD also reduced maintenance efforts and costs by increasing use of Amazon Web Services (AWS)-native capabilities, streamlined versioned deployments with a DevOps pipeline, and documented the architecture principles followed in CRE development along with considerations for applying them to potential CRE development within FAA infrastructure.

FY22 PLANS: CAASD will expand the CRE to support a broader range of separation standards and operational concept studies, including procedure conformance analysis for the MARS concept and foundational research supporting closely spaced parallel operations and potential separation standard reductions. Completing a transition to use GovCloud for the CRE will be a first step toward demonstrating interoperability of the MITRE CRE with other cloud-based CREs in the FAA's EIM system and a vision of rapid technology transfer of CAASD-developed prototypes into the FAA enterprise.

FY23–25 LOOK-AHEAD: Demonstration of interoperable CREs within the FAA's EIM system will evolve toward rapid technology transfer of CAASD prototype capabilities into FAA infrastructure to support safety studies. Further expansion of the CRE will enable a broader range of collaborative activities between the FAA, CAASD, and industry stakeholders, including integrated modeling and simulation capabilities and artificial intelligence and machine learning frameworks. These activities will enable the FAA to effectively leverage research from CAASD and other stakeholders to improve the safety and efficiency of the NAS.

IFP Development Automation

For more than a decade, CAASD has been working with the FAA to create modular software criteria engines to allow users to design and evaluate IFPs against the latest FAA criteria in a matter of hours rather than the days/weeks required when these procedures are manually designed and evaluated.

CAASD began this effort by working closely with the FAA to design criteria software logic that fully aligns with the U. S. Standards for Terminal Instrument Procedures—the standard for IFP development. CAASD has developed 13 separate criteria engines and integrated them within the FAA's IFP development tool, Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS), which has allowed the FAA to retire expensive legacy systems and provide evaluation capabilities for approximately 94 percent of the IFPs in the FAA's IFP inventory. More recently, CAASD has begun research into automated procedure design suggestions based on IFP designer-defined goals and constraints to further evolve how procedures are developed.

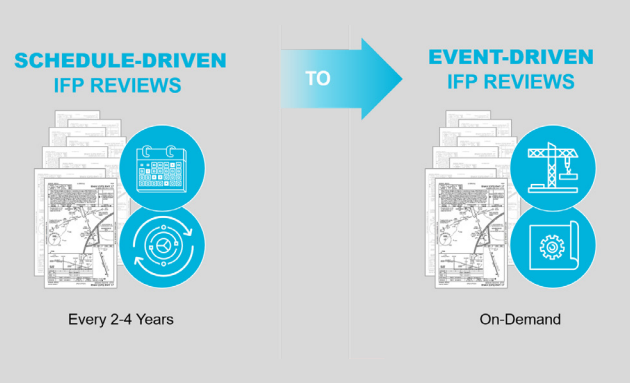
FY21 ACCOMPLISHMENTS: In FY21, CAASD developed and deployed criteria assessment and automation functions to evaluate PBN and conventional approach sidestep procedures. CAASD also continued to work with the FAA's TARGETS maintenance contractor to update existing criteria engines to ensure they represent the latest criteria, to update the software test suites to reflect the latest versions of the software, and to achieve additional criteria engine technology transfer, including the transfer of the RNAV Departures module. CAASD continued work on designing a new criteria engine to allow for the design and evaluation of ground-based Standard Instrument Departure (SID) procedures in preparation for an FY22 deployment.

Finally, CAASD initiated work on a criteria engine for Category II and III Instrument Landing System (ILS) approaches and for new functionality for PBN procedures to transition to ILS approaches.

CAASD continued work on developing a prototype automated procedure design capability for RNAV Global Positioning System (GPS) approach procedures and expanded the capability to support RNAV RNP approaches with radius-to-fix legs. CAASD coordinated with FAA IFP developers to demonstrate the prototype capability and collect their feedback on usability and performance. Additionally, CAASD began work to automate RNAV Standard Terminal Arrival Route (STAR) procedure development that aims to consider the complicated design constraints that differ greatly from approach procedure design.

FY22 PLANS: In FY22, CAASD plans to deploy the ground-based SID criteria engine, new functionality for PBN helicopter En Route and arrival procedures, and the new capability to design and evaluate PBN procedures to transition to conventional ILS approaches. In addition, CAASD will make updates to both PBN and conventional arrival criteria engine modules, along with several conventional departure modules, to keep current with the latest Terminal Instrument Procedures (TERPS) criteria. CAASD also plans to complete the first phase of technology transfer of the PBN and Conventional Approach criteria engines to the TARGETS maintenance contractor. CAASD also will continue work to mature the RNAV approach automated design capability and plan to deploy the tool to the FAA for initial use.

FY23–25 LOOK-AHEAD: The FAA envisions CAASD will continue work on ILS Category II/III and Special Authorization (SA) Category I/II approaches and begin work on automation of additional flight procedure types including PBN departure helicopter procedures and Advanced RNP (A-RNP) approach procedures. The completion of this work will provide IFP evaluation capabilities for approximately 98 percent of the IFPs in the FAA's NAS inventory. Criteria engine technology



transfers will continue, with a goal of updating the existing criteria engines with the latest FAA design criteria and transferring two engines per year to the FAA's TARGETS maintenance contractor.

CAASD will also continue development of automated procedure design capabilities including consideration of additional design goals and constraints (e.g., flyability, navigation coverage, and IFP design best practices) to further improve the quality of the IFP suggestions. This research will help transition IFP design tasks from being human-designed/computer-validated to computer-designed/human-validated and enable a more responsive and efficient future state of the NAS that can more easily accommodate new entrants and new technologies.

Streamlining IFP Maintenance

For more than a decade, CAASD has been working with the FAA on the automation of IFP design criteria to support IFP development. In recent years, CAASD conducted research that leverages these IFP development capabilities to enable large-scale automated IFP evaluations within decision support tools to improve common IFP maintenance tasks.

These improvements will assist the FAA in reducing the resources required to maintain the approximately 21,000 IFPs in the NAS, which will enable those IFP development resources to be applied to modernizing the NAS. These research areas include the automated evaluation of procedures for periodic review and proposed obstruction impact assessments.

FY21 ACCOMPLISHMENTS: CAASD completed the initial deployment of the Automated Periodic Review (APR) operational capability for RNAV GPS and PBN approach procedures to streamline the FAA's IFP periodic review process by reducing the number of manual evaluations required. To provide this capability, CAASD deployed APR to the FAA's IFP Automation (IFPA) production environment. CAASD also deployed a similar IFP automation capability—the Fully Leveraged Obstacle Assessment Tool (FLOAT)—to help streamline the process of evaluating the potential impact of proposed obstructions on nearby IFPs. FLOAT is currently deployed to support FAA User Acceptance Testing (UAT), a final step prior to transitioning the initial FLOAT system capability for RNAV approach procedures to the FAA Cloud Services (FCS) production environment.

FY22 PLANS: CAASD will complete the initial deployment of FLOAT for RNAV approach procedures to the FCS environment for the FAA's daily operational use.

CAASD will also expand the APR capability to include evaluation of conventional approach procedures and PBN STAR procedures. CAASD will also expand the FLOAT capability to include evaluation of conventional approach procedures and obstacle departure procedures. Additional enhanced capability development for FLOAT may include conventional and RNAV Graphic Obstacle Departure Procedures (ODP), SIDs, and/or visual approach procedures. Furthermore, through the ongoing evaluation of APR and FLOAT results, CAASD will continue to assist the FAA with improving the quality and completeness of IFP data required as input to these and other automation capabilities intended to support the FAA's mission to streamline the IFP lifecycle workflows and processes.

FY23–25 LOOK-AHEAD: CAASD will continue development of the APR and FLOAT capabilities to expand the procedure types available for evaluation and to help facilitate technology transfer to the FAA or an FAA maintenance contractor. In addition, CAASD will explore new and future opportunities for other FAA lines of business that would benefit from leveraging these and other automated IFP evaluation capabilities.

Optimization of the IFP Inventory

Today there are approximately 21,000 IFPs in the NAS; however, a significant portion of those procedures are believed to be underutilized or otherwise operationally redundant. Retaining these procedures, which provide little benefit to the NAS, results in significant maintenance costs and limits the FAA's bandwidth to implement more efficient procedures and meet the needs of new entrants in a rapidly evolving NAS.

CAASD is partnering with the FAA on the Optimization of the IFP Inventory initiative to introduce a recurring and data-driven process to reduce the time and resources needed for the review, removal, and modification of existing routes and procedures. This process is intended to evolve over time based on the changing needs of the NAS and therefore needs to consider not only automation capabilities but also how to integrate into existing IFP production workflow processes.

FY21 ACCOMPLISHMENTS: CAASD collaborated with multiple organizations across FAA Mission Support Services (AJV) to develop a new process for the review, removal, and modification of IFPs that maximizes the use of objective metrics and existing automation systems, as well the automation systems necessary to enable this new process. This work drew on numerous existing capabilities and integrated them to accelerate NAS-wide impact.

The new optimization process is intended to achieve significant short-term benefits by implementing automated processes to identify, contextualize, and

coordinate the retirement of IFPs that are considered operationally redundant. CAASD expanded its existing IFP retirement recommendation models and developed new data visualizations to provide FAA specialists with increased context for the retirement recommendations. The visualizations of IFP data-driven retirement recommendations were integrated as a new module within the IOAA platform.

The longer-term goals of the Optimization of the IFP Inventory initiative are to implement a sustainable, recurring, and adaptive process that not only considers removing procedures but also considers how to improve the overall quality of the IFP inventory. To enable this recurring process, CAASD developed the IFP Optimization Pipeline, which connects multiple existing capabilities (including the IFP retirement models, APR, and Automated Procedure Design) into a unified decision-support system to automatically review and optimize individual procedures based on the IFP periodic review schedule.

As part of the IFP Optimization Pipeline, the Automated Procedure Design for approaches was enhanced to support non-interactive usage and enable automated repair of existing procedures, as well as other performance and reliability improvements. In addition, CAASD conducted research into extending the Automated Procedure Design concept to RNAV STAR procedures and developed prototype implementations.

FY22 PLANS: In FY22, CAASD will continue to engage with Optimization of the IFP Inventory stakeholders to monitor the implementation of the optimization process and revise the process, capabilities, or analytics based on feedback received. To that end, iterative testing and feedback with stakeholders will be a primary focus to ensure the process and capabilities are accepted, reliable, and satisfy stakeholders' business needs. This will include identification of NAS sites to conduct evaluations of new processes and capabilities in practical real-world conditions. Another focus will be on deployment of developed capabilities on FAA IT infrastructure to ensure they are available for stakeholder use to support business processes.

In addition, the scope of the concept has expanded to encompass optimization of airspace services, with IFPs representing one type of airspace service; others potentially include services associated with airspace classification, new entrant services, etc. This part of the research will encompass identification of relevant services, connection with FAA review processes, and opportunities to leverage data and capabilities.

FY23–25 LOOK-AHEAD: The Optimization of the IFP Inventory initiative is planned to be a multi-year process providing ongoing benefits to the NAS. In the FY23–25 timeframe it is expected that the IFP retirement analytics will be operationally deployed and incorporated into the IFP production process. In addition, a recurring review of NAS operational needs and revision of IFP retirement criteria will be introduced to enable sustainment of the optimization concept. Incorporation of automated IFP optimization and repair suggestions into IFP maintenance processes will further reduce the workload of specialists.

Metrics will also be available to enable the FAA to monitor progress toward achieving strategic goals as well as provide automated identification of further opportunities to streamline the IFP production process. Additionally, as the operational requirements for airspace optimization emerge, development and integration of additional capabilities to support those activities will facilitate

broader efficiency improvements.

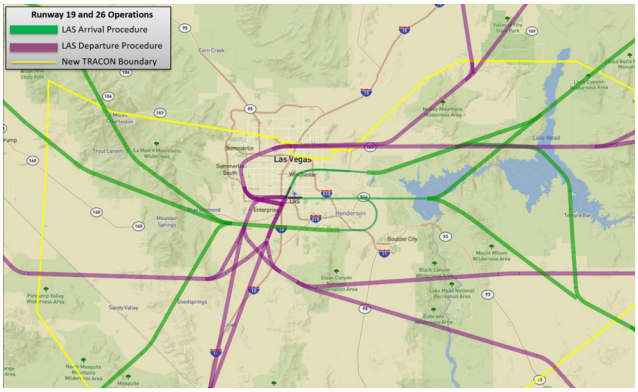
Metroplex and Procedure Design

The Metroplex program is the FAA's NextGen initiative to implement PBN procedures and redesign the complex airspace surrounding major metropolitan areas.

The overall goal is to improve operational efficiencies around the nation's busiest airports by reducing reliance on aging, ground-based navigation infrastructure and leveraging modernized capabilities (e.g., Data Communications [DataComm], iTBO, ADS-B, etc.) that are no longer dependent upon legacy communication, surveillance, or automation systems.

By transitioning the NAS to PBN operations and enabling optimal integration of airspace, procedures, and automation, the FAA is providing more efficient and more predictable flight paths, reducing pilot/controller communications, and reducing maintenance and infrastructure costs. CAASD has fulfilled many roles with the FAA since the Metroplex program's inception. These include characterizing operational issues, providing subject matter expertise on proposed design concepts, conducting both fast-time and real-time ATC simulations, and performing aviation data analyses (including detailed post-implementation analyses) to assess implementation impacts. Further, CAASD worked with the FAA to develop processes to engage communities and educate them on the impacts of Metroplex-related flight path changes.

FY21 ACCOMPLISHMENTS: In February 2021, CAASD partnered with the FAA to implement the Las Vegas Metroplex project, the 10th Metroplex project completed. The project was particularly challenging due to the close proximity of mountainous terrain and



Special Activity Airspace, which limits where aircraft can fly and constrains traffic flows. CAASD partnered with the FAA to implement new arrival and departure procedures for Las Vegas McCarran International Airport, as well as for nearby satellite airports, including Henderson Executive Airport. CAASD's post-implementation analysis indicated that aircraft operators are saving 1 to 1.5 million gallons of fuel per year flying the new procedures, which equates to 2.7 to 4.3 million dollars. Post-implementation analyses and procedure amendment activities were completed, and the project was closed out in September 2021.

In parallel, CAASD and the FAA conducted a phased implementation of South/Central Florida Metroplex procedures in April and August 2021. This was the 11th and final Metroplex site implementation, and it was unique in that it was the only Metroplex site that included four Core 30 airports. Due to concerns over expanding environmental review and community engagement requirements, as well as associated schedule, budget, and resource implications, the project was rescoped in 2017 to reduce the number of low-altitude changes. As a result, instead of fuel savings, the project focused on deconflicting operations, improving departure throughput, reducing reliance on ground-based navigation, improving En Route connectivity, and addressing community noise concerns. Airspace complexity and flow dependencies necessitated tradeoffs to capture these benefits, resulting in longer flight paths to provide

deconfliction and address community noise concerns, as well as fewer opportunities to reduce and remove level segments. As a result of these tradeoffs, CAASD's analysis predicted the project may increase fuel burn by 1.3 million gallons annually, or 3.8 million dollars.

FY22 PLANS: In FY22, CAASD will conduct the Florida post-implementation analyses and work with the FAA to close out the project. Since the FAA will sunset the Metroplex program at the end of FY22, CAASD is working to ensure the program leaves an enduring legacy of best practices and lessons learned that can be used to accelerate and streamline future airspace modernization activities. CAASD will estimate programmatic costs and benefits, document programmatic best practices and lessons learned, and compile an archived compendium of authoritative information on the program and the 11 completed projects. While CAASD has yet to conduct post-implementation analyses for Florida, preliminary estimates suggest that the 10 metroplexes completed to date save airspace users 41 million dollars in fuel costs annually. That's good for the environment, too, since less fuel means reduced carbon dioxide emissions. So far, the Metroplex program has reduced those emissions by 123,000 metric tons per year.

FY23–25 LOOK-AHEAD: The Metroplex program will be completed by the end of FY22, but the FAA is planning additional airspace modernization activities across the NAS in accordance with the Airspace Modernization Roadmap, which CAASD is currently helping the FAA develop. CAASD's lessons learned and best practices from Metroplex design and implementation, knowledge of airspace and procedure integration considerations, understanding of TFM and NAS systems, and expertise in new entrants and NextGen capabilities will enable the FAA to continue to implement beneficial airspace infrastructure

improvements across the NAS over the coming years.

Northeast Corridor (NEC) Airspace and Procedures Analysis & Strategic Planning

The airspace in the Northeast Corridor (NEC) between Washington, D.C. and Boston remains the most complex and congested in the country. As a result, the FAA and the NextGen Advisory Committee prioritized implementation of new capabilities and new airspace and procedure designs to improve operations and increase efficiency within the NEC.

Beyond 2021, the FAA will continue to introduce new capabilities and implement airspace and procedures enhancements to achieve iTBO objectives and address existing and emerging operational shortfalls in the NEC.

CAASD has partnered with the FAA in its efforts to modernize this complex airspace. CAASD's work involves conducting strategic planning and systems engineering activities to assess the feasibility, risks, and benefits of proposed changes as well as developing conceptual designs and evaluating their environmental impacts through modeling and simulation.

FY21 ACCOMPLISHMENTS: In FY21, CAASD worked closely with the FAA on specific NEC-related activities to deliver on existing commitments. While there were some delays due to COVID, CAASD's system engineering activities continued to advance the phased implementation of the Eastern Seaboard High Altitude PBN Routes, a critical activity to shift the NEC high-altitude route structure from ground-based to satellite-based navigation. CAASD also developed and leveraged a scheduling methodology to conduct

strategic planning activities to help the FAA make data-driven decisions regarding the waterfall of route modification activities needed to support the Very High Frequency Omnidirectional Range Minimum Operational Network (VOR MON).

CAASD also partnered with the FAA to initiate the development of a strategic plan for airspace modernization activities in the NEC, with a focus on the New York metropolitan area. CAASD identified operational shortfalls in the New York airspace and developed conceptual designs to address those shortfalls by mapping enablers (e.g., MARS) to specific applications and solutions. CAASD estimated the potential benefits of the conceptual designs, developed an initial timeline and process for New York airspace modernization activities, and conducted noise screening analyses to ensure planned improvements would not result in significant environmental impacts. Based on CAASD's initial analysis, it is expected that New York airspace modernization activities could result in over 50 million dollars in annual benefit.

FY22 PLANS: In FY22, the FAA and CAASD will continue to advance the design and implementation of airspace and procedure solutions in New York and the NEC. CAASD will continue to support the implementation of the Eastern Seaboard High Altitude PBN Routes, with full implementation anticipated by the end of 2022. CAASD will also continue to conduct analyses and strategic planning activities to help the FAA make data-driven decisions regarding the waterfall of route modification activities needed to support the VOR MON.

For the New York metropolitan area, CAASD will continue the up-front work to prepare for a future New York airspace modernization effort. CAASD will validate and refine the conceptual design developed in FY21 and will develop a comprehensive plan including refined cost/benefit estimates and timelines. CAASD will also continue the preparatory analysis for advanced concepts such as MARS to ensure a complete understanding of the potential operational requirements for deploying the proposed separation

standard. The goal of this work will be to have a clearly articulated plan and FAA buy-in on a path forward to address operational shortfalls in this highly congested and complex airspace.

FY23–25 LOOK-AHEAD: Going forward, it is envisioned that CAASD will continue to partner with the FAA to meet NEC commitments; develop environmental, community engagement, and design and implementation strategies; implement beneficial airspace and procedure solutions; and evolve NEC operations to iTBO and beyond. This is particularly challenging because of the density and complexity of the airspace, the close proximity of the airports, and the multiple ATC facilities involved. To progress toward the mid-term visions, it is envisioned that CAASD will leverage its knowledge of emerging NextGen capabilities and the work on the mid-term conceptual design to plan and execute an airspace modernization project. The project will consider lessons learned from airspace, procedure, and automation implementation activities in major metropolitan areas across the NAS. Through this work, CAASD will also help the FAA operationalize and institutionalize the use of benefits-enabling technologies that are foundational for transitioning New York to TBO.

OUTCOME 04

SAFETY AND TRAINING

FAA Outcome Manager: Mr. Scott LeMay and Mr. Joe Bello

CAASD Outcome Leader: Wally Feerrar

Outcome Statement: An improved NAS system safety environment that:

- Implements safety standards for operations, airport and airspace design features, and infrastructure.
- Institutes safety assurance processes as an integral part of normal operations.
- Utilizes metrics to proactively detect issues prior to incidents or accidents.
- Leverages the collaboration of operational experts across the agency and research into technologies and capabilities to improve safety.
- Improves the delivery, quality, flexibility, and standardization of controller training, reduces the training time and costs to certify a controller, and facilitates a more effective operational transition of NextGen solutions.

Highlighted Accomplishments

Uniform Safety Continuum

The FAA has long recognized the existence of different public expectations for safety assurance across the range of aviation products and services, or sectors. Accordingly, the agency applies different levels of oversight rigor to sectors consistent with these expectations. This concept is rooted in law, as Title 49 of the U.S. Code of Federal Regulations (CFR) directs the FAA to apply the highest standard of safety to air carrier operations, and tailor oversight to the characteristics of other sectors. Currently, however, FAA organizations do not operate with a shared understanding of this Safety Continuum to align their oversight efforts with the public's expectations. This situation undermines the system perspective and collaboration needed to ensure the implementation of an optimal mix of safety controls for a given sector.

FY21 ACCOMPLISHMENTS: CAASD continued to partner with the FAA's Office of Safety (AVS) to develop a Uniform Safety Continuum framework that will foster alignment across the office's safety oversight activities. The framework identified a set of distinct aviation sectors based on characteristics believed to drive public expectations for safety. CAASD conducted workshops with FAA subject matter experts to develop these sectors and drafted guidance for using them with the Uniform Safety Continuum. In addition, CAASD provided guidance on Safety Continuum principles to an FAA rulemaking team. The FAA Modernization of Special Airworthiness Certificates (MOSAIC) team leveraged this guidance to refine the set of proposed rule changes, demonstrating the value of the Uniform Safety Continuum as an oversight alignment framework.

FY22 PLANS: CAASD will work with FAA subject matter experts to extend the framework to systematically characterize sector safety risks and inform sector-specific risk management strategies. This will result in a comprehensive tool that will serve as a common reference for setting sector safety objectives and coordinating oversight accordingly across impacted AVS services and offices. This work will support the drafting of an AVS Order establishing the Uniform Safety Continuum as policy, in partnership with the AVS Safety Initiative team charged with developing the framework.

FY23–25 LOOK-AHEAD: The publication of a Uniform Safety Continuum order will represent a significant milestone toward FAA's vision of a system approach to safety oversight. Looking ahead, CAASD will help the FAA socialize, refine, and implement the framework within and across the agency.

Aviation Risk Identification and Assessment (ARIA)

The CAASD-developed Aviation Risk Identification and Assessment (ARIA) capability has begun to revolutionize the way the FAA identifies, evaluates, and learns from aviation safety event. ARIA automatically analyzes surveillance data for the entire U.S. airspace in near-real time, identifying aviation events that pose a safety concern.

ARIA then prioritizes these events for deeper investigation. ARIA provides risk-index information to support ATO's risk-based safety management approach, in alignment with the Administrator's Risk-Based Decision Making (RBDM) strategic initiative. ARIA data encourages a more positive safety culture, enabling aggregate analysis where system- or design-level flaws can be identified and mitigated.

FY21 ACCOMPLISHMENTS: CAASD continued to make enhancements to the ARIA platform within EIM to increase operational reliability and stability, and to migrate new EIM data services to enrich the ARIA data. In addition to these enhancements, CAASD developed operations documentation for the Surface and Airborne ARIA modules as part of the technical transition of the full production and maintenance of ARIA to the FAA.

CAASD also explored a range of applications of ARIA data to enhance the Safety and Technical Training (AJI) office's risk-based safety management needs, to include:

- Research to understand the implications of operational decision making on safety, as well as a prototype capability for identifying causal relationships.

- Methodologies for integrating ARIA data with equipment outage reports to identify when outages contributed to reduce safety barrier effectiveness.
- Initial development of a collaborative research enclave for understanding interrelationships of ARIA and other data sources.
- Experiments designed to assess the feasibility of using past ARIA data to predict future ARIA event patterns.

FY22 PLANS: CAASD will continue to support the technical transition of Airborne and Surface ARIA modules to the FAA within EIM. CAASD will also develop and prepare for the implementation of a third ARIA module related to Controlled Flight into Terrain (CFIT). Additionally, CAASD will continue research into utilizing ARIA data to evaluate safety barriers, leveraging information from prior similar ARIA encounters to inform the assessments of future risks, and understanding the implications of operational decision making on safety risks.

FY23–25 LOOK-AHEAD: CAASD will continue to explore how to accelerate the utilization of ARIA and associated data to inform ATO's risk-based safety management requirements through the development of additional ARIA modules to characterize total potential risk within an airspace; fast-time decision support capabilities that span safety and operational trade-space; and barrier analysis assessment.

Safety Information Sharing / ASIAS: Integrated Safety Teams and Governance

To advance the mission of the Aviation Safety Information Analysis and Sharing (ASIAS) program—to lead in cutting-edge aviation safety analysis, to proactively identify hazards, and to inform safety improvements across the aviation industry—it will be critical to engage new partners. This may include new operators, private pilots, university researchers and academia, private technology companies, global entities, and others. The future success of ASIAS is dependent on continued outreach and expanded engagement with the broader safety community and new entrants to aviation.

ASIAS conducts analysis as requested by ASIAS partners, the FAA, safety teams, and other aviation safety teams, leveraging massive volumes of proprietary data. A significant activity for the ASIAS program moving forward is to manage the data governance policies to protect all stakeholders and optimize data access. The governance model and adherence to data-protection agreements must ensure that the ASIAS program continues as a trusted partner to aviation industry groups and international stakeholders.

FY21 ACCOMPLISHMENTS: In November 2020, the ASIAS Executive Board (AEB) approved use of the Third-Party Cooperative Agreement (TPCA) as an additional strategy for performing targeted outreach to operators who have active data collection programs. Through the agreement, a third-party data vendor can solicit ASIAS program participation among its current customers as an advocate, in turn expanding the program's outreach mechanisms. The TPCA will have an immediate impact on the growth of the GA ASIAS community, specifically by allowing participation by smaller GA operators who may not necessarily have large safety programs.

The ASIAS program expanded its participation by including the rotorcraft community. The Rotorcraft Issue Analysis Team (R-IAT), established in May 2020 and consisting of members from government and industry, drafted the Rotorcraft Procedures and Operations (P&O) governance document, which provides technical process and community protocol guidance for executing the program. The AEB approved the draft Rotorcraft P&O in December 2020, authorizing establishing the community within the program. The Rotorcraft P&O document largely aligns the GA P&O, with the largest change being enabling multiple ASIAS Operational Support Entities (OSE).

Due to the diverse nature of the industry, the rotorcraft ASIAS program will ingest data from many different sources, including data facilitated by the WJHTC and through various trusted third parties. This ingest of data will be performed in coordination with the future rotorcraft data architecture environment, the Rotorcraft ASIAS Integrated Services Environment (RAISE). For the commercial and GA communities, CAASD is the OSE and is part of the tri-chaired leadership with industry and government. Rotorcraft entry into the ASIAS program will engage with multiple OSEs and as a result, the R-IAT leadership will only be co-chaired by government and industry. On the R-IAT, OSEs will serve as technical advisors working closely with the government and industry chairs.

In 2020, due to the impacts of the COVID-19 pandemic, the two scheduled Aviation Safety InfoShare conferences were cancelled. To compensate, on November 18, 2020, ASIAS hosted an online meeting for all commercial and GA fixed-wing stakeholders. Stakeholders participated in presentations and

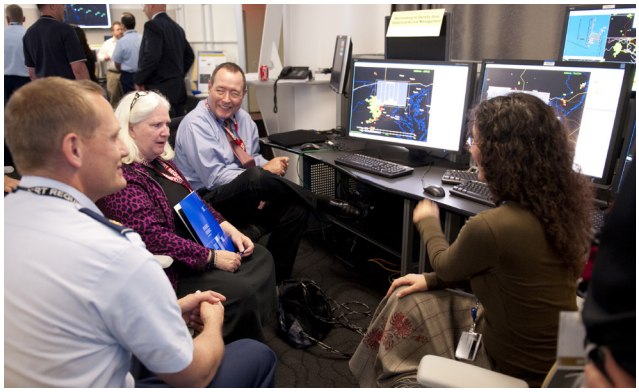
interactive discussion sessions to learn and share about current aviation safety issues. Other ASIAS communities, including rotorcraft and light GA, will discuss planning a similar type of engagement specific to their operations at their respective IATs. Going forward, it is expected this type of online engagement will continue as necessary, providing transparency to the program, training, and collaboration opportunities to stakeholders. In total, 112 attendees from 62 different stakeholder organizations attended the online meeting. The stakeholder organizations included 30 different business aviation operators, 21 Part 121 operators, 7 industry organizations, and 4 manufacturers.

FY22 PLANS: In FY22, ASIAS plans to work with the data vendors who sign the new TPCA, developing a strategy for outreach to their customers. In addition, ASIAS will ingest rotorcraft digital flight data into the cloud-based architecture known as RAISE. The rapid provisioning of compute resources in this environment will enable multiple OSEs to ingest the data, process it, and perform analysis. The RAISE architecture is a model of the next-generation system.

FY23–25 LOOK-AHEAD: ASIAS seeks to collaborate with fleet owners in government and military organizations. In addition, ASIAS aims to provide safety information and analysis related to international operations and supporting the FAA, global organizations, commercial operators, and others. ASIAS will explore governance models to support analysis and share relevant safety intelligence with the global aviation community to identify and inform the mitigation of safety hazards.

Safety Management System (SMS) Training

A Safety Management System (SMS) is a proactive management system that has the capability to expand levels of operational safety well beyond regulatory minimums by treating safety as a core business enterprise. The International Civil Aviation Organization (ICAO) requires SMS for all safety service providers. CAASD offers an SMS course several times a year, which provides participants with a solid foundation in basic SMS concepts. It is consistently booked to capacity. In FY21, CAASD conducted seven training sessions, all virtual, with a total of 188 students.



Safety Information Sharing / ASIAS: Advancing AI/ML Capabilities

ASIAS leverages advanced analytical capabilities to identify and assess safety-related vulnerabilities. ASIAS will integrate predictive analytics into its processes, using new and historical data to forecast hazardous activity, behavior, and trends. Predictive analytics use historical data and observations to anticipate the likelihood of future outcomes. Predictive analytics are not meant to predict the future, but rather to forecast what might happen in the future, because all predictive analytics are probabilistic in nature.

Advanced processes will apply statistical analysis, advanced query capabilities, and ML algorithms to data to understand the likelihood of certain occurrences. Risk identification capabilities will improve as ASIAS leverages advanced methods to identify complex patterns within the data. AI technologies supporting predictive analytics will be incorporated for studies, and enhanced text-mining techniques will increase the efficiency of the vulnerability discovery process.

FY21 ACCOMPLISHMENTS: ASIAS leveraged and unsupervised an ML technique called Mallet Latent Dirichlet Allocation topic modeling to determine what safety topics were being reported in a subset of uncategorized pilot Aviation Safety Action Program (ASAP) reports. CAASD identified 23 different topics that were commonly reported in the pilot ASAP reports, including but not limited to medical emergencies, fatigue, smoke and fume events, and dispatch paperwork. In addition to the identification of 23 safety topics that are not currently being tracked by ASAP metrics, topic modeling also provides benefit to the ASIAS program by identifying emerging safety topics and detecting when language is changing. By running topic modeling at periodic intervals, the ASIAS program can monitor if any new clusters of events are emerging. These new clusters could represent a new type of safety event being reported or a change in the way an existing event is being described in report narratives.

The ASIAS program is applying human-machine teaming to mine insights from all safety reporting data, rather than limiting itself to the subset of reports that can be vetted by analysts. For example, in the vulnerability discovery process, the output of the emerging terms/reports tool is used to direct the attention of subject matter experts to a subset of reports identified by an ML algorithm as containing new and emerging safety issues.

The ASIAS program monitors approach and landing accident risk by monitoring the unstable approach metric calculated from participants' Flight Operations Quality Assurance (FOQA) data. ASIAS leveraged fusion data to correlate unstable approaches to energy "signatures" on approach. Flights' energy on approach was calculated from surveillance data sources. These energy trajectories were then clustered into eight common signatures. By leveraging ASIAS fusion data, CAASD was able to identify two clusters that contained high rates of unstable approaches. By monitoring the percentage of arrivals to an airport that fall into these clusters, ASIAS can monitor unstable approach risk at airports without FOQA coverage. CAASD tested this by examining 20 airports that have poor FOQA coverage in the ASIAS program. The results identified a period of time at DeKalb-Peachtree Airport (KPDK) where 40 percent of arrivals had an energy signature associated with unstable approaches. When analyzing those results, CAASD discovered that a large construction process to install an Engineered Material Arresting System (EMAS) on the main runway was occurring at that time, disabling the localizer and shortening the landing distance available. This construction resulted in more flights using

a secondary runway, with higher overall energy and a shorter final approach—all things that are associated with an increase in approach risk.

These results demonstrate that monitoring energy signatures at airports can be used as a proxy for FOQA-based unstable approach metrics for airports where FOQA coverage is sparse. This allows the ASIAS program to better monitor smaller airports with large amounts of corporate jet travel or international traffic where monitoring with FOQA data is difficult or impossible. Furthermore, monitoring the changes in energy signatures calculated from surveillance data allows the ASIAS program to detect changes much more quickly than FOQA data would allow.

FY22 PLANS: In FY22, ASIAS will work to operationalize AI/ML capabilities to operate on ASIAS data and in the vulnerability discovery process and ASIAS studies to identify and detect emerging trends in safety.

FY23–25 LOOK-AHEAD: The ASIAS program will continue to operationalize AI/ML capabilities and improve existing capabilities to ensure that ASIAS models keep up with operational changes and reduce the cost of developing and applying AI/ML models for new safety concepts, new entrants, and new data sets. ASIAS will also utilize the data and gap analysis conducted over the last few years to shape new capabilities and integrate MITRE/CAASD-sponsored research. ASIAS will seek to build capabilities to ensure that analysts can apply the full breadth of analytical techniques for vulnerability discovery, directed studies, quick-look studies, and SIRs.

Safety Information Sharing / ASIAS: Proactive Monitoring and Vulnerability Discovery

ASIAS is constantly in demand to conduct a wide variety of analyses on many types of aviation safety issues. These may include quick-look studies for an initial investigation of emerging safety issues, or formal directed studies undertaken to dive deeply into systemic issues and gain insights into underlying contributing factors.

ASIAS also produces sophisticated dashboard metrics to monitor safety trends, detect safety issues, and assess the effectiveness of implemented Safety Enhancements (SE) and benchmarks that allow airlines to compare their operations against aggregate data. ASIAS monitors Commercial Aviation Safety Team (CAST) SEs, mitigation efforts, and other known aviation hazards by measuring and analyzing data to determine significant systemic risk.

FY21 ACCOMPLISHMENTS: ASIAS continues to create, maintain, and enhance ASIAS Benchmarks to support the ASIAS airline stakeholders that provide proprietary data to the ASIAS program. Individual ASIAS participants have the capability to trend their own data, but the ASIAS Benchmarks enable individual ASIAS airlines to quantitatively baseline their performance to the nationally aggregated benchmarks, which helps them prioritize internal safety initiatives. In FY21, at the stakeholders' request, additional features were added to the CAST Metrics Overview workbook. Additional metrics (overbanks and stall

warnings) were added for reviewing airplane state awareness. Using ICAO State Safety Programme (SSP) Safety Performance Indicators as a standard guideline, the data is shown in a manner that allows a user to easily compare the previous year's performance to the current year. A new GA Metrics Overview workbook was published to mirror the changes made available to the CAST community.

In FY21, the vulnerability discovery team focused on the efficiency and thoroughness of the vulnerability discovery process. The goal was to move toward identifying and vetting vulnerabilities faster and adopting a workflow that captured in detail the day-to-day operations. The team used an agile issue tracking and program management capability (Jira) to specifically track each vulnerability. Each week, vulnerabilities are assigned, vetted, and reviewed by an internal panel, checked for data availability, and posted to the ASIAS Portal. In addition, vulnerability discovery also introduced the IAT Vulnerability Discovery Working Group (VDWG), increasing transparency and sharing of vulnerabilities with the IAT for review and prioritization for studies. The IAT working group meets bi-weekly to ensure that the most important and safety-relevant vulnerabilities can move efficiently to a study. Overall, the improvements to the system ensured all vulnerabilities in the system were reviewed; 60 vulnerabilities were removed from the queue in the first two months of implementation. In addition, the vulnerability discovery process reviewed 104 vulnerabilities in eight months.

FY22 PLANS: ASIAS will continue working on methodologies, models, and processes to identify safety hazards and efforts to prioritize them for further analysis.

FY23–25 LOOK-AHEAD: In ASIAS, continuous automated monitoring includes the processes and technology that detect safety issues in the operational aviation environment, using advanced automation. While ASIAS will continue to rely on subject matter experts to provide context and judgement for studies, development activities will embrace automation to decrease analysts' reliance on manual processes. Continuous monitoring of ASIAS data will offer insight into the effectiveness of safety controls over time, helping to determine whether mitigation activities should be adjusted or replaced. ASIAS will continue to expand the data sets and safety concepts for continuous monitoring and automatically add more context to potential anomalies using the latest AI/ML techniques.

Speech Recognition Technology

Air traffic controllers and pilots use radio voice communications to exchange important information, such as clearances, pilot requests, and information for situation awareness. As a result, these controller-pilot voice communications contain information about what happens in the NAS and often provide the best data source regarding why something happened.

To automatically process and understand controller-pilot voice communications, the FAA and CAASD have developed and use technologies based on AI and ML. These technologies, which include automatic speech recognition using deep neural networks, can be used both in real-time applications and post-operations analysis capabilities to improve safety and efficiency in the NAS.

FY21 ACCOMPLISHMENTS: CAASD leveraged its existing ATC speech recognition and understanding capabilities as part of the development of a prototype demonstration of an ATC student performance assessment capability. This prototype demonstrates the concept of using automatic operational data analysis to meet the FAA's need to increase objective measurement of ATC training effectiveness.

CAASD produced a prototype to demonstrate how voice data, ARIA safety risk index data, and technical operations outage information could be fused

together to enable more efficient review of events to identify systemic risks in the NAS.

CAASD applied speech data analysis to support Air Traffic Services (AJT) in facilitating discussions between the Denver Terminal Radar Approach Control Facility (TRACON) and ARTCC about how arrival runway transition assignments are handled, providing information that can only be obtained from voice communications, such as the time at which the runway transition was issued.

CAASD applied ML technology to identify and automatically extract pilot reports of weather information. Applying this capability on one year of historical voice data demonstrated an order of magnitude increase in the number of pilot reports that can be captured automatically compared to the number currently captured in the NAS, which in turn provides a richer data set of weather information for improved safety and effective flight planning.

FY22 PLANS: CAASD has begun to work with AJI and the EIM team to stand up voice data processing capabilities within the FAA's EIM cloud environment to lay the foundation for timely access to safety intelligence information and to make better use of voice data within the FAA's business processes, such as by providing voice transcripts to quality assurance specialists to improve their productivity in analyzing the NAS for systemic safety risks.

CAASD is planning to test a similar capability at the FAA Training Academy in FY22 to inform requirements for the ATC student performance assessment capability.

CAASD is continuing to work with AJI Runway Safety to conduct a test demonstration of a real-time system to detect wrong-surface arrivals in progress. This testing was planned for FY21 but was delayed due to the COVID-19 pandemic and the FAA's approval processes.

FY23–25 LOOK-AHEAD: CAASD will continue to research and develop speech data analysis capability improvements to increase the ways in which voice information can be leveraged to inform safety and operational decision-making. This includes developing advanced ML capabilities to identify and monitor safety risks in the NAS, as well as exploring how speech recognition can inform TFM decision making. In addition, CAASD will continue to work with the FAA to establish speech data analysis capabilities in the FAA's infrastructure to enable the FAA to leverage these analysis capabilities internally. This collaboration includes developing an efficient process for transferring newly developed improvements from CAASD to the FAA.

Digital Copilot

Digital Copilot is a cognitive assistant research prototype designed to improve the safety of flight through real-time processing of the information available in the cockpit, inferring intent, and providing timely feedback in the form of notifications and alerts directly to the pilot.

To date, approximately 50 assistive technologies, aimed at both fixed-wing and rotorcraft operations, have been developed, tested, and made available to industry via MITRE's Technology Transfer process. The research prototype has also been used to accelerate the development of technologies for various sponsors across the FAA, including taxi conformance monitoring, required time of arrival for GA, and simplified pilot report generation and transmission.

FY21 ACCOMPLISHMENTS: Safety-enhancing algorithms and flight deck notifications were developed for several application areas. These included the incorporation of new weather data sources, new weather-related insights and pilot notifications, awareness of additional airspace users, depiction and notification of relevant Notices to Airmen (NOTAM), and several flight performance notifications. Continued technology transfer efforts led to multiple features being released in commercially available electronic flight bag apps for pilots. A significant effort to extend the Digital Copilot to rotorcraft operations resulted in five new safety features, along with two methods for inferring the rotorcraft's phase of flight. Testing of the algorithms and features was accomplished in both simulators and Robinson R44 helicopters. The testing provided data that was subsequently used to tune the algorithms for usability.

FY22 PLANS: In FY22, CAASD will continue the development, testing, and refinement of safety-enhancing algorithms in support of ongoing technology transfer efforts, which will result in more features being available to pilots. CAASD will also work closely with industry groups such as the U.S. Helicopter Safety Team to identify and prioritize new algorithms for development and to identify potential technology transfer partners who could commercialize the features. Further, CAAS will continue simulation and in-flight testing of features.

FY23–25 LOOK-AHEAD: In future years, CAASD will continue to research and prototype newly identified safety features. CAASD will work closely with existing and new industry partners to create an ongoing technology transfer pipeline. CAASD plans to realize further safety improvements among flight operations due to Digital Copilot-developed algorithms and concepts. CAASD also plans to expand into commercial flight operations, both single-pilot and crew-based, as well as UAS. Additionally, CAASD will investigate potential non-aviation domains where a cognitive assistant may improve operational safety.

Air Traffic Control Training Performance Assessment

Accurate and objective performance assessment is a critical component of effective training. The FAA has a critical need for accurate, standardized, and objective measures of operational performance to understand ATC student and workforce training needs, identify overall training effectiveness for meeting mission needs, address training content and design shortfalls, and support a learner-centered and competency-based model of training. To meet this need, CAASD is defining, developing, and testing a capability that measures ATC student performance during simulation training using operational and NAS data.

FY21 ACCOMPLISHMENTS: CAASD achieved a significant "proof of technology" milestone by developing an initial prototype capability to test and demonstrate the data collection, data assessment, and performance feedback functionality. The prototype was tested in the MITRE IDEA Lab. The test included the collection of data from a high-fidelity ATC training simulation scenario, the automated assessment of that data, and performance feedback from that assessment. The test successfully proved the initial data collection and assessment functionality and provided the foundation for the next prototype development milestone, an operational test at the FAA Academy.

FY22 PLANS: CAASD will achieve a limited operational test at the FAA Academy. The test will collect and assess data from an Academy high-fidelity training scenario being operated by ATC students and will provide assessment feedback. The test will specifically

address the logistical and technical challenges associated with moving the initial Performance Assessment Prototype from the IDEA Lab to the Academy and creating an interface between the initial prototype and the Academy training simulation system. The test will also provide an initial demonstration of the concept of use and operational benefits to FAA and NATCA stakeholders.

FY23–25 LOOK-AHEAD: CAASD will work in partnership with the FAA, NATCA, and other stakeholders to support successful operationalization of the performance assessment capability through technology transfer and risk reduction and will continue to develop and test the capability's expanded use and benefits. Expansion opportunities include development and testing at ATC field facilities, the potential to support training performance measurement in other ATC domains (e.g., Traffic Management Coordinator training), and use in developing broader training performance standards that can be used across all ATC training. This ongoing work will be instrumental in the transformation of air traffic training toward a more competency-based and learner-centered model that will support workforce needs and achievement of NAS operational objectives.

Voluntary Safety Reporting Program (VSRP) Implementation

AVS has launched a Voluntary Safety Reporting Program (VSRP) to enable AVS employees to confidentially report issues that may have a negative impact on aviation safety. The VSRP launch is part of a broader AVS strategy to improve aerospace safety through the "establishment and expansion of voluntary safety programs."

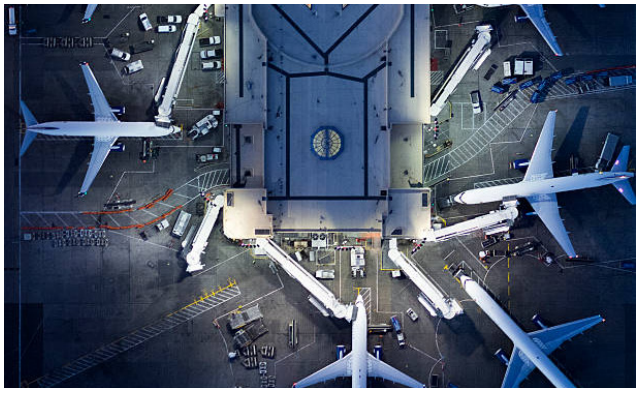
FY21 ACCOMPLISHMENTS: Since FY19, CAASD has been working closely with the FAA Office of Quality, Integration and Executive Services (AQS) to meet one of the FAA AVS Strategic Plan objectives: to develop, implement, and field an operational VSRP. On April 5, 2021, the CAASD-developed VSRP Reporting Tool went into operations. The tool is housed and maintained at the MITRE Data Center in McLean, Virginia and is available at www.avsvsrp.aero to the entire AVS employee population of 7,500+ employees. CAASD worked with AQS as well as the AVS VSRP Matrix Team to finalize the complex system and user requirements, develop training material, and conduct training in a series of workshops prior to the Reporting Tool going live. After launch, CAASD has worked with AQS and the AVS VSRP governing body to further refine the tool.

FY22 PLANS: CAASD will assist AQS in ensuring that the Reporting Tool continues to evolve per the needs of its users. Additionally, CAASD will focus on preparing the Reporting Tool for technology transfer to the FAA infrastructure by working with AQS and the Office of Information and Technology (AIT) and Information Security and Privacy Service (AIS).

FY23–25 LOOK-AHEAD: In future years, CAASD will finalize technology transfer of the Reporting Tool to the FAA infrastructure.

Enterprise Safety Assessment

Over the past several years, the aerospace industry has experienced challenges that require increased attention to safety. These challenges include increased demand from new types of operations, higher levels of automation and shifting roles of human operators, greater scrutiny on government regulators to provide safety oversight of industry activities, and uncertainty resulting from the pandemic. These changes, among others, are expected to continue in the future.



The FAA is evolving safety management practices to foster increased collaboration among global stakeholders and to enable data-driven, risk-based, and system-level decision-making to be able to address these emerging challenges. In support of this evolution, the FAA asked CAASD to assess how the FAA currently manages safety and to identify opportunities to enhance safety.

FY21 ACCOMPLISHMENTS: In FY21, the FAA and CAASD agreed on two phases of effort: (1) to collect and synthesize information about safety initiatives and (2) to assess gaps and opportunities to enhance safety. CAASD performed an in-depth assessment involving interviews, research, and analysis. This effort examined the FAA's activities supporting domestic operations, foreign operations of U.S. manufactured aircraft, and foreign operations of U.S. operators. CAASD engaged an FAA Steering Committee composed of representatives from several FAA lines of business and staff offices to refine the scope, organize the interviews, evaluate findings, and coordinate recommendations from this work. As a part of this work, CAASD:

- Collected and synthesized information about more than 400 safety initiatives by developing an As-Is Safety Roadmap, which was delivered to the FAA in June 2021. The roadmap provided a synthesis of the FAA's safety vision and strategies, captured FAA perspectives on challenges and opportunities for realizing the safety vision, and identified current safety initiatives and their relationships.
- Conducted an independent assessment of gaps and opportunities for the FAA to improve aerospace safety by examining enterprise-level alignment between FAA's safety initiatives currently underway in FY21 and FAA's vision and strategies for evolving safety as documented in the As-Is Safety Roadmap.
- Developed recommendations to foster cross-FAA-line-of-business engagement on defining a system safety approach, refining existing strategies and initiatives, and mapping out the implementation and coordination with external stakeholders.

FY22 PLANS: In FY22, CAASD will continue discussions with multiple FAA organizations to build on and address assessment findings from FY21. CAASD will engage with FAA leadership and facilitate focus groups to inform FAA's Flight Plan 21 Safety Pillar and develop policy and technical solutions to address the identified gaps and opportunities

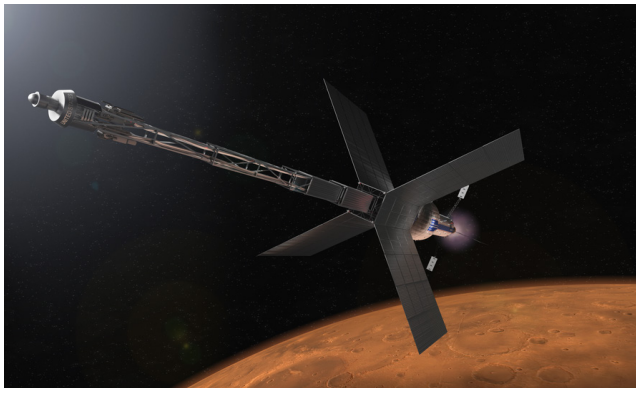
FY23–25 LOOK-AHEAD: In planning.

Streamline Commercial Space Nuclear Fission Reactors Safety Analysis

In August 2019, long-standing U.S. policy was revised, permitting commercial use of Space Nuclear Systems (SNS) for the first time. The Secretary of Transportation was tasked with providing guidance to industry on the licensing approval process for the launch and reentry of commercial SNS. CAASD was subsequently tasked with preparing a report on the public safety concerns of commercial fission reactors in space and developing guidance on the licensing process and safety analysis for commercial SNS.

Through three rounds of work, CAASD performed in-depth studies on the public safety implications of commercial SNS, performed deep-dive analysis on the risk of collision in Earth orbit and cybersecurity concerns of SNS, and created streamlined guidance applicable to all parties interested in launch, utilization, or reentry of SNS under the new streamlined licensing rule, 14 CFR Part 450. CAASD also provided recommendations to the FAA on how to ensure applicants are navigating the complex national and international treaties, laws, regulations, and policies that surround both spacecraft and nuclear technology.

In performing this analysis, CAASD developed the Probability of Conjunction, a new statistical method for predicting the operational impacts of future space congestion. We developed a tool to perform the calculations and have released it on the GitHub to provide free access to the interested public. Through a presentation at the 2021 American Institute of Aeronautics and Astronautics' (AIAA) ASCEND conference,



CAASD publicly shared both the method and the tool, providing a lasting benefit to future space mission planners.

FY21 ACCOMPLISHMENTS: In FY21, CAASD delivered four technical reports detailing public safety concerns, guidelines, and regulatory analysis for SNS.

CAASD also developed a new approach for predicting the operational impacts of future orbital congestion (the Probability of Conjunction) and created a streamlined launch licensing approach that is adaptable and scalable to every type of SNS.

FY22 PLANS:

- Provide technical support to the FAA as the combined nuclear guidance goes through an abbreviated interagency review period.
- Assist the FAA in obtaining final approval from the Secretary of Transportation to publish the combined SNS guidance.

FY23–25 LOOK-AHEAD: N/A. This work will conclude in FY22.

Independent Study on Type Certification Reform

The Aircraft Certification, Safety, and Accountability Act of 2021 (ACSAA), Sec. 136, directed the FAA to contract with an appropriate FFRDC to conduct analyses, make assessments, and provide recommendations regarding the two proposals within Section 136 to reform the type certification process for transport category aircraft. The FAA selected CAASD. Section 136 also requires that the analysis consider the investigations resulting from the 737 Max accidents.

FY21 ACCOMPLISHMENTS: CAASD conducted a review of reports, regulations, policies, and studies as required by the Congressional language, followed by a focused analysis of reports relating to Boeing 737 Max certification issues to assess any relationship between the conclusions of the investigations and the proposed changes to the certification process.

A key concern motivating this study is that there is a regulatory gap between the most current 14 CFR Part 25 Airworthiness Standards and the actual certification basis when issuing amended type certificates for derivative aircraft. To assess this gap, CAASD categorized all Part 25 standards and amendments to identify and evaluate each gap's impact on safety. CAASD focused its evaluation on Boeing 737, Airbus A320, and Bombardier's Challenger/CRJ series.

FY22 PLANS: For FY22, CAASD will identify instances where aircraft were certified to an airworthiness standard amendment other than the latest and determine whether that may have contributed to accidents or the issuance of new Airworthiness Directives (AD). CAASD will also conduct subject matter expert interviews across the aviation industry as well as with key experts within the FAA. Based on analysis of the data and the results of the interviews, CAASD will describe the safety benefits and related costs of the proposed changes.

FY23–25 LOOK-AHEAD: N/A. This independent study concludes in FY22.

Based on analysis of the data and the results of the interviews, CAASD will describe the safety benefits and related costs of the proposed changes.

Validation of Target Level of Safety

AJI tasked CAASD with evaluating the current use of the Target Level of Safety (TLS) within ATO and determine if changes are required to keep pace with the national airspace as it continues to grow and evolve in complexity and diversity.

FY21 ACCOMPLISHMENTS: CAASD delivered a comprehensive assessment of the current TLS construct and its use to guide airspace changes and integration decisions for new entrants like UAS and commercial space operations. CAASD determined that a single TLS value is no longer appropriate given the diversity of operations. Instead, CAASD proposed several changes, including a hierarchical framework with multiple levels of TLS, each separate but complementary to the others, for the purpose of providing policy guidance that connects the upper, strategic levels to the tactical, daily decision-making guidance at the lower levels of the hierarchy. Additionally, CAASD evaluated the various metrics used to measure the safety performance of the NAS and recommended an approach to conform the use of such metrics to a more standardized set of outputs such that expressions of safety performance are more logical, comparable to one another, and meaningful across the various categories of airspace users.

FY22 PLANS: CAASD is participating in an FAA effort, titled NAS Safety Performance Measures Alignment and Global Leadership, to review the various metrics used to express safety performance in the NAS, with the intent to select common performance measurements. Part of CAASD's FY21 task is directly aligned with this effort and should help to accelerate the work of this group as it matures.

FY23–25 LOOK-AHEAD: CAASD anticipates additional funding in future years to help the FAA further pursue changes to its airspace safety evaluation using standardized metrics that more clearly reflect the agency's progress toward its airspace safety improvement goals.

Acceptable Level of Risk

AJI has pursued development of procedures with the Office of Orders and Notices (AJV-P) to reduce the risk to aircraft in the event of a space vehicle launch or space capsule reentry failure that results in the potential for falling debris to collide with aircraft operating anywhere from an airport surface to En Route altitudes.

Previous CAASD analysis helped to establish the safety effects from proposed procedures in the En Route environment by using launch and reentry hotline and other, more timely data. In FY21, CAASD was tasked to determine the vulnerability of aircraft to falling debris when operating on or near the airport surface.

FY21 ACCOMPLISHMENTS: CAASD conducted technical analysis that determined the vulnerability of typical commercial transport and business jet aircraft was significantly reduced when operating on or near the surface of airports as opposed to operating at higher altitudes and speeds. This risk was quantified at various lower altitudes and speeds typical for airport operations and then briefed to the FAA. CAASD received key artifacts and guidance from the Office of Commercial Space Transportation (AST) that supported this analysis. It is expected that all of CAASD's results will be used to help develop procedures and guide future decision-making affecting the integration of commercial space operations into the national airspace.

FY22 PLANS: There are currently no plans to continue this work in FY22.

FY23–25 LOOK-AHEAD: There is currently no identified plan for this work in the out-years. It is conceivable this work will be reviewed and possibly augmented with additional analysis should procedures need to be implemented, depending on the pace and growth of commercial space launches and reentries.

UAS Risk Assessment Automated Tool

CAASD conducted a comprehensive assessment of collision risk in the NAS between unmanned and manned aircraft and delivered estimated collision rates in FY20. Additionally, Wichita State University, as part of the FAA's UAS Center of Excellence—the Alliance for System Safety of UAS through Research Excellence (ASSURE)—has delivered research results regarding the severity of such collisions. For FY21, AJI asked CAASD to compile all this information and enable electronic access to it by Safety Risk Management Panels (SRMP) charged with assessing requests for unmanned aircraft integration.

FY21 ACCOMPLISHMENTS: CAASD delivered an electronic tool, compatible with FAA laptops, to enable access to likelihood and severity of collision data between unmanned and manned aircraft for all airspace classes from surface to 60,000 feet. The tool, which the FAA named the UAS Risk Assessment Automated Tool, allows SRMPs to determine initial risk and manipulate the data, based on existing system states and proposed mitigations, to determine the final/residual risk that can be plotted on the Safety Risk Management (SRM) Hazard Table matrix. This provides much of the core analysis and results necessary to make an integration decision.

FY22 PLANS: CAASD and AJI are leveraging the experience gained from development of the UAS analysis tool to develop a version of it for use by SRMPs assessing manned aircraft safety issues and associated integration decisions.

FY23–25 LOOK-AHEAD: AJI desires both tools to be upgraded to web-based capabilities to further enhance their data access and flexibility. Additionally, both tools will require some amount of maintenance and refinement to achieve a stable version of each. Though not yet discussed, CAASD can envision a technology transfer of both tools to the FAA.

NAS Safety Performance Measures Alignment and Global Leadership

Multiple Lines of Business (LOB) within both ATO and AVS, as well as external government and private agencies, generate and report safety performance measures.

However, these measures are not always aligned or consistent. CAASD was asked to inform the agency vision for aligned safety performance metrics across the FAA by:

- Identifying what system-level safety performance measures exist, where there is alignment, why there may not be alignment, and whether misalignment is important.
- Obtaining shared knowledge of these safety measures.
- Harmonizing the methodologies used to calculate, report, and monitor safety performance by different LOBs within the FAA to ensure accuracy and consistency.

FY21 ACCOMPLISHMENTS: CAASD facilitated and participated in cross-agency discussions to understand key safety performance measures reported by individual LOBs and to develop a vision for cross-agency alignment regarding these measures. This resulted in a vision document that will be signed by FAA executives holding their organizations accountable for alignment. The vision document outlines a compelling, aspirational, yet simple and succinct description of why it's critical that the FAA become more aligned, and what that looks like.

FY22 PLANS: CAASD will refine the vision and perform a comparative assessment of cross-agency safety performance measures, developing a knowledge management capability to provide transparent and shared understanding of these measures. The goal for this work is to have clear agreement as to the safety performance measures that should be reported out across the LOBs and how they will compile the safety performance measures, and to address any barriers or disconnects that may exist.

FY23–25 LOOK-AHEAD: Beyond FY22, this project will expand toward sharing FAA's aligned approach to safety performance measurement to the global community by engaging with international organizations (e.g., ICAO and the Civil Air Navigation Services Organization).

OUTCOME 05

COMMUNICATIONS, NAVIGATION, SURVEILLANCE, AND CYBERSECURITY

FAA Outcome Manager: Mr. Malcolm Andrews

CAASD Outcome Leader: Frank Buck

Outcome Statement: Enable the FAA to take a global leadership role in aviation Communications, Navigation, Surveillance (CNS) and information system security. Provide sustainable, cost-effective, and secure information technology and CNS infrastructure through modernizing the NAS in such a way that it:

Implements safety standards for operations, airport and airspace design features, and infrastructure.

- Establishes the CNS foundation for FAA's mid-term and far-term evolution strategies and improves operational safety, efficiency, access, and capacity while enabling environmentally friendly and efficient operations.
- Reduces overall lifecycle cost for CNS and cybersecurity services.
- Provides the FAA and the aviation community with flexible, resilient, reliable communications services.
- Enables greater controller productivity and improves the overall provision of the Air Traffic Service.
- Focuses cybersecurity efforts on FAA mission assurance by promoting situational awareness, agility, resilience, recoverability, and reconstitution in the eventuality of successful cybersecurity attacks.
- Enables the transformation of the NAS by leveraging the benefits of navigation performance with surveillance, automation, and communications systems.
- Enables the FAA to deliver value-added aeronautical, weather, and flight information services to the NAS and the aviation community user base.
- Promotes CNS international harmonization and seamless global airspace interoperability.

Highlighted Accomplishments

Data Communications

Data Communications is on the cusp of fulfilling its promise as a transformational capability in the NAS. After suffering implementation delays due to COVID, the program is renewing its deployment to the remaining 17 domestic ARTCCs with a set of initial en route Controller-Pilot Data Link Communication services using Future Air Navigation Systems (FANS)-1/A. This initial implementation will be closely followed by the rollout of additional En Route services.

Building upon airspace user enthusiasm for these en route services, the FAA is exploring a set of enhanced services that support trajectory-based operations and a transition from the Aircraft Communications and Reporting System (ACARS) to the Internet Protocol Suite (IPS).

FY21 ACCOMPLISHMENTS: In FY21, CAASD's Data Communications work focused on maturing the IPS by providing leadership in the international aviation community standards development process that is developing Standards and Recommended Practices (SARPS), Minimum Operational Performance Standards (MOPS) and Minimum Aviation System Performance Standards (MASPS), providing avionics technical requirements, and conducting a Security Risk Assessment (SRA). Complementary work was also accomplished focusing on the implementation strategy for IPS in the NAS.

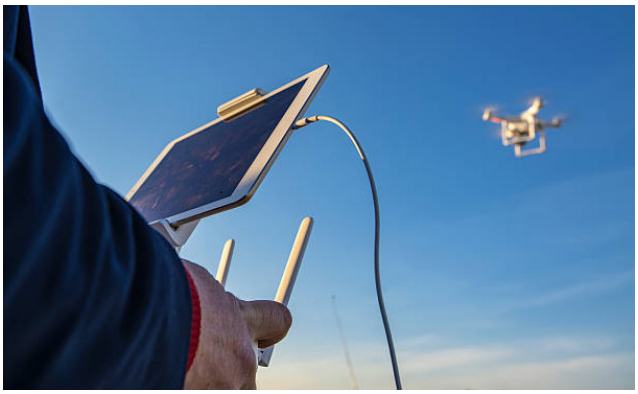
FY22 PLANS: In FY22, the IPS standards work moves toward completion of the draft SARPS, MOPS, MASPS, and SRA in FY23Q1, and the acquisition and implementation strategy matures as IPS enters the FAA's acquisition management process. Likewise, CAASD will continue to develop the enhanced FANS services, with a focus on the shortfalls in the expected operational environment and the functional definition and allocation across the Data Communications system architecture.

FY23–25 LOOK-AHEAD: In FY23, the IPS standards work moves toward approval as the implementation planning accelerates to support a CY24Q4 final investment decision by the FAA. On a parallel track, the enhanced FANS services are also headed to a CY24Q4 final investment decision. CAASD leadership in both these areas will continue to be crucial for the success of the Data Communications program.

CAASD will continue to develop the enhanced FANS services, with a focus on the shortfalls in the expected operational environment and the functional definition and allocation across the Data Communications system architecture.

Controller to UAS Pilot Voice Communications

As the FAA moves to accommodate the needs of UAS operating in controlled airspace, there is a need for remote UAS pilots, located on the ground, to communicate via voice with air traffic controllers. CAASD has explored the development of an addressable voice capability that links air traffic controllers with remote pilot operators of UAS flying in controlled airspace.



FY21 ACCOMPLISHMENTS: CAASD developed an operational scenario and high-level functional requirements for voice communications leveraging the Voice-over-Internet Protocol (VoIP) capabilities that are expected to exist in the NAS. Our work started in FY20 when we examined an operational scenario for UAS voice communications that was confined to en route operations. In FY21, the investigation was expanded to address additional airspace environments. As a part of the enlarged scope, CAASD validated the functional requirements that were developed in FY20 and reassessed the technical approach for addressing those requirements to integrate with a broader set of NAS automation systems.

CAASD developed a notional system architecture for ATC to UAS communications that leverages elements of the FAA's VoIP Communications Enterprise (VoICE) program; however, additional capabilities are needed to allow large UAS flying in controlled airspace to communicate with controllers. Proposed new elements/functions include a Voice Authority Server, national/local Session Initiation Protocol (SIP) registrars, and a UAS connection manager.

FY22 PLANS: With this work concluding in FY21, we suggest the FAA pursue the following next steps:

- Conduct a shortfall analysis based on the overall concept of operations and functional decomposition CAASD developed.
- Continue concept development for handling off-nominal operations such as the loss of ATC-UAS communication between the controllers and the remote UAS pilot; the inclusion of the off-nominal cases may create additional system elements within the functional view.
- Develop an overall acquisition/development strategy, validated requirements, and interface definitions for the new functionalities.

FAA Enterprise Networking Services

The FAA Enterprise Networking Services (FENS) capability will succeed the current FAA Telecommunications Infrastructure (FTI) program and enable the FAA to modernize and transform its networking and enterprise services. FENS will introduce new technologies and the concept of managed services to the NAS.

Fully understanding the potential risk of using new technologies and service paradigms will be necessary to inform the requirements development process and address issues prior to release of the final Screening Information Request (SIR).

Transition from the FTI network to FENS will impact multiple critical services such as air-to-ground voice, flight data, surveillance, and Data Communications. Careful planning is needed to manage transition risk and avoid negative impacts to critical NAS operations. FENS source evaluation needs to be carefully conducted so that the government can identify best value and avoid protests.

FY21 ACCOMPLISHMENTS: CAASD developed material to familiarize FENS evaluators with advanced telecommunications technologies and best practices in preparation for the source selection. CAASD prepared and presented modules in the areas of Multi-Protocol Label Switching (MPLS) and carrier ethernet, big data analytics and AI/ML, business /operations support systems, Long-Term Evolution (LTE) 5G and SATCOM, Software-Defined Wide Area Network (SD-WAN), and network security techniques. CAASD prepared and presented a daylong module on how to be an effective evaluator, drawing on its experience in supporting source selections across the federal ecosphere including the Department of Defense (DoD), the Department of Homeland Security (DHS), and the Internal Revenue Service (IRS). CAASD also helped the FAA to develop FENS sample problems to augment the SIR, focusing on areas of importance to FAA such as survivability, cybersecurity, and resilience.

CAASD subject matter experts were selected as technical advisors to the source selection and are actively engaged. The source selection commenced in February 2021 and is expected to continue into FY22. The information within SIRs is proprietary to the offerors, and source selection activities are considered highly sensitive.

FY22 PLANS: CAASD will continue to advise on the source evaluation, which is expected to conclude sometime in FY22. CAASD will help the FAA identify strengths, weaknesses, and risks, advising on advanced telecommunications technologies, cybersecurity controls, and best practices. Once the award is announced, CAASD will assist the FAA in preparing for the contract negotiation phase of FENS, identifying areas where requirements may need to be clarified in advance of final agreements.

Navigation Infrastructure

Per Title 14, the FAA has the responsibility to provide for safe navigation capabilities in the NAS. A transition to PBN has implied a transition to satellite-based navigation and surveillance. However, due to various threats satellite-based methods face, some ground infrastructure must be maintained.

Over the last decade, CAASD has architected much of the transition for the FAA from using these systems as a primary means to an alternative means. The existing ground-based navigation aids are very old, with an average age of over 30 years. In addition, CAASD has played significant roles in the deployment and improvement of satellite navigation, including major contributions to the GPS III program and space-based augmentation systems for GPS.

FY21 ACCOMPLISHMENTS: New service volumes for existing ground-based navigation aids—a concept CAASD created years ago—were introduced in FY21. The reconfiguration of navigation aids through decommissioning of unneeded sites and commissioning of new sites aligned the infrastructure with the new mission of these systems. CAASD provided prioritization of impact information for the scheduling of these NAS changes to allow benefits to be realized earlier. CAASD provided technical guidance for an FAA program to recapitalize enduring, essential navigation aids.

CAASD provided essential technical leadership that led to the approval of new ICAO standards and recommended practices for air navigation. CAASD provided key recommendations to the GPS III program that protect the safety of civil air navigation using GPS.

FY22 PLANS: CAASD will continue to provide technical guidance and offer alternatives as the reconfiguration of ground-based navigation aids poses new challenges. CAASD will also provide technical expertise for space-based augmentation to GPS and civil requirements review of the deployment of GPS III.

FY23–25 LOOK-AHEAD: The long-term goal is to have navigation aids reconfigured so that reliable space-based capabilities provide our principal means of navigation with a solid, enduring, but cost-effective ground-based alternative allowing for maximum efficiency while ensuring a resilient national navigation infrastructure. CAASD will continue to provide technical leadership to all the navigation programs at the FAA to help achieve this shared goal.

CAASD will continue to provide technical guidance and offer alternatives as the reconfiguration of ground-based navigation aids poses new challenges.

GNSS Resiliency

The threat of interference to GPS—and Global Navigation Satellite Systems (GNSS) more generally—through jamming and spoofing can affect aircraft navigation, surveillance, and many other aircraft safety systems. The threat of misleading position and timing information being digested by both airborne and ground systems continues to increase at the same time the NAS continues to migrate toward a higher dependance on satellite-based navigation and surveillance systems. New standards are being produced, but the long lead time involved for full deployment implies the need for near-term awareness capabilities.

FY21 ACCOMPLISHMENTS: CAASD explored several low-cost airborne methods to detect GPS spoofing, including the use of existing commercial chipsets, cellular phone capabilities, and software-defined radios. Each of these methods provided detection capabilities over a range of performance capabilities during flight testing. CAASD prototyped an ADS-B-based outage mapping capability that would allow for better situational awareness about which areas a GPS event affected and those it did not affect. CAASD reviewed various commercial products for airport-based detection. CAASD also developed a concept of operations describing how all these systems could be integrated to create a common view of a dynamic event and be coordinated across the FAA and other government agencies.

CAASD conducted a review of the various alternative forms of navigation to GNSS. A variety of FAA and CAASD subject matter experts provided input on priorities of various metrics to help determine the most likely alternatives to be successful as future complementary Position, Navigation, and Timing (PNT) capabilities to GNSS.

FY22 PLANS: CAASD will continue to explore low-cost airborne detection methods for effectivity. CAASD will refine the ADS-B-based detection capability prototype using additional data sources, industry standards, and FAA feedback.

FY23–25 LOOK-AHEAD: The goal is to have a comprehensive strategy for mitigating the risk of both loss of GNSS and misleading GNSS. This would include the technology transfer and widespread use of the airborne detection methods and an FAA system for automatic tracking of NAS GNSS health via ADS-B data and other inputs.

Spectrum

The FAA must ensure the integrity and availability of the electromagnetic spectrum used to deliver the CNS services that meets its obligation to provide aviation safety. Because spectrum enables all wireless communications, demand continues to grow at an increasing rate; however, there is a finite practical supply.

Pressure is mounting from the telecommunications industry for increased access to bands currently reserved for aviation usage. The consequences of providing access to these aviation bands or the increased utilization of aviation-adjacent bands for telecommunications and other commercial usage could result in degraded operational safety, reduced flight efficiency, and increased operational costs, and constrained technical innovation for legacy and new entrant aviation operations.

FY21 ACCOMPLISHMENTS:

- Collaborated with a cross-FAA team to mature the Congressional report on UAS command and control communications spectrum needs mandated in

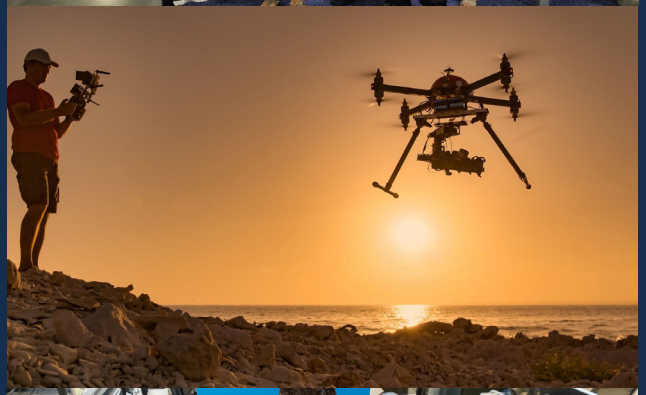
Section 374 of the 2018 FAA Reauthorization Act.

- Contributed to an intermodal investigation of collaborative spectrum sharing directly supporting the life safety of the traveling public.
- Continued to support U.S. positions at the International Telecommunication Union – Radio-communication, World Radiocommunication Conference 2023, Radio Navigation-Satellite Service/ Wide Area Augmentation System compatibility, and other spectrum issues.
- Initiated work to define an FAA enterprise spectrum strategy.
- Undertook additional work across the range of CNS capabilities to explore and address current and future spectrum-related issues.

FY22 PLANS: CAASD continues its FY21 work in FY22. In addition, CAASD is collaborating across the FAA and other MITRE sponsors, including DoD and the Department of Commerce, to provide interference testing results, operational impact analyses, aircraft equipage estimates, and other data pertaining to the potential impact of 5G mobile telephone transmissions on safety-critical radar altimeter aircraft equipage. This high-visibility, high-impact threat to aviation safety is a harbinger of spectrum encroachment challenges to come.

FY23–25 LOOK-AHEAD: With the mounting demand from mobile network operators and other commercial spectrum users for spectrum resources, CAASD anticipates that emergent threats to the aviation spectrum ecosystem will materialize. CAASD is uniquely positioned to collaborate with the FAA and the aviation community to identify these emerging threats; assess the policy, operational, business, and technical consequences of alternate courses of action; and enable mitigations that preserve aviation safety, flight efficiency, and the future of aviation.


MITRE
ARCH FROM SURFACE TO SPACE



OUTCOME 06

UNMANNED AIRCRAFT SYSTEMS

FAA Outcome Manager: Mr. Bill Crozier

CAASD Outcome Leader: Michelle Duquette

Outcome Statement: A transformed NAS and NextGen system that:

- Meets national goals for the safe and efficient integration of UAS into non-segregated airspace.
- Balances the access needs of a diverse set of aviation system users.
- Maintains the highest levels of system safety and security.
- Implements standards for safe operation of UAS without compromising safety or efficiency of the NAS.
- Institutes safety assurance and cybersecurity processes as an integral part of normal operations.
- Utilizes metrics to proactively detect issues prior to incidents or accidents.
- Leverages the collaboration of operational experts across the agency and research into technologies and capabilities to improve safety and efficiency of UAS integration into the NAS.

Highlighted Accomplishments

ATO UAM Strategic Analysis

Advanced Air Mobility (AAM)—and its urban counterpart, Urban Air Mobility (UAM)—is a vision for new aviation operations that leverage advances in flight automation, electrical propulsion, and vertical flight technologies to address passenger and cargo needs for short- and medium-range air transport. Use cases include intercity thin-haul operations, private/recreational activities, cargo delivery, and passenger transport. After years of technology development, private industry seeks greater clarity on various operational considerations for eventual integration into the NAS.

The ATO aims to publish a strategy and plan for integrating AAM and UAM vehicles into the NAS. The plan must consider different proponent technologies, aircraft configurations, concepts of use, and potential business models that challenge existing airspace designations, flight rules, and traffic control procedures.

FY21 ACCOMPLISHMENTS: CAASD developed scenarios for various stages of UAM maturity in select geographic markets to identify and explore with internal FAA working groups how existing air traffic constructs might evolve to accommodate upcoming UAM operations. Industry proponents desire increased automation and operational freedom, with reduced reliance on ATC instructions and separation procedures. CAASD facilitated internal FAA discussions to explore the challenges and opportunities for the potential of increasing automation.

FY22 PLANS: CAASD will continue to support the development of the ATO UAM strategic plan by facilitating working group discussions on key topics and by coordinating UAM activities across FAA lines of business. Additionally, CAASD aims to identify feasible UAM routes between market-driven OD pairs that consider existing airspace constraints, current users, and air traffic control needs.

FY23–25 LOOK-AHEAD: The AAM and UAM industry is expected to start initial, low-volume operations as early as FY24 using existing airspace and procedures. Changes to airspace structures and ATC procedures will likely be necessary to accommodate the projected surge in UAM operations. Existing users of the NAS will likely adopt new technologies, including an increase in automation. CAASD anticipates supporting these changes by analyzing impacts to existing NAS users while enabling new airspace constructs, new routes, and new procedures.

CAASD aims to identify feasible UAM routes between market-driven OD pairs that consider existing airspace constraints, current users, and air traffic control needs.

UAS Operational Analysis and Forecasting

Over the last few years, UAS operations have seen rapid growth in the United States and throughout the world. The FAA has observed an increasing trend in operational requests, via waiver of Part 107 regulations, for expanded UAS operations such as Night Operations, Operation of UAS Over People, and Beyond-Visual-Line-of-Sight (BVLOS) operations. As the demand for both large and small UAS operations continues to grow, the FAA is committed to ensuring safe integration of UAS operations into the NAS. To support that objective, the FAA Office of Aviation Policy and Plans (APO) produces forecasts of UAS activities to help inform planning, prioritization, rulemaking, and other decisions across the FAA.

FY21 ACCOMPLISHMENTS: CAASD conducted analysis of UAS demand and operational trends and developed approaches to help the FAA forecast UAS and AAM demand for select operator and mission types. In addition, CAASD participated in technical exchanges with the FAA, NASA, and industry to share the latest research findings and methods to analyze demand for future UAS and AAM operations.

FY22 PLANS: CAASD will continue to support the FAA with UAS forecasting and analysis, with the focus on emerging commercial large UAS activities (such as unmanned air cargo and precision agriculture UAS) to incorporate them into current large UAS forecasts. CAASD will continue to lead and facilitate technical exchanges with the FAA, NASA, and industry, which will benefit the broader research community.

FY23–25 LOOK-AHEAD: As the capabilities and commercial adoption of UAS continue to strengthen, more UAS operations are expected to migrate from segregated airspace at low altitudes (i.e., further away from manned traffic) into non-segregated airspace at higher altitudes. This means the sharing and prioritization of NAS resources will be even more critical. In addition, the UAS Traffic Management (UTM) ecosystem will continue to evolve as new aircraft systems, automation, and capabilities become available. CAASD anticipates supporting the FAA in evaluating new UAS growth determinants and updating forecast scenarios to inform FAA strategic planning.

UAS Research Identification Framework (URIF)

Increasing interest in commercial applications of UAS provides unique challenges for their integration in the NAS. The FAA must identify and conduct key research within the appropriate timeframe to enable integration of these future operations. A systematic approach is necessary to identify research that informs significant policy, regulatory, and operational decisions. A repeatable and scalable process is essential to meet the expected demand and increased complexity of operations.

FY21 ACCOMPLISHMENTS: In FY21, CAASD worked closely with the FAA's UAS Integration Office (AUS)-320 to enable the identification of research gaps that will inform the key decisions to support a repeatable and scalable approval and oversight process for UAS operations. This collaboration resulted in the UAS Research Identification Framework (URIF), which

considered research documented in the FAA's UAS Integration Research Plan 2021–2026 to identify research gaps. Research gaps were identified for BVLOS operations, UTM, small package delivery, UAM, and integrated operations. The research gaps covered four key areas: operating requirements and limitations; contingency management; airspace and services; and CNS and supporting infrastructure.

CAASD also developed the URIF prototype, a cloud-based solution that facilitates prototype deployment and controlled access to selected stakeholders at the FAA and other organizations. The prototype supports effective workflows, efficient analysis, improved management of research data, and automated documentation of UAS research.

FY22 PLANS: In FY22, CAASD will focus on critical UAS/AAM/UAM research gap analysis. This analysis will inform the identification, documentation, and scoping of research requirements, decisions, rulemaking, and policy as well as the development of the UAS/AAM Integration Research Plan. CAASD will continue to evolve the URIF and set the path for a technology transfer of the URIF prototype to the FAA.

FY23–25 LOOK-AHEAD: Over the next three years CAASD will continue to work closely with AUS to evaluate key challenges and develop solutions to UAS/AAM/UAM integration in the NAS.

ATO Unmanned Strategic Planning

The FAA released UTM ConOps v2.0 in 2020. The FAA's ATO is working to better understand the equities, responsibilities, and collaboration needed to realize this concept.

FY21 ACCOMPLISHMENTS: In 2021, CAASD provided technical enterprise insights and analysis to the ATO's UTM working group to understand the paradigm and fundamental UTM concepts, realize the implications of UTM to ATO, and identify the key decisions and questions the ATO must address to enable the implementation of UTM.

FY22 PLANS: CAASD is continuing to work to quantify potential UTM operational impacts; execute a functional decomposition of unmanned concepts; and identify the ATO implications, needs, requirements, roles, responsibilities, and accountabilities in the implementation and oversight of UTM.

FY23–25 LOOK-AHEAD: The ATO will continue to evolve its strategic positioning as new NAS disruptive operations emerge. CAASD will partner with ATO's Mission Support Strategy Division (AJV-S) to decompose FAA future visions and concepts, identify ATO implications and engineer mitigation solutions, compile collective ATO commitments, and transition into actionable ATO strategies.

Government/Industry Partnerships

The FAA's BEYOND program and Partnership for Safety Program (PSP) seek to build upon the success of UAS pilot programs of the last years and achieve repeatable, scalable, economically feasible BVLOS operations in the NAS. The focus is centered on three types of missions—package delivery, infrastructure inspection, and public safety operations—and three environments with increasing levels of risk: rural, suburban, and urban.

FY21 ACCOMPLISHMENTS: CAASD provided 15 technical products in support of the BEYOND program objectives, including Command and Control (C2), quantitative safety analysis, data architecture and strategy, detect and avoid, safety framework and risk evaluation, and weather research. The CAASD team worked closely with the FAA team and the FAA's partners to help develop safety cases and systematically analyze air and ground risks associated with operations as operators transition to operation by rule. CAASD's team worked on an implementation approach to efficiently process and effectively evaluate incoming FAA partner data and develop associated metrics and dashboards. In addition, CAASD evaluated use of LTE performance for C2 in different partner use cases and assessed if L-band whitespace is available for C2 in particular locations as needed. CAASD provided a technical assessment of requirements for routine small UAS (sUAS) operations in controlled airspace, including feasibility of ADS-B or similar technologies as a risk mitigator. CAASD also developed a holistic safety risk analysis framework to consider societal risk benefits and explore the quantification of benefits associated with drone use.

FY22 PLANS: For FY21, CAASD will continue to support the FAA program team with relevant technical research and analysis as needed to accelerate progress toward the FAA's objectives those of its partners in the BEYOND and PSP partnership teams.

FY23–25 LOOK-AHEAD: It is expected that over the next two to three years the FAA will mature rules and processes for routine operations of drones in BVLOS in the NAS.

CAASD will continue to support the FAA program team with relevant technical research and analysis as needed to accelerate progress toward the FAA's objectives those of its partners in the BEYOND and PSP partnership teams.

OUTCOME 07

SPECIAL STUDIES, LABORATORY, AND DATA ENHANCEMENTS

FAA Outcome Manager: Mr. John Raper

CAASD Outcome Leader: Eric Zakrzewski

Outcome Statement: Execute cross-cutting management and technical activities that improve effectiveness of the individual CAASD Outcomes, address key issues as directed by FAA senior management, and inform cross-cutting capability evolution. Enable objective FAA decision-making by providing a system of cost-effective, agile, and innovative research and development capabilities to the CAASD Outcomes.

Highlighted Accomplishments

FAA Data Strategy and Evolution

The FAA desires to optimize data use for improving FAA mission outcomes. CAASD is partnering with FAA leadership to help clarify mission priorities, evolve data strategies, and develop constructs to enable strategic investments and application of data to the mission.

The FAA's data strategy and EIM initiative aims to transform the FAA into an information-centric enterprise, with sustainable enterprise data solutions. In parallel, organizational LOBs and Staff Offices (SO) aim to optimize their data-to-decision processes and seek to leverage enterprise data solutions where appropriate. The FAA established Data Champions for each LOB and SO to help federate and mature data leadership and advocacy across the agency.

CAASD is partnering with the FAA's Chief Data Office (ADO), EIM, and mission application stakeholders to help identify and document cross-cutting data needs to help inform EIM requirements and prototype technical implementations to enable mission applications and end users to effectively use and integrate with EIM solutions. We also are providing strategic consultation to the ATO and AVS Data Champions.

FY21 ACCOMPLISHMENTS: CAASD supported ATO and AVS Data Champions to develop initial constructs and plans to evolve their respective LOB strategic data approaches. For example, ATO established the Data Evolution Leadership Team, which has met regularly since July 2021 to begin cataloging and mapping data initiatives against strategic priorities. CAASD developed a centralized knowledge management system for all FAA Data Champions to begin alignment on roles and expectations, and to encourage consistent, leveraged approaches across LOBs and SOs.

In partnership with ADO, CAASD established a persistent Virtual Private Cloud within the FCS environment that is interoperable with EIM technical capabilities (data and tools) to allow for more collaborative and shared development and evolution of technical solutions, both for the enterprise and LOB/SO applications.

FY22 PLANS: CAASD will continue to serve in a trusted advisor role to help position ATO and AVS for consistent, strategic management of data to meet emerging business needs and inform data investments for cost-effective data capability evolution. CAASD also anticipates continued support of the FAA's Office of Finance and Management (AFN) and ADO to aid in consistent and coordinated approaches across all LOBs and SOs. In addition, CAASD will continue to inform the evolution of EIM technical solutions by leveraging the experience and lessons learned of operating large-scale enterprise data systems at the FFRDC, with the goal of streamlining research into mission operations through coordinated delivery processes.

FY23–25 LOOK-AHEAD: Optimizing data capabilities and practices to improve mission outcomes will be a persistent challenge and opportunity. Continued support for data leadership and advocacy across the FAA is anticipated to sharpen the vision and inform consistent and informed investments. As data practices and capabilities mature, there will be opportunities to leverage more advanced technology to further optimize mission outcomes, such as predictive and adaptive data systems. The complexity and scale of such systems will require contributions across aerospace stakeholders; that will require a new level of digital collaboration in shared environments amenable to cocreation to streamline research into mission operations.

Enterprise Capability: Simulation

The Simulation Platform provides a set of essential fast-time simulation services to explore the impact of various changes in the NAS and other air traffic systems. These simulation services are maintained as persistent resources to provide consistent approaches and coherent recommendations across the work program.

The platform's capabilities include two primary environments: *systemwide*Modeler and Akela. *systemwide*Modeler can simulate new technology, procedure changes, redesigned airspace, and other operational changes at NAS scale, but its lifecycle is coming to an end as a few of its technologies reach obsolescence. Akela is a newer simulation capability that is transitioning from its FY21 completion in the Outcome 8 Mission-Oriented Investigation and Experimentation (MOIE) program into operational use in the CAASD work program. Akela allows projects to model NAS components at higher fidelity. Together, these capabilities allow analyses that span a range of scale, complexity, and fidelity requirements.

FY21 ACCOMPLISHMENTS: While maintaining *systemwide*Modeler, CAASD prepared Akela to assume its role in system-wide analysis. CAASD achieved four objectives. The first was the development of a scenario-generation process to quickly specify input describing tens of thousands of historical flights. The second was the development of a new Akela flight model that is responsive to instructions to absorb delay at a level of abstraction consistent with system-wide analysis. Third was porting the *systemwide* Modeler airport model to the Akela environment. Lastly, CAASD made several improvements to Akela's underlying simulation framework to enable run times amenable to system-wide experimentation.

CAASD also invested in the tools and training for scenario generation and output analysis for Akela simulations. For the former, the tools now incorporate some IDEA Lab scenario-generation capabilities, and there is now a mode wherein Akela validates flight input at several levels. CAASD added output analysis features to the R package and dashboard to provide insight into TBM behavior. CAASD also developed and delivered new training to over a hundred staff that introduces these capabilities and provides interactive tours.

To facilitate further adoption of an enterprise mindset in CAASD's simulation work, a new stewardship model was designed and adopted for the various related assets. CAAS identified about 20 assets, selected stewards, and established expectations. CAASD also started new bodies to coordinate governance and information exchange among simulation practitioners.

As FY21 draws to a close, seven projects continue to use Akela or are getting underway with their experimentation plans. They span questions about TFM, TBO, terminal area ATC, oceanic ATC, and safety hotspots.

FY22 PLANS: The main objectives of the Outcome in FY22 are grouped by stewardship and enhancement of the Akela simulation environment. The former are to ensure successful use of Akela by projects, partly through support and training of users and partly through management of continuing development activities.

One major enhancement objective is to stand up an infrastructure and process enabling Akela to regularly simulate recent historical situations and record validation measures. The intent is both to establish a track record and to continually inform modeling priorities. A second major enhancement objective leverages the same infrastructure to routinely execute benchmark experiments and measure runtime performance. The intent is to inform performance enhancement initiatives with empirically identified bottlenecks.

FY23–25 LOOK-AHEAD: It is CAASD's intention for MITRE and others to leverage the Akela simulation

for fast-time simulation needs. To do so, CAASD will continue to extend what it can represent and how well, as motivated by projects and informed by their experience. Akela's architecture and modeling paradigm were designed for this extensibility.

A major emerging need for fast-time simulation is to support planning and operational decision making by predicting the effects of candidate TFM actions. CAASD's work to support these use cases and those for related post-event analysis will involve articulating and meeting fidelity, validity, and speed requirements. CAASD will also pursue deployment of the simulation environment where it is accessible to these workflows.

CAASD also intends to continue more integrated real-time and fast-time simulation work, both by consolidating capabilities for modeling, scenario generation, and output analysis and by pursuing opportunities wherein Akela performs certain functions in otherwise real-time experimentation. Finally, CAASD will continue leveraging the data platform to efficiently craft and make sense of simulation experiments.

Enterprise Capability: Data Analysis and Transportation Data Platform

The seminal problems facing data-driven organizations today are integrating enormous amounts of data coming from diverse sources in different formats and then giving analysts the ability to access this data easily.

The TDP addresses these problems. It offers a set of expertise, capabilities, and products provisioned within a comprehensive ecosystem that allows users to quickly build big-data analytic systems that can ingest, integrate, and transform data—regardless of type or volume—into a set of coherent, fused data assets.

The power of TDP comes from its ability to be used and reused to jumpstart the development and deployment of domain-specific applications or products. The most recognized of these is the CAASD Threaded-Track and Flight Story, which integrates four petabytes of data from over 50 different data sets into a threaded track for each flight operating in the NAS over the past ten years.

FY21 ACCOMPLISHMENTS: To meet CAASD and MITRE's business needs, we focus our activities for TDP in the five areas: scalability, portability, security, lowering barriers, and timeliness. These focus areas are described more fully below, along with our FY21 accomplishments in each area.

- Scalability – Reduce Operations and Maintenance (O&M) burden and technical debt and increase contributors and ways to contribute.
  - Streamlined product development – CAASD embraced agile development practices and standardized and documented best coding and testing practices for TDP products.
  - Streamlined operations – Developed tools and processes to automate delivery of TDP data products.
  - Enhanced automation – Enabled automated data processing operations.
  - AI/ML Model Repository – Enabled a capability for AI/ML analysts to include their models into TDP analytics.
- Portability – Increase reusability of software, cloud deployments, and interoperability with capabilities.
  - Cloud-based TDP – Deployed a subset of TDP capabilities in AWS that provides access to data and analytics while also facilitating collaboration with external organizations.
  - Tableau in AWS – Provided international aviation sponsors with direct access to Tableau dashboards.
  - Portable libraries – Refactored TDP data models and algorithms for reuse beyond TDP capabilities.
- Security – Position data products to handle sensitive data (e.g., Controlled Unclassified Information [CUI] compliance).
  - Role-based access controls – Enabled sponsors' ability to restrict access to their data and analytics in the cloud-based TDP.
- Lowering Barriers – Make it easier for users to start and continue using TDP.
  - SQL access – Deployed and now support Apache Impala for TDP that provides users with SQL access.
  - GraphHopper – Deployed and now support a capability to graphically explore data and relationships between data, and build queries that can be translated into Python, SQL, or other data science programming languages.

- Timeliness – Enable near-real-time decision making.
  - Streamlining data ingest – Migrated all data ingest software to Apache NiFi. Data ingest processes are now more reliable and easier to maintain.
  - Timely data processing – Shrank time to make data available to users to three days from three weeks.
  - FY22 Plans: In FY22, CAASD is working toward additional goals in its five focus areas, as outlined below.
- Scalability:
  - Provide reliable user services – Scale user services to meet the demands of a growing user community. This includes a more reliable REST API, and faster web access of TDP meta data.
  - Scaled product development – Create capabilities to allow multiple development teams to work on same TDP product/capability.
- Portability:
  - Generate TDP data and analytics in AWS – Extend cloud-based TDP so that it can generate needed data and analytics in AWS. The current cloud-based TDP cannot do this now.
- Security:
  - Achieve Standard User Identifier (SUI) compliance – Enable TDP capabilities, data, and analytics to be hosted in an SUI-compliant environment.
- Lowering Barriers:
  - Enhanced user documentation – Improve and develop documentation that focuses on new users and facilitates their use and understanding of TDP.
- Timeliness:
  - Near-real-time analytics – Deploy a capability that provides TDP users with access to data and analytics within minutes rather than hours or days.
  - FY23–25 Look-Ahead: CAASD's longer-term goals for the five TDP focus areas are described below.
- Scalability:
  - Promote shared stewardship – Establish guidelines for shared stewardship over large data products. We will seek ways for others, outside the core TDP development team, to own and steward data analytic products while ensuring these products are part of an integrated TDP.
- Portability:
  - Cloud-native TDP – Refactor TDP software to be cloud-native, which allows MITRE/CAASD to deploy a user-specific TDP in the cloud environment of the user's choice.
- Security:
  - Achieve CUI compliance – Enable TDP capabilities, data, and analytics to be hosted in a CUI-compliant environment.
- Lowering Barriers:
  - Product owner guidelines – Develop guidance that TDP product owners can use to understand how to develop TDP software (e.g., DevOps practices, testing, acceptance testing, deployment, automated workflow) and how to manage TDP software development teams.
- Timeliness:
  - Real-time access – Develop access to real-time data and analytics using the tools and capa-bilities that exist today.

MITRE Labs

IDEA Lab

The IDEA Laboratory provides real-time capability for human-in-the-loop experimentation and research including concept development, demonstration, and consensus building.

It consists of a persistent set of curated, interoperable real-time laboratory capabilities used by CAASD projects that accelerate delivery of high-quality experiments and demonstrations. This includes the set of core simulation services—simulation configuration and execution, simulation data transfer and interfaces, data collection, scenario generation, vehicle modeling, and visualization—that are essential to all real-time simulations. It also includes a comprehensive collection of composable transportation system models: ERAM, TFMS, TBFM, TFDM, Standard Terminal Automation Replacement System (STARS), and Airport Surface Detection Equipment System–Model X (ASDE-X), along with communication and flight deck systems that can be used to fulfill project needs.

FY21 ACCOMPLISHMENTS: While FY21 was a challenging year, full of remote work and delayed large-scale evaluations, the IDEA Laboratory still maintained consistent availability, exceeding the benchmarks of 90 percent availability for lab users, and over 90 percent user satisfaction. The lab hosted eight evaluations over 76 days. Additionally, it expanded accommodation of third-party applications to enable greater stakeholder participation in demonstrations and evaluations, added enhancements to laboratory capabilities to accommodate large-scale evaluation scenarios with more (and remote) human participants and scenario complexity, and created a modernized TFMS simulation to enable more evaluations of TFM operations in the TBO and 2035 operating environments.

FY22 PLANS: In FY22, to meet CAASD's ever-evolving work program needs, the IDEA Lab plans to continue to meet experimentation and demonstration needs by making sure its Real-Time Simulation capability is ever-ready to be used by projects and plans to continue to enhance the services provided. Some enhancements include ground handling and fidelity enhancements to the Flight Modeling and Control capability, upgrades to the Simulation Data Transfer capability, and greater standardization of interfaces for better integration with third-party applications.

FY23–25 LOOK-AHEAD: In the upcoming years, the IDEA Lab will continue to increase its fidelity in real-time flight modeling as well as vehicle ground modeling, enabling increasing accuracy in performance assessment. Additional enhancements to flight models will better represent a diverse set of users and vehicle types for future NAS operations. Broadening simulator representation will enable evaluation and enhancement of safety innovations for rotorcraft and other user types. Additionally, the IDEA Lab plans to continue its investment in remote and hybrid simulation environments to enhance engagement with ATC facilities as the lab uses its enhanced interoperability capabilities to evaluate complex multi-domain environments in the NAS. Expansion and streamlining of scenario-generation capabilities will feed a broader set of simulation and analytic capabilities, both internally and externally.

Discovery Lab

The Discovery Lab focuses on aviation safety analysis and vulnerability discovery through the analysis of extensive aviation data. The Discovery Lab provides the secure environment needed to collect, store, and analyze the sensitive and proprietary data our government and industry partners have entrusted to us.

Other MITRE Labs

CAASD also leverages MITRE's entire suite of laboratory capabilities and platforms, including the Simulation, Experimentation, and Analytics, or "SEAL" Laboratory, Cybersecurity labs, and more—all of which can interconnect to enable collaborative experimentation across multiple agencies and stakeholders.

Tracker 2.0

Tracker is the FAA and CAASD's official product delivery system of record and a critical tool in CAASD's daily business with the FAA.

Tracker includes:

1. The Product-Based Work Plans (PBWP) for each fiscal year.
2. Documents from key advisory and oversight committees, including the FFRDC Executive Board (FEB) and Quarterly Product Review Board (QPRB).
3. All final products (formal and informal, as outlined in the PBWP) delivered to the FAA.

Tracker is a contractual requirement, outlined by the FAA. FAA personnel have direct access to Tracker through a special connection, so that product sponsors can read and review products, search products, and view the PBWP. CAASD staff also have access to Tracker.

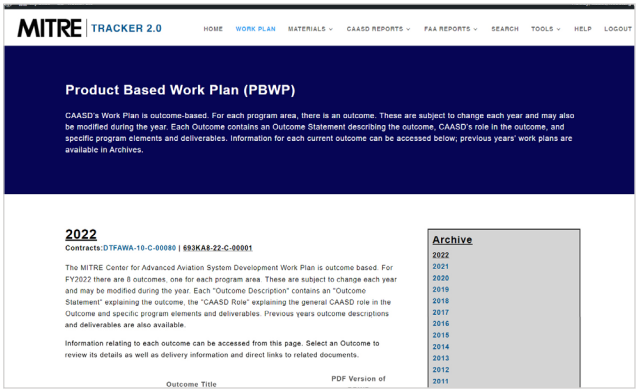
CAASD, in coordination with the FAA, created Tracker 20 years ago. Now it is an aging system on an outdated platform with severe limitations and a single point of failure. A modern, user-friendly, and robust system is needed that is still in line with the FAA's contractual requirements (e.g., access, reporting, connectivity to FAA systems) as well as CAASD's needs (product archiving and searching) on a platform that can be easily updated and maintained. In September 2019, CAASD initiated an "agnostic" top-to-bottom systems requirements review of Tracker to understand what would be needed to update the entire system and create Tracker 2.0. The assessment was completed in January 2020 and provided a comprehensive set of

system requirements and a detailed work breakdown schedule for an upgraded Tracker 2.0. In May 2020, CAASD kicked off the initial phase of the Tracker modernization project. We focused on building out the architectural and back-end components that are foundational to Tracker 2.0:

- Built out new Tracker 2.0 database (will serve as master database to enable search and reporting).
- Created Smart Industrial Work Request (IWR) form to standardize data entry and facilitate automated data ingest.
- Automated PBWP ingest and generation.
- Created new search and dashboard prototypes to gather user requirements.
- Identified new security protocols (access control).
- Finalized Tracker 2.0 architectural design.

FY21 ACCOMPLISHMENTS: CAASD developed the Tracker 2.0 system in partnership with the FAA CAASD Program Management Office and MITRE's Corporate IT team. The accomplishments include the following:

- Improved business efficiency and data collection by automating IWR forms and PBWPs processes.
- Improved Tracker website's performance, reliability, security, extensibility, and maintainability.
  - Built Tracker 2.0 in MITRE's Corporate IT environment.
  - Completed new Tracker 2.0 front end, which enables customizable and role-specific dashboard/reporting.
  - Created a more capable and robust document search capability.
  - Finalized sustainment/maintenance plan.
- Completed all Tracker 2.0 system documentation (instructions, architectural design, key components, roles/responsibilities, maintenance plan).
- Continued to document planned future enhancements (e.g., online IWR).



FY22 PLANS:

- Complete Tracker 2.0 and its rollout to both FAA and CAASD users.
- Improve Tracker 2.0 data dashboards.
- Expand Tracker 2.0 to facilitate and streamline contract modifications and base data-call business processes.
- Help FAA improve product receipt and acceptance processes.
- Explore potential for additional out-year enhancements.

FY23–25 LOOK-AHEAD: Beyond sustainment and maintenance, the future evolution of Tracker 2.0 could include mobile applications, additional electronic forms, and facilitated delivery of new product types via a collaborative research environment.


Airspace
Midford
Grove
North
South
OAK ATCT
HWD ATCT
Other ATCTs

OUTCOME 08

MISSION-ORIENTED INVESTIGATION AND EXPERIMENTATION

FAA Outcome Manager: Mr. Paul Fontaine

CAASD Outcome Leader: Emily Stelzer

Outcome Statement: An FFRDC that prepares the FAA for future needs by:

- Fostering and maturing innovative solutions to system problems to streamline regulatory and air navigation service provider operations
- Identifying future technologies, understanding their benefit or disruption to the air traffic operation, and formulating clarity and focus on a path forward
- Developing the skills and tools needed to analyze and engineer the future NAS.

Background:

The CAASD sponsoring agreement recognizes the importance of innovative, future-looking research and analysis, and establishes a mechanism for conducting that research.

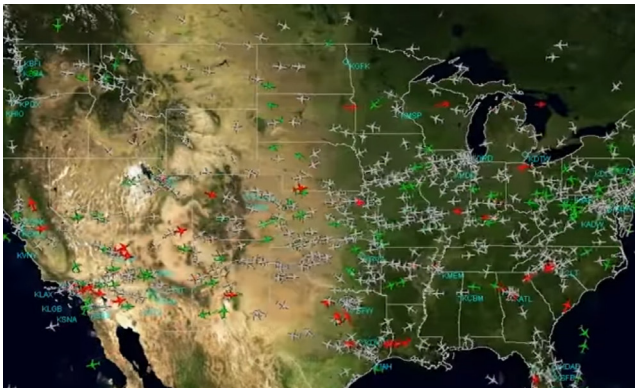
Within the FAA Base work program, this independent research program is known as the Mission-Oriented Investigation and Experimentation (MOIE) program. The FAA and CAASD jointly define the MOIE work program prior to the start of each fiscal year.

CAASD and the FAA develop the research and development program so that it is comprised of projects that are mission-focused, transformative, unproven, and conducted collaboratively with government, research organizations, and private industry.

During 2021, the research portfolio was comprised of seven independent research and development projects. These projects were conducted to advance the three key missions of the work program: innovating solutions, formulating clarity and focus, and preparing the FAA to engineer the future.

The eight FY21 MOIE research projects included:

- Mobile Technologies for Advanced Avionics
- Self-healing NAS
- Predictive Analytics for Aviation Safety Hazard Detection
- In-Time Safety Risk Metrics
- AI Enabled Traffic Flow Management
- Aircraft-Based Navigation System Performance Monitoring and Analysis
- Performance-Based Methods for Higher Airspace
- Reconfigurable Fast-Time Aviation System Simulation



Highlighted Accomplishments

Performance and Risk-Based Strategic Deconfliction

New technology is resulting in an exponential increase of new entrant operations that need to be safely integrated into the NAS. CAASD is a exploring a performance and risk-based strategic deconfliction method for new entrant operations that would improve their access to airspace while maximizing safety and efficiency.

At the core of the method, operators provide a service provider with the volume of airspace within which their operation is expected to occur at discrete times in the future, via contours which represent different levels of positional certainty. These contours are the basis for calculating the risk of undesirable events (such as a mid-air collision).

Deconflicting strategically (i.e., identifying and solving conflicts well in advance of the expected conflict) allows operators to better plan their missions and is necessary for some vehicles that are not able to deconflict tactically.

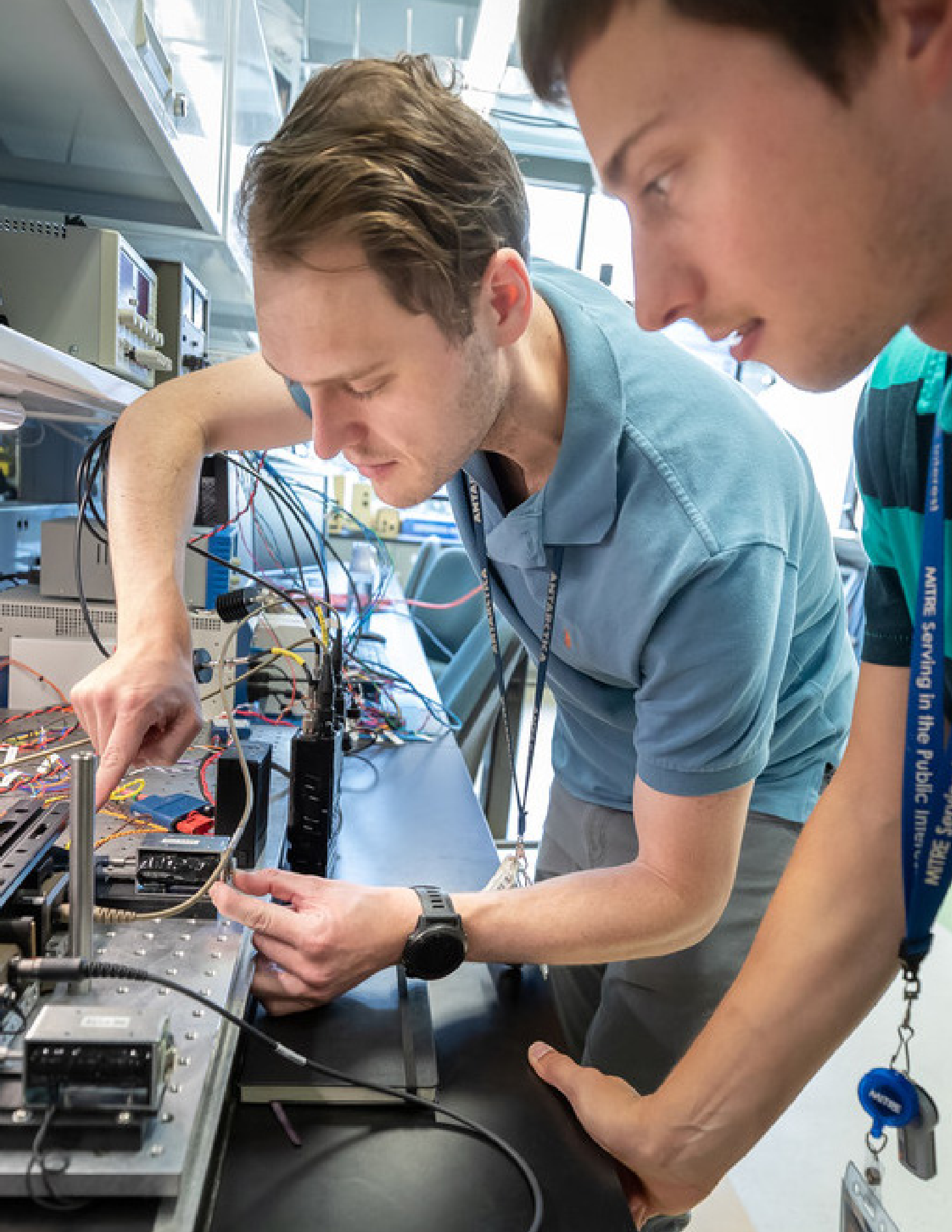
FY21 ACCOMPLISHMENTS: In 2021, CAASD built upon the previous year's strategic deconfliction work by engaging with industry members and working groups to refine and advance the strategic deconfliction method for higher airspace operations (generally operations above Flight Level 500). CAASD also leveraged their simulation and modeling capabilities to successfully simulate a proof of concept for calculat-ing undesirable events using contours for higher airspace operations. In addition, CAASD co-authored a paper with industry that developed a risk framework for higher airspace operations enabled by CAASD's strategic deconfliction method. The resulting paper, Adaptive Risk-Based Conflict Detection for Stratospheric Flight Operations, was the cover story for the Spring 2021 edition of the Journal of Air Traffic Control.

FY22 PLANS: CAASD will develop initial specifications for the contours needed for strategic deconfliction (e.g., how many contours, how often do the contours need to be updated) by studying tradeoffs in safety, efficiency, false alarm rates, and the amount of information that needs to be developed and exchanged. CAASD will engage with industry members to explore modifying and implementing the strategic deconfliction method for new entrant operations beyond higher airspace. Simulation and modeling will be used to demonstrate the safety and efficiency benefits of this method compared to other strategic deconfliction methods.

FY23–25 LOOK-AHEAD: It is expected that CAASD will collaborate with industry partners and the FAA to officially incorporate the strategic deconfliction method into future FAA concept of operations and more detailed specifications documents. CAASD will also partner with industry to prototype and test the strategic deconfliction method in a lab environment initially and advancing to real world test operations.

The FY22 MOIE portfolio will program will focus on:

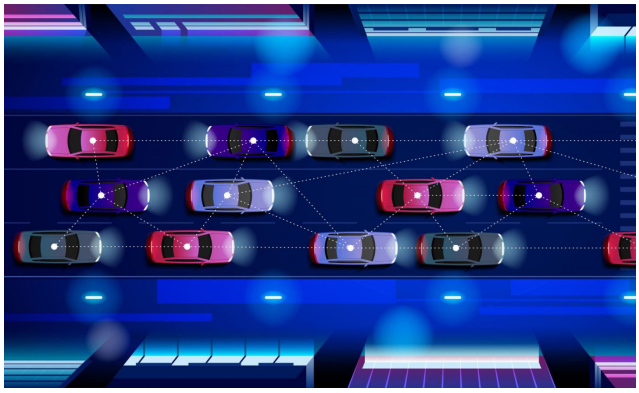
- Realizing the next level of safety by identifying emerging risks, enabling actional mitigations, and revolutionizing certification
- Advancing the future vision by exciting R&D and speeding the development of needed services and capabilities.


MITRE Serving in the Public Interest

INNOVATION AND ACCELERATION

Surface Transportation

As technology and innovations are deployed to enhance surface transportation, CAASD is using its independent, data-driven systems engineering approach to enhance and sustain a safe and secure surface transportation system in the U.S.



In 2021, CAASD focused on maximizing the safety benefits that transportation technology advances can bring. Our partnerships with government and the automotive industry expanded this year, providing data to give us insights into emerging safety opportunities—and unexpected challenges—that today's advanced driver assistance systems offer.

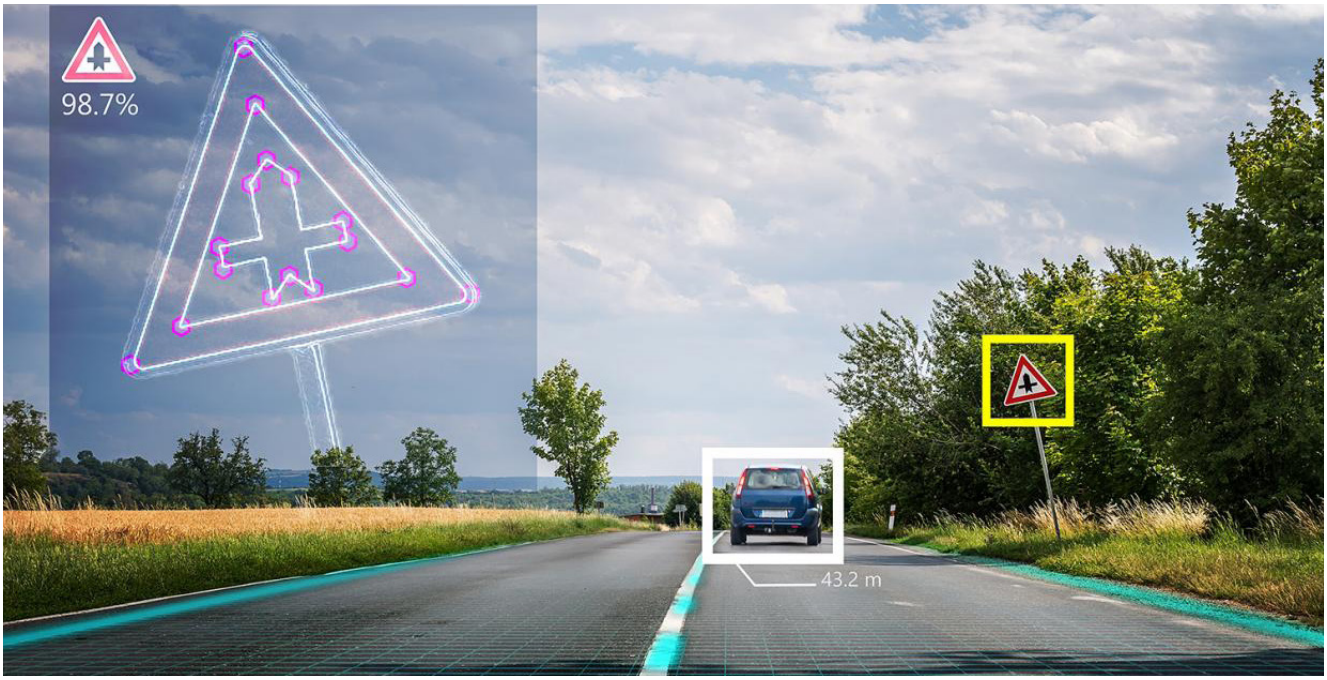
These partnerships laid the groundwork for our research on highly autonomous vehicles of the future, including our proposal for a new paradigm in the design, development, and testing of highly automated vehicles. We also outlined a new safety management system (SMS) approach for organizations across the industry through workshops and in public resources.

From groundbreaking micromobility research to automated safety resources, CAASD is working to advance automated vehicle and highway safety, to reduce crash and fatality rates across surface transportation modes, and to prevent unauthorized or hostile cyber-threat activity that disrupts transportation systems.

We're working with government and industry to transform transportation and realize the promise of revolutionary innovations and technologies.

FY21 Highlights

- General Motors signed a contract with MITRE to immediately start work to advise GM on improvements to their safety data analytics with telemetry data, with the goal of improving and accelerating how GM finds and understands safety and quality issues in real-world customer vehicles. The maturity of telemetry data programs varies across industry. Telemetry data fills a critical gap in traffic safety research, allowing for the understanding of real-world usage of safety technology.
- MITRE also delivered its next generation of results to the Partnership for Analytics Research in Traffic Safety (PARTS), measuring the crash reduction effectiveness of automatic emergency braking, as well as initial results for lane management systems. Eight automakers shared nearly 50 million vehicle records that contain proprietary information about what safety technologies were built on each vehicle. The dataset contains over 90 makes and models from model years 2015–2020. The National Highway Traffic Safety Administration (NHTSA) contributed data on nearly 8 million crashes for the current study and has shared data on 13 million crashes for the next phase of the study. The collaborative analysis enables NHTSA and other partners to gain real-world insights into the safety benefits and opportunities of emerging advanced driver assistance systems and automated driving systems. This study is the largest of its kind and it represents a major milestone in the PARTS program.



A Look Ahead

In the coming year, CAASD's focus will be on applying our SMS expertise to the transit industry, where a Federal Transit Administration mandate requires light passenger commuter rail, trolley, bus, and metrorail operators to implement these systems. As part of that effort, we're collaborating with the industry to instill a safety mindset throughout transit organizations.

As the federal government strives to ensure that all Americans—including people with disabilities and those in underserved communities—have access to transportation that supports quality of life, we're applying our social justice tools and frameworks to meet that need.

To support the government's goal of reducing transportation's impact on climate change, we're studying the electrification of passenger vehicles and buses, with a focus on battery safety.

And as the acceleration of vehicle automation introduces new cybersecurity risks, we're studying how to better anticipate and thwart cyberattacks that could give a nefarious actor control of a vehicle—or even a fleet of them.

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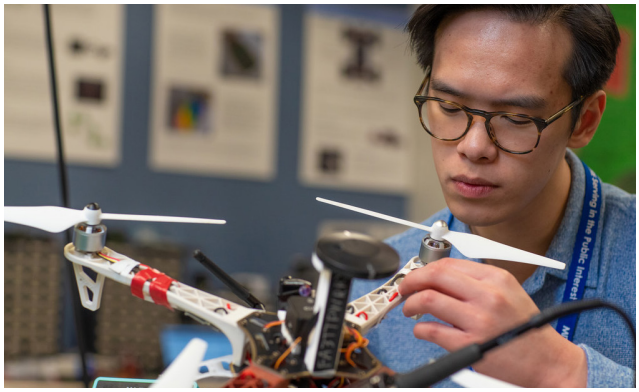
MITRE Innovation Program

In addition to the FFRDC MOIE program, MITRE invests in research across the aviation, aerospace, and surface transportation domains under its MITRE Innovation Program (MIP). MITRE seeks to build towards a safer and more efficient U.S. transportation system by addressing key subjects that pose risks to that future. Progress in these areas in FY21 is summarized below.



Autonomous Vehicles

Increasing automation is transforming ground and air vehicles alike. Automating cars, buses, and trucks could greatly improve roadway safety and provide access to underserved populations. Autonomous drones have many applications, from delivering packages to inspecting infrastructure to assisting farmers in managing their crops. But there are significant technical challenges to deploying autonomous vehicles without introducing new risks and problems.

In FY21, MITRE completed a three-year project to establish a lab and experimental testbed vehicle for autonomous ground vehicle technologies. This testbed has been used to create an approach for developing autonomous vehicle recording requirements. The results have been delivered to the Department of Transportation and used to inform our participation in industry standards committees. The testbed has also been used to support autonomy projects for the U.S Army, and for gathering position, navigation, and timing data to support the CAASD Digital Copilot project. At the end of FY21, we integrated a new sensor technology—event-based cameras, that detect tiny changes in light level rapidly, rather than capture entire frames—onto the testbed and will be evaluating whether it can improve the performance of automobile emergency braking systems.

MITRE has also been exploring methods to ensure safe operation of autonomous vehicles around manned vehicles, people, and other autonomous systems. This year, we developed and demonstrated an approach to mathematically guaranteed safe vehicle autonomy using some recently developed control techniques. The algorithms produced can be embedded in drones or autonomous ground vehicles to prevent collisions, to keep vehicles from entering prohibited areas, and to coordinate teams of vehicles safely.

Finally, the benefits of autonomous vehicles must be weighed against these vehicles' impacts on the environment, travel demands, and the economy. To this end, we developed an integrated energy-environmental-economic-engineering modeling framework that can address the complex system interactions between technologies, the environment, and the economy to support a more holistic analysis of autonomous vehicle effects.

System Resilience

As transportation systems become more reliant on automation, they also present more opportunities for cyber-attacks and other malicious behavior. We continued work applying a MITRE-developed cyber risk framework to railroad systems, collaborating with a major railroad and vendors of essential rail safety

systems to identify cyber threat scenarios, rank the impact and difficulty of them, and identify countermeasures that could be taken to prevent them. We also did the groundwork for a similar effort to analyze cyber threats to the trucking industry.

MITRE continued development of a low-cost method for securing Global Navigation Satellite Systems (GNSS), such as the Global Positioning System (GPS) against "spoofing" attacks, which attempt to corrupt the navigation solution (position, velocity, time) of a GNSS receiver. GNSS receivers are fundamental components in nearly all modes of transportation, and spoofing attacks can have significant consequences. The method developed can be implemented in software on a receiver, or even deployed on a smartphone with a cheap peripheral device, to alert vehicle operators that their navigation equipment cannot be relied upon. Methods for correcting the spoofing in real-time are also being developed as part of this research.

Climate change is another threat to transportation system performance. MITRE researchers have developed use cases and models to address this in the context of maritime supply chains, which can be disrupted by a variety of climate phenomena, and when disrupted, cause wide ripple effects through the economy. The goal is to understand the risks and interconnections well enough to inform coordinated responses to threats and thus improve the resilience of maritime supply chains.

Air traffic is also subject to disruptions, and MITRE is studying how to improve the resilience of our NAS to disruptions, such as severe weather. In FY21, we began defining a framework for modeling and quantitatively evaluating the robustness and resilience of the NAS, and for identifying when NAS performance is beginning to degrade, so that traffic managers can be alerted.

Safety

Transportation safety is a continuing focus of our research program, and we explored safety issues across the transportation spectrum. In the aviation context, a MITRE Early Career Research Program participant developed a new technique to quantitatively evaluate whether installed aircraft systems can be effectively used by the flight crew to react to emergency situations. This will be an important tool in design and certification of such systems.

On the surface, we continued our work on micromobility systems such as e-scooters and e-bikes, which hold great promise for improving access and reducing emissions. In FY21 we studied the safety aspects of micromobility, identifying emerging trends in risk factors that lead to accidents and fatalities in e-scooter operation. We also explored proposed methods for using technology to reduce fatalities among pedestrians and other vulnerable road users, identifying the key technical challenges to be overcome for successful development of a useful alerting system.

In all transportation modes, and indeed in other sectors where safety is a prime concern (e.g., healthcare), there is a desire for techniques that can predict a safety issue before it happens. MITRE has partnered with Idaho National Labs to explore state-of-the-art predictive analytic techniques and their application to safety. In FY21 we completed an extensive literature search to identify such human behavior prediction algorithms. This work will be used to build and explore some specific use cases in transportation where predictive safety tools appear feasible.

Efficiency

MITRE continues to study ways to increase the efficiency of the NAS, which is especially important given the impact of the COVID-19 pandemic on flight operators. We collaborated with two airlines this year to understand how they plan to reprioritize and recover from the pandemic effects, and what that means for effective management of air traffic. We worked with American

Airlines to apply voice data analysis to better understand what is happening in day-to-day airport surface operations and how to improve it. We also analyzed the simplified operational procedures that were used when traffic demand was low due to the pandemic and explored where these streamlined procedures could be maintained as traffic levels return to normal.

MITRE also explored the use of multi-scale graph networks to model NAS performance, with the eventual goal of gaining insight into the complex dynamics of traffic behavior in the presence of disruptions (e.g., from weather) and the traffic management initiatives put in place to manage demand in those situations. These representations are useful both to visualize these dynamics and to provide feature vectors for advanced analytical techniques such as machine learning.

NAS efficiency is also affected by the availability of effective decision support systems, and traditionally, these have taken many years to acquire. Our researchers looked across government to identify successful applications of current information technology, modern software architectures, and Agile methods to speed acquisition. Based on the findings, recommendations were made to several FAA programs on how to speed acquisition within the current Acquisition Management System (AMS) framework.

Sharing the Airspace

The U.S. airspace is collaboratively shared by commercial aviation, military operations, and space launch operations. The pace of space launches is increasing, the need for military operation airspace is changing due to newer aircraft with different training needs, and new airspace users such as Urban Air Mobility (UAM) vehicles are emerging. MITRE's research has been exploring new methods for sharing, scheduling, and coordinating airspace use under these new and changing demands.

In FY21, we continued to develop a dynamic special-use-airspace concept for the FAA and DoD to be more flexible in sharing airspace to accommodate the needs of modern aircraft and transitioned this work to direct funding by the FAA and DoD. We also studied in detail the needs of operators, launch facilities, DoD, and the FAA in scheduling and operating commercial space missions, using this data to refine an operational concept with associated automation support to coordinate airspace management across all types of users. The concept covers the entire scheduling process, from early planning and reservation of airspace to later phases in which conflicting demands on airspace need to be resolved prior to schedule approval.

UAM vehicles are becoming reality, with several manufacturers testing electric-powered designs that are intended to move people and freight around metro regions quickly and efficiently. We studied how UAM will interact with general aviation aircraft, through a human-in-the-loop simulation study which evaluated pilot workload and perceptions under a variety of UAM integration scenarios. We also evaluated a new microscale weather model that can effectively predict the small-scale wind and turbulence conditions that occur near the urban vertiports that UAM operations will use.

Technology Transfer

CAASD develops new aviation-related technology as part of its work program. CAASD products include technical and operational analyses that inform new concepts, standards, prototypes, and other work products that are needed by the FAA but are often not enough in and of themselves to establish operational capabilities that provide the FAA benefit and value. In those instances, CAASD and the FAA initiate a technology transfer process to transition the technology to the FAA and/or industry to ensure that end-user value is achieved.

Technology transfer is possible via the following methods:

- Commercial Licenses
- Non-commercial Licenses
- Open-Source Code
- Software Applications
- Papers/Publishing
- Industry Standards/Consortia.

CAASD staff produce innovations that, through their technology transfers, have advanced the state of the art and have had practical application to the safety of ATM.

In FY21, the following technology agreements and licenses were issued for FAA-funded and or MITRE/ CAASD-developed technologies in the aviation domain:

CAASD Technology	FY21 Technology Agreements/Licenses Issued
Exhaust Plume Analyzer	9
Small UAS Receiver Emulator	1
GNSS Test Architecture	4
TBFM Trajectory Performance Evaluation Tool	1
TARGETS	3
Total	21

The following patents most closely aligned with the CAASD work program were filed, issued, or continued in FY21:

Issue Date	Name	Patent No.	Application Date	Patent Type	Patent Status
09/21/2021	Flight Management System Operator	11,127,309	08/09/2011	Utility	Issued
04/06/2021	Performance-based Link Management for Air Traffic Control	10,972,175	03/26/2019	Continuation	Issued
01/12/2021	Digital Copilot	10,891,867	09/15/2017	Utility	Issued

Additionally, the following were submitted as patent applications in FY21:

Date	Title
2/11/2021	GNSS Spoofing Detection Using a Suppression Channel
3/1/2021	Method and System for Dynamically Navigating Routes According to Safety-Related Risk Profiles
3/4/2021	Wiener Process Disorder Detection Algorithm for Global Navigation Satellite System Spoofing Protection
6/1/2021	Bulk Aircraft Navigation Data Simulator and Comparison Tool
8/26/2021	Carry-on GPS Spoofing Detector

FFRDC OPERATIONS AND STEWARDSHIP

Governance

The FAA's CAASD Program Manager is responsible for all programmatic actions including, technical oversight, program plan validation and coordination, appropriate work determinations, resource allocation, coordination with the CAASD director's staff, liaison with other government agencies, and contact with industry concerning FFRDC matters.

Day-to-day oversight of CAASD occurs through ongoing interaction between the FAA and CAASD Program Manager, the FAA and CAASD Contracting Officers, and the FAA OMs and CAASD OLs and staff performing the work. In addition, the FAA's CAASD Program Manager participates in monthly contract management review meetings to monitor financial and schedule performance and address contractual items.

The FAA's FFRDC Executive Board (FEB), FAA Group of 4 (G4), and the CAASD Program Management Office (PMO) provide overall oversight, guidance, and management for the work program. While each of these entities has its specific role and responsibilities, collectively they ensure that CAASD focuses on the FAA's most pressing needs.

FEB: The FEB meets semi-annual to prioritize, shape, and evaluate CAASD FFRDC work program.

GROUP OF 4: The FEB created the G4 to ensure a fresh look is independently applied annually to all planned CAASD work considering agency shifts in needs, priorities, and to address the most critical problems facing the FAA and the aviation community.

AVIATION ADVISORY COMMITTEE: The MITRE Board of Trustees' Aviation Advisory Committee (AAC) provides strategic advice and counsel through CAASD on key issues that need to be addressed in modernizing

the aviation system. AAC members include high-ranking officials from aviation industry organizations and selected members of the board. The AAC meets three times per year and senior FAA executives regularly participate in the meetings.

OUTCOME MANAGEMENT: CAASD's work program is structured around eight FAA outcomes that reflect the FAA's strategic objectives:

- Outcome 1: NAS Concept of Operations Architecture and Integration
- Outcome 2: ATM Operational Evolution
- Outcome 3: Airspace and Performance-Based Navigation
- Outcome 4: Safety and Training
- Outcome 5: Communications, Navigation, Surveillance and Cybersecurity Infrastructure
- Outcome 6: Unmanned Aircraft Systems
- Outcome 7: Special Studies, Labs and Data Enhancements
- Outcome 8: Mission-Oriented Investigation and Experimentation

Each year, the FAA prepares detailed Product-Based Work Plans (PBWP) that define the work, products, and deliverables for each outcome. The PBWP is CAASD's contractual statement of work. It includes work that is funded by the Base budget line item and work funded through Industrial Funding (IF).

Products CAASD delivers to the FAA are also electronically available to all FAA employees via the CAASD Tracker archive. Deliverables are organized according to the work plan for each fiscal year by outcome. The work statements are provided in full in each Outcome's PBWP and the URLs for individual products are embedded throughout the task descriptions. Tracker makes all PBWP information and CAASD products readily available to the agency.

FISCAL YEAR 2021 PRODUCT AND OUTCOME EVALUATIONS: The FAA evaluates CAASD's performance on each outcome semi-annually; evaluates and accepts CAASD's individual products as delivered; reports on product receipt and acceptance monthly; and hosts formal Quarterly Product Review Boards (QPRB).

The FAA evaluates CAASD's *overall performance* by Outcome through semiannual Outcome Manager (OM) performance evaluations. The OM performance evaluations include FAA stakeholders and beneficiaries' inputs and provide an overall assessment of CAASD's technical, schedule, and resource management of each outcome. Cost management is assessed as part of the evaluation by the FAA's CAASD program manager. The evaluation results are presented to the FFRDC Executive Board (FEB) semiannually. CAASD consistently receives very high marks in all the evaluation categories.

The two FY21 Semi-annual Outcome Manager evaluations FY-H1 and FY-H2 responses indicated the fol-lowing averages (on a 1 to 4 scale with 1 marginal, 2 satisfactory, 3 excellent, and 4 outstanding) shown in the table below.

	FY21-H1 (9 of 10 OMs) Oct - March	FY21-H2 (1 of 10 OMs) April - Sept
Flight Management System Operator	3.94	3.75
Performance-based Link Management for Air Traffic Control	3.74	3.75
Digital Copilot	3.55	3.75

All CAASD products are evaluated and rated by their cognizant FAA stakeholder reviewer(s) at time of receipt and individually accepted by FAA's Technical Liaison Officers (TLOs). The summary results of these reviewer evaluations are also presented to the FEB semi-annually. Products are evaluated as outstanding, above average, average, below average, or poor. Product evaluations are a valuable element of the FAA's oversight and contribute to CAASD's continued focus on product quality.

In FY21, a total of 389 products (plus 7 supplementals) were delivered. As of 1/14/2021, 236 of the 389 delivered products received FAA product reviewer grades. The reviewed products received the following grades:

Grade	Number of Reviewed Products
Outstanding	97
Above Average	117
Average	21
Below Average	0
Poor	1
Not Graded	153

The 1 below average grade is being addressed and adjusted with the FAA sponsors. Remaining products will be graded and reported on at upcoming FY22 FEB and QPRB meetings.

Partnerships

To support the FAA and accelerate the adoption of new technologies and methods, CAASD partners with industry, academia, non-profits, stakeholder organizations, and government to diversify interactions and engagements and maintain an innovative edge.

Partnerships are formalized through non-disclosure agreements; memorandums of understanding; collaborative research agreements; or licenses for intellectual property that enable the broad set of stakeholders to mature new ideas, operationalize concepts or prototype capabilities, and ultimately deliver improved safety, efficiency, and access to airspace users.

Advocacy

A primary objective of CAASD's mission as an FFRDC is to share findings with the broader aviation community, associated government agencies, and members of industry.

CAASD researchers are encouraged to publish key findings, participate in forums and panels, and ensure that they are collaboratively contributing to the broader body of knowledge that will move the transportation domain forward.

Key 2021 Conference Participation

CAASD participates in a broad range of aviation and aerospace conferences each year to both learn and share. CAASD staff are frequent contributors of technical papers and presentations and are often invited to serve as subject matter experts on educational panels and plenary sessions. Key CAASD technical personnel also are regular keynote speakers.

In FY21, the conference world continued to be challenged by COVID-19. Despite virtual and hybrid conferencing, CAASD continued to have significant participation in numerous domestic aviation industry conferences, participating in educational webinars and panels and sharing technologies and demonstrations as part of virtual and physical booths. MITRE also hosted several virtual convenings on a variety of topics. Highlights included:

- Digital Avionics Systems Conference (DASC)
- RTCA Webinar Series
- ATCA: Aviation Cybersecurity, Technical Symposium, Annual Conference
- Association for Unmanned Vehicle Systems International (AUVSI) XPONENTIAL
- FAA Managers Association (FAAMA) annual conference
- AIAA: ASCEND, AVIATION, SciTech
- Transportation Research Board (TRB) annual conference and Automated Road Transportation Symposium
- Professional Women Controllers (PWC) National Training Conference
- Advancing Safety Management Implementation Across the Automated Driving System Industry: Virtual Kickoff and Forum (MITRE-hosted events—May and September)
- ASIAS InfoShare meeting: MITRE hosted
- Commercial Spaceflight Federation/MITRE Workshop: Space Health
- MITRE Digital Twins Virtual seminar (September 2021)

CAASD also had numerous papers submitted by staff and accepted for presentation at additional technical conferences, including ICNS, IEEE, American Meteorological Society, Flight Safety Foundation, ATM R&D, and Aviation Psychology/Human Factors.

Featured Content In External Publications

CAASD has content partnerships with several aviation industry publications and frequently shares technical pieces and FAA project success summaries as part of its advocacy role. In addition, CAASD publishes select project stories on www.mitre.org to highlight important FAA mission achievements as well as technical thought pieces and publications. Content is frequently prepared in partnership with and with the approval of the FAA. In FY21, CAASD-provided content appeared in:

- FAAMA's *Managing the Skies*
- *ATCA Bulletin*
- *ATCA Journal*
- *AIAA's Aerospace America*
- *Aviation Week*
- *ATM Magazine*
- *Air Traffic Technology International*
- Civil Aviation Authority of Singapore's *The Leading Edge*
- *The Hill*
- *IEEE Spectrum*
- *UV Daily@AUVSI*

CAASD also participated in several podcasts on Federal News Network and the XEO podcast live in addition to producing a tri-annual aviation industry update podcast for external consumption.

In September 2021, *CIO Coverage Magazine* named MITRE one of the Top 10 Leading Aerospace and Aviation Providers to watch, highlighting CAASD 60+ year partnership the FAA.

GLOSSARY

Acronym	Definition
4D	4-dimensional
4DTLFD	Four-Dimensional Trajectories Live Flight Demo
AAAE	American Association of Airport Executives
AAC	Aviation Advisory Committee
AAM	Advanced Air Mobility
ACSAA	Aircraft Certification, Safety, and Accountability Act of 2021
ACT-IAC	American Council for Technology–Industry Advisory Council
AD	Airworthiness Directive
ADO	FAA Chief Data Office
ADS-B	Automatic Dependent Surveillance–Broadcast
AEB	ASIAS Executive Board
AES	Automation Evolution Strategy
AFN	FAA Office of Finance and Management
AFP	Airspace Flow Program
AHA	Aircraft Hazard Area
AI	Artificial Intelligence
AIAA	American Institute of Aeronautics and Astronautics
AIR	Aircraft Certification Service
AIRS	ADS-B In Retrofit Spacing
AIS	FAA Office of Information Systems Security and Privacy Service
AIT	FAA IT Organization Office of Information and Technology
AJI	FAA Office of Safety and Technical Training
AJT	FAA Air Traffic Services
AJT	Air Traffic Services
AJV	FAA Mission Support Services
AJV-P	FAA Office of Orders and Notices
AJV-S	FAA Mission Support Strategy Division
ANG	FAA Office of NextGen
ANSP	Air Navigation Service Provider
API	Application Programming Interface
APO	FAA Office of Aviation Policy and Plans
AQS	FAA Office of Quality, Integration, and Executive Services
APR	Automated Periodic Review
ARIA	Aviation Risk Identification and Assessment

Acronym	Definition
A-RNP	Advanced Required Navigation Performance
ARTCC	Air Route Traffic Control Center
ASAP	Aviation Safety Action Program
ASDE-X	Airport Surface Detection Equipment–Model X
ASEPS	Advanced Surveillance–Enhanced Procedural Separation
ASIAS	Aviation Safety Information Analysis and Sharing
ASR	Automated Speech Recognition
ASSURE	Alliance for System Safety of UAS through Research Excellence
AST	FAA Office of Commercial Space Transportation
ATC	Air Traffic Control
ATCA	Air Traffic Controllers Association
ATCSCC	Air Traffic Control System Command Center
ATD-2	Airspace Technology Demonstration–2
ATM	Air Traffic Management
ATO	FAA Office of Air Traffic Operations
AUS	FAA UAS Integration Office
AUVSI	Association for Unmanned Vehicles Systems International
AVS	FAA Office of Aviation Safety
AWS	Amazon Web Services
BA	Business Aviation
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CA	CDTI-Assisted
CAASD	Center for Advanced Aviation System Development
CARF	Central Altitude Reservation Function
CAS	CDTI-Assisted Separation
CAST	Commercial Aviation Safety Team
CDM	Collaborative Decision Making
CDR	Critical Design Review
CDTI	Cockpit Display of Traffic Information
CFiT	Controlled Flight into Terrain
CFR	Code of Federal Regulations
CLT	Charlotte Douglas International Airport
CNS	Communications, Navigation, and Surveillance
ConOps	Concept of Operations
ConUse	Concept of Use
CRE	Collaborative Research Environment
CSG	CDM Stakeholders Group
CUI	Controlled Unclassified Information

Acronym	Definition
DASC	Digital Avionics Systems Conference
DataComm	Data Communications
DFW	Dallas/Fort Worth International Airport
DHS	Department of Homeland Security
DoD	Department of Defense
EE3	ERAM Enhancement 3
E-IDS	Enterprise Information Display System
EIM	Enterprise Information Management
EMAS	Engineered Material Arresting System
ERAM	En Route Automation Modernization
ERAU	Embry-Riddle Aeronautical University
EUIE	Early User Involvement Event
FAA	Federal Aviation Administration
FAAMA	FAA Managers Association
FANS	Future Air Navigation Systems
FAT	Factory Acceptance Test
FCS	FAA Cloud Services
FEB	FFRDC Executive Board
FENS	FAA Enterprise Networking Services
FF-ICE	Flight and Flow Information for a Collaborative Environment
FFM	Future Flow Management
FFRDC	Federally Funded Research and Development Center
FID	Final Investment Decision
FLOAT	Fully Leveraged Obstacle Assessment Tool
FLXM	Flow Information Exchange Model
FMDS	Flow Management Data and Services
FOQA	Flight Operations Quality Assurance
FOTO35	Future of the Ocean 2035
FTB	Florida NextGen Test Bed
FTI	FAA Telecommunications Infrastructure
FY	Fiscal Year
G4	Group of 4
GA	General Aviation
GAMA	General Aviation Manufacturers Association
GDP	Ground Delay Program
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HITL	Human-in-the-Loop

Acronym	Definition
IAC	Industry Advisory Council
IARD	Investment Analysis Readiness Decision
IAT	Issue Analysis Team
ICAO	International Civil Aviation Organization
ICNS	Integrated Communications Navigation and Surveillance
IDEA Lab	Integration Demonstration and Experimentation for Aeronautics Laboratory
IDS	Information Display System
IF	Industrial Funding
IFP	Instrument Flight Procedures
IFPA	IFP Automation
ILS	Instrument Landing System
IM	Interval Management
IOAA	IFP, Operations, and Airspace Analytics
IP	Internet Protocol
IPS	Internet Protocol Suite
IRS	Internal Revenue Service
iTBO	initial Trajectory-Based Operations
IWR	Industrial Work Request
KDPK	Dekalb-Peachtree Airport
L/R	Launch and Reentry
LOB	Line of Business
LTE	Long-Term Evolution
MARS	Multiple Airport Route Separation
MASPS	Minimum Aviation System Performance Standards
MBSE	Model-Based Systems Engineering
ML	Machine Learning
MOIE	Mission-Oriented Investigation and Experimentation
MON	Minimum Operational Network
MOPS	Minimum Operational Performance Standards
MOSAIC	Modernization of Special Airworthiness Certificates
MPLS	Multi-Protocol Label Switching
NAC	NextGen Advisory Committee
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NBAA	National Business Aviation Association
NEC	Northeast Corridor
NextGen	Next Generation Air Transportation System

Acronym	Definition
NITRO	NAS Integration of Transiting and Higher Airspace Operations
NOD	NAS Operations Dashboard
NOTAM	Notice to Airmen
O&M	Operations & Maintenance
ODP	Obstacle Departure Procedure
OM	Outcome Manager
OSE	Operational Support Entity
P&O	Procedures and Operations
PBN	Performance-Based Navigation
PBWP	Product- Based Work Plan
PNT	Position, Navigation, and Timing
PSP	Partnership for Safety Program
QA	Quality Assurance
QPRB	Quarterly Product Review Board
RAISE	Rotorcraft ASIAS Integrated Services Environment
RBDM	Risk-Based Decision Making
R-IAT	Rotorcraft Issue Analysis Team
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
SA	Special Authorization
SARPS	Standards and Recommended Practices
SASE	Separation Automation System Engineering
SBA	Space-Based ADS-B
SciTech	Science and Technology
SD-WAN	Software-Defined Wide Area Network
SE	Safety Enhancement
SID	Standard Instrument Departure
simTBO	Simulated TBO
SIP	Session Initiation Protocol
SIR	Screening Information Request
SMS	Safety Management System
SNS	Space Nuclear System
SO	Staff Office
SOA	Service-Oriented Architecture
SRA	Security Risk Assessment
SRM	Safety Risk Management
SRMP	Safety Risk Management Panel

Acronym	Definition
SSE	Separation Services Engineering
SSP	State Safety Programme
STAR	Standard Terminal Arrival Route
STARS	Standard Terminal Automation Replacement System
sUAS	small Unmanned Aircraft System
SWIM	System Wide Information Management
TARGETS	Terminal Area Route Generation, Evaluation, and Traffic Simulation
TBFM	Time-Based Flow Management
TBM	Time-Based Management
TBO	Trajectory-Based Operations
TDP	Transportation Data Platform
TERPS	Terminal Instrument Procedures
TFDM	Terminal Flow Flight Data Manager
TFM	Traffic Flow Management
TFMS	Traffic Flow Management System
TLO	Technical Liaison Officer
TLS	Target Level of Safety
TMI	Traffic Management Initiative
TPCA	Third-Party Cooperative Agreement
TRACON	Terminal Radar Approach Control Facility
U.S.	United States
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UAT	User Acceptance Testing
URIF	UAS Research Identification Framework
URL	Uniform Resource Locator
UTM	UAS Traffic Management
VDWG	Vulnerability Discovery Working Group
VoICE	VoIP Communications Enterprise
VoIP	Voice-over-Internet Protocol
VOR MON	Very High Frequency Omni-Direction Range Minimum Operational Network
VOR	Very High Frequency Omni-Direction Range
VSRP	Voluntary Safety Reporting Program
WJHTC	William J. Hughes Technical Center

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