FY20 ACHIEVEMENTS IN AEROSPACE AND TRANSPORTATION

CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT
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CAASD
Annual Report

FY 2020

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A Letter from Gregg Leone, Vice President and Director of MITRE's Center for Advanced Aviation System Development

It would be an understatement to say 2020 was an extraordinary year. As the COVID-19 pandemic turned our everyday lives upside down, the aviation world was presented with urgent challenges from passenger safety to global supply chain issues. Despite these evolving challenges, the FAA continues to deliver on its mission of providing the safest, most efficient aerospace system in the world. CAASD is helping the FAA forge ahead with initiatives to improve global airspace operations, while focusing on resiliency to confront the new normal.

Since CAASD's origination as the FAA's FFRDC, our work has helped to improve aviation safety and security, increase the capacity and efficiency of the national airspace, reduce flight delays and traffic management constraints, and modernize and harmonize global aviation systems. This unprecedented time cannot deter us from advancing plans for the future, which include creating a fully connected and highly resilient aerospace system built through public-private partnerships.

While this report is a retrospective of FY20 accomplishments, it also offers a glimpse of the work to come and an outlook for the future. Today, we are helping ensure the cybersecurity of aviation-related networks, co-developing safety standards for unmanned vehicles, and streamlining the process of approving flight paths. We are also exploring how to build situational awareness with real-time monitoring of the effects of the coronavirus on aviation operations to help inform crucial decision making. Our work continues even as air traffic levels rise again.

CAASD is committed to supporting the FAA and its Administrator's goals of safety and ensuring public trust, operational excellence, global leadership, stakeholder engagement, and fostering people and culture.

We are also focused on resilience and applying our research and experimentation environment to identify new and innovative solutions for next-generation safety and cybersecurity.

Our significant knowledge of the FAA, combined with a profound perspective of the National Airspace System and global challenges, allows us to provide a unique vantage point. Our relationships across the aerospace and transportation community help us serve the FAA as an advocate. And our not-for-profit status ensures we offer an honest, objective, and independent view.

One of CAASD's greatest strengths is our history operating as the FAA's FFRDC. We are extremely proud to be the FAA's mission partner, and our joint commitment to enable a safe, secure, and efficient global aerospace ecosystem is now more important than ever.

The world will continue to evolve and change more rapidly than ever as new and yet-to-be-identified challenges emerge. Aerospace and transportation are the engine of our global economy, and we will continue to work to keep passengers and goods safe—from surface to space.

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 aviation operations.

To meet this need, the FAA has invested in the unique laboratories, modeling, simulations, and analytic capabilities at CAASD 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 civil aviation authorities around the world, 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 knowledge of best practices in aviation, advance international harmonization of aviation and Air Traffic Control (ATC) standards and technology, and share information with the FAA and other stakeholders.

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.

The next sections outline CAASD's Fiscal Year 2020 (FY20) mission accomplishments, and provide an overview of plans for FY21. The sections are organized by the FAA Administrator's goals:

- Safety, Operational Excellence, and Ensuring Public Trust
- Global Leadership
- Stakeholder Engagement
- Fostering People and Culture
- Resilience

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

FY20 MISSION ACCOMPLISHMENTS

SAFETY, OPERATIONAL EXCELLENCE, & ENSURING PUBLIC TRUST

We understand that safety is at the heart of the FAA's mission and effective safety solutions rely on a strong, collaborative relationship between government and industry. We partnered with the FAA and stakeholders in the aviation industry to create the Aviation Safety Information Analysis and Sharing (ASIAS) initiative. As a result, we have a singular perspective on the hurdles that were overcome by the government as it established this groundbreaking sharing of critical safety information.

Today, we are moving beyond a forensic approach, where only past aviation accident or incident data is examined, to a *proactive approach* focused on detecting risk and implementing mitigation strategies before accidents or serious incidents occur. Our ability to quickly harness more, new, and better data allows us to push the limits of discovery and eliminate risks from increasingly complex and dynamic systems.

CAASD is already working to enable the FAA to advance to the next level of safety by harnessing today's information advances to make a robust data sharing environment possible through collaborative research enclaves and programmatic access to big data and the tools to interpret and derive safety insights with all stakeholders. We have deployed advanced capabilities leveraging natural language processing in addition to artificial intelligence (AI) and machine learning (ML) concepts that are offering new insights to aviation safety.

From the single pilot to commercial airline passengers, our focus is to ensure new systems and capabilities are both operationally integrated and introduced to the field in a coherent manner to achieve the envisioned enhancements.

ASIAS Impact

- Since 2007, 22 safety enhancements have been made based on ASIAS analyses performed by CAASD.
- ASIAS continues to ingest proprietary data on a rolling five-year window. In FY20, ASIAS collected

  33,062,523

  Flight Operations Quality Assurance (FOQA) records and

  397,287

  Aviation Safety Action Program (ASAP) records.
- As of the end of November 2020, 217 stakeholder organizations from government, industry, and academia actively participate in the ASIAS public-private partnership.

Uniform Safety Continuum

Society's tolerance for safety risk varies across a broad range of aviation sectors. Safety assurance and oversight must adapt to address the safety risks that increasingly complex operations and vehicles pose. The Uniform Safety Continuum policy framework, which CAASD worked with the FAA to develop, provides a methodology FAA services and offices can use to deliver more standardized, complementary, and integrated oversight to address public expectations more consistently for each aviation sector.

CAASD's research on the Uniform Safety Continuum will allow the FAA's Aviation Safety organization (AVS) to systematically prioritize its resources in accordance with the public's tolerance for risk in different aviation sectors. It will provide insight into the target level of safety needed for each sector (e.g., transport category, experimental, or traditional aircraft) based on public expectations. The Continuum allows AVS services and offices to develop joint risk-mitigation strategies in a collaborative manner to achieve target levels of safety, and it facilitates life-cycle thinking and decision making across the AVS services and offices.

FY20 ACCOMPLISHMENTS: CAASD collaborated with the Aircraft Certification Service (AIR) and a team across AVS services and offices to develop an initial Uniform Safety Continuum framework. The framework included descriptions of the safety continuum concepts and operating principles that provide the foundation for the Continuum. It helped to align and shape the thinking around this concept and approach across AVS services and offices.

CAASD also developed use cases describing AVS services' and offices' roles and responsibilities in applying the framework. In collaboration with the FAA, the Modernization of Special Airworthiness Certification (MOSAIC) notice of proposed rulemaking (NPRM) was selected as a preliminary use case for the application of the new concept.

FY21 PLANS: In FY21, CAASD will continue to collaborate with AIR and a cross-AVS team of subject matter experts (SMEs) to develop and apply Uniform Safety Continuum methods and tools. CAASD will evolve the FY20 Uniform Safety Continuum Framework developed in FY20 based on feedback and will work across AVS services and offices to socialize it. CAASD will collaborate with the MOSAIC team to inform the development of the MOSAIC NPRM in alignment with Continuum concepts and principles. CAASD will develop methods and tools to facilitate risk-based decision making at the FAA leadership and workforce levels. CAASD will also develop data requirements for the Safety Continuum based on specific use cases and applications.

Aviation Risk Identification and Assessment

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 events. 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.

FY20 ACCOMPLISHMENTS: ARIA went live on October 1, 2020, and will provide substantial benefits to the FAA and the flying public. ARIA will help the FAA's Quality Assurance Group reallocate roughly 50,000 staff hours previously devoted to finding anomalous events to performing deep-dive analyses on the most important safety events. ARIA is deployed via the FAA's shared cloud computing environment utilizing modern computing approaches.

Much of CAASD's efforts in 2020 were focused on achieving deployment. This included completing validation efforts for the Airborne ARIA implementation, and preparing technical documentation to help ensure that the FAA or its chosen operator

can operate the Airborne ARIA and Surface ARIA algorithms, a necessary component for the complete tech transition of responsibility for ARIA to the FAA. CAASD has also continued development of data visualization and data analysis and exploration capabilities of ARIA results. Additionally, CAASD completed development on Surface ARIA algorithms and began related validation and technical documentation efforts.

In FY20, a joint National ARIA Safety Metric Workgroup was formed. Its members include representatives from CAASD, the National Air Traffic Controllers Association (NATCA), Orders and Notices (AJI1), Policy and Performance (AJI3), and Air Traffic Safety Oversight (AOV). This group focused on developing a reportable national, aggregated safety metric. In addition to efforts to roll out the Airborne ARIA algorithms, CAASD performed research on the extensibility of Airborne ARIA risk-index scoring for broader evaluations of the safety impacts arising from procedural changes or airspace redesigns. CAASD also explored a process for evaluating controller recovery from high-risk events by coupling ARIA event data with voice data analysis.

FY21 PLANS: CAASD will deliver technical documentation to ensure the FAA or its chosen operator can successfully operate and maintain the ARIA algorithms in the Enterprise Information Management (EIM) software environment. CAASD will also finalize the tech transfer of Surface ARIA to prepare for its rollout in October 2021 and will continue development on the Event Replay and Data Visualization Tool for use by quality assurance (QA) specialists. In addition, CAASD will conduct a technical analysis of space-based Automatic Dependent Surveillance-Broadcast (ADS-B) data composition, quality, and data coverage. Based on the results of this analysis, CAASD will make recommendations for computational frameworks and system requirements to support routine processing of the ADS-B data source as a potential input for ARIA algorithms.

Additionally, CAASD will continue research into utilizing ARIA data to evaluate safety barriers, provide an aggregate risk score for a region or airspace, correlate that score with operational constraints in effect at the time to understand the implications of operational decision making on safety, and further understand controller recovery from high-risk events.

Safety Information Sharing

ASIAS: ROTORCRAFT TAXONOMY WORKING GROUP

CAASD has worked with the rotorcraft industry and the FAA William J. Hughes Technical Center (WJHTC) since 2016 to create Rotorcraft ASIAS. CAASD has worked to establish relationships within the rotorcraft safety community with the goal of developing an ASIAS rotorcraft program similar to that of the General Aviation (GA) ASIAS community.

In 2017, CAASD and the WJHTC worked closely with the U.S. Helicopter Safety Team (USHST) to identify the top safety issues impacting the rotorcraft community. Several Safety Enhancements (SEs) were developed to address the identified issues: low-altitude operations, unintended flight into instrument meteorological conditions, and loss of control. In 2017, USHST set a goal to reduce fatal helicopter accidents by 20 percent by 2020.

WJHTC and the Partnership to Enhance General Aviation Safety Accessibility and Sustainability (PEGASAS) have been involved in a Helicopter Flight Data Monitoring (HFDM) research project. Since 2016, CAASD has engaged in weekly PEGASAS telecons where ongoing research efforts—such as defining rotorcraft parameters, providing feedback for the HFDM database, and assisting with rotorcraft studies—are shared, with the goal of building on existing work and applying it to ongoing ASIAS endeavors. CAASD has begun to apply the PEGASAS research efforts, as well as existing WJHTC methods, to analyses using HFDM data that rotorcraft operators have provided. The results of these analyses were shared

in an ASIAS report delivered in December 2020.

Stakeholder engagement and outreach have been a significant part of the effort to grow the ASIAS rotorcraft community. CAASD has partnered with the USHST, via both in-person studies as well as telecon meetings, to support SEs resulting from a review of 54 fatal accidents. A CAASD representative served as part of the team that reviewed National Transportation Safety Board reports over the course of 18 months to develop the SEs, which can be found at the USHST website. In addition to the SE meetings, CAASD supported ongoing USHST face-to-face meetings, including the most recent, in August 2019 at Robinson Helicopter. Lastly, CAASD regularly participated in the annual Helicopter Association International Heli-Expo, which has included HFDM sessions, USHST meetings, USHST booth support as a USHST member, PEGASAS research briefings, and work with WJHTC and PEGASAS on next steps for rotorcraft ASIAS.

Over the past year, CAASD collaborated with Air Medical Operators Association (AMOA) to support sample analysis of HFDM data. Ongoing results of this analysis are shared with the FAA and participating operators during bi-monthly working group meetings. Recent analysis efforts included developing an initial safety report taxonomy, as well as establishing a data standardization process and a data dictionary for both safety reports and Flight Data

Monitoring (FDM) data. Since 2016, CAASD has also had ongoing discussions with the FAA regarding data architecture and the hosting of HFDM data.

The Fall 2019 Aviation Safety InfoShare conference marked the first inclusion of a rotorcraft breakout session. At this session, CAASD presented an overview of the ASIAS program, a path forward for increased rotorcraft participation and the benefits thereof, as well as a digital flight data analysis demonstration. CAASD also briefed a stakeholder's meeting on rotorcraft expansion efforts and outcomes. These two briefings have been provided to the ASIAS Program Manager via the ASIAS portal.

FY20 ACCOMPLISHMENTS: The Rotorcraft Taxonomy working group, comprised of government and industry representatives, assesses rotorcraft data with a view to standardizing it as much as possible for future ingest and analyses. To date, three AMOA operators, whom CAASD has agreements with to share sample HFDM data, have shared sample HFDM data for assessment, totaling approximately 7,500 flights. The working group has convened bi-weekly since November 2019, improving data coverage and evaluating data parameters for future analysis.

FY21 PLAN: The taxonomy working group will merge with the Rotorcraft Issue Analysis Team to set the technical direction for rotorcraft data analyses and will leverage conclusions from the sample data assessment to expand data participation to additional operators.

ASIAS: SAFETY TEAMS (JIMDAT, GA IAT, COMMERCIAL IAT)

At the onset of the COVID-19 pandemic, the Joint Implementation Measurements and Data Analysis Team (JIMDAT) meetings increased in frequency (from monthly to weekly). This was done to discuss and prioritize activities related to the commercial aviation industry's response to the pandemic. The JIMDAT stressed a need to have visibility of the impact COVID-19 was having on the industry and the ability

to react to metric changes as quickly as possible. In response to this need, a working group was created to digest COVID-19-related safety reports, and baseline metrics were published to the ASIAS portal for better visibility of risks within the metrics.

In addition, the GA and Commercial Issue Analysis Teams (IATs) increased their meeting frequencies to share topic information identified through the Office of Accident Investigation and Prevention's (AVP-220) analysis of nonpublic Aviation Safety Reporting System (ASRS) reports. These COVID-19 discussions occurred bi-weekly in addition to the full quarterly IAT meetings. The GA IAT concluded and briefed out two prominent studies: GA Midair Collision Risk; Traffic Alert and Collision Avoidance System (TCAS) Directed Study and GA Incorrect Surfaces. The commercial aviation IAT meetings, held biweekly, focused on the impact to safety due to reduced/ceased operations and the safe resumption of operations.

FY20 ACCOMPLISHMENTS: In FY20, the JIMDAT identified safety issues, studied causal factors, and worked proactively with airports authorities, air traffic controllers, and operators to develop mitigations. One significant accomplishment was the identification of unauthorized drone operations at low altitudes on approach to McCarran International Airport and sharing data with local ATM for resolution. Additionally, JIMDAT identified increases in minimum fuel and emergency fuel declarations via the monitoring of non-public ASRS reports (and is currently analyzing potential causal factors). The JIMDAT also developed a process to capture path deviations on approach at airports without precision approaches with vertical guidance.

During FY20, the GA IAT identified and resolved several safety issues relevant to GA operations. They include identification of a lack of pilot/aircrew currency/proficiency leading to potential issues (e.g., altitude deviations and unstable approaches, speed deviations, flap overspeed, and delayed landing configurations, some of which result in go-arounds). In addition, GA pilots reported airspace deviations and temporary flight

restrictions (TFR) busts since some pilots rely on ATC services to prevent these incursions and ATC have a higher-than-expected ATC workload due to COVID-19 protocols. Some GA pilots, unfamiliar with abnormal tower operating hours/closures, are flying the wrong traffic pattern, leading to airborne conflicts. These situations are exacerbated by high traffic, which under normal conditions would not be a problem since the tower would provide control services.

Highlights from the commercial IAT include the identification of increased unstable approaches at Austin-Bergstrom International Airport since the implementation of new approach and star procedures. The JIMDAT and IAT discerned that the primary cause for the increase in unstable approaches was a result of shorter distances between waypoints and an increase in descent gradients; those insights enabled the community to provide effective mitigations.

The IAT continues work with SE-186 (TCAS Sensitivity Level Command) via a consensus-based and data-driven approach to resolve the issue of nuisance TCAS alerts at high-altitude airports like Denver International Airport. Operators also shared concerns about getting FOQA data from parked planes; failure to obtain this data before planes go into long-term parking can result in permanent data loss. The IAT discussed issues with systems that have resulted in unreliable airspeed indications, leading to high-speed rejects. These discussions spurred new maintenance procedures for

inspecting pitot-static systems. The IAT has also identified and shared data on issues related to lightweight aircraft operations, including long landings, hard landings, high taxi speeds, and an increase in high-speed rejected takeoffs.

FY21 PLAN: CAASD will maintain a meeting frequency consistent with the community needs and continue to proactively identify and resolve aviation safety issues.

Safety Management System (SMS) Training Courses

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 FY20, CAASD held five training sessions, all virtual, with a total of 221 students who took and passed the course exam.

Initial Trajectory-Based Operations Implementation at FAA Operating Areas

The FAA is in the process of deploying the necessary automation systems and operational procedures to support Trajectory-Based Operations (TBO) in the NAS. TBO is an ATM methodology for strategically planning, managing, and optimizing flights throughout the NAS by using time-based management (TBM), information exchange between air and ground systems, and the aircraft's ability to fly precise paths in time and space. The foundation of TBO is the aircraft trajectory. Defined in four dimensions—latitude, longitude, altitude, and time—the trajectory represents a common reference for an aircraft that is defined prior to departure, updated by controllers in response to emerging conditions and operator inputs, and shared between stakeholders and systems as needed.

TBO is a long-term target of the Next Generation Air Transportation System (NextGen) program, building upon prior NextGen infrastructure investments in modernized automation systems (such as En Route Automation Modernization [ERAM], Standard Terminal Automation Replacement System [STARS], and enhanced Communications, Navigation, and Surveillance [CNS]). The NAS's transition to TBO begins with the recent and forthcoming NextGen investments in TBM automation systems and decision-support tools, improved electronic information exchange, and strategic planning capabilities and processes.

The FAA is implementing TBO in phases. The first several years are focused on implementation of initial TBO (iTBO), which introduces the use of coarse, predicted four-dimensional (4D) trajectories for Traffic Flow Management (TFM) decision making predominantly via use of gate-to-gate TBM. The predicted flight trajectories are largely defined by published navigation procedures and routing and use of time is applied on a discrete basis at predefined constraint points. These predicted flight trajectories are coordinated with the operators in advance and are updated on an event-driven basis.

Four NAS operating areas are targeted for iTBO implementation: the Northwest Mountain area, with a focus on Denver; the Mid-Atlantic area, with a focus on Atlanta; the Southwest area, with a focus on Los Angeles; and the North East Corridor (NEC). Achieving iTBO implementation will rely upon successful operational integration of new systems and capabilities with existing ones as well as the introduction of new air traffic procedures. It will also rely heavily upon the successful operational transition of the ATM and operator workforce to this new methodology.

As the FAA progresses to TBO, there will be more system-wide use and scaled integration of TBM across the NAS that will provide enhanced benefits. Research is ongoing to improve upon iTBO via new automation enhancements and greater use of flight deck technologies. These capabilities will be used to enable more customized, predicted 4D flight trajectories (tailored to the operator's business objectives) that can be maintained more continuously throughout variable operating conditions.

INITIAL TRAJECTORY-BASED OPERATIONS PERFORMANCE ASSESSMENT REPORTING

The FAA is incrementally deploying new capabilities in the NEC and in other selected locations to move the NAS toward iTBO. During CAASD's support of this effort, it has been noted that the FAA needs to be able to clearly articulate expected benefits for iTBO on a site-specific basis, and track progress toward iTBO objectives and success criteria as new capabilities are implemented in the NAS. To that end, a framework to address these needs has been exercised for Philadelphia International Airport and Newark Liberty International Airport to provide a baseline against which to assess progress. The findings provide site-specific operational baselines, a preliminary assessment of progress made toward the success criteria, and a qualitative description of additional benefits that can be expected based on the planned implementation of new capabilities for those locations. The FAA intends to provide regular updates toward iTBO success criteria for all iTBO focus areas.

FY20 ACCOMPLISHMENTS: The FY20 framework is expected to better enable data-driven analysis of progress toward iTBO objectives. The intent is to apply this approach to iTBO operating areas to monitor long-term incremental progress as new capabilities are implemented. It is important to note that analysis of progress must include examination of both the quantitative metrics and qualitative information gathered from the field and other stakeholders. Additionally, the intent is not that metrics be viewed individually, but rather that they be examined collectively for a comprehensive understanding of whether and how NAS operations are changing. Metrics and metrics categories were chosen to provide a broad view of different aspects of iTBO objectives that are often interrelated. That is, changes in one category or metric should be evaluated in the context of changes in other metrics (e.g., whether gains in one area are offset by reductions in another category). The framework is intended to be a starting

point for future analysis. However, there is additional work that the FAA must undertake to build a more robust analytical framework.

FY21 PLANS: CAASD will provide customized analytical abilities and evaluation methods to address incremental, site-specific improvements at additional locations. These capabilities will be designed to detect iTBO impacts and changes in performance, including operational gains from a set of distinct improvements. The assessment of site-specific metrics and data necessitates an expanded set of visualization tools to track progress toward success criteria. These tools must provide different-level data views to support specific stakeholder information needs and decision making (e.g., FAA executive and field personnel). In FY21, CAASD will work with FAA stakeholders to identify the analytical platform requirements and enhancements they require. This research will also include enhancing the analytical platform with new algorithmic methodologies and additional data sets to accommodate the desired set of post-implementation benefit metrics for each of the planned iTBO sites. Finally, this effort will identify the steps remaining to complete development of the iTBO analytical platform.

OPERATIONAL INTEGRATION OF ENABLING AUTOMATION

TBO implementation will rely upon the successful operational integration of new systems and capabilities with existing ones, as well as the introduction of new air traffic procedures. Many TBO capabilities and systems are already in place and actively used throughout the NAS, while other TBO capabilities are still in development.

CAASD is working with the FAA to integrate these systems and capabilities to achieve the objectives of TBO. To provide seamless TFM decision support throughout the NAS, CAASD is informing enhancements to and integrating across three key automation platforms: Traffic Flow Management System (TFMS), Time-Based Flow Management (TBFM), and Terminal Flight Data Manager (TFDM). Together, these automation platforms enable gate-to-gate TBM by strengthening strategic planning of traffic flows and tactical resolution of capacity-to-demand imbalances.

CAASD is also performing technical analyses to address site-specific operating area attributes that may pose unique challenges to successful automation deployment and workforce acceptance. Finally, CAASD has been working closely to identify, track, and mitigate iTBO implementation risks through a series of diverse analytical efforts. These efforts span broad stakeholder engagement events to detailed human-in-the-loop (HITL) evaluations conducted in MITRE's Integration Demonstration and Experimentation for Aeronautics (IDEA) Laboratory.

FY20 ACCOMPLISHMENTS: CAASD analyzed diverse operational data sets, provided technical and operational insights, and used newly developed fast-time simulation and modeling capabilities to address FAA-prioritized implementation questions about iTBO operating areas. The series of technical analyses CAASD completed studied topics such as arrival throughput tradeoff concerns, improving TBM predictability, performance effects of site-specific operational complexities (such as variable winds, frequent runway

configuration changes, and airspace load balancing), Performance-Based Navigation (PBN) procedure utilization, and operating area implementation feasibility factors. The resulting outputs support the FAA's efforts to address and resolve key issues associated with the iTBO operating areas, and they inform the FAA's implementation planning decisions.

Additionally, CAASD conducted an interoperability assessment of the Northwest Mountain operating area. That assessment provides a holistic perspective for the use of TBO systems and capabilities (ERAM, STARS, TBFM, TFDM, and TFMS) that will be available to manage traffic in different operational scenarios. It also offers insight into how changes to existing ATC and traffic manager procedures will impact decisions that must be made (and resulting actions that must be taken) among and between facilities. CAASD also developed another interoperability assessment to study the NEC operating area. That assessment, which will involve operational personnel, is expected to be conducted by the summer of 2021. This upcoming interoperability event accounts for several FAA NEC commitments and foundational assumptions spanning multiple en route and terminal facilities as well as the Air Traffic Control System Command Center (ATCSCC). This assessment is designed to validate operational expectations and enable early discovery of risks to integration among systems, procedures, and people.

Finally, CAASD provided technical contributions via the FAA's TBO Risk Working Group (RWG). CAASD's contributions included providing subject matter expertise on automation system-related risks, informing risk mitigation activities and analyses, and dispositioning findings to drive key agency actions and decisions. The risk mitigation plans CAASD developed span automation as well as policy, procedure, and training needs, and CAASD is collaborating with the FAA risk-owning organizations to finalize them.

FY21 PLAN: In FY21, CAASD will continue to work closely with the FAA in the execution of its iTBO operational transition and implementation planning

for the identified operating areas. Toward this goal, CAASD will provide data and operational insights, performing technical analyses to study high-priority system and operational risks, and developing and validating appropriate risk mitigations. CAASD's efforts will include addressing known TBO automation system risks and any emerging ones resulting from increased field utilization. CAASD will continue to partner with the FAA in the methodical tracking and resolution of iTBO implementation risks as part of the TBO RWG. The results of the technical analyses will drive key assumptions for the interoperability assessment simulation design so that mitigations can be validated with operational personnel. In FY21, CAASD will also conduct the NEC interoperability assessment and initiate new planning and development of the next interoperability assessment, currently targeted for the Mid-Atlantic operating area. These efforts will reduce iTBO implementation risk, help foster stakeholder acceptance and commitment, and provide a clear plan for incremental changes at a given operating area.

ENSURING TIME-BASED MANAGEMENT PERFORMANCE

The TBFM system is a key enabling ground-automation system for TBM that generates flight-specific crossing times at pre-defined constraint points via a schedule. The PBN network of procedures and routes available across the NAS defines very specific

three-dimensional (3D) paths (latitude, longitude, and altitude) that allow times to be applied as a common planning factor. Furthermore, the improved aircraft navigational accuracy PBN enables along those 3D paths provides a compatible framework to incorporate the use of time to manage constraint points (e.g., merge points). This can be done with great precision by designating desired crossing times. That improves TBM trajectory predictability, yielding more accurate TBFM Estimated Times of Arrival (ETA), which are then used to calculate schedule times and decision-support information. The use of TBM also improves the likelihood that flights will adhere to their planned procedures. This is because TBM smartly allocates delays along the flight path such that speed changes alone are generally sufficient to meet the schedule times. Together, TBM and PBN routes and procedures define the 4D trajectory that is the cornerstone of enabling TBO. As such, PBN procedures and TBFM adaptation must be designed in an integrated manner or systems may not work as intended, harming operational acceptance and resulting in unmet TBO objectives and benefits. Additionally, to achieve desired TBO benefits, it is important to be able to measure and ensure the appropriate TBFM ETA accuracy required at different flight phases, especially as the TBFM system software is updated to include additional TBM enhancements.

FY20 ACCOMPLISHMENTS: To help achieve integrated PBN/TBM design, CAASD matured and validated a fast-time scheduling simulation functionality within the Integrated PBN and TBM Design Capability. That simulation functionality supports throughput evaluations given TBFM adaptation choices, PBN procedure designs, and representative traffic scenarios. Additionally, CAASD implemented several new workflows to assist TBFM adaptation specialists and PBN procedure designers in validating and evaluating integrated designs. The analytical functions developed support the application and evaluation of the Integrated PBN and TBM Design principles, which were documented as recommended

integrated design guidance. These accomplishments enable a reduction in the time needed to generate integrated designs and the level of subject matter expertise required, while also improving the quality of candidate designs for field implementation.

Toward ensuring sufficient TBFM system performance, CAASD applied the TBFM ETA accuracy measurement process to assess factors that impact ETA accuracy for departing flights scheduled to a meter point (to assist controllers in merging departures into the overhead traffic stream). Currently, the FAA does not have a TBFM ETA accuracy requirement defined for departure operations, so CAASD performed a top-down analysis to establish an ETA accuracy requirement for departures and recommended that the FAA adopt it. Using a stand-alone analytical tool developed by CAASD (the TBFM ETA Accuracy Tool or TET), CAASD also demonstrated the process for evaluating ETA performance against the proposed ETA accuracy requirement for a nominal departure operation. Using the process via CAASD's tool, which includes trajectory generation software to simulate trajectories from takeoff roll to landing, CAASD evaluated ETA accuracy performance for departures, given different facility adaptation choices. Finally, CAASD performed analyses that identified TBFM adaptation enhancements and provided guidance to help further improve ETA performance accuracy for departures. These accomplishments enable the FAA to independently measure and track TBFM ETA accuracy to ensure the appropriate system performance level is met so that TBO benefits can be realized.

FY21 PLAN: In FY21, CAASD will continue developing the Integrated PBN and TBM Design Capability with a focus on incorporating new features and functionality to support TBFM departure scheduling, extended metering adaptation, and their respective evaluation use cases. Additionally, CAASD will work with users at the WJHTC to begin incorporating the new analysis functionality (including the fast-time scheduling simulation functionality) into their workflows. This will be done in incremental steps to progress toward a technology transfer of those functions to the FAA. CAASD will continue to incorporate refinements and new features to address the needs and use cases that current and future user groups identify. CAASD will also continue to define integrated design guidance for departures that PBN procedure designers and TBFM adaptation specialists can use. Finally, CAASD will collaborate with the FAA's Second Level Engineering (SLE) group to apply the TBFM ETA Accuracy measurement process as TBFM software updates are incorporated. CAASD will also continue to build the SLE's knowledge in applying elements of CAASD's analytical tool to ensure adequate system performance.

Data Communications

The FAA's Future Vision for ATM Services foresees a fundamental shift in the technical, operational, and business mechanisms the FAA uses to provide safety services to airspace users. Ubiquitous connectivity is foundational to the evolution of these services as the aviation community evolves from aviation-specific technologies and business models to nth-generation commercial communication services. In the new environment, native Internet Protocol Suite (IPS) applications will support full connectivity between ATC systems and airspace users.

Simultaneously, the FAA is evolving toward TBO in conjunction with PBN to enhance the predictability and effectiveness of the NAS. Controllers and pilots would be challenged to provide these advanced ATM services using only voice communications.

Through a partnership between the FAA, aircraft operators, aircraft and avionics manufacturers, and commercial communication service providers, domestic air/ground data communication (DataComm) capabilities are being introduced into the NAS to enable exchange of 4D trajectories—longitude, latitude, altitude, and time—and aircraft intent information enabling trajectory-based operations. As the IPS standards mature, domestic air/ground DataComm capabilities will transition from legacy aviation protocols to internet protocols (IPs) tailored to support safety services with appropriate security mechanisms.

FY20 ACCOMPLISHMENTS: In FY20, CAASD continued to mature Future Air Navigation Systems (FANS) operational use cases. This was accomplished through laboratory assessments to validate operational feasibility and derived functional attributes of aircraft- and ground-system changes needed to support enhanced

FANS services and FAA investment decisions. CAASD also provided assessments of shortfalls and benefits, a business case that identifies remaining unresolved key operational and functional issues related to enhanced FANS services, and recommendations for next steps for functional validation and implementation.

By leveraging relationships across the FAA and industry, CAASD drafted a strategy for validation and implementation planning of IP standards for air/ground DataComm services in the NAS.

FY21 PLANS: With an expanded focus on the transition from legacy aviation protocols to IPs, CAASD will contribute to the completion of the IPS standards. CAASD will also collaborate with the FAA to ensure that the IPS standards are validated to reduce the risks to implementation.

Speech Recognition Technology

Air traffic controllers and pilots communicate important information to each other over voice radio, 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 begun to use technology based on AI and ML. This technology, which includes 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. For example, speech and surveillance information can be used together to detect potential safety issues, such as when a pilot is attempting to land on the wrong runway.

FY20 ACCOMPLISHMENTS: In FY20, CAASD continued to leverage advancements in AI/ML to make accuracy and capability improvements to automated speech recognition capabilities, including better identification of aircraft identifiers in the voice data. CAASD worked with various FAA and industry working groups to apply the capabilities toward specific operational analysis efforts. For example, CAASD used AI/ML analytical capabilities to detect and classify arrival and departure blunder events, to study the controller phraseology surrounding departure and arrival procedure clearances and accompanying altitude instructions, and to explore the impact of datalink implementation on ATC voice communications. CAASD also detected unmanned aircraft system (UAS) encounters across the NAS by coupling pilot/controller voice communications and Mandatory Occurrence Reports (MORs). In addition, to inform best practices for controller recovery and training, CAASD explored a process for evaluating controller recovery from high-risk events. This was done by coupling voice data analysis with the ARIA risk-index data.

CAASD coordinated arrangements for testing a proof-of-concept system at an FAA facility to inform the technical feasibility of alerting controllers to potential wrong-surface operations. However, due to the implications of the COVID-19 pandemic, the test itself was delayed until FY21.

FY21 PLANS: At an FAA facility, CAASD will initiate a test of a proof-of-concept system to inform the technical feasibility of alerting controllers to potential wrong-surface operations. CAASD will also analyze the results of that test. Following this "shadow mode" test, CAASD will begin an operational field test in collaboration with the FAA and NATCA.

As the FAA continues to explore and operationalize post-operations voice data analysis capabilities, CAASD will focus resources on how speech recognition can address a variety of needs. These include determining flight procedure usage to inform optimization of existing routes and procedures,

using voice-based metrics to bolster the situational awareness of safety-related issues within the runway surface environment, discerning Metroplex procedure design changes' post-implementation impact on ATC, incorporating operational metrics derived from voice communications into the development of controller workload models, and leveraging voice data analysis to qualify the benefits of iTBO.

For further development of real-time applications, CAASD will explore voice-based memory aids that could provide controllers with better in-time awareness of potential safety hazards.

In addition, CAASD will continue to work collaboratively with the FAA to establish a tech transition plan for instantiating voice data analysis capabilities in the FAA's EIM architecture.

Enterprise Information Display System

In FY20, the FAA received FID approval to provide an Enterprise Information Display System (E-IDS) that will replace five legacy Information Display Systems (IDS) with a common NAS-wide platform.

The fundamental limitations of current IDSs are their reliance on obsolete technology and interfaces and their facility-centric, inefficient data organization and manual update methods. These limitations make it cumbersome for IDS users to search, retrieve, and display information. This adds to the workload of controllers who use the IDSs and the administrators who tailor IDS information to meet the needs of each position. E-IDS is an enterprise-level platform that will leverage NextGen capabilities and provide secure, timely, and accurate information to all ATM service providers. E-IDS will also improve the safety of the NAS and the efficiency of flight-specific ATC operations by providing faster access to specific information on the display, as well as a common platform for training and logistics. E-IDS is expected to provide increased efficiency in sustainment and replacement management activities, as well as operational benefits in the form of enhanced ATM service provider productivity, increased NAS user efficiency, and improved safety.

E-IDS will use modern data structures, communication systems, web services, and System Wide Information Management (SWIM)-enabled services to retrieve, integrate, and display static information (e.g., approach plates) and dynamic information (e.g., Notices to Airmen [NOTAM], meteorological information). E-IDS will support operations in over 500 facilities including Air Route Traffic Control Centers (ARTCCs) [en route and oceanic], Terminal Radar Approach Control (TRACON) facilities, towers, and FAA-operated Flight Service Station facilities. It will be utilized by over 5,000 operational and other relevant positions (e.g., controller, operational supervisor, traffic flow manager, authorized external users). E-IDS will also interface with the FAA's Remote Monitoring and Logging System to ensure effective monitoring of all E-IDS systems and allow for rapid remedial action to be initiated in the event of malfunction or failure.

FY20 ACCOMPLISHMENTS: CAASD has been an integral E-IDS team member and trusted partner to the FAA since the beginning of the E-IDS Acquisition Management System process, working in coordination with many FAA stakeholders. CAASD performed key analyses via the EIM platform that have informed FAA decisions regarding architecture alternatives, final architecture design, performance metrics, benefits, human factors design issues, and failure modes and safety risks. CAASD also used the EIM platform to conduct analyses supporting the Federal Information Processing Standard classification, final Information Systems Security assessment, and partitioning and use of selected data and capabilities to the FAA's Mission Support Network. This usage of the EIM platform is the first instance in which data from the Mission Support Network has been leveraged to support ATC operations.

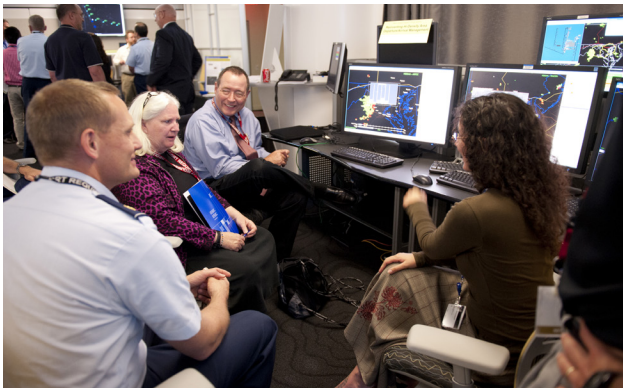
CAASD strongly influenced the coordination, development, and final adoption of the E-IDS architecture.

CAASD led the development of key engineering specifications; interface documents; and air traffic, data administration, and maintenance concepts in preparation for a successful FID. CAASD ensured the alignment of key concepts and engineering principles throughout the design and documentation processes, thereby guaranteeing that the requirements met the operational need.

As a key participant in the E-IDS working groups, CAASD developed air traffic human factors and data administration materials to inform E-IDS requirements and mature the concepts. In addition, CAASD developed and refined an E-IDS demonstration prototype to facilitate discussions with ATC personnel and solicit feedback on key components of the human-factors design. These inputs were used to inform E-IDS high-level requirements. The development of this material was instrumental in maturing the concept of operations, computer-human interface requirements, and concept of use for the FID. CAASD also completed safety scenarios that informed the development of the preliminary hazard assessment.

Additionally, CAASD conducted analyses to inform the final architecture solution and developed details of the preferred architecture including security, Department of Defense (DoD) and non-NAS user access to E-IDS, and architectural extensions to update and maintain static and dynamic data on the EIM platform. CAASD collaborated with EIM to define and develop an initial client Application Programming Interface (API) to interface with and test the available EIM national static data APIs. This test API will greatly reduce the risk for E-IDS. by ensuring that the national static data is accessible prior to contractor software design/development, and to support the later system testing and roll-out program phases. E-IDS will be the first FAA NAS program to leverage EIM.

In preparation for the successful FID, CAASD developed a set of technical transfer materials that informed the vendor of prior work and analyses. CAASD was also a key contributor to the technical evaluation of vendor proposals. In addition, CAASD



developed a tool to help integrate the evaluators' scoring and comments in a manner that facilitated the discussion and aided in reaching consensus.

FY21 PLANS: CAASD will continue to ensure the intended operational and technical integrity of the E-IDS's overall design and underlying requirements through engineering exchanges and formalized assessments. Specifically, CAASD will provide independent system and software assessments to ensure a successful Preliminary Design Review (PDR). As a member of the E-IDS Requirements Board, CAASD will provide evaluations and requirements assessments. As noted, a key component of success for E-IDS is an interface with the EIM platform. To reduce E-IDS risk with EIM platform integration, CAASD will continue to collaborate with EIM on the development of tools, interfaces, and architecture for static and dynamic data. To coordinate knowledge sharing, CAASD will continue to develop and brief materials at technical exchanges (specifically with the vendor as part of requirements, human factors, architecture, security) and safety working groups.

Metroplex Airspace and Procedures 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 by leveraging modernized capabilities (e.g., 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 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.

FY20 ACCOMPLISHMENTS: In March 2020, CAASD partnered with the FAA to implement the Denver Metroplex airspace and procedures. Given the challenges of the COVID-19 pandemic, CAASD participated in the first-ever virtual "go team" to address immediate implementation issues. CAASD also virtually collected lessons learned and conducted project closeout activities. The FAA and CAASD are applying these lessons learned (and those from prior Metroplex sites) to the two remaining Metroplex sites, Las Vegas and South/Central Florida, which the FAA plans to implement in FY21. CAASD also worked to integrate the PBN designs with ongoing TFM evolution activities, ensuring that the procedure designs consider iTBO.

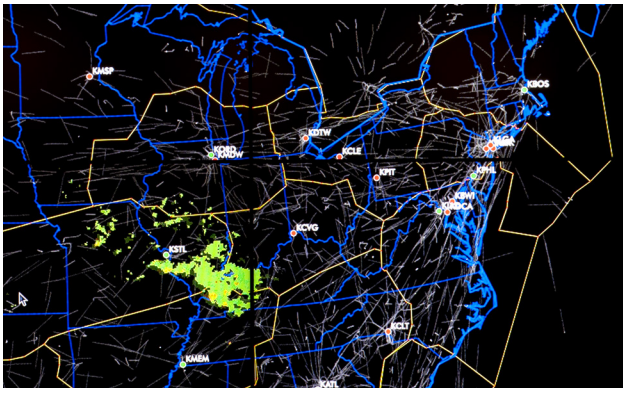
FY21 PLANS: In FY21, CAASD will provide operational and systems engineering expertise to the FAA to implement the last two Metroplex projects, collect lessons learned, initiate post-implementation analyses, and make any necessary post-implementation adjustments to ensure the airspace and procedure changes are performing as intended. This will move the program toward completion, following the implementation of over 800 new or amended routes and procedures that improved the safety and efficiency of the airspace above 11 major metropolitan areas across the NAS.

Northeast Corridor Airspace and Procedures

The airspace in the 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. The FAA has committed to meeting NEC airspace and procedure assessment and implementation milestones through December 2021. Beyond 2021, the FAA will continue to introduce new capabilities and implement airspace and procedure 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.

FY20 ACCOMPLISHMENTS: In FY20, CAASD's system engineering activities helped the FAA achieve several milestones to improve NEC operations through innovative airspace and procedure solutions. CAASD collaborated with the FAA on environmental review, community engagement, and design and implementation strategies to ensure an integrated approach to developing and implementing changes to airspace and procedures.



For specific changes, CAASD analyzed operational data to identify near-term design opportunities and potential benefits/risks, and engaged stakeholders to educate them on planned initiatives, capabilities, and technologies. CAASD's noise screening analyses enabled the FAA to meet federal environmental review requirements for changes to LaGuardia Airport departure procedures that shift flights away from a densely populated area. CAASD also worked with the FAA to begin implementing new high-altitude routes that reduce the reliance on ground-based navigation in this airspace. Finally, CAASD explored future concepts to identify opportunities beyond the existing NEC milestones, including use of Multiple Airport Route Separation (MARS), which has high potential to deconflict operations at the closely spaced airports in the NEC.

FY21 PLAN: In FY21, the FAA and CAASD will continue to advance the implementation of mature airspace and procedure solutions. Less mature concepts such as MARS are being evaluated to assess operational benefits and risks, and CAASD is developing a New York mid-term (2025) conceptual design to inform a strategy for future airspace evolution activities. CAASD also developed a regional noise baseline model that will provide a robust platform for screening a broad range of individual proposals; it

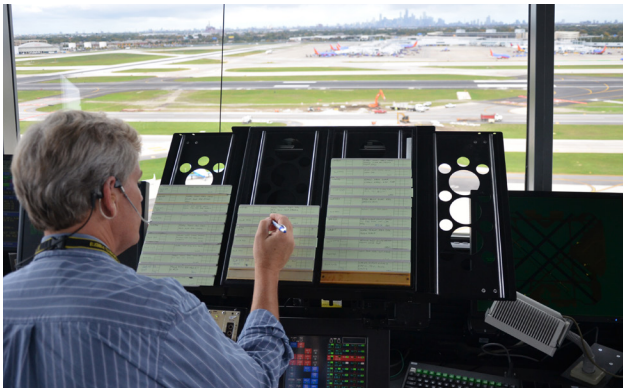
will also help refine NEC environmental and community engagement strategies. CAASD is also working with the FAA to ensure coordination with related activities, such as the strategic effort to reduce the number of conventional navigational aids (NAVAIDs) in the NAS. CAASD will continue to partner with the FAA to achieve NEC implementation commitments, while also exploring future concepts and looking for opportunities to apply them toward operational needs beyond the NEC.

Separation Management

The FAA is executing a pre-implementation program that is developing concepts to assist controllers in Separation Management, i.e., in maintaining aircraft separation while optimizing the use of airspace system capacity (e.g., improved time keeping to support TBM). These concepts will inform automation enhancements for the en route, terminal, and oceanic domains. They will also support both planned NextGen operational improvements and the transition to the FAA's emerging vision for the NAS. One focus is on automation enhancements and the development of acquisition artifacts for FAA's ERAM system: ERAM Enhancement 3.

Another focus is part of a larger FAA effort aimed at examining a service-based approach for the delivery of ATM automation capabilities to reduce cost and enable a more rapid, agile deployment of capabilities in the NAS. This is consistent with the FAA's emerging Automation Evolution Strategy and the future vision for the NAS. In this approach, capabilities are defined as individual components, with defined inputs and outputs to promote capability independence and reuse across domains. Potential Separation Management capabilities for this service-based approach include the track-based Conflict Alert for the provision of tactical alerts (e.g., up to 2 ½ minutes of warning time to the controller) and the Conflict Probe for more strategic trajectory-based alerts.

FY20 ACCOMPLISHMENTS: CAASD conducted engineering analyses to refine concepts, enhance technical readiness, and reduce acquisition risk.



CAASD examined specific capabilities that include trajectory modeling, conflict probe, trial planning, and clearance entry enhancements to ERAM and their application to TBO. CAASD developed updates to proposed algorithmic specifications for FMS-compatible turn-smoothing and conflict probe enhancements to support PBN descents. A laboratory assessment was conducted at the MITRE IDEA Lab that demonstrated the successful incorporation of these and the following prototype enhancements:

- Conflict Probe alert notification at the Radar Position
- On-demand access to aircraft trajectory and conflict probe information at the Radar Position
- Advisories to facilitate the entry of the controller clearance intent and the maintenance of schedule adherence in the presence of separation problems
- Support for the uplink of advisories that builds on DataComm capabilities currently being deployed in ERAM
- PBN route and procedure enhancements planned for the assessment sectors
- Arrival scheduling and terminal routing enhancements being developed for the TBFM Terminal Sequencing and Spacing capability

FY21 PLANS: CAASD is currently conducting algorithmic development and simulation analyses

on proposed trajectory modeling, conflict probe, trial planning, and clearance entry enhancements to support the execution of PBN procedures, and to maintain schedule adherence while meeting separation constraints. In addition, CAASD is continuing to provide technical and operational inputs to support the ERAM Enhancement 3 acquisition and will support the development of preliminary Program Requirements in preparation for an Initial Acquisition Readiness Decision.

In support of a transition to a service-based provision of automation for separation management, CAASD will evaluate the feasibility of deploying ERAM's Conflict Alert and Conflict Probe functions as independent services that could be applied not only to en route but to other domains (e.g., terminal, oceanic, offshore) as well. These analyses will include assessments of functional and technical alternative requirements.

Automatic Dependent Surveillance-Broadcast In Applications

Air traffic modernization in the NAS has focused largely on techniques and tools that bring demand into conformance with usable capacity, primarily through the application of delay. While previous methods have helped improve usable capacity through better coordination of merging traffic flows and the issuance of advisories that reduce guesswork, delivery accuracy has nonetheless remained a fundamental impediment to increasing usable capacity. Arrival capacity also degrades when flight crews can no longer accept visual separation clearances because the final spacing realized between aircraft during visual separation operations is often closer than the separation required when ATC must apply other standards.

Improvements in CNS systems in the NAS have led to the development of multiple concepts to improve efficiency, capacity, and enhance safety. These include the deployment of ADS-B and the 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. The first phase of ADS-B In-enabled applications (termed "Phase 1")—such as Interval Management (IM) and Cockpit Display of Traffic Information (CDTI)-Assisted (CA) applications—are designed to help maintain capacity and realize TBO objectives.

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, by reducing controller reliance on vectors off the published procedures, which lengthen the distances flown and reduce the path and fuel efficiencies the aircrafts' avionics are able to achieve, the use of IM will result in lower fuel burns. The Phase 1 CA applications 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.

FY20 ACCOMPLISHMENTS: CAASD helped author the Concept of Operations and ground automation requirements for the Phase 1 applications and brought to bear research that examined the integration of flight deck-centric applications with ground-based metering operations in the terminal area. CAASD also played a major role in the final publication of the avionics standards documentation for the full suite of IM and CA applications within RTCA Special Committee (SC) 186, providing committee leadership, authoring significant sections of the standards documents, conducting technical analyses to inform and validate avionics requirements, and developing test procedures and test data. CAASD also performed technical analysis and delivered final HITL research results to inform ground automation requirements and resolve open questions within the committee.

In addition, CAASD has brought years of research to bear to help mature the IM and CAS operational descriptions as part of the American Airlines/FAA ADS-B In Retrofit Spacing (AIRS) team. This activity is intended to demonstrate benefits in the field of the first set of ADS-B In applications. CAASD has also participated in FAA/industry forums on ADS-B In, such as at TBO Industry Day and Equip2020, providing overviews of research demonstrating concept viability and benefits to industry stakeholders.

FY21 PLANS: The FAA is focused on maturing ADS-B In Phase 1 ground automation requirements

and the computer-human interfaces needed to enable ADS-B In Phase 1 operations. This includes working with the FAA's vendors to review requirements, prototype solutions, and test plans. CAASD is involved in these activities, including the development of an interactive demonstration capability in the IDEA Lab that FAA operational experts are using to exercise CAS and IM scenarios to understand the operational concept and to evaluate proposed computer-human interface requirements.

In addition, CAASD has been tasked to use HITL simulations to validate the general feasibility and acceptability of IM operations to dependent parallel runways in a metering environment from ATC and flight crew perspectives. These experiments will inform FAA concept and requirements documents for ADS-B In operations to be implemented after Phase 1.

Secure Information Exchange Between Pilots and Air Traffic Control

Information exchange between pilots and ATC is essential for safe and efficient NAS operations. Today, much of that information exchange relies on voice communications. DataComm methods exist for limited applications and locations, however the cost of adopting DataComm for much of the GA community is impractical due to the cost and complexity of the equipment required on the aircraft.

CAASD has been exploring electronic information exchange methods that leverage mobile technology to exchange pre-departure information such as Instrument Flight Rules (IFR) clearances and collaborative decision making (CDM) intent information. A vast majority of pilots use mobile technology and apps for flight planning and execution. Adding pilot-ATC information exchange capabilities to those apps will provide a mechanism for pilots and ATC to share information efficiently and securely.

FY20 ACCOMPLISHMENTS: In FY20, CAASD matured two information exchange prototypes. The Mobile IFR Services prototype allows a pilot and air traffic controller to electronically conduct pre-departure clearance delivery at towered and non-towered airports and IFR release and IFR cancellation at non-towered airports. CAASD defined an architecture that assures the accuracy and security of the IFR clearance information being exchanged, explored the identity and access management considerations, and refined the prototype to closely emulate accepted DataComm information exchange methods. The system architecture component became an influencing factor in the FAA's thinking on the future of Flight Information Management.

The Pacer prototype was enhanced to accommodate concept exploration at Las Vegas McCarren International Airport and airports in the Dallas-Fort Worth metropolitan area. Pacer allows pilots to view the expected departure demand for select airports and submit updated departure intent. Pacer uses the submitted information to further refine the accuracy of the departure demand information. CAASD socialized both concepts and prototypes with FAA stakeholders, the GA and business aviation (BA) communities, and mobile app service providers.

FY21 PLANS: Mobile IFR Services is progressing toward making the architecture and prototype to support accurate and secure information exchange a reality. CAASD is exploring the integration of several mobile-related concepts to align with the FAA's Flight Information Management modernization efforts. CAASD's goal is to help shape the vision for how mobile technology can aid in transforming NAS systems into an environment that supports the agile, cost-effective, and rapid development and deployment of new capabilities.

The Pacer prototype will be expanded for use at eight Ski Country airports in Colorado and at Charlotte Douglas International Airport in North Carolina. The Pacer interface is being refined to provide more accurate data to users and include arrival demand data at airports where there is a dependency between arrivals and departures, particularly the Ski Country airports. CAASD is also working with the FAA to define the role of GA and BA in CDM information exchange as the FAA prepares to deploy TFDM and implement surface metering (Configuration A) at 27 airports across the NAS. CAASD is focused on the cultural changes required for the GA and BA communities to participate in providing updated data to the NAS. CAASD is also exploring passive methods of data collection through service providers.

Digital Copilot

Solo-pilot operations make up the majority of GA flights and are riskier than two-pilot flights. This is partly due to the high workload associated with flying an airplane, and the lack of a second pilot to crosscheck decisions. There is a lot of information competing for the pilot's attention, and losing situational awareness can be a precursor to an accident.

CAASD proposed and prototyped a system called Digital Copilot that provides cognitive assistance directly to the pilot of an aircraft. Cognitive assistance is cooperative automation designed to augment human cognition rather than replace it and is typically enabled by automatic speech recognition software and state data such as location awareness. In Digital Copilot, this means providing contextually relevant information to a pilot based on inferred intent in a manner that augments the pilot's decision-making process. This system requires no connections or modifications to existing aircraft systems, and is very cost-effective for operators, lowering many traditional barriers to entry.

FY20 ACCOMPLISHMENTS: Through continued industry outreach via the tech transfer process, CAASD demonstrated the benefits of existing and newly developed features of Digital Copilot, resulting in safety enhancements being adopted by industry and made available to pilots. The development team prototyped and demonstrated capabilities that address some of the shortcomings currently found in the NOTAM and Pilot Report systems. The team also fused weather data with Instrument Approach Plate altitude and temperature minima, enhanced traffic pattern and surface movement awareness, and developed tools to reduce the risk of aircraft operations involving wrong surfaces. The

Digital Copilot research platform was also leveraged by projects performing research into connected aircraft concepts and TBO.

FY21 PLAN: In FY21, CAASD will continue to use the Digital Copilot research platform to further enhance and expand on the cognitive assistance capability delivery to the pilot. Research and development efforts focused on rotorcraft-specific phase-of-flight inference will begin in FY21, as will situation awareness and safety notification algorithms. Fixed-wing-focused safety algorithms that relate to mature ASIAS metrics will be explored, and where appropriate, developed and tested. Digital Copilot will also be used to continue surface awareness support in both the cockpit and ATC tower environments.

Unmanned Aircraft Systems Command and Control

Since 2006, CAASD has performed research, analysis, and modeling to resolve technical issues arising in the development of command and control (C2) link standards for UAS by RTCA SC-228 and its predecessor committee, SC-203. As unmanned aircraft proliferate in the national airspace, the performance and reliability of their C2 links will become increasingly critical to air safety.

CAASD's FY20 work was focused primarily on radio-frequency (RF) spectrum and interference issues potentially affecting planned UAS C2 links in the 5030–5091-megahertz (MHz) frequency band that the Federal Communications Commission has reserved for such links.

CAASD performed modeling and simulation to predict the spectrum-limited capacities of several alternative terrestrial C2 link architectures (i.e., how many C2 links using each architecture would be able to operate simultaneously, without mutual interference, in available spectrum above the contiguous U.S.). This effort also analyzed aggregate effects of multiple interferers among UAS C2 links operating at an airport to ascertain how many UAS equipped with those links could land and/or take off there at any given time. CAASD recommended measures to prevent interference between UAS C2 links and other RF systems (i.e., Aeronautical Mobile Airport Communication System [AeroMACS] and a potential future Global Positioning System [GPS] link) in adjacent frequency bands.

SC-228 is planning to publish two major documents that will include substantial contributions from the collective previous CAASD research: minimum operational performance standards (MOPS) for terrestrial UAS C2 links, and minimum aviation system performance standards for terrestrial and satellite-based UAS C2 links.

This work concluded in FY20.

Small Unmanned Aircraft Systems Risk Analysis

The integration of small UAS (sUAS) into the NAS poses a unique challenge: how to assess the collision risk posed to manned aircraft. This challenge includes estimating both the baseline, unmitigated risk of collision (before mitigations are applied), and the effects of technology or procedures to mitigate that risk. An additional area of concern and research focus is assessing the risk of sUAS ground collisions with people or moving vehicles.

The difficulty of these challenges is compounded by the lack of established standards for technologies designed to reduce the chance of collision and standards to reduce sUAS failures that could cause them to fall from the sky.

FY20 ACCOMPLISHMENTS: In FY20, CAASD provided likelihood-of-collision metrics between UAS and manned aircraft from the surface to 60,000 feet for the contiguous U.S. using CAASD's Volumetric Collision Risk Analysis capability. These metrics will significantly increase the accuracy of the UAS data ATO's Safety Risk Management (SRM) Panels will use when considering airspace access approvals for increasing numbers of UAS operators.

CAASD partnered with the UAS Center of Excellence (CoE), or "ASSURE," to produce severity-of-collision results between various sUAS and a Cessna 182. This supplemented other FAA-funded collision-severity results CAASD provided for commercial and business jet aircraft. These results, combined with the likelihood-of-collision data, complete the proposed

update to the ATO SMS Hazard Table for UAS.

CAASD also conducted system safety assessments that contributed to the development and approval of MOPS for versions of the Advanced Collision Avoidance System (ACAS X) for both large (ACAS XU) and small (ACAS sXU) UAS.

In other work, CAASD developed the Operational Risk Assessment Prototype, a capability designed to provide process standardization and accelerated processing timelines for FAA analysts when they assess operational waiver proposals associated with unmanned aircraft integration requests. In FY20, CAASD delivered the prototype, along with initial capability requirements documentation.

Additionally, CAASD developed and refined its Ground Collision Risk Analysis capability to determine the risk to people and moving vehicles on the ground for multiple UAS operators participating in the Integration Pilot Program (IPP). These risk calculations were used to inform the airspace approval process.

Further, CAASD delivered a collision risk analysis for the U.S. Navy's Triton UAS covering a 2,000-mile radius area centered on Guam. CAASD's analysis is a key component of the Navy's layered approach to safety for its trans-oceanic UAS platforms.

FY21 PLAN: In FY21, CAASD will develop an electronic (web-based) version of the SMS UAS Hazard Table to extend FAA SRM functionality and streamline sensitive safety analytics requested by UAS safety panels.

CAASD will also provide progressions of safety assessments to the ACAS Program Office supporting maturing research and testing of ACAS sXU requirements.

CAASD will conduct a safety validation analysis of the RTCA SC-228 Designated Accrediting Authority (DAA) MOPS, supporting the objective to achieve a Technical Standard Order for these airborne and ground-based technologies that UAS use to detect and avoid other aircraft.

CAASD will provide air and ground collision risk

analysis for the FAA's BEYOND program. Additionally, CAASD will support the FAA in identifying and promulgating key enablers for UAS beyond visual line of sight (BVLOS) operations as derived from BEYOND activities. CAASD will also identify sources of data and the types of information ATO needs to evaluate and manage NAS safety performance in a UAS traffic management (UTM)-type environment.

Further, CAASD will conduct airspace risk analysis and DAA analysis of alternatives for the U.S. Navy's and Royal Australian Air Force's global employment of the Triton UAS.

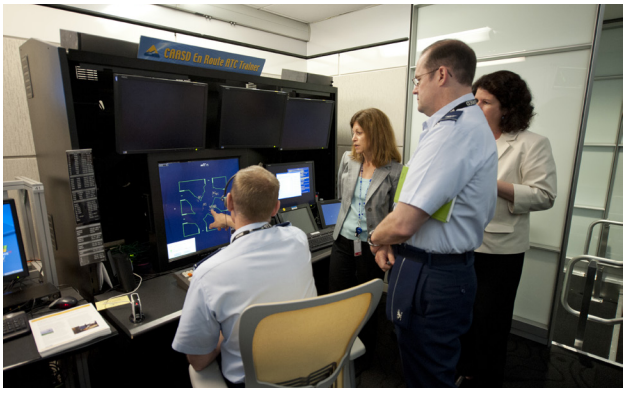
FAA Enterprise Networking Services

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. The potential risk of using new technologies and service paradigms must be fully understood 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, and surveillance DataComm. Careful planning is needed to manage transition risk and avoid negative impacts to critical NAS operations. FENS source evaluation needs to be carefully planned as well so that the government can identify best value and avoid protests.

FY20 ACCOMPLISHMENTS: CAASD contributions helped the FAA release the final FENS SIR in September 2020. CAASD worked to finalize key technical and security requirements to ensure important aspects of the FENS program concept (such as the use of managed services and shared commercial networks) were sufficiently represented.

CAASD also identified a low-risk hybrid approach for planning transition of FTI IP services to FENS. CAASD identified transition best practices and highlighted the need for extensive coordination when performing cutovers from FTI IP to FENS IP services.



Finally, to ensure consistent evaluation across offeror proposals, CAASD proposed an approach for training the FENS proposal evaluators on key technology areas such as Software Defined Networking, Network Function Virtualization, shared Multi-Protocol Label Switching, 4G/5G Long-Term Evolution (LTE), emerging satellite-based access technologies, Business Support Systems/Operational Support Systems, AI, and ML.

FY21 PLAN: CAASD will continue to work with the FAA in achieving successful implementation of the FENS program. This will include helping the FAA plan the source evaluation, including the development of material for training evaluators. CAASD will help the FAA amend FENS requirements as needed prior to the source evaluation process. CAASD will assist the FAA in developing FENS sample problems to augment the SIR, emphasizing the need to craft high-value sample problems that highlight innovation and provide the government with important information not likely to be included in offeror technical and management volumes. CAASD will provide technical advice and expertise to the FENS source selection, identifying strengths, weaknesses, and risks. Finally, CAASD will assist the FAA in preparing for the contract negotiation phase of FENS once the award is announced, identifying areas where requirements may need to be clarified in advance of final agreements.

Navigational Aid Role Evolution

The original NAS was designed around the locations of ground-based NAVAIDs. The NAS has evolved to use PBN using Global Navigation Satellite Systems (GNSS) as the primary means of navigation. The role of the ground-based NAVAID has changed from being the primary NAVAID defining all airspace, routes, and procedures to being exclusively a backup for loss of GNSS.

CAASD has helped the FAA with this transition by adjusting the deployment of NAVAIDs to better address the new mission. These FAA programs and initiatives include the Very High Frequency Omni-Directional Range (VOR) Minimum Operational Network (MON), NextGen Distance Measuring Equipment (DME)/Tactical Air Navigation (TACAN) [DVT] MON, and Instrument Landing System (ILS) rationalization.

FY20 ACCOMPLISHMENTS: With 82 total discontinuations, the VOR MON Phase I overachieved its annual goal. CAASD's VOR MON data analysis and visualization tools provided critical support for these discontinuations.

CAASD facilitated changes to both aircraft database standards and the FAA's flight data distribution system to allow for new larger service volumes for NAVAIDs. CAASD assisted the FAA in requirements evaluation and engineering performance analysis of DME, VOR, and TACAN ground-based NAVAIDs to generate evolving requirements for the DVT sustainment program. CAASD also developed and presented a plan for ILS discontinuance, but this initiative is currently on hold at the request of FAA senior leadership.

FY21 PLANS: Implementation issues for both the VOR MON and NextGen DME continue to occur. As the FAA's trusted advisor, CAASD provides the FAA with subject matter expertise and analysis tools to help develop alternatives to unanticipated program plan changes. The NextGen DME program is planning to commission new DMEs in FY21 for enhanced en route coverage at locations CAASD selects based on its coverage tools. CAASD is further refining the TACAN MON for the FAA in FY21; CAASD began this work under DoD sponsorship in FY20. CAASD will also continue to serve as an essential partner to the FAA on the DVT program as it moves closer to procurement.

Avionics Equipage and Forecasting

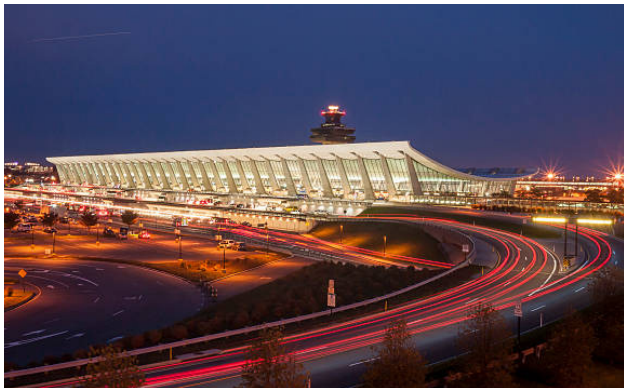
The FAA's NextGen vision for modernizing the air transportation system includes using new technologies and capabilities on aircraft. The FAA and its partners work together to ensure that these new avionics will be implemented in a timeframe that meets shared NextGen milestones.

The information needed cuts across multiple domains of CNS and safety. In addition to the cross-cutting nature of the information, detailed forecasts and projections of market offerings, and planned acquisitions from operators, suppliers, and manufacturers are extremely sensitive and need to be kept out of the public information domain. Each year, CAASD provides a common, comprehensive summary of the industry's current and forecast aircraft fleet capability. The information reported includes equipage trend information, opportunities and challenges to equipage, and significant factors that could substantially change equipage projections for individual capabilities. The information provides the FAA, operators, and industry a common view of fleet evolution toward NextGen and allows the FAA to make data-driven policy and investment timing decisions.

FY20 ACCOMPLISHMENTS: CAASD performed an analysis that examined current and forecast fleet capability and incorporated the information into a yearly summary report of Aircraft and Avionics Evolution. In support of the January 1, 2020 ADS-B Out rule implementation, CAASD provided detailed analysis of aircraft equipage rates and fleet details to assist the FAA, industry, and operators in ensuring a smooth transition to ADS-B operations. Additionally, CAASD assessed and reported emerging avionics systems in UAS and non-air transport aircraft that may impact future air transport capabilities. This assessment informs FAA policies and plans for aircraft technology evolution.

FY21 PLANS: CAASD continues to work with the FAA and industry stakeholders to collect, synthesize, and analyze aircraft avionics equipage and capabilities. This year, CAASD's analysis takes on a new dimension because of COVID-19's significant potential impact on airlines, fleet equipage, and capabilities, with effects that may impact future operations and FAA policies as well. This year, the Avionics Evolution report will be evolved to show potential COVID-19 impacts to the air transport, air taxi, foreign carrier, corporate/GA, and helicopter fleets, including a range of potential future states that may result from the pandemic.

Data-Driven Airport Planning and Investment



The FAA Office of Airports invests in airport infrastructure to improve the safety and efficiency of operations at airports NAS-wide. CAASD is leveraging its Transportation Data Platform (TDP) capabilities to provide insights into aircraft runway performance, enabling data-driven decisions on infrastructure investment.

Historically, the FAA has used manufacturer-supplied data and/or specialized (and expensive) data collection methods to understand aircraft operational performance requirements that drive key airport design characteristics such as runway length and width and protection from obstacles. CAASD is enabling the FAA to replace these outdated means of defining airport design standards with a data-driven approach that leverages the large volume of data in CAASD's TDP, allowing real-world performance to drive investment decisions.

FY20 ACCOMPLISHMENTS: In FY20, CAASD developed a Runway Length Evaluation Tool prototype. The tool is populated with observed/modeled aircraft performance data obtained from processing aircraft track data from airports with Airport Surface Detection Equipment, Model X (ASDE-X) equipment. The performance data includes the statistical properties of takeoff and landing distances for 105 of the most common aircraft types operating in the NAS from August 2011 to June 2017.

To use ASDE-X data in safety assessments, it is necessary to characterize and correct for data errors. To estimate these errors, CAASD—with the support of the FAA's WJHTC—devised an analytical approach that used data from laser rangefinders placed at select runways. The resulting corrections enabled CAASD to derive a set of aircraft lateral distribution at touchdown, validating the safety performance of Group VI aircraft on 150-foot-wide runways and enabling the FAA to reduce the requirement from the current 200-foot width.

FY21 PLANS: The FAA is currently evaluating the runway length tool. CAASD will respond to feedback from FAA users, making any necessary adjustments to the tool and the associated user guide. This is expected to complete work on the tool.

CAASD's FY20 work resolved lateral accuracy issues in ASDE-X data. To address safety issues for airport design standards that have a vertical component, it is necessary to correct for vertical errors. Toward this end, CAASD has developed an approach to measuring these errors that uses cameras placed on select runways. In FY21, WJHTC will place cameras near runways at several airports. CAASD will use the camera data to characterize vertical data accuracy of ASDE-X data and develop methods to correct for the errors.

Flight Procedure Assessments

For more than a decade, CAASD has worked with the FAA to create modular software criteria engines to allow users to design and evaluate instrument flight procedures (IFP) against the latest FAA criteria in a matter of hours rather than the days/weeks it has taken 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 14 criteria engines and integrated them within the FAA's IFP development tool, TARGETS, which has allowed the FAA to retire expensive legacy systems and provides evaluation capabilities for approximately 94 percent of the IFPs in the FAA's IFP inventory.

FY20 ACCOMPLISHMENTS: CAASD, in partnership with the FAA's TARGETS maintenance contractor, developed criteria assessment and automation functions to evaluate approach visibility for PBN and conventional approach procedures. CAASD also successfully completed the technology transfer of two additional criteria engines to the TARGETS contractor as part of updates made to align with the latest FAA criteria. Four of the 14 criteria engines have now been transferred to the contractor, with plans defined to complete the transfer of the remaining criteria engines. Lastly, CAASD began development of requirements for a ground-based Standard Instrument Departures (SID) criteria engine. This task involves working with the FAA to understand existing criteria and to identify and clarify any current gaps.

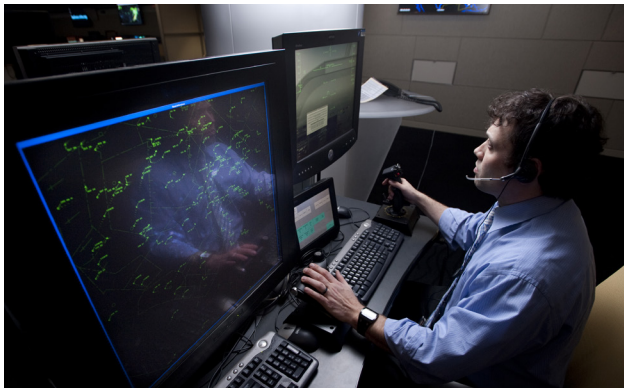
FY21 PLANS: CAASD will develop criteria assessment and automation functions to evaluate PBN and conventional approach sidestep procedures. CAASD will also continue to work with the FAA's TARGETS maintenance contractor to update existing criteria engines to ensure they represent the latest criteria, to update the software test suites to reflect the latest versions of the software, and to achieve additional criteria engine technology transfer. Lastly, CAASD will continue work on designing a new criteria engine to allow for the design and evaluation of ground-based SID procedures, with a focus on refining the requirements and beginning the capability development work to achieve an FY22 deployment.

Instrument Flight Procedure Workflow Modernization

For more than a decade, CAASD has worked with the FAA on the automation of IFP design criteria to support IFP development. In recent years, CAASD has conducted research to enable large-scale automated IFP evaluations within decision-support tools to improve common IFP design and maintenance tasks. These research areas include the automated evaluation of procedures for periodic review, proposed obstruction impact assessments, and automated procedure design suggestion based on IFP designer-defined goals and constraints.

FY20 ACCOMPLISHMENTS: CAASD completed the initial development of an Automated Periodic Review (APR) capability for PBN approach procedures. The capability is designed to streamline the FAA's IFP periodic review process by reducing the number of manual evaluations required. CAASD also completed the initial development of a capability to assess the impact of proposed obstructions on nearby IFPs, the Fully Leveraged Obstacle Assessment Tool (FLOAT). CAASD is in the process of transitioning both capabilities to the FAA for production deployment in FY21.

CAASD also developed a prototype automated procedure design capability for Area Navigation (RNAV) GPS approach procedures. It utilizes optimization techniques to suggest candidate approach designs that satisfy FAA IFP design criteria and consider the IFP designer's defined goals and constraints. The prototype aims to produce more efficient IFP designs, while reducing development time. It does so by leveraging automation for complex calculations to achieve the designer's goals through fewer iterations than is done today.



FY21 PLAN: In FY21, CAASD will complete the initial deployment of APR and FLOAT to the FAA. CAASD will expand the APR capability to include evaluation of conventional approach procedures and PBN Standard Terminal Arrival Route (STAR) procedures. CAASD will also expand the FLOAT capability to include evaluation of conventional approach procedures and obstacle departure procedures. CAASD will expand the automated procedure design capability to include RNAV Required Navigation Performance (RNP) approaches and PBN STAR

procedures. Additionally, CAASD will expand the automated procedure design capability to consider additional design goals and constraints, including flyability, navigation coverage, and IFP design best practices to further improve the quality of the IFP suggestions. CAASD will expand on previous work to generate data-driven IFP retirement recommendations and develop a visualization capability that links the recommendations with other relevant data. Finally, as part of an initiative to optimize the inventory of routes and procedures in the NAS, CAASD is integrating the APR, automated procedure design, and data-driven IFP retirement capabilities into a unified process to automate recommendations for repairing or retiring procedures as they come due for periodic review.

It is envisioned that CAASD will continue development of the APR and FLOAT capabilities to expand procedure types available for evaluation and to help facilitate technology transfer to the FAA or an FAA maintenance contractor.

GLOBAL LEADERSHIP

The FAA has a leadership role in improving global safety, air traffic efficiency, and environmental sustainability around the world. The FAA does this through shaping aviation standards and participating in international aviation organizations. CAASD's work provides the integrated, data-driven analysis that shapes global standards, enables collaboration, and aligns FAA resources to the international harmonization activities that ensure global interoperability.

Future Vision for the National Airspace System

Aviation is changing rapidly as new vehicle types, mission profiles, and operational models are being researched, developed, and seek to be introduced into the NAS.

The future NAS must migrate toward a new paradigm that enables this greater diversity and number of operations to flourish. At the same time, an information revolution has produced technologies for daily life that are now mature enough to be applied to safety-centric industries such as ATM. Leveraging these technological advancements within the NAS provides opportunities for safety and performance enhancement in aviation, just as it has in other industries. Achieving such a transformation requires a vision for the NAS that informs all stakeholder planning and investments. To this end, the FAA has developed a future vision for the NAS where an information-centric aviation ecosystem would support the rich diversity of future operations.

FY20 ACCOMPLISHMENTS: In collaboration with the FAA's Office of NextGen (ANG), CAASD developed a preliminary vision for the future of air traffic services and further refined that vision through agency review. CAASD delivered numerous high-level presentations on the vision across multiple FAA and external stakeholder forums. The future vision is grounded in key principles while incorporating significant changes in aviation, leveraging technological opportunities, and driving toward a performance-based NAS. Anticipated changes in operations, infrastructure, and integrated safety management are all described. CAASD collaborated with the FAA on the vision, taking the first steps toward making it a reality by defining an initial set of necessary key activities for the agency to undertake. CAASD began the development of a high-level concept of operations for the vision, working with the ANG to define scenarios and further elaborate future visionary changes.

FY21 PLANS: CAASD continues to refine the future vision in response to inputs from across the FAA. It is expected that the FAA will release the final vision in mid FY21.

This fiscal year, CAASD will obtain input from across the FAA for the development of a high-level concept of operations, using scenarios and elaboration of the changes sought by the future vision. CAASD will complete this concept in FY21. CAASD is also aligning a portion of its work program to address some key challenges to achieving the vision.

Oceanic Vision for 2035

The FAA, as a leader in the global aviation community, manages the largest volume of oceanic airspace in the world. It does so using advanced operating procedures and has taken the lead to establish a clear direction for the evolution of the FAA's oceanic ATM operations through 2035.

This vision and its associated program goals define a path for enhancing trajectory-based oceanic operations via new capabilities, procedures, policies, and technologies that provide benefits to airspace users and air traffic service providers in the near-, mid-, and far-term timeframes. The vision includes elements such as advanced CNS technologies; weather observation and forecasting technologies; advanced automation with ML capabilities; collaborative decision making; and new aircraft separation standards and procedures. The FAA is engaged in strategic planning and budgeting efforts to define and implement initiatives in support of these goals.

FY20 ACCOMPLISHMENTS: CAASD worked collaboratively with the FAA to develop a vision for the evolution of its oceanic ATM operations through 2035. The vision addresses the challenges, opportunities, and path for enhancing trajectory-based oceanic operations via new capabilities, procedures, policies, and technologies. It also describes the benefits to airspace users and air traffic service providers (ATSPs) in the near-, mid-, and far-term timeframes.

CAASD developed concept vignettes (i.e., use cases) to illustrate elements of the planned operations. Those vignettes facilitated discussion, leading to concept development and informing potential policy, procedure, and infrastructure changes.

FY21 PLANS: CAASD recently conducted a qualitative shortfall analysis based on existing and emerging operational needs in the oceanic environment. That analysis will inform the goals for the Oceanic Vision 2035 program and substantiate the FAA's funding request. The analysis will also inform FAA decision makers on the breadth of shortfalls (and the affected stakeholders) that could be addressed by new program initiatives aligned with the oceanic vision and program goals.

In coordination and collaboration with the FAA, CAASD will develop the concept of operations for 2035 along with operational descriptions for the near-, mid-, and far-term timeframes. In addition, CAASD will conduct the following analyses to further mature the elements of the vision and program goals:

- Assess key concept elements and technologies (e.g., delegated spacing/separation, ML, 4D trajectory modeling and contention, space operations, integration with domestic and offshore) via lab visualizations, demonstrations, and fast-time simulation.
- Assess and describe the functionality for a trajectory model that takes advantage of data from different sources—such as 4D flight trajectories, surveillance, and weather data from aircraft and Flight Operation Centers—to improve trajectory accuracy and predictive capabilities.
- Assess viable communications and surveillance technology solutions that will meet FAA goals.
- Assess the potential for current separation procedures to be supported with enhanced surveillance sources (e.g., five-minute climb-through with Space-Based ADS-B reports).
- Conduct a policy analysis for "better performing, better served" to assess the impact on different airspace users (i.e., equipped and non-equipped flights) and on overall oceanic system efficiency, and identify which oceanic regions would benefit from these policy changes.
- Conduct a policy analysis for the collection of user fees in oceanic airspace.

Global Data Exchange and Harmonization

Global aviation relies on data exchange to provide air traffic services to flights operating across international boundaries. Yet current global data exchange standards, protocols, and associated procedures must be modernized to deliver performance enhancements through TBO. To this end, the FAA is collaborating with the global aviation community in the development, validation, and planning of international standards and implementation guidance leading to the Flight and Flow Information for a Collaborative Environment (FF-ICE). Such an information environment provides the flexibility to accommodate the changing needs of global aviation.

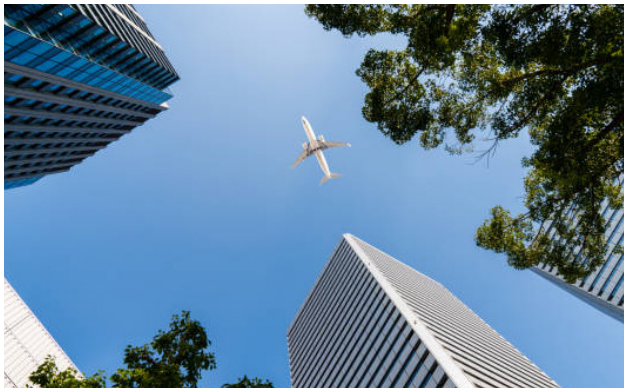
FY20 ACCOMPLISHMENTS: In partnership with the FAA, CAASD participated on the ICAO ATM Requirements and Performance Panel (ATMRPP), which developed the FF-ICE concept and is now developing standards, guidance, and an implementation strategy. CAASD provided review and analyses of proposals for amendments to the flight planning and filing provisions known as FF-ICE Release 1 as it nears completion. Building upon capabilities from Release 1, CAASD also helped define and validate, in collaboration with the FAA and international partners, processes and data needs for post-departure negotiation, known as FF-ICE Release 2. CAASD's participation in live flight and laboratory demonstrations, tabletop exercises, and supporting software development are an essential part of the validation of Release 2.

FY21 PLANS: The FAA provides global leadership in planning future demonstration activities with international partners leveraging FF-ICE capabilities, such as the Multi-Regional TBO demonstration. CAASD continues to collaborate with the FAA in planning, analysis, tabletops, software development, and laboratory demonstrations in support of such demonstrations. Together with FAA partners, CAASD is identifying gaps and further defining FF-ICE Release 2 processes and data needs. CAASD is applying lessons learned from the development of FF-ICE Release 1 to provide the ATMRPP with artifacts supporting the goal of improving development time.

Environmental Policy and Concepts

Increasing opposition to aircraft noise in recent years has made it more difficult for the FAA to implement critical NextGen improvements. In particular, the implementation of IFP needed to enhance safety and operational efficiency is taking longer and costing more. To address these changes, over the last several years CAASD has partnered with the FAA using a three-pronged approach consisting of understanding the issues and opportunities, engaging with communities and stakeholders, and mitigating the noise concerns where possible.

FY20 ACCOMPLISHMENTS: In FY20, CAASD continued to enhance the tools and data used for noise screening to accelerate FAA decision making. In addition, CAASD partnered with the FAA to identify near-term opportunities to increase the use of existing noise abatement procedures. CAASD also explored future concepts such as using systematic dispersion to mitigate noise impacts on communities living directly under concentrated flight paths. Lastly, CAASD provided visualizations to support the FAA's understanding of operational and environmental trends and clearly convey them to community stakeholders.



FY21 PLAN: In FY21, CAASD is continuing to enhance noise screening tools and data to accelerate FAA decision making and provide critical noise information earlier in the IFP design and implementation process. CAASD is also continuing to partner with the FAA to increase the use of noise abatement procedures to proactively build goodwill with communities.

International Highlights

CAASD's international program development efforts have led to a great variety of important projects in many countries in Europe, the Middle East, Latin America, and Asia Pacific. CAASD works with various international civil aviation authorities, airport operators, airlines, and other aviation organizations in their mission to provide safe and efficient services to their customers. This work is done with the approval and encouragement of the FAA; many of these programs have direct applicability and benefit to our FAA work and further promote global harmonization.


NO ESCORT REQUIRED
MITRE

STAKEHOLDER ENGAGEMENT

The aviation community has numerous stakeholders, all with different perspectives and requirements. Ensuring stakeholder needs are captured and understood is critical to consensus building and successful change efforts. CAASD's role as an independent and trusted advisor is to do just that. Through collaborative experiments and demonstrations in our labs, participating in working groups within the aviation community, creating partnerships, and publishing, we help drive to integrated solutions that consider all perspectives.

New Entrants Partnerships

Federal government partnerships with the private and public sectors have been a key pillar in the successful and safe advancement of UAS integration, in support of the FAA's mission and strategy. CAASD has been a key team member in the FAA's UAS partnerships since day one. Starting with partnerships for small cargo delivery research, the pathfinder partnerships (CNN, Precision Hawk, BNSF Railway) and continuing with the Partnership for Safety Program (PSP) and the UAS IPP, CAASD's contributions have helped the FAA and its industry partners progress safely to operational approvals through the use of sound data, systems engineering processes, and scientific approaches to decision making.

CAASD has provided independent, cross-FAA domain engineering experience and scientific rigor supporting IPP and other public-private partnerships. Additionally, CAASD's deep understanding of FAA process needs has accelerated challenge mitigation efforts. CAASD's contributions streamline progress timelines by informing, for example, FAA/partner joint strategy for approvals and safe operational deployments, safety case development, data-based decision tools, performance requirements, innovative approaches to certification, and defendable test and validation analytics necessary for operational integration of UAS.

Over the years, CAASD has also acted as the FAA's partner in maintaining corporate history and know-how. Additionally, CAASD has served as a liaison between the technical and program staff of multiple FAA lines of business, allowing the FAA to evolve

internal teams and projects with a UAS knowledge continuum.

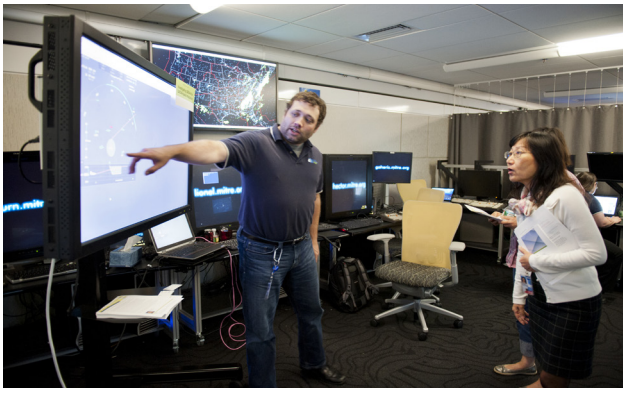
FY20 ACCOMPLISHMENTS: The White House/Department of Transportation (DOT)/FAA Drone IPP officially came to an end at the 36-month mark, as planned. Over the course of FY20, CAASD had direct involvement with each listed IPP milestone in the capacities described above, contributing to the following accomplishments (among others):

- Over 20,500 drone flight operations were conducted.
- The first two Part 135 drone air carriers (Alphabet and UPS) were approved.
- UPS and Matternet completed 1,500 drone medical deliveries in Raleigh, North Carolina.
- Alphabet's Wing completed 2,400 commercial drone package deliveries in Virginia, including pandemic-related relief deliveries.
- Uber established food delivery by air in San Diego while demonstrating remote ID.
- Kansas, North Dakota, and Alaska established routine infrastructure inspection with drones.
- FedEx established routine drone operations at Memphis Airport for inspection and surveillance.
- The Chula Vista, California Police Department introduced drones as first responders, leading to over 500 arrests that would not otherwise have been possible.

As a result of these and other accomplishments, the FAA and DOT have decided to initiate a new multi-year program to continue building on IPP's successes.

FY21 PLAN: CAASD will continue to support the FAA execution of the next partnership program, called BEYOND. CAASD's core areas of contribution will include:

- Designing and refining actionable strategy and execution plans for all post-IPP partnerships as well as PSP and other partnerships, in alignment with the overall FAA UAS integration strategy
- Integrating systems engineering across partnerships, working closely with the FAA partnerships leadership team to coordinate technical progress
- Identifying program exit criteria and success definitions and outcomes
- Influencing the necessary outcomes from post-IPP partnerships that will allow routine, scalable, and economically viable operations
- Providing program-critical decision-support tools and expertise, lessons learned, technical and procedural independent assessments, and informational briefings to FAA rule-making teams
- Providing data-supported recommendations to support a BVLOS path forward, to include industry guidance
- Providing strategic advice and technical decision tools to FAA UAS Integration Office (AUS) program leadership partners and AIR teams focused on advancing the certification approaches that are unique to UAS
- Assisting the FAA with DAA performance metrics development, testing, and DAA system evaluation to establish standards and requirements that, in turn, will enable BVLOS solutions that mitigate operational risk to acceptable levels for waiver or exemption approvals
- Conducting safety and quantitative risk analysis across partnership efforts



- Contributing to C2 and spectrum strategy, testing, and technical evaluation
- Conducting data analytics and contributing to a program-level data management strategy
- Evolving IPP testing methods and metrics to meet nuanced needs of the BEYOND program

CAASD will continue to support the FAA execution of the next partnership program, BEYOND.

Unmanned Aircraft Systems Approvals

As UAS regulations and policies continue to evolve, their supporting systems must also evolve. DroneZone (DZ) is a system that serves as a one-stop shop to provide UAS operators with a single website from which to access a variety of UAS-related capabilities. The DZ project focuses on planned enhancements pertaining to the Part 107 operational waiver processing functions. DZ must be aligned with current and evolving operational approval methodologies. CAASD is working alongside FAA experts in the refinement of unmanned operational approval concepts, technical requirement contributions, and User Acceptance Testing (UAT) of DZ for future scheduled enhancement releases.

FY20 ACCOMPLISHMENTS: In FY20, CAASD worked on an agile FAA Flight Standards Office-IT Organization (AFS-AIT) team to identify, design, and coordinate requirement refinements and assist in the deployment of the first phase of DZ enhancements. This effort included addressing reviews by the FAA's Office of the Chief Counsel and Office of Communications. CAASD planned and facilitated UAT, analyzed the UAT results, and updated requirements to incorporate user feedback from UAT. CAASD ultimately delivered a final set of requirements for the first phase of the enhancements that the FAA deployed on time in November 2020.

FY21 PLANS: As the focus shifts to follow-on phases of the enhancements, CAASD will continue to serve as a critical team member. Changes to the Part 107 rule, expected in early 2021, will require corresponding DZ modifications. In addition, as the FAA continues to make progress enhancing the objectivity and repeatability of the operational waiver risk assessment process, CAASD will coordinate the requirements development with the ongoing risk assessment process improvements to ensure that DZ operational waiver data capture satisfies the latest risk assessment data needs. CAASD will also coordinate requirements updates with the FAA to collect additional operational information from applicants and incorporate feedback on the Phase 1 deployment.

Unmanned Aircraft Systems Strategic Alignment and Enterprise Planning

The introduction of UAS into the NAS is a unique challenge to the FAA for many reasons, including its impact on and involvement of offices and decision makers from all parts of the Agency. CAASD continues to partner within the FAA organizations and forge new relationships with the UAS industry to inform and align strategic planning efforts.

FY20 ACCOMPLISHMENTS: CAASD provided strategic guidance to the FAA ATO to create its UAS Services Plan, which identifies the major goals and actions needed to expand UAS operations in the NAS in the next four years. In addition, CAASD developed an FAA enterprise-wide strategic framework to explore the potential implications of the UTM operational concept, with a focus on ATO's roles and responsibilities, key decisions, and research needed for its successful implementation and operation. Additional technical analyses revealed expected impacts of UAS and UTM on NAS infrastructure and related dependencies within the ATO organization.

FY21 PLAN: In FY21, CAASD is developing a business planning process to position ATO's strategy organization within Mission Support Services to proactively manage incoming and future unmanned concepts (such as UTM). Principal elements include a concept maturity framework tailored to ATO actioning criteria, operational implementation readiness assessment tools, and a UAS strategic decision identification framework. This collective process will enable decomposition of ATO responsibilities from vision documents and will allow ATO to identify and prioritize unmanned-related decisions and activities to be captured and prioritized within the ATO UAS Services Plan, Business Plans, and budgeting. It will also give ATO the ability to influence future concept development in ways that will accelerate operationalizing and result in successful implementation planning.

Urban Air Mobility

New mobility stakeholders are developing the vision and technologies to provide a broadened set of short-haul air transportation services. Urban Air Mobility (UAM) brings significant safety challenges and operational integration issues. Updated policies, procedures, and regulations will be needed to enable operations at scale. Since 2018, CAASD has performed independent research activities to explore the challenges of enabling UAM. These challenges will become increasingly important to FAA business units as UAM technology matures.

FY20 ACCOMPLISHMENTS: In FY20, CAASD performed independent research activities focused on two UAM challenge areas: airspace integration and micro weather impacts. CAASD also coordinated numerous technical exchange forums to share findings and engage with UAM industry stakeholders. The CAASD team explored and documented approaches to integrating UAM operations in the NAS to include guiding principles of future UAM airspace. CAASD used, and in some cases designed, simulation and modeling techniques to understand and quantify wind variability and fluctuations of micro weather impacts in urban areas. This research will help identify wind hazard probabilities that can inform future standards and policy development.

FY21 PLAN: CAASD is continuing its independent research efforts while also directly supporting the FAA in strategically preparing and planning for the future of UAM. CAASD is conducting a UAM operational assessment to determine what air traffic services the ATO can expect to provide under future UAM operations. The assessment will also identify gaps in policies, procedures, and standards to support increasing UAM integration. Further, CAASD is developing a conceptual model and a prototype forecasting framework to evaluate the outlook and potential hotspots for UAM operations. Finally, CAASD is identifying the research needs to inform repeatable and scalable approvals of UAM operations.

Space Launch and Reentry Vehicle Operations in the NAS

To increase NAS efficiency during space launch and reentry (L/R) operations, CAASD explored the concepts of Time-Based Launch Procedures (TBLP) and Dynamic Launch and Reentry Windows (DLRW). TBLP enables efficiency by strategically identifying and rerouting only those aircraft that will intersect an Aircraft Hazard Area (AHA) while it is active during a launch.

DLRW provides actionable information from L/R operators to reduce the amount of time AHA airspace is segregated for these operators' sole use. This allows the FAA's ATO Space Operations office to more effectively provide notification of the start and end times of AHA activity. TBLP are then used to tactically identify aircraft eligible to take advantage of the AHA airspace made available with the information from DLRW.

FY20 ACCOMPLISHMENTS: CAASD supported development of end-to-end data flow and data exchange processes to identify industry and FAA data that can enable TBLP and DLRW concepts. CAASD also identified the stakeholder roles and responsibilities necessary to leverage the efficiencies TBLP and DLRW enable. This information will help socialize TBLP and DLRW procedures, concepts, and associated data exchange processes with FAA operational personnel, space L/R operators, and flight operators. Achieving the desired efficiencies of TBLP and DLRW requires clear, timely, and actionable information and data exchange on the part of all participants. The data exchange descriptions CAASD provided include the data source, the data user, when the data is exchanged, the data exchange mechanism, how the data is used, and a breakout of data exchange elements. Where identified, potential data exchange improvements and operational considerations concerning the use of data were included.

FY21 PLANS: In concert with the FAA, CAASD will define and finalize a training activity to enhance TBLP/DLRW process and procedures awareness. This work is focused on improving collaboration and enhancing information sharing in support of L/R operations utilizing the TBLP and DLRW processes and procedures.

Civil/Military Aerospace Integration

The United States Air Force (USAF), in support of the DoD, is working to ensure that DoD aircraft and air traffic systems can integrate into the NAS in a manner consistent with the performance-based intent enabled by NextGen. In addition, because the DoD controls roughly 20 percent of the NAS, it is important that DoD air traffic controllers and systems operate seamlessly with civil ATC personnel and systems, especially during times of disaster relief and/or homeland defense. The focus of the Civil/Military Aerospace Integration effort is to ensure that the USAF civil aerospace-related programs can safely and efficiently integrate into the NAS to promote agency and public interests.

FY20 ACCOMPLISHMENTS: MITRE, leveraging its ability to work across government agencies, supported the integration of USAF aviation activities into CAASD to better align aerospace efforts between the DoD and the FAA. Specific efforts were tied to Deployable ATC and Landing Systems (D-ATCALS), ATC Future Technologies (AFT), CNS/ATM implementations on USAF aircraft, and the migration of USAF weather data and applications to a cloud-based computing architecture. (Specific accomplishments of each of these efforts are captured in the subsections below.) Similarly, CAASD is supporting a cooperative assessment of remote tower technology by the FAA and DoD, as described in the Remote Tower section of this Annual Report.

FY21 PLANS: CAASD will continue its FY20 efforts into FY21 in each of the specified areas. In addition,

CAASD will work to identify other areas where USAF/DoD aerospace-related efforts can benefit from FAA activities to evolve NAS infrastructure and operations. CAASD will also explore opportunities for the FAA to benefit from USAF/DoD efforts and investments that benefit the NAS.

AIR TRAFFIC CONTROL FUTURE TECHNOLOGY DEVELOPMENT

The USAF must be able to deploy forces rapidly in all weather conditions to ensure freedom of movement, commitment to our partners, and demonstration of our resolve. ATC and Landing Systems (ATCALS) provide vital mission support to enable the USAF to deliver responsive and effective global vigilance, reach, and power. The majority of ATCALS equipment in the USAF inventory was designed for use on large main-operating bases and is not suitable for expeditionary forward-operating sites. A need was identified for small footprint, lightweight, and agile technologies to support aircraft launch and recovery in an Agile Combat Employment (ACE) environment and in humanitarian and restoral missions.

FY20 ACCOMPLISHMENTS: CAASD prepared a technology development strategy to address the need for small and agile ATCALS technologies for non-precision approach, precision approach, and ATC surveillance. CAASD identified gaps between current systems/technologies and desired future capabilities and

outlined potential technology development concepts/efforts to bridge the gaps. Following development of the strategy, CAASD identified specific technology development project plans that the USAF used to initiate contracts for Small Footprint Precision Approach and Landing Capability (SF-PALC) proof-of-concept component-level designs and a Multifunction Tactical Radar System (MTRS) prototype.

SF-PALC system design contracts were awarded for two different technology approaches for systems that can provide CAT 1 precision approach guidance and be transported in one-tenth of the cargo space required for the existing deployable instrument landing system (D-ILS). The MTRS contract is developing a prototype phased-array radar that will be of a similar size as the SF-PALC and will be used to explore potential system design and performance tradeoffs.

FY21 PLAN: CAASD will oversee the development of two prototype systems: the MTRS and a new high-power man-portable TACAN prototype scheduled to be put on contract in the first quarter of FY21. The new TACAN system will provide a significant increase in range without increasing the size and weight of the legacy man-portable systems. CAASD will also define a plan to initiate the development of an SF-PALC prototype. The first phase of the SF-PALC prototype development is scheduled for contract award in FY21.

TACTICAL AIR NAVIGATION MINIMUM OPERATIONAL NETWORK

CAASD conducted an assessment of NAS-based TACAN beacons to help the DoD assemble a proposal for the FAA to create a TACAN MON without impacting DoD operations. CAASD used tools created for the assessment of FAA VOR and DME coverage volumes to determine which TACANs could be decommissioned without major impact.

FY20 ACCOMPLISHMENTS: CAASD worked with the DoD Policy Board on Federal Aviation (PBFA) to create a NAS navigation operational strategy and used it to assess which TACANs could be divested without impact. Previous FAA TACAN divestment proposals were met with significant resistance and resulted in only 10 of the 500+ TACANs being made available for divestment. CAASD's analysis leveraged FAA plans to implement expanded frequency protection service volumes for many of its VORs and DMEs. By understanding the DoD's operational strategy and applying the extended service volume definition to TACANs, CAASD was able to provide the PBFA with a quantitative analysis identifying 123 TACANs that could be divested. This proposal would allow the DoD to maintain the existing capability while the FAA reduces the number of TACANs that need to be continuously maintained.

FY21 PLAN: No direct work is planned for the DoD, but CAASD expects to support the FAA's NAVAID rightsizing efforts.

NAVIGATION DATA QUALITY

As part of its longstanding support to the USAF CNS/ATM CoE, CAASD developed validation and verification tools, led the development of avionics industry standards, and developed/performed audit processes across the federal government and industry. Based on collaborations with the USAF, the FAA, the National Geospatial-Intelligence Agency (NGA), and commercial database suppliers, these analysis and support tools ensure a continued focus on the reliability and safety of the Navigation Database supply chain and the DoD's participation in the evolution of global airspace to PBN standards.

FY20 ACCOMPLISHMENTS: CAASD continued development and release of Navigation Database analysis tools, including refactored procedure comparison functionality that performs a global comparison of SID routes and STAR procedures in less than 10 minutes, a vast improvement from the four to six hours this process took previously. The public release of the ARINC 424 Extensible Markup Language (XML) API was also completed, creating a machine-generated data importer for conversion of older data formats into ARINC 424 XML. Additionally, CAASD analyzed data alteration in databases and terminal procedures to understand the impact to airspace utilization. Responding to these discoveries, and working with RTCA SC-217, a proposal on data alteration descriptions to baseline understanding across the civilian/military community was approved and scheduled for release in FY21. In preparation for future work, CAASD observed and provided comment to an initial audit of the United Kingdom's Aeronautical Information Documents Unit for global data sharing and demonstrated the TARGETS toolset and automated criteria checks to NGA.

FY21 PLAN: CAASD will continue analysis of DoD's use of Navigation Databases and standards driving their evolution. Building upon several years of procedure analysis software tools, CAASD plans to further develop tooling on a standard "inherent" path definition error to model what errors are present in navigation databases. Efforts are also planned to support the NGA Digital Aeronautical Flight Information File (DAFIF) to ARINC 424 transition, including development of an early operational prototype that will import/export ARINC 424 XML data from either DAFIF 8.1 or Legacy ARINC 424. CAASD will also use its leadership role within the ARINC 424 XML committee to develop ARINC 424 XML schemas to be used as the basis for future civil and DoD navigation information exchange. Additionally, CAASD will contribute to industry standards with the RTCA for acceptable data alteration processes to reduce errors and increase data availability.

AIR FORCE WEATHER CLOUD MIGRATION

The USAF Weather (AFW) enterprise ingests approximately 80 terabytes and outputs approximately five terabytes of data daily and operates at multiple classification levels. The AFW enterprise is migrating eight data centers to Amazon GovCloud over the course of multiple years. These data centers represent approximately 9,000 computing cores and more than 50 million lines of source code. AFW is one of the first "mission" systems to operate in the cloud, highlighting the need for resilience to ensure mission objectives are met, to include maintaining safe operations in U.S. civil airspace.

FY20 ACCOMPLISHMENTS: CAASD supported development of the AFW enterprise cloud architecture, establishing:

- Architectural and implementation guidelines that document the enterprise strategy for cloud portability and interoperability, which were adopted by the AFW enterprise technical review board
- A resilient communications architecture to support mission operations that forms the basis for discussions with all communications stakeholders
- Changes to fielded equipment to support effective transition to cloud operations
- A cross-domain risk-mitigation strategy and testing approach for XML data conversions
- A way ahead for data engineering that the program uses to contract support services

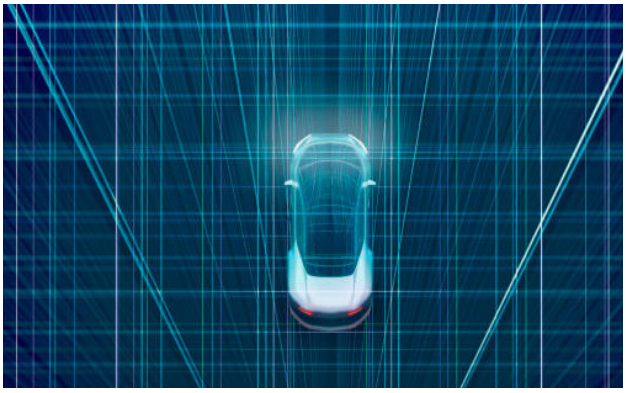
FY21 PLAN: CAASD will accelerate implementation of the cloud infrastructure and a big data analytics platform. CAASD will also address the program's cross-domain risk by introducing hands-on rapid prototyping and risk-reduction efforts in a laboratory environment that includes the contractor baseline. Further, CAASD will establish an architecture for cloud failure modes using multiple availability zones and multiple regions to address mission requirements spanning near-real time alerting to continuity of operations.

Surface Transportation

As technology and innovations are deployed to enhance surface transportation, CAASD has a unique opportunity to use its independent, data-driven systems engineering approach to enhance and sustain a safe and secure surface transportation system in the U.S. CAASD's goals focus on safety and security outcomes: to reduce crash and fatality rates across surface transportation modes, and to prevent unauthorized or hostile cyber-threat activity that disrupts transportation systems.

During the past two years, CAASD laid the groundwork for these efforts. This included establishing strong relationships, increasing brand awareness in the domain, identifying and adapting CAASD capabilities for surface transportation, and better understanding and adapting business processes. Moving forward, CAASD will execute on opportunities in the areas of proactive safety assurance, safety culture assessment, cyber resiliency, and economic, policy, and environmental assessments.

FY20 ACCOMPLISHMENTS: CAASD's surface transportation efforts yielded two major accomplishments in FY20. CAASD executed a contract with the DOT Office of the Secretary of Transportation (OST) to continue to fund Phase 2 PARTS, the Partnership for Analytics Research in Traffic Safety. PARTS is a data sharing partnership between eight auto manufacturers and the National Highway Traffic Safety Administration. PARTS' mission is to improve traffic safety in an enduring data-sharing partnership by generating unique analytic results that inform action.



CAASD developed a strategy and approach for automated vehicle (AV) safety in FY20. In this initiative, CAASD developed a relationship with an AV developer and started an assessment with their SMS process.

FY21 PLANS: In the proactive safety assurance space, CAASD will conduct a proof-of-concept research study with an auto manufacturer to improve its ability to conduct safety analysis using telematic data. This will be accomplished by innovating on the manufacturer's end-to-end data analytic process.

CAASD will also co-host a virtual summit on SMS for AVs, targeting the AV developer community. In addition to a virtual summit, CAASD will publish a paper on managing safety risk for automated driving systems. Additionally, CAASD will conduct an SMS assessment of an AV developer.

Finally, CAASD will build on and identify new business opportunities for surface transportation in the areas of cyber resiliency and privacy, vehicle-to-everything (V2X) communications, economic and policy modeling, and environmental impact.

Integration Demonstration and Experimentation for Aeronautics Lab

The MITRE IDEA Lab enables FAA improvements to current ATM systems. It also provides an environment to envision future needs and test possibilities for future aerospace and transportation systems. The lab is a real-time modeling and simulation environment where concepts can be matured and vetted with key stakeholder groups. The IDEA Lab is flexible enough to handle a wide range of exploratory concepts, yet realistic enough to provide a high-quality user experience. It brings together a broad set of integrated ATM capabilities for HITL simulation and visualization to enable the investigation of a wide array of ATM/CNS concepts.

FY20 ACCOMPLISHMENTS: In FY20, the IDEA Lab hosted 10 major evaluations/experiments, including 68 days of data collection. In advance of these major demonstrations and evaluations/experiments, CAASD devoted more than 237 days to project preparation (e.g., integration testing, dry runs, scrubs). Additionally, the lab conducted 30 project demonstrations, 20 of which were to sponsors and other external participants.

The IDEA Lab was heavily utilized in the first half of FY20, reflecting the trend seen in previous years. From March on, the ability to conduct HITL events was affected by COVID-19. The number of demonstrations dropped and did not recover, but evaluation preparation and the evaluations themselves recovered back to pre-COVID-19 levels. These events recovered due to implementation of new protocols for social distancing and the use of past investments in making the laboratory more robust and accessible from remote locations. Together, the procedures, the investments, and the creativity of platform users and developers were able to minimize the impact of COVID-19.

FY21 PLANS: If the social distancing effects of COVID-19 remain in place, FY21 will see utilization numbers analogous to FY20, with about 10 major evaluations/experiments, 20 project demonstrations, and over 200 days of project preparation. If the social distancing constraints are removed, FY21 will see figures more in line with FY18 and FY19, with about 20 major evaluations/experiments, 80 to 100 project demonstrations, and over 300 days of project preparation.

Aviation Discovery Lab

The MITRE Aviation Discovery Lab provides a unique, configurable capability to access any of CAASD's aviation-related data sources from one location. The lab serves as a collaborative problem-solving and consensus-building space where analysts and decision makers, along with government and industry working groups, can work with data in a controlled and secure environment.

The lab focuses on aviation safety analysis and vulnerability discovery through the analysis of aviation data, including proprietary airline data. The lab provides the analytical foundation and tools to enable decision makers to better understand safety risks in the NAS, to support the development of mitigations of safety risks in the NAS, and to support the development of safety cases for new capabilities. The lab, designed with collaboration in mind, is the only facility of its kind in the world, and is fully integrated with the IDEA Lab.

The Aviation Discovery Lab is an integral part of CAASD's efforts to help the FAA and the aviation community better understand and develop ways to mitigate safety risks in the NAS. The lab offers capabilities that are specifically designed to support aviation safety work, but these same capabilities can be applied to other FAA work areas. Key among these capabilities is a protected environment in which to work with proprietary airline and air traffic safety data. The lab is a secure space where the FAA and CAASD can host external work groups seeking to identify systemic risks by analyzing aggregate de-identified flight data and, when necessary, individual flight data that are not de-identified.

FY20 ACCOMPLISHMENTS: In FY20, due to the COVID-19 pandemic, the Discovery Lab conducted 50 percent fewer demonstrations and government/industry working group sessions in support of ASIAS and the Commercial Aviation Safety Team (CAST). In January 2020, the Approach and Landing Misalignment Joint Safety Analysis and Implementation Team/Directed Study working group concluded the study with a CAST risk and mitigation assessment, along with a mitigation cost-versus-risk reduction assessment. This is one example of a multi-day session leveraging the lab's collaboration capabilities to enable SME review of study findings and in-depth analysis into the identified safety risks, without proprietary data ever leaving the CAASD facility. The continual use of the lab enables direct access to the data and rapid response to queries of the data when investigating systemic risks. It means CAASD can get recommendations to CAST and the General Aviation Joint Steering Committee in a timely manner for mitigation.

FY21 PLANS: CAASD will continue to leverage the lab to support new communities. For example, CAASD will support the rotorcraft community as it develops analytical capabilities and a governance model to analyze safety data, prioritize the top safety risks, and develop risk mitigations with the USHST to ensure an acceptable level of safety.

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 aerospace domain forward.

KEY 2020 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 SMEs on educational panels and plenary sessions. Key CAASD technical personnel also are regular keynote speakers.

In FY20, the conference world changed significantly due to COVID-19. Despite the challenges of virtual conferencing, CAASD continued to have significant participation in educational webinars and panels and shared technologies and demonstrations in virtual booths as part of major domestic aviation conferences, including:

- Air Traffic Controllers Association (ATCA) Annual (Fall 2019): featured integrated flight deck and Pacer demos in the CAASD booth; five presentations in educational theaters
- FAA Managers Association (FAAMA) Gathering of Eagles (Fall 2019): featured integrated flight deck and NAS Operations Dashboard (NOD) demonstrations in the CAASD booth along with providing key demos to FAA leadership
- Singapore Airshow 2020 (February 2020): featured Optimizing Safe and Efficient Flight Trajectories demo and video
- RTCA Symposium (Summer 2020): featured sponsor of two RTCA webinars, providing a Tech Talk and serving as a panelist
- American Council for Technology-Industry Advisory Council (ACT-IAC) Conference (Summer 2020): invited participant as Pacer nominee for Igniting Innovation Award; hosted virtual booth with Pacer demo and materials
- Association for Unmanned Vehicle Systems International (AUVSI) Xponential Conference (Summer 2020): hosted virtual booth with cross-MITRE unmanned research and materials
- ATCA Technical Symposium (August 2020): featured sponsor of the event and hosted virtual booth that included Q&A video with FAA's Steve Bradford

CAASD also had numerous papers submitted by staff and accepted for presentation at technical conferences, including AIAA SciTech, Transportation Research Board, ICNS, AIAA Aviation 2020, American Meteorological Society, and DASC.

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. Content is frequently prepared in partnership with and with the approval of the FAA. In FY20, CAASD-provided content appeared in:

- FAAMA's *Managing the Skies*
- *ATCA Bulletin*
- *ATCA Journal*
- American Institute of Aeronautics and Astronautics's *(AIAA) Aerospace America*
- American Association of Airport Executives' (AAAE) *Airports Magazine*
- *Air Traffic Technology International*


MITRE
Engineering in the Public Interest

FOSTERING PEOPLE AND CULTURE

Culture is not a single project or campaign, rather it is something to be integrated into the overall employee experience. It's woven into communications, activities, initiatives, and events across everyday work. Building a successful culture starts with creating a trust environment, providing employees training and development, communicating consistently and regularly, and applying organizational change management processes. CAASD's experience in employee surveys, organizational change, and workforce training is helping the FAA prepare its people and culture to meet the demands of the future global aerospace system.

Workforce Transition to Initial Trajectory-Based Operations

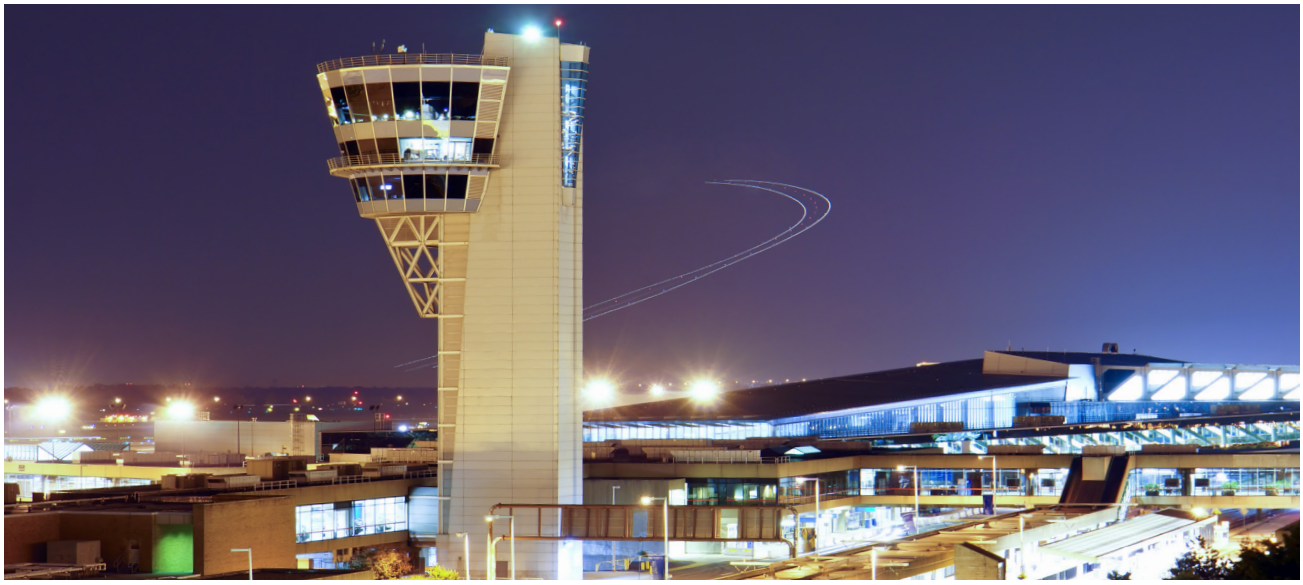
Successful TBO implementation will rely heavily upon the successful operational transition of the ATM and operator workforce to this new traffic management methodology. iTBO will introduce significant operational changes that the workforce will need to understand and be prepared to change their actions and behaviors to accommodate.

To support workforce adoption of TBO, CAASD has partnered with the FAA to execute a change management strategy designed to educate and motivate stakeholders on the anticipated impacts of TBO to their processes and operating models. More specifically, CAASD has developed TBO education and training materials, helped the FAA plan and deliver stakeholder communications, and informed the definition of operating procedure changes to support use of TBO automation in the field. CAASD has also performed various analyses to characterize expected benefits and to further clarify evolving ATM roles and responsibilities.

FY20 ACCOMPLISHMENTS: In collaboration with the FAA, CAASD developed a series of artifacts to communicate and foster improved understanding of TBO among FAA and industry stakeholders. Among them are a description of how iTBO works, with a focus on the individuals who will execute the operation. CAASD's work also included the development of workflow diagrams to illustrate key ATM positions' current and evolving responsibilities, which capabilities they are using to support those decisions, and key interactions with other positions. The CAASD-developed description provides an authoritative source for describing iTBO. It will be used to inform stakeholder communications, education and training materials, future operating procedures, and operational risk mitigation activity test cases. CAASD also developed industry-focused TBO artifacts consisting of scenarios and associated use cases, impact vignettes, and operational narratives that were coordinated with industry representatives via a CDM sub-team; the objective was to set TBO expectations, spur workforce curiosity, and elicit feedback on key perceptions.

Additionally, CAASD made significant contributions to advance TBO training. These included developing a near-term training plan to guide the setting of priorities and objectives, a TBFM fundamentals course, and other education artifacts that were used to facilitate implementation of incremental field changes. As part of the FAA's TBO Training Workgroup, CAASD provided inputs on major training objectives and priorities over the next two to three years, and advised on best practices for training strategy, planning, and delivery.

Toward the goal of clarifying roles and responsibilities, CAASD provided Facility Operation and Administration (JO 7210.3) and Air Traffic Control–Document Information (7110.65) with significant inputs into the ATC procedure updates needed to support iTBO. This effort resulted in detailed changes that are undergoing final review.



Finally, CAASD generated communication artifacts to foster field discussions about initiatives to introduce extended metering to Denver and departure scheduling to Philadelphia. CAASD worked closely with the FAA's Air Traffic Services (AJT) and System Operations (AJR) leadership to prepare the FAA's Change Strategy team to engage and support the field regarding TBO, plan and develop core messages and supporting material for presentation at the FAA's TBO Summit, and initiate an ATCSCC workforce transition plan.

FY21 PLANS: In FY21, CAASD will continue to collaborate closely with AJT and AJR leadership to execute and refine the TBO change strategy for mobilizing leadership at headquarters, and with the NAS workforce and aircraft operators. Building on the industry engagements completed in FY20, CAASD will develop a communication campaign for engaging the operator community on TBO. This work will include identifying and planning effective forums to engage operators, such as the NextGen Advisory Council work groups and the National Customer Forum. One key TBO-focused FAA event (Industry Day) is planned for January 2021; CAASD is already working with the FAA to prepare core messages and supporting communication artifacts that can set industry expectations about new automation and capabilities, secure industry leadership buy-in on TBO, and identify where industry may need to invest in decision-support tools and education of their workforce.

In addition, as part of the FAA's TBO Training Workgroup, CAASD will continue working with the FAA to finalize an ATCSCC workforce transition plan, validate and finalize recommendations on updates to JO 7210.3 and JO 7110.65, and support the development of content/artifacts for delivering the next major TBO training priority. CAASD will also work to introduce lightweight, real-time performance insights to operational personnel at the facilities to help foster trust and understanding in operational changes associated with the transition to TBO. Finally, CAASD will develop a training roadmap to outline strategic decisions and investments to help the FAA plan for longer-term training initiatives for implementing iTBO and beyond.

Workforce Training Improvements

The FAA is preparing for the future by improving how it trains its workforce. The FAA needs a workforce with leadership abilities and technical and functional skills to ensure the U.S. has the world's safest and most productive aviation sector. CAASD is drawing upon its change management expertise to help the FAA to address its ATC workforce training priorities.

Organizational change management and effectiveness are critical to any significant organizational and cultural change. Working in partnership with FAA leadership, CAASD helped design a strategic approach to systematically align people to changes in process and technology to prepare for implementing iTBO. This approach emphasized leadership accountability, stakeholder engagement, communications, field evolution planning, training and education, and organizational alignment. In addition, CAASD supported the FAA by analyzing stakeholders' concerns and perceptions and fostering stakeholder understanding of the operational change and impact. These efforts yielded results that served as the foundation for defining an overall iTBO communications plan as well as tailored communications.

CAASD works in collaboration with the FAA to define key implementation roles, responsibilities, and workforce behaviors, and to survey teams to understand how best to empower people so they can focus on innovation.

AIR TRAFFIC CONTROL APTITUDE TESTING

A significant challenge to the FAA's ATC hiring and training goals is that, currently, 50 percent of the FAA's controller candidates do not successfully complete training. By considering student proficiencies early in the training process, the FAA could tailor the training of ATC students and reduce training costs by reducing failure rates.

To explore the validity and benefits of early proficiency assessment, CAASD developed three aptitude test prototypes focused on the following areas: vectoring, awareness and planning, and information filtering and inductive reasoning.

CAASD initially developed a prototype Radar Vectoring Aptitude Test (RVAT) and has completed evaluation of the RVAT prototype with ATC students. The results from the evaluation indicated that the RVAT is a predictor of student success in ATC training and that RVAT provides extensive detailed information regarding student fundamental ATC abilities and proficiencies.

The second prototype—the Scanning, Planning, and Flexibility (SPF) test—has also been evaluated with ATC students and has been shown to predict student performance in initial training at the FAA Academy. Moreover, SPF has been demonstrated to provide additional predictive information above and beyond the information that RVAT is providing. The third and final prototype, the Filtering and Inductive Reasoning (FaIR) test, is ready to be evaluated at the FAA Academy with ATC students.

FY20 ACCOMPLISHMENTS: In FY20, CAASD completed the assessment of field qualification training performance data to determine the correlation between RVAT performance and student overall performance in training. This assessment demonstrated that RVAT predicts student performance in ATC training. CAASD also completed the initial assessment of SPF data and student performance data, which demonstrated that SPF is predictive of student success at the FAA Academy. Further, CAASD completed the FaIR test prototype, which is ready for evaluation.

FY21 PLANS: CAASD will work with the FAA to leverage the success of RVAT and SPF and determine how to best use the data they are providing to improve ATC training outcomes, increase student success, and support a more student-centered training model.

Real-Time Air Traffic Control Training Performance Assessment

As the FAA works to improve overall ATC training success, past research by CAASD and others has indicated that objective measurement of operational performance is critical to understanding training effectiveness, meeting training objectives, and achieving the NAS's operational mission. Not only can objective operational performance data reveal training shortfalls, it can also identify individual student and workforce training needs and support an evolution to a competency-based model of training.

To improve the use of objective, data-driven measurement in ATC training, CAASD has proposed an innovative method to use operational data (captured during ATC training and live operation) to provide an assessment of performance as well as student/controller feedback. The data and performance assessment metrics and feedback can be used to measure and improve training effectiveness and provide individualized training to controllers and students based on need.

FY20 ACCOMPLISHMENTS: CAASD developed an operational concept and functional description for a data-driven approach to capturing and assessing operational performance data, to be used to measure training effectiveness. CAASD also developed use case examples to illustrate the concept, along with a development plan and roadmap to support implementation.

FY21 PLANS: In FY21, CAASD will create an initial prototype illustrating the operational concept and functional design of the performance data collection, assessment, and feedback approach. This prototype will support lab-based demonstration, socialization, and assessment of the design, use, and benefits.

Safety Culture Assessment

AVS asked CAASD to conduct an independent assessment of the AVS safety culture to identify culture enablers and barriers to the successful design and implementation of a new online Voluntary Safety Reporting Program (VSRP). The new VSRP will provide a mechanism for AVS employees to report safety issues without fear of retribution. The VSRP initiative directly supports one of the nine strategic initiatives identified in the FY20–24 AVS Strategic Plan, a document that prioritizes AVS investments for the next five years.

FY20 ACCOMPLISHMENTS: CAASD created and performed the assessment using a rigorous, proven methodology to measure ten critical dimensions of a safety culture. A CAASD report summarizes the findings from the assessment based on executive and labor leader interviews, an online survey of the 7,000+ AVS employee workforce, and employee focus groups held in key FAA locations across the country. CAASD provided recommendations for strengthening the AVS safety culture such that a successful VSRP can be developed.

FY21 PLANS: CAASD will help the FAA execute a plan to establish and maintain a safety culture that embraces collaboration, embodies trust, and rewards expected behaviors. Through this AVS VSRP development work, CAASD will ensure a VSRP design that is consistent with these goals.

Voluntary Safety Reporting Program

AVS is launching a VSRP to enable AVS employees to confidentially report issues that may have a negative impact on aviation safety. This is part of a broader AVS strategy to improve aerospace safety through "establishment and expansion of voluntary safety programs."

FY20 ACCOMPLISHMENTS: CAASD developed and is securely hosting an operational prototype to serve as a pre-production system. The system was successfully demonstrated to an FAA VSRP stakeholder team to affirm functional requirements and governance responsibilities.

FY21 PLAN: CAASD will evolve the prototype to include additional functionality, as requested by AVS. CAASD plans to start a transfer of system technology to an FAA vendor at year's end so that a production-level system can be built within the FAA computing infrastructure.

RESILIENCE

How can the aviation community combat the challenges of passenger health and cybersecurity to ensure aviation remains the safest mode of transportation in the world? Addressing the challenges associated with achieving the next level of passenger safety and cyber resiliency will require the cooperation of the entire global aviation community. CAASD is helping the FAA forge ahead with initiatives to improve global airspace operations, while focusing on resiliency to confront the new normal.

Remote Towers

Providing ATC services at airports using a conventional tower is expensive. The FAA and air navigation service providers around the world are examining ways to reduce those costs. Toward that goal, the FAA is assessing the viability of providing tower services from a facility (on or off the airport) without a direct out-the-window view of the airport surface and instead using video cameras and panoramic displays to provide tower services.

FY20 ACCOMPLISHMENTS: Previously, CAASD explored an analytical method to estimate how well a planned remote tower video camera system will provide controllers with operational information, thus reducing risk during system deployment. In FY20, CAASD developed a prototype tower visibility toolkit that incorporates camera system specifications, estimates visibility performance, and compares that performance to FAA tower siting guidance. These outputs inform the FAA's site deployments, potentially reducing long and costly operational testing.

CAASD also interviewed the program team and key stakeholders to identify ongoing lessons learned, project risks, and associated mitigation strategies. CAASD's findings are informing the FAA's plans to evaluate safe remote tower services in FY21 and beyond.

Finally, CAASD continued to explore remote tower technology with the USAF and leverage lessons learned to inform the FAA's efforts. In FY20, CAASD developed a plan to assess whether remote tower technology is suitable for operations at USAF airfields.

FY21 PLANS: CAASD will continue to work with the FAA to lower the cost and time to approve remote tower services in the NAS. This includes enhancing the prototype tower visibility toolkit, supporting international guidance for remote tower systems, and informing site test plans. The FAA anticipates using the tower siting toolkit to support additional remote tower sites. In FY21, CAASD will also assess remote tower technology at selected USAF sites.

Cybersecurity Architecture: Zero Trust

With increasing advances in technology and reductions in the effectiveness of traditional cyber architectures, many industries now assume that cyber attackers will be able to penetrate their trusted networks, and they are taking steps to ensure that those breaches are immediately detected and thwarted. Many are adopting a new approach called "zero trust," where no user, system, or network—whether inside or outside the organization's network—is trusted.

The FAA is following suit. Over the past year, the agency examined the use of the emerging zero-trust (ZT) model as it moves to a shared IP-based infrastructure. This approach differs markedly from the FAA's current, privately-owned, largely Time Division Multiplexing (TDM) infrastructure, which employs a traditional castle-moat cybersecurity model, where security is concentrated at a network's perimeter. ZT is not one capability but is made up of both existing and new cybersecurity capabilities that, when combined, create a new model for securing data both at rest and in transport.

CAASD is leading new work in cybersecurity for the FAA by applying state-of-the-art ZT concepts and capabilities to introduce stronger, more resilient cybersecurity for the FAA's mission-critical infrastructure. CAASD is also applying the ZT model to the FAA's longer-term objective: the 2035 future vision. In that vision, the FAA envisions ubiquitous communications between all users of its aviation ecosystem. CAASD is examining how the ZT model can be applied to enable secure information transfer in that environment.

FY20 ACCOMPLISHMENTS: In FY20, CAASD performed analyses on the application of ZT to the near-term FENS environment as well as to the 2035 future vision. CAASD worked to socialize ZT concepts across many FAA organizations. CAASD worked with FAA ATO Program Management (AJM) and Technical Operations Services (AJW) in the area of implementation in FENS, and with the Office of Information Systems Security (AIS) and the ANG to ensure ZT could meet current and future needs. CAASD's work led to the FAA embracing this new technology for its mid- and far-term information architecture.

CAASD produced a ZT report that examines various uses cases exploring data flows both within and external to the FAA. As part of that analysis, CAASD examined how a ZT architecture could enable new capabilities (e.g., cloud computing) more easily, cost effectively, and securely.

CAASD also wrote articles and briefed senior FAA leaders on the ZT model and its potential to mitigate many of the weaknesses inherent in the castle-moat architecture employed in today's operational and support systems.

CAASD will leverage its work with the ZT pilot program to make recommendations on the phased implementation of ZT capabilities across the NAS and the aviation ecosystem.

FY21 PLANS: The FAA is now poised to take advantage of the benefits of ZT. In FY21, CAASD will explore ZT capabilities that enable information assurance and support the secure transfer of information across the aviation community.

The FAA's plan to modernize its telecommunications system provides an opportunity for change. In FY21, the FAA will evaluate FENS vendor proposals for a new IP-based telecommunications infrastructure. CAASD's work in FY20 will help guide the evaluation process from a cybersecurity perspective.

In addition, CAASD will work with the FAA to establish a ZT stakeholder task force, a ZT roadmap, and a ZT pilot program. CAASD will identify ZT capabilities, identify further ZT use cases, and develop proof-of-concept demonstration plans to investigate ZT capabilities for use by the FAA.

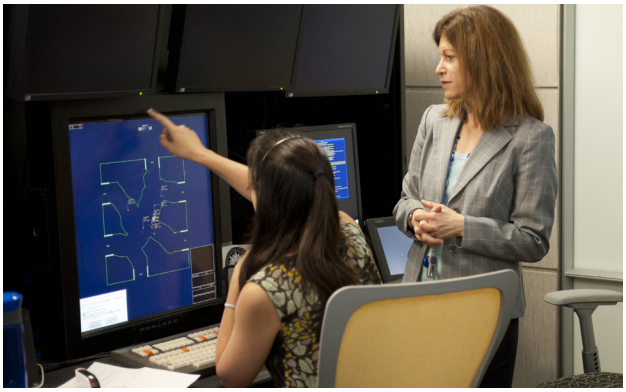
NAS Operations Dashboard

The NOD is a proof-of-concept research platform providing an integrated view of real-time performance data to improve FAA traffic managers' situational awareness of the NAS. NOD research supports NAS TFM ongoing collaboration activities between the FAA and NAS stakeholders at various levels (system-wide, regional, and airport-specific) and in various operational phases (planning, execution, and review). These activities require constantly establishing situation awareness from the data provided in various planning, monitoring, and alerting tools.

NOD provides operational intelligence information via a NAS-wide monitoring and alerting dashboard. The dashboard provides visualization of a consolidated set of data, enabling users to see what is happening and initiate appropriate action. This allows a simplified way for FAA traffic managers and their industry counterparts to monitor changes in status, receive alerts about potential problems, collaborate, and review past actions.

FY20 ACCOMPLISHMENTS: CAASD supported the FAA's aims to make ATM more collaborative, transparent, strategic, and predictive. To achieve these objectives, CAASD performed the following activities:

- Integrated data from the Planning, Execution, Review, Train, and Improve (PERTI) tools into the NOD platform
  - Identified operational needs for the data integration to support the PERTI process
  - Developed the necessary cross-platform data integration to facilitate TFM planning and execution, including new capability use cases and recommended platform effectiveness and usability improvements
- Enhanced real-time TBFM monitoring and alerting capabilities
  - Developed, matured, and integrated real-time TBFM departure performance monitoring and alerting capabilities
  - Identified real-time data sources/gaps of TBM arrival data to provide FAA users with performance metrics for TFM
- Performed additional platform capability enhancements and sustainment activities
  - Explored real-time data sources (e.g., SWIM)
  - Engaged FAA traffic managers and industry on need identification
  - Developed appropriate status information for situation awareness and enhanced TFM collaboration (e.g., Traffic Management Initiative [TMI] usage, alternative route options, usage and coordination, and rapid agile software development to collect and display NAS COVID-19 impacts)
- Outlined technology transfer of the NOD platform.



FY21 PLANS: CAASD will engage FAA and NAS stakeholders to identify research and development needs regarding TFM collaboration and day-of execution activities. Additionally, CAASD will support the integration of the PERTI planning tools and data into the real-time platform to enhance day-of execution capabilities. CAASD will also identify regional and CDM-generated issues such as Chicago ARTCC (ZAU) regional departure relief efforts, Denver ARTCC (ZDV) iTBO integration efforts, NAS impacts (e.g., COVID-19), and recovery efforts. CAASD will also design, improve, or enhance the platform infrastructure to meet ever-growing software development needs, and will evolve the tech transfer plan for FAA consideration.

NAS Automation Evolution Strategy

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 insertion opportunities, growing cybersecurity threats, and the scalability of information management capabilities. These issues exert additional pressure on the FAA to enhance and update its automation systems. As a result, the FAA is seeking an approach that reduces the time to develop, integrate, and deploy new capabilities.

FY20 ACCOMPLISHMENTS: To address these challenges, CAASD, working with FAA leadership, has defined an automation evolution strategy that describes a Service-Based Architecture. This architecture promotes independent, loosely coupled components to help reduce costs and enable more rapid and agile deployment of NAS automation capabilities. Key elements of this strategy include industry engagement as well as agile and Development, Security, and Operations (DevSecOps) processes and tools. In FY20, CAASD worked with FAA leadership to receive initial approval of this strategy and to begin socializing it across a broad set of stakeholders.

CAASD also established an overall set of work areas that will support a transition to the automation strategy vision. These work efforts emphasize maturing the strategy (e.g., defining a reference architecture) while also preparing for a transition to the Service-Based Architecture (e.g., acquisition approach, change management, workforce preparation).

FY21 PLANS: In collaboration with the FAA, CAASD will define an initial reference architecture describing the architectural principles, design patterns, software platforms, and development practices that will be used to incrementally implement the FAA automation evolution strategy. In parallel with that effort, CAASD will define a range of potential transition strategies, conduct tradeoff studies, and establish an initial transition strategy. This strategy will include activities to both reduce system sustainment costs and move the FAA toward a more dynamic Service-Based Automation structure that supports rapid deployment of needed capabilities and enhancements. To mitigate key automation evolution risks and capitalize on transition opportunities, CAASD will collaborate with the FAA (and potentially an industry partner) to identify, select, and initiate one or more potential "pathfinder" prototyping projects.

Operations in the Age of COVID-19

LAB PROTOCOLS

The CAASD work program often includes the evaluation of NAS technologies and procedures by SMEs in a controlled and realistic operational environment. Laboratories at CAASD were designed for this purpose. However, the COVID-19 pandemic and associated social distancing requirements make traditional use of such in-person facilities impossible. To avoid adverse impacts to FAA projects that had planned experiments and demonstrations in CAASD laboratories, staff developed technology and updated protocols to enable the continuation of work and completion of contractual products on time.

New lab protocols include:

- Delay of non-critical lab activities such as tours or non-urgent demonstrations
- Occupancy limits for the different areas of the laboratory
- Use of masks and minimum 6-foot separation of all staff and participants
- Rescheduling of lab activities to eliminate simultaneous use
- Updated cleaning guidelines.

Lab technology enhancements that enabled continuity of operations during COVID-19 include:

- Intelligent Aviation Agents (2020) – CAASD created automated intelligent agents that represent NAS roles, responsibilities, and actions. This reduced the need for human participants for every role.
- Modernization of Simulation Configuration (2020) – CAASD is continuing its modernization of SimBuilder to provide web access and control.

- Extending Lab Data Interfaces (2019) – CAASD extended the laboratory DataComm framework to support WebSockets and Representational State Transfer (REST) technologies for external interfaces.
- SimPilot Agent (2018 to present) – CAASD created a lab-wide simulated pilot (sim-pilot) agent that alleviates the need for live/human sim-pilots during the development and testing phases of a simulation.
- Enhance and Maintain the IDEA Lab Survey App (2018) – CAASD incorporated the Qualtrics survey tool, which includes a web/remote front end for participants.
- Lab Mobile Capabilities (2018) – CAASD enabled use of mobile devices (tablets and smart phones) in the lab.
- Improvement of Cloud infrastructure Tools (2017) – CAASD enabled cloud-based infrastructure to shift computation to off-site resources.

As a result of these steps, the number of evaluations conducted in the lab recovered to pre-COVID 19 levels by the end of FY20.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INNOVATION AND ACCELERATION

Mission-Oriented Investigation and Experimentation

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.

The three objectives of the research and development program include:

1. Identifying the intersection of new capabilities or methods and the needs of the aerospace industry, as a catalyst for transformational improvement or change
2. Understanding future technologies and operations, to reduce risk and build consensus, organizing the FAA and broader stakeholder communities in a forward direction
3. Preparing the FAA for the future by ensuring that information, methods, and models have been defined and developed to answer the FAA's emerging needs

To meet these objectives, CAASD and the FAA developed the research and development program so that it is comprised of projects that are mission-focused, transformative, risky, and conducted collaboratively with government, research organizations, and private industry.

During 2020, 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. These research thrusts support the FAA's research goals associated with improving airport operations, air traffic, and air space management capabilities; accelerating the use of new technologies for aerospace vehicles, airports, and spaceports; and improving integrated modeling capabilities and system-wide analysis.

The seven FY20 research projects included:

1. Electronic Flight Bags to Accelerate Equipage for Future Operations
2. Industry 4.0 Technologies for Certification in a Future Aviation System
3. Automated Health Monitoring and Self-Healing for the Aviation System
4. Developing In-Time Safety Risk Metrics for Airports
5. Performance-Based Deconfliction Methods for Higher Airspace
6. Artificial Intelligence Enabled Traffic Flow Management
7. Reconfigurable Fast-Time Aviation System Simulation

The FY21 MOIE portfolio will be conducted within the three objectives as outlined below:

1. *Innovating Solutions*
   - Mobile Technologies for Advanced Avionics
   - Self-Healing National Airspace System
   - Aviation Safety Predictive Analytics
   - In-Time Safety Risk Metrics
2. *Formulating Clarity and Focus*
   - Artificial Intelligence Enabled Traffic Flow Management
   - Aircraft-Based Navigation System Performance Monitoring and Analysis
   - Performance-Based Methods for Higher Airspace
3. *Preparing the FAA to Engineer the Future*
   - Advanced Composable Modeling for Fast-Time Simulation

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 FY20 is summarized below.

AUTONOMOUS DRIVING

Autonomous "self-driving" vehicles provide an unprecedented opportunity to improve roadway safety. More than 37,000 people are killed and more than three million injured per year on U.S. roadways; many of these crashes could be avoided through partly- or fully-autonomous driving systems. However, we need to understand how well these systems work to gain the maximum safety benefits, and make sure we are not introducing new risks to drivers and passengers by deploying them.

MITRE continued to explore driverless, autonomous vehicle technologies through development of an experimental testbed vehicle. MIP provides a collaborative environment, used by autonomy-related projects across MITRE, and has been used to inform our participation in industry standards committees that seek to define the data logging requirements for driverless vehicles. These standards will be essential for assuring the safety of such vehicles.

We also explored the utility of the advanced driver assistance systems (ADAS) that are installed on many vehicles today, such as adaptive cruise control and lane keep assist systems. We instrumented several

MITRE employees' cars to capture data and understand the performance of ADAS. For example, several scenarios were identified in which lane keep assist systems fail to track lane boundaries. These findings have been shared with automakers and should lead to future work in this area.

MICROMOBILITY

Micromobility-on-demand services represent a two-fold paradigm shift in surface transportation: they combine the "on-demand" complexity and convenience of ridesharing services with the lightweight efficiency and vulnerability of classic two-wheeled vehicles like bicycles and scooters. Current infrastructure and transportation policies are unprepared to handle this shift on two fronts:

1. Adapting to changes in land use from decreased ownership and parking needs
2. Safely facilitating micro-vehicles to share the transportation system with pedestrians and automobiles, while minimizing risk and disruption to traffic

MITRE developed a new data-driven approach for micromobility policy analysis and used it to show how construction of modern bike lanes in Boston led to a significant increase in bikeshare trips along and near the routes where these lanes were built.

CYBER-PHYSICAL SYSTEM RESILIENCE

As transportation systems become more reliant on automation, they also present more opportunities for cyber attacks and other malicious behavior. MITRE is conducting two research efforts in this space. The first is to apply a framework MITRE developed for evaluating cyber risks to industrial control systems to the rail industry, through a collaboration with Norfolk Southern. Researchers worked through a test case that identified how an attacker could affect the rail switching infrastructure and identified mitigations to such an attack.

The second project involves securing GNSS 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. A CAASD researcher developed a novel technique, implementable in a standard GNSS receiver, to identify and nullify spoofing attacks. It has been proven to work well against an accepted standard battery of tests, and we will be working on technology transfer to industry in FY21.

COVID-19 IMPACTS ON TRANSPORTATION

The COVID-19 pandemic greatly disrupted the air transportation system. In response, MITRE re-directed some aviation research efforts in the MIP toward understanding the impact and providing data and tools for airlines and the FAA to mitigate the impacts. Data analysts and experts from MITRE's Health Innovation Center synthesized a wide variety of data sets, applied ML algorithms, and produced a dashboard that predicts both air travel demand and the level of COVID-19 risk over the next month on an airport-by-airport basis. This is intended to help airlines plan flight operations and to help the FAA and airport operators gauge the level of risk to their employees and operations.

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 (e.g., drones and urban air taxis) are emerging. MITRE's research has been exploring new methods for sharing, scheduling, and coordinating airspace use under these new and changing demands.

In FY20, we have defined a new "adaptive airspace" technique for the FAA and DoD to be more flexible in sharing airspace to accommodate the needs of modern aircraft. We have also defined an operational concept with associated automation support to coordinate airspace management across all types of users and published a detailed operational concept for integrating UAM operations (e.g., Uber Elevate) into the airspace.

Sharing the airspace can also involve conflicts in use of spectrum, and MITRE prototyped a new method for measuring interference in the 1090 MHz band, shared by several critical FAA and military systems. This method uses ground sensors rather than test flights, and thus can be done much more cheaply and allow much more extensive data collection aimed at measuring, modeling, and ultimately alleviating interference in this critical band.

Technology Transfers

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 FY20, the following technology agreements and licenses were issued for FAA-funded, CAASD-developed technologies:

CAASD Technology	FY20 Technology Agreements/Licenses Issued
Exhaust Plume Analyzer	9
Layered TMI Metrics Capability	1
***runway*Simulator**	6
TARGETS	5
Total	**21**

FFRDC OPERATIONS AND STEWARDSHIP

KEY CAASD CAPABILITIES

MITRE offers a world-class research and computing infrastructure to provide CAASD a broad and capable set of modeling, simulation, and analysis capabilities to support the FAA work program.

Transportation Data Platform (TDP)

Aviation systems produce large, complex data sets, which when leveraged correctly, can enable evidence-based decisions. However, most stakeholders face significant challenges extracting and processing these data sets to generate meaningful indicators to support decisions.

CAASD's TDP uses sophisticated methods and tools developed to understand current operational realities, track events of interest (e.g., safety, capacity, and efficiency), infer relationships between events, monitor system effectiveness, and predict the effectiveness of changes. TDP captures a broad array of disparate aviation data sources such as radar updates, weather conditions, and airspace sectorization, combining sources to generate operational metrics. For example, TDP computes a single synthetic flight path (or "threaded track") from a range of surveillance sources (e.g., radar, GPS, surface), flight plans, and airport weather conditions. TDP has four main functions:

1. Operational Reality: provides an understanding of events, both timely (next-day analysis), and historical (trending and pattern detection), including identifying events of interest
2. Operational Causality: provides insights into the causal factors that contributed to events of interest and a means to quantify relationships between events
3. Operational Effectiveness: provides means to quantify system effectiveness and to predict the impact of a proposed operational change
4. Cost-Effective Enterprise Workflows: provides common data integration framework (methods, tools, and infrastructure) across projects

by streamlining processing, centralizing data sources, minimizing redundancy, and enabling consistent analysis and reporting

To support FAA data analysis, CAASD maintains and evolves over 60 base and derived data services, amounting to 100 Gigabytes (GB) of data per day, five petabytes using 7000 analytic nodes, with over 200 analysts and data scientists responding to over 10,000 queries per month. The TDP supplies data and analysis to multiple business applications, including:

- AFS Analytics Dashboard
- ASIAS Fusion
- TARGETS
- IDEA Lab
- Partnership for Safety
- Airborne Risk Analysis
- MITRE Global Flight Informatics (MGFI)
- AJI Safety KPIs
- Voice Data Analysis.

FY20 ACCOMPLISHMENTS:

TDP/TFM Agile: TFM stakeholders recognized the potential benefits of leveraging TDP for detailed views of NAS-wide demand and capacity alongside the tactical and strategic impacts of TFM decisions. An agile TDP/TFM project was completed that enhanced the availability and utility of TFM-related data within the TDP. Focused analytic areas included Miles-in-Trail (MIT) Restrictions, Demand Prediction, and related Operational Impacts, resulting in six new and three enhanced data services in TDP.

Procedure Conformance: The TDP team improved the flight plan management (parsing, interpretation, fusion, etc.) that is a crucial component for procedure conformance and usage algorithms. TDP has completed a suite of analytics that include assigned route, procedure usage, procedure conformance, and route deviation metrics.

Migration of Legacy CAASD Repository System (CRS) Data Services: Efforts continued toward a single, unified data platform under a consolidated technology stack to maximize value of research and operations and maintenance investments. The TDP team migrated 20 legacy-data services from CRS into TDP in FY20. This effort included coordinating with SMEs to help complete verification and validation of these data sets to help promote these services to a mature level.

FY21 PLAN:

Streamline Operations: TDP currently provides over 60 data services to more than 200 users and helps contribute to an estimated 40 percent of the deliverables in CAASD. With growth in users and service demand predicted to continue to grow, the team will focus on ways to optimize operational costs (e.g., automation of processes) to support this predicted growth.

TDP for External Users: The FAA Sponsor receives insights generated by TDP indirectly through deliveries of analyses, dashboards, or reports, or they receive TDP data isolated from the tools and services that were designed to work with it. These users are not able to work with and explore the data as an internal MITRE user would. Ideally, an FAA analyst would be able to sit down and perform ad-hoc analyses on data, work with and collaborate with MITRE users, and generate their own insight using TDP. We will focus development on enabling deployment of such an FAA-facing capability.

Simulation Platform

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

Its 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. Akela is a newer simulation capability that is transitioning from the Outcome 8 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.

FY20 ACCOMPLISHMENTS: In FY20, *systemwide*Modeler was maintained and available for CAASD project use. Minor updates were applied to better represent arrival rates from capacity curves when there is insufficient demand present. *systemwide*Modeler was used for the Simple FACT project for the FAA Office of Airports to study airport congestion related delays. Metrics of interest included the percentage of hours in which the hourly delays exceeded a delay threshold. Results identified U.S. airports expected to be capacity constrained in the 2025 and 2030 timeframes.

Akela's simulation model was enhanced with an improved time advancement architecture. A Ground Delay Program (GDP) decision-support tool was implemented and will be a key component for TBO experiments. The controller agent was enhanced to respond to stimulus from the TBFM decision-support tool (i.e., meet Scheduled Times of Arrival [STAs]). Tower controller agents were also added that can issue ground delays based on Expected Departure Clearance Times (EDCTs) or other controlled departure times and ensure separation between subsequent departures off of dependent runways. A new user interface in R was developed to facilitate model execution through an analyst-friendly parameter setting. Additionally, Akela was exercised to train an artificial ATC agent to prevent separation conflicts in a four-corner post arrival scenario.

FY21 PLAN: Akela will become the focus of simulation environment investments, including migration of some *systemwide*Modeler components into Akela. Akela will be enhanced in terms of user experience, flexibility, and validity. With regard to user experience, the team will produce detailed documentation and training so that more analysts can use Akela. The team will also make it easier for users to compose simulations, analyze simulation results, and visualize simulation playback. With regard to flexibility, the team will make the controller agents more configurable. For example, users will be able to configure when controllers issue speed commands versus altitudes or vectors. And with regard to validity, the team will perform and document validation of all components within Akela.

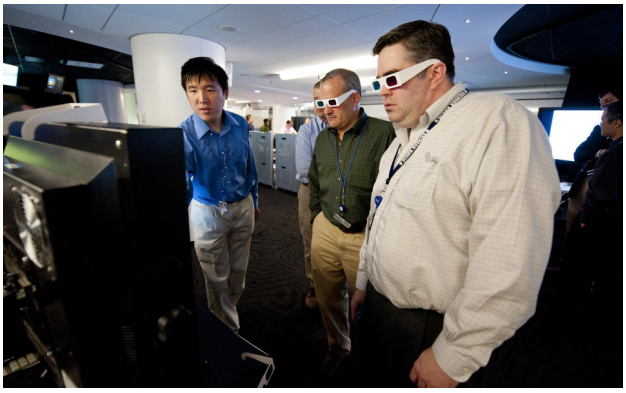
Experimentation and Demonstration Platform

The Experimentation and Demonstration Platform (EDP) provides a set of essential software services to projects requiring real-time and human-centered experimentation and consensus building activities. These services are designed to be persistent and scalable to support the project's evolving needs and to accelerate delivery of robust and repeatable data for decision makers.

EDP services include:

- Experiment Configuration and Execution
- Simulation Data Transfer and Interfaces
- Audio System
- Data Collection and Reporting
- Scenario Generation
- Flight Modeling and Control
- Collaborative Visualization Environment
- Capability Management and Planning

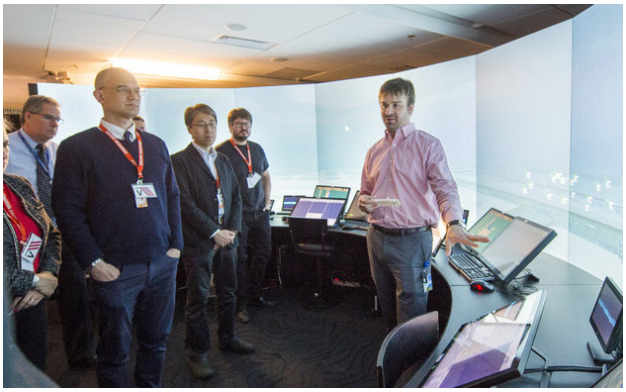
FY20 ACCOMPLISHMENTS: The EDP exceeded both its 90 percent availability and 90 percent user satisfaction performance targets in FY20. In addition, the platform was enhanced to include a new GA simulator into the laboratory infrastructure, enhanced scenario generation capabilities to produce advanced traffic files needed for TBO simulations, advanced Text-to-Speech (TTS) and Automated Speech Recognition (ASR) for the laboratory-wide sim-pilot agent, and solutions to make the laboratory operational TBFM system handle non-real-time events.



FY21 PLAN: To meet emerging CAASD work program needs, the EDP will continue to meet the 90 percent availability and 90 percent user satisfaction performance targets and will continue to enhance EDP-provided services. The EDP will also provide the following new strategic capabilities:

- Expanded accommodation of third-party applications to enable greater stakeholder participation in demonstrations and evaluations.
- Enhancements to laboratory capabilities to accommodate large-scale evaluation scenarios with more (and remote) human participants and scenario complexity.
- Modernized TFMS Simulation to enable more evaluations of TFM operations in the TBO and 2035 operating environments.
- Expanded interface to TDP to include real-time streaming of TDP data products and services.

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 Outcome Managers (OMs) and CAASD Outcome Leaders 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 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.

THE FEB AND 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).

GLOSSARY

3D	3-dimensional
4D	4-dimensional
AAAE	American Association of Airport Executives
AAC	Aviation Advisory Committee
ACAS X	Advanced Collision Avoidance System
ACE	Agile Combat Environment
ACT-IAC	American Council for Technology-Industry Advisory Council
ADS-B	Automatic Dependent Surveillance-Broadcast
AFS	FAA Flight Standards Office
AFT	Air Traffic Control Future Technologies
AFW	U.S. Air Force Weather
AHA	Aircraft Hazard Area
AI	Artificial Intelligence
AIAA	American Institute of Aeronautics and Astronautics
AIR	Aviation Certification Service
AIRS	ADS-B In Retrofit Spacing
AIS	Office of Information Systems Security
AIT	FAA IT Organization
AJI	Safety and Technical Training
AJI-1	Orders and Notices
AJI-3	Policy and Performance
AJM	FAA Program Management Organization
AJR	System Operations
AJT	Air Traffic Services
AJW	Technical Operations Services
AMOA	Air Medical Operators Association
AMS	Acquisition Management System
ANG	Office of NextGen
AOV	Air Traffic Safety Oversight
API	Application Programming Interface
APR	Automated Periodic Review
ARIA	Aviation Risk Identification and Assessment
ARINC	Aeronautical Radio, Incorporated
A-RNP	Advanced Required Navigation Performance

Acronym	Definition
ARTCC	Air Route Traffic Control Center
ASDE-X	Airport Surface Detection Equipment, Model X
ASIAS	Aviation Safety Information Analysis and Sharing
ASRS	Aviation Safety Reporting System
ATCA	Air Traffic Controllers Association
ATCALs	Air Traffic Control and Landing Systems
ATCSCC	Air Traffic Control System Command Center
ATM	Air Traffic Management
ATMRPP	ATM Requirements and Performance Panel
ATO	Air Traffic Organization
ATSP	Air Traffic Service Provider
AUS	FAA UAS Integration Office
AUVSI	Association for Unmanned Vehicle Systems International
AV	automated vehicle
AVP-220	Office of Accident Investigation and Prevention
AVS	Aviation Safety
BA	Business Aviation
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CA	CDTI-Assisted
CAASD	Center for Advanced Aviation System Development
CAST	Commercial Aviation Safety Team
CAT	Category
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CFiT	Controlled Flight into Terrain
CHI	Computer-Human Interface
CNS	Communications, Navigation, and Surveillance
CoE	Center of Excellence
CRS	CAASD Repository System
DAFIF	Digital Aeronautical Flight Information File
D-ATCALs	Deployable Air Traffic Control and Landing Systems
DAA	Designated Accrediting Authority
DASC	Digital Avionics Systems Conference
DataComm	Data Communication
DevSecOps	Development, Security, and Operations
D-ILS	Deployable Instrument Landing System
DLRW	Dynamic Launch and Reentry Windows
DME	Distance Measuring Equipment

Acronym	Definition
DoD	Department of Defense
DOT	Department of Transportation
DVT	Distance Measuring Equipment (DME)/Tactical Air Navigation (TACAN)
DZ	DroneZone
EDCT	Expected Departure Clearance Time
EDP	Experimentation and Demonstration Platform
E-IDS	Enterprise Information Display System
EIM	Enterprise Information Management
ERAM	En Route Automation Modernization
ETA	Estimated Time of Arrival
FAA	Federal Aviation Administration
FAAMA	FAA Managers Association
FaIR	Filtering and Inductive Reasoning
FANS	Future Air Navigation Systems
FDM	Flight Data Monitoring
FEB	FFRDC Executive Board
FENS	FAA Enterprise Networking Services
FF-ICE	Flight and Flow Information for a Collaborative Environment
FFRDC	Federally Funded Research and Development Center
FID	Final Investment Decision
FLOAT	Fully Leveraged Obstacle Assessment Tool
FMS	Flight Management System
FOQA	Flight Operational Quality Assurance
FTI	FAA Telecommunications Infrastructure
FY	Fiscal Year
G4	Group of 4
GA	General Aviation
GB	Gigabyte
GDP	Ground Delay Program
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HFDM	Helicopter Flight Data Monitoring
HITL	Human-in-the-Loop
IAC	Industry Advisory Council
IAT	Issue Analysis Team
ICAO	International Civil Aviation Organization
ICNS	Integrated Communications, Navigation and Surveillance
IDEA Lab	Integration Demonstration and Experimentation for Aeronautics Laboratory

Acronym	Definition
IDS	Information Display System
IF	Industrial Funding
IFP	Instrument Flight Procedures
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Interval Management
IOC	Initial Operating Capability
IP	Internet Protocol
IPP	Integration Pilot Program
IPS	Internet Protocol Suite
iTBO	initial Trajectory-Based Operations
JIMDAT	Joint Implementation Measurements and Data Analysis Team
JO 7110.65	Air Traffic Control–Document Information
JO 7210.3	Facility Operation and Administration
L/R	Launch and Reentry
LTE	Long-Term Evolution
MARS	Multiple Airport Route Separation
MGFI	MITRE Global Flight Informatics
MHz	Megahertz
MIT	Miles in Trail
ML	Machine Learning
MOIE	Mission-Oriented Investigation and Experimentation
MON	Minimum Operational Network
MOPS	Minimum Operational Performance Standards
MOSAIC	Modernization of Special Airworthiness Certification
MTRS	Multifunction Tactical Radar System
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NAVAID	Navigational Aid
NEC	Northeast Corridor
NextGen	Next Generation Air Transportation System
NFV	Network Function Virtualization
NGA	National Geospatial-Intelligence Agency
NOD	NAS Operations Dashboard
NOTAM	Notices to Airmen
NPRM	Notice of Proposed Rule Making
OM	Outcome Manager

Acronym	Definition
OST	Office of the Secretary of Transportation
PARTS	Partnership for Analytics Research in Traffic Safety
PBFA	Policy Board on Federal Aviation
PBN	Performance-Based Navigation
PBWP	Product Based Work Plan
PDR	Preliminary Design Review
PEGASAS	Partnership to Enhance General Aviation Safety Accessibility and Sustainability
PERTI	Planning, Execution, Review, Train, and Improve
PSP	Partnership for Safety Program
QA	Quality Assurance
QPRB	Quarterly Product Review Board
RBDM	Risk-Based Decision Making
REST	Representational State Transfer
RF	Radio Frequency
RNAV	Area Navigation
RNP	Required Navigation Performance
RVAT	Radar Vectoring Aptitude Test
RWG	Risk Working Group
SA	Special Authorization
SC	Special Committee
SciTech	Science and Technology
SE	Safety Enhancement
SF-PALC	Small Footprint Precision Approach and Landing Capability
SID	Standard Instrument Departure
Sim-pilot	Simulated pilot
SIR	Screening Information Request
SLE	Second Level Engineering
SMS	Safety Management System
SPF	Scanning, Planning, and Flexibility
SRM	Safety Risk Management
STA	Scheduled Time of Arrival
STAR	Standard Terminal Arrival
STARS	Standard Terminal Automation Replacement System
sUAS	small Unmanned Aircraft System
SWIM	System Wide Information Management
SY	Staff Year
TACAN MON	Tactical Air Navigation Minimum Operational Network
TACAN	Tactical Air Navigation
TARGETS	Terminal Area Route Generation, Evaluation, and Traffic Simulation

TBFM	Time-Based Flow Management
TBLP	Time-Based Launch Procedures
TBM	Time-Based Management
TBO	Trajectory-Based Operations
TCAS	Traffic Alert and Collision Avoidance System
TDM	Time Division Multiplexing
TDP	Transportation Data Platform
TET	TBFM ETA Accuracy Tool
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
TFMS	Traffic Flow Management System
TFR	Temporary Flight Restriction
TLO	Technical Liaison Officer
TMI	Traffic Management Initiative
TRACON	Terminal Radar Approach Control Facility
TTS	Text-to-Speech
U.S.	United States
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UAT	User Acceptance Testing
URL	Uniform Resource Locator
USAF	United States Air Force
USHST	U.S. Helicopter Safety Team
UTM	UAS Traffic Management
V2X	Vehicle-to-everything
VOR	Very High Frequency Omni-Directional Range
VOR MON	Very High Frequency Omni-Directional Range Minimum Operational Network
VSRP	Voluntary Safety Reporting Program
WJHTC	William J. Hughes Technical Center
XML	Extensible Markup Language
ZAU	Chicago Air Route Traffic Control Center
ZDV	Denver Air Route Traffic Control Center
ZT	Zero Trust

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