FY19 AEROSPACE AND TRANSPORTATION ACCOMPLISHMENTS

CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT
THE MITRE CORPORATION

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Fiscal Year 2019 was a pivotal year for the Federal Aviation Administration (FAA) and MITRE's Center for Advanced Aviation System Development (CAASD).

NextGen delivered numerous benefits in 2019, including DataComm and the ADS-B mandate, which prepared the way for the coming rollout of Trajectory-Based Operations in 2020. With these foundational components now in place, the FAA is now focused on what the most urgent challenges will be in the years ahead. And there is no other organization more experienced and equipped to take on a bold future vision than the FAA.

As the FAA's federally funded research and development center (FFRDC), CAASD is poised to help the FAA realize this vision. Our mission remains unchanged because it is the FAA's mission, and our work has never been so critical as it is today.

While this report is a retrospective of FY19 accomplishments, it also offers a glimpse of the work to come and an outlook for the future. One of CAASD's greatest strengths is our history operating as the FAA's FFRDC and our deep understanding of aviation and Air Traffic Control operations, systems, and FAA oversight requirements and processes to drive the future.

CAASD is uniquely positioned with its significant knowledge of the FAA and a profound perspective of the National Airspace System (NAS). In addition, our international work, which is supported and encouraged by the FAA, provides us a global understanding of the challenges across the aviation landscape. We remain committed to supporting the FAA and encouraged and excited to work with and on behalf of FAA Administrator Dickson's new goals and focus, including safety and ensuring public trust, global leadership, stakeholder engagement, and fostering people and culture. We are also focused on a concerted effort to identify new and innovative initiatives as we look to help the FAA articulate the future vision of aviation—from surface to space.

Today, we are looking beyond aviation to the larger aerospace and transportation needs of tomorrow. We are also applying the lessons learned in aviation to other modes of transportation—enabling safer highways through data sharing, fusion, and analysis; securing ports and railways using drones and sensors; and, preparing for tomorrow's highly interconnected transportation and global aerospace system.

We expect the world will continue to evolve and change more rapidly than ever as new and yet-to-be-identified challenges emerge. The needs of tomorrow's aerospace and transportation systems can't be met by doing what has done before. We are prepared and positioned for all of it: our technical experts have strong relationships with stakeholders and industry; we offer a unique vantage point and an objective and independent view; we work across the whole of government; and we solve problems for a safer world.

We look forward to a strong, continuing partnership with the FAA, and we are extremely proud to be their FFRDC and mission partner.

Best regards,

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 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 is encouraged by the FAA to increase knowledge of best practices in aviation, to advance international harmonization of aviation and Air Traffic Control (ATC) standards and technology, and to share information with the FAA and other stakeholders.

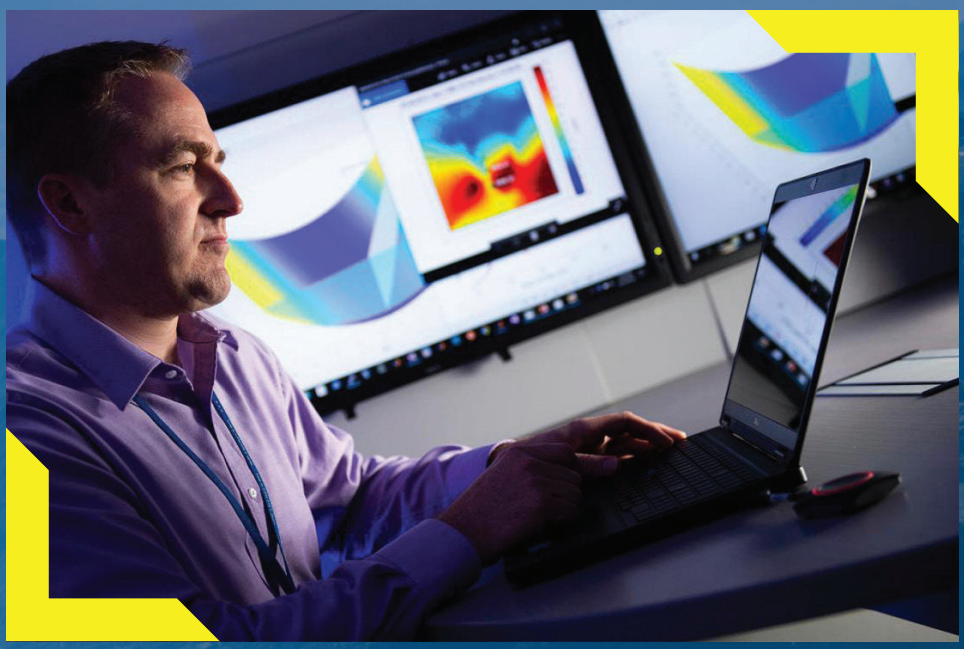
As airspace evolves and expands to include multiple modes of transportation on the surface and into space, CAASD has expanded its capabilities to prepare for these future challenges.

The next sections outline CAASD's FY19 mission accomplishments, provide an overview of plans for FY20, and offer a longer-term outlook for the years ahead. The sections are organized by the FAA's four new FY19–FY22 Strategic Objectives:

1. **Safety – Improve Transportation Safety Through a Systemic Safety Approach**
2. **Infrastructure – Improve Systems Reliability and Efficiency**
3. **Innovation – Development and Deployment of Innovation**
4. **4. Accountability – Advance Information Technology (IT) Modernization, Workforce Improvements, and Regulatory Reform**

Subsequent sections provide detail on CAASD innovations and push for acceleration; governance and operations of the FFRDC; and financial and staffing performance data.

FY19 MISSION ACCOMPLISHMENTS, PLANS, AND OUTLOOK



SAFETY

IMPROVE TRANSPORTATION SAFETY THROUGH A SYSTEMIC SAFETY APPROACH

Safety is always the priority. CAASD is focused on supporting the FAA in making its safety processes smarter to enable system-level and risk-based decisions.

The work in this area builds on safety management principles that allow the FAA to proactively address emerging safety risks. This involves using consistent, data-informed approaches to enhance decision-making processes, redefine oversight models for industry, and improve standardization, data access, and modeling integration. The Aviation Safety Information Analysis and Sharing (ASIAS) program is the crown jewel in these efforts.

Today, there is greater emphasis on acquiring, sharing, and analyzing aviation safety data to help us move beyond a forensic approach, where only past accident or incident data is examined, to a proactive approach focused on detecting risk and implementing mitigation strategies before accidents or serious incidents occur. To do this effectively, the global aviation community must collaborate in the transparent sharing and analysis of safety data.

Data analysis continues to enable the prevention of future accidents, but more and better data is needed as is the ability to get data at the right time. CAASD is working to harness technologies to compile the data it provides to the FAA and its sponsors to keep pushing the limits of discovery, and to eliminate risks from increasingly complex and dynamic systems.

As the quantity of shared data increases, artificial intelligence (AI) concepts and machine learning (ML) techniques needed to be introduced into complex, data-driven models to predict actions, recognize patterns, and uncover hidden insights. These techniques have led to improved aviation safety solutions.

CAASD engineers are developing ML frameworks to assist in identifying potential new or emerging safety issues, then evaluating and validating these frameworks. The efforts cut across surface, terminal, and en route operations to make aviation safer. CAASD is pioneering together with the FAA, industry partners, and academia to find the answers.

Safety Information Sharing

AVIATION SAFETY INFORMATION ANALYSIS AND SHARING

The ASIAS program is a public-private partnership that serves as a central conduit for the exchange of safety information among the FAA and others in the aviation community. ASIAS uses proprietary and other relevant data to conduct proactive safety analysis. It is a national resource for the aggregation, analysis, and dissemination of aviation safety data and products.

[FY19] In collaboration with ASIAS participating airlines and the FAA, CAASD performed numerous analyses. Some of these analyses are highlighted below.

ASIAS ANALYSIS OF APPROACH INTO MEXICO CITY INTERNATIONAL AIRPORT

CAASD researchers identified risk in the approach phase of flight using ML applications in the vulnerability discovery process.

ASIAS identified eight categories of risk factors: ATC handling, airspace design, Instrument Landing System (ILS) localizer capture, language gap, airport location (high-density altitude and terrain), runway surface condition, departures and arrivals management, and loss of Global Positioning System (GPS) signal.

To help formulate strategies for tackling issues associated with operating into Mexico City International Airport (MMMX), the ASIAS team, in coordination with the Pan-America–Regional Aviation Safety Team (PA-RAST), briefed the Mexican Aviation Authority and Navigation Service Provider, International Civil Aviation Organization (ICAO), and International Air Transport Association (IATA) on the study's findings.

BOEING 737 MAX ANALYSIS

As part of ASIAS's routine response to significant incidents or accidents, CAASD leveraged the ASIAS national archive of digital flight data and safety reports to conduct extensive analyses following the October 2018 Lion Air accident and the March 2019 Ethiopian Airlines accident, both of which involved Boeing 737 (B737) aircraft.

ASIAS received a request from the FAA's office of the administrator (AOA-1) to help assess risks associated with runaway stabilizer trim events across the B737 fleet (both MAX and Next Generation [NG] models). After approval by the ASIAS Issues Analysis Team (IAT), CAASD completed two analyses in April and May 2019. One reviewed Aviation Safety Action Program (ASAP) report narratives to identify occurrences and causal factors of runaway trim, trim-related malfunctions, and angle-of-attack failures. The other used Flight Operations Quality Assurance (FOQA) time series data to identify angle-of-attack failures, extreme trim conditions, and extended trim inputs or movements.

CAASD presented the study results to the ASIAS IAT and subsequently provided the findings to the AOA-1 working group to support their efforts to develop a data-driven process to reinstate the B737 MAX into service. In addition, CAASD provided the analysis to Boeing to support the process of developing several mitigations to the angle-of-attack vane-failure-induced issues.

[FY20] CAASD will complete an analysis to identify systemic risks associated with and contributing factors leading to the go-around phase of flight. The Approach and Landing Go-Around study, commissioned by the Commercial Aviation Safety Team (CAST) addresses the risks associated with crews' decisions to continue approaches that appear to warrant a go-around, and the risks associated with poorly executed go-arounds.

The study was motivated by the fact that efforts to address unstable approaches have not fully mitigated the

risk. Some noteworthy go-around events have resulted in undesired aircraft states that could have preceded serious incidents. The study has leveraged ASIAS integrated data sets and provided participants a better understanding of the rate of occurrence of go-arounds that result in undesired states. The events under investigation are relatively rare; most such events appear to occur on the order of 1 per 100 go-arounds (1 per 100,000 approaches) or fewer.

The study has not uncovered factors, if they exist, that lead consistently or predictably to these events. Undesired states may stem from a complex combination of sequential states of aircraft automation, crew situational awareness, and other human factors not fully recorded.

CAST and the ASIAS Executive Board (AEB) also chartered a second study, Approach and Landing Misalignment (ALM), to investigate wrong-surface approaches/landings. In FY20, CAASD will complete an analysis to characterize systemic risks associated with aircraft lining up to an incorrect surface for landing. While actual incorrect-surface landing and takeoff events have previously been found to be rare, the fatality risk is highly concerning. At the end of this study, there should be an advancement of industry's understanding of factors influencing misaligned approaches and landings, a proposal of mitigation strategies to reduce ALMs across the NAS, and a formulation of feasible methods to monitor for frequency of future ALM events. The mitigation strategy to be implemented will help reduce the severity of ALM events through a combination of long- and short-term strategies. Immediate action can be taken via policy and procedure changes, airport level changes, and community outreach. Long-term strategies will tackle flight deck and ATC technologies and systems.

In FY20, CAASD will also complete analysis on a third study that examines Traffic Collision Avoidance System Resolution Advisory (TCAS RA) events involving General Aviation (GA) aircraft at three high-occurrence airports: Boeing Field (BFI), Teterboro Airport (TEB), and Van Nuys Airport (VNY). Using ML in combination with expertise from each of the focus airports, the study is identifying similar clusters of TCAS events across the NAS. The comparison leverages localized experience to find areas that may share contributing factors so that mitigation strategies

can be targeted at the areas where they would be most effective.

In addition, it is expected that additional studies and analyses will be conducted based on issues identified from ASIAS data analysis, such as anomaly detection and emerging terms and based on requests from industry and FAA.

[FY21–FY23] The FAA envisions CAASD will continue the tactical and strategic execution of the ASIAS program—developing, enhancing, and modernizing capabilities to better manage, integrate, and process aviation safety data and enable routine data fusion. This effort will enable CAASD to increase the depth and impact of the ASIAS work program by improving the program's agility, including faster analysis turnaround time and enabling stakeholder participation in analytical efforts.

As the NAS continues to expand both in capability via Next Generation Air Transportation System (NextGen) initiatives and in operational tempo with the advent of Unmanned Aircraft Systems (UAS) and the continued growth of Commercial and GA, CAASD will leverage advances in AI and industry data knowledge databases to automatically identify emerging hazards in the NAS and develop in-time mitigations.

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 and 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.

[FY19] In FY19, CAASD continued to increase the accuracy of automated speech recognition capabilities and began development of AI/ML techniques for understanding the semantic content of controller and pilot speech. CAASD also improved post-operations voice data analysis capabilities, establishing a mature process for extracting information from recorded controller-pilot audio and fusing it with other aviation data to answer research questions. CAASD developed a regularly updated NAS-wide capability for the exploration of approach utilization trends. CAASD also leveraged approach clearance data to evaluate flight performance and safety on different approach types, and evaluated speed, altitude, and heading clearance trends across the NAS. Further, CAASD began preparation and coordination for a field test of a real-time capability for detecting potential wrong-surface operations.

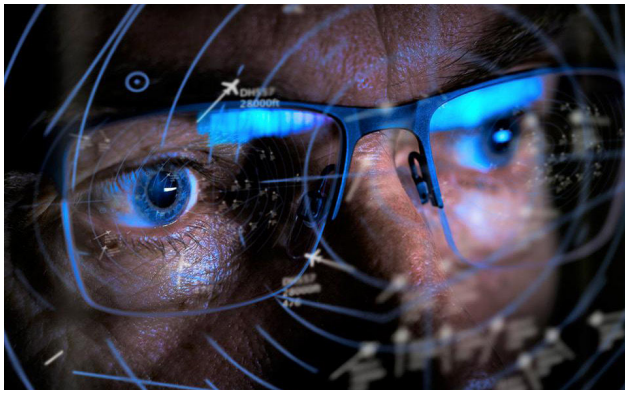
[FY20] CAASD is continuing to leverage advancements in AI/ML to make accuracy and capability improvements to automated speech recognition capabilities, including better identification of aircraft identifiers in the voice data. CAASD is working with various FAA and industry working groups to apply the capabilities towards specific operational analysis efforts, including study of controller phraseology surrounding departure and arrival procedure clearances and accompanying altitude instructions. In addition, to inform best practices for controller recovery and training, CAASD will develop a process for evaluating controller recovery from loss of separation events.

CAASD will also test a proof-of-concept system at an FAA facility to inform the technical feasibility of alerting controllers to potential wrong-surface operations.

[FY21–FY23] The FAA envisions it will leverage post-operations voice data analysis capabilities across a variety of analysis areas to provide insight into NAS operations not previously understood or attainable at a large scale. CAASD's research will help the FAA understand application feasibility and the potential benefits the technology offers. In addition, the FAA envisions CAASD will continue to conduct research into real-time applications of speech recognition technology to inform FAA decision making on the acquisition of real-time speech recognition capabilities for the NAS.

Aviation Risk Identification and Assessment

The CAASD-developed Aviation Risk Identification and Assessment (ARIA) capability will 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.



[FY19] Development on ARIA's near-real time data processing algorithms began in FY18. That foundational work enabled CAASD and the FAA to launch an initial, test version of ARIA in February 2019. For six months thereafter, CAASD researchers collaborated with subject matter experts from the FAA's Quality Assurance Group to refine the ARIA algorithms as necessary.

In addition to prioritizing safety events for efficient review, ARIA provides FAA investigators with a more complete safety picture. A piece of the puzzle missing until now was data from flights operating under "visual flight rules," many of which involve small fixed-wing personal aircraft and commercial-use rotary aircraft. This expansion will provide the FAA with a more comprehensive view of potential risk in the system.

ARIA's risk-based approach will also enable the FAA to marry risk analysis and compliance. This goes beyond traditional processes, which focus primarily on compliance with existing rules and regulations. With ARIA, it's becoming possible to evaluate risk alongside compliance to form a more complete risk picture. For example, if an operation is compliant with the rules, but there is still risk observed, that may indicate a rule is ineffective at achieving the desired level of safety. On the other hand, if the operation is noncompliant, but no risk is detected, that may be an indication that the rule warrants re-evaluation. By associating measures of risk with adherence to specific rules or regulations, the FAA can both identify risky behaviors and evaluate its own rules and regulations to determine which ones warrant review, revision, or simply greater emphasis.

[FY20] ARIA will provide substantial benefits to the FAA—and the flying public—when it goes live in spring 2020. 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. Additionally, CAASD will migrate ARIA to the FAA's new enterprise cloud computing environment and finish development on "Surface ARIA" algorithms.

[FY21-23] CAASD will continue to develop additional capabilities to enable ARIA to automatically detect other types of risk on NAS operations (e.g., Dangerous Terrain Proximity detection) and will continue to work with the FAA to move to a risk-based culture.

Single-Pilot Operations Safety

Solo pilot operations account for most of the GA flights. Due to high workload and the lack of a second pilot to cross-check decisions, these solo operations are less safe than two-pilot flights. There is a lot of information competing for the pilot's attention. Since losing focus or situational awareness can be a precursor to an accident, the pilot must focus on the correct information at the correct time and avoid distractions.

[FY19] To provide that right information at the right time, CAASD prototyped Digital Copilot, which provides cognitive assistance directly to the solo pilot. Closely related to AI aids, cognitive assistance is cooperative automation designed to augment human cognition rather than replace it. Enabled by automatic speech recognition and location awareness, Digital Copilot provides contextually relevant information to a pilot, based on inferred intent, to supplement the pilot's decision-making process.

In FY19, CAASD conducted human-in-the-loop experiments designed to assess the impact of Digital Copilot use on pilot performance and workload. CAASD presented the Digital Copilot research both to the Flight Safety Foundation Business Aviation Safety Summit and as a part of the National Transportation Safety Board (NTSB) Most Wanted List Roundtable–Alaska Part 135 Flight Operations. In addition, CAASD is sharing the technology with external partners in both government and industry. Some of the Digital Copilot-inspired functionality, released through MITRE's technology transfer process, has been incorporated into commercially available systems.

In addition to the experiments conducted, new development in FY19 focused on prototyping safety-enhancing capabilities in the areas of wrong-surface operations (e.g., takeoff from taxiway, approach to wrong runway), progressive procedures (e.g., instrument approach, departure), and taxi operations.

[FY20] CAASD is conducting research and development to refine and expand the prototype's capabilities. Since the goal is to assist the GA pilot without annoyance or hindrance, understanding the human-machine partnership and evaluating impact on human memory and time to perform tasks are central to Digital Copilot development. Human-in-the-loop experiments will assess the impact on pilot performance as compared to traditional techniques. Capability development is currently focused on taxi conformance, human-computer interface options, and weather-related insights.

In addition to Digital Copilot feature development, the team is working on integrating the Digital Copilot with a MITRE-patented prototype audio interface box that will allow tighter coupling between the pilot and Digital Copilot. There are also plans for industry partners to release additional Digital Copilot features into commercially available systems.

[FY21–FY23] The FAA envisions CAASD will continue to coordinate with GA industry stakeholders, collect evaluation data, and conduct post-operational analysis. It is expected that more of the prototype functionality will be released to pilots via industry partnerships. As industry adoption of Digital Copilot capabilities increases, GA safety trends should continue to improve. CAASD will continue to explore expansion of Digital Copilot applicability. Some areas of opportunity include use on commercial aviation flight decks and integration into panel-mounted avionics. Outside of the cockpit, some possible domains include new entrants to traditional aviation (e.g., UAS, commercial spacecraft), ATC, and the wider transportation system.

INFRASTRUCTURE

IMPROVE SYSTEMS RELIABILITY AND EFFICIENCY

In order to deliver the benefits of NextGen to NAS users, the FAA must keep the initiative on deployment schedule and on budget, and it must also ensure new systems and capabilities are both operationally integrated and introduced to the field in a coherent manner to achieve the envisioned operational enhancements. CAASD's work on defining, maturing, and implementing NextGen investments helps evolve the NAS to an enhanced operating model that achieves prioritized benefits, such as delivering more efficient, predictable, and streamlined air traffic services, integrates new user entrants, and applies innovative technology to drive solutions.

Trajectory-Based Operations and Initial Trajectory-Based Operations

Trajectory-Based Operations (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.

TBO is a long-term target of the NextGen program, building upon prior NextGen infrastructure investments in modernized automation systems (like En Route Automation Modernization [ERAM] and Standard Terminal Automation Replacement System [STARS]), and enhanced Communications, Navigation, and Surveillance. Recent and forthcoming NextGen investments in TBM automation systems and decision support tools, improved electronic information exchange, and strategic planning capabilities and processes begin the transition of the NAS to TBO.

Initial TBO (iTBO) is scheduled for completion by the end of 2022. It is the first major implementation milestone to achieving the FAA's TBO vision. It will require significant operational change resulting from predominant, gate-to-gate application of TBM. Three operating areas in the NAS are targeted for iTBO implementation. They include Denver, Atlanta, and the North East Corridor (NEC). This implementation will rely upon successful operational integration of new systems and capabilities with existing ones and the introduction of new air traffic procedures; it will also heavily rely upon the successful operational transition of the ATM and operator workforce to this new methodology.

[FY19] CAASD worked closely with the FAA in implementation planning for iTBO at the three targeted operating areas and engaged with field facilities and key stakeholders to prepare for the operational change. This included defining operating area evolution plans and transition roadmaps, refining implementation success criteria and post-implementation measurement processes, informing new governance and processes for effective implementation, and informing workforce engagement activities, such as the FAA's iTBO Summit and facility visits.

As a first step towards preparing the ATC workforce for the operational changes iTBO will introduce in FY20, CAASD's FY19 completed a training needs assessment that defined position-centric knowledge needs and effective methods for controller and traffic manager training. This needs assessment is now serving as the basis for iTBO training development by an FAA contractor.

In FY19 CAASD worked closely with the FAA to lay a strong foundation for iTBO implementation in the NEC, an operating area targeted for iTBO due to its complex operating constraints. As part of that effort, CAASD completed technical analyses to inform improved airborne metering of arrivals into Philadelphia International Airport (PHL) and the use of departure scheduling out of New York's airports. CAASD also provided facility and workforce training for use of the Integrated Departure Route Planning (IDRP) prototype tool and performed feasibility analyses for using the Converging Runway Display Aid (CRDA) to achieve improved arrival throughput at Newark Liberty International Airport (EWR) and PHL.

Throughout the year, CAASD worked with the FAA to identify, track, and mitigate iTBO implementation risks. CAASD also conducted several risk mitigation analyses to provide detailed insights into specific enterprise-level risks and identify potential resolutions/mitigations for ensuring iTBO implementation success. In the spring, CAASD

conducted a flight-deck study with pilots in the Integration Demonstration and Experimentation (IDEA) lab aircraft simulator that presented different iTBO scenarios to ensure flight crew operational integration with the changes iTBO will bring about. In the summer, CAASD conducted a stakeholder engagement event in the IDEA lab tower simulator to address key iTBO departure management risks and identify mitigating solutions. In the fall, CAASD conducted a cross-domain and cross-facility (Tower, Air Route Traffic Control Center [ARTCC], Terminal Radar Approach Control [TRACON]) iTBO interoperability assessment of future operations expected for the Denver operating area to validate expectations regarding air traffic roles, collective use of technologies, and operating procedures. This interoperability assessment was the first real-time, gate-to-gate demonstration of iTBO using a mix of operational system software and simulated systems to manage flights in nominal conditions and during disruptive NAS conditions. Beyond identifying risk mitigations, these analyses help to engage and educate key stakeholder groups on the envisioned iTBO and help highlight differences that will be introduced regarding operating principles and strategies.

TIME-BASED FLOW MANAGEMENT SYSTEM-SPECIFIC ANALYSES

Key to enabling TBM is the Time-Based Flow Management (TBFM) system—complex ground automation that provides all departure and arrival scheduling functionality for iTBO. First introduced decades ago, the envisioned use of this system has evolved with a series of enhancements and new capabilities having been introduced. Foundational to iTBO implementation success is for the TBFM system to perform sufficiently and be appropriately adapted to the operational constraints. In FY19, CAASD completed analyses to support those goals.

To ensure system performance, CAASD evaluated TBFM system trajectory prediction accuracy for arrivals into the terminal. CAASD also developed a method and supporting analytical tool to allow the FAA to independently measure system performance. Additionally, CAASD identified key TBFM system performance issues in the current baseline software and in new functionality currently in development.

CAASD reported these performance issues and their potential impact to the FAA and its vendor for resolution.

Toward appropriate system adaptation, CAASD conducted a series of analyses on TBFM and Performance Based Navigation (PBN) design interdependencies. The results were used to define integrated-design best practices and guidance to achieve PBN procedure and TBFM adaptation compatibility, which is of central importance to enabling iTBO. CAASD also developed an integrated design tool that was tech transferred to FAA Second Level Engineering and is currently being used to adapt TBFM for the Denver operating area.

Finally, CAASD identified feasible options for reducing TBFM system complexity to improve ease of testing, application of the system, and improve processing efficiency.

New enhancements for TBFM and for achieving iTBO are currently under consideration—some are still being matured while others are under-going investment decision making. Candidate capabilities currently under-going investment include controller and traffic manager decisions support tools for applying and sustaining TBM operations.

CAASD worked closely with the FAA to ready these TBO-enabling technologies and concept by completing the systems engineering, technical analyses, and stakeholder engagement needed to successfully move them through the FAA's investment decision-making process. CAASD also completed integration analyses to use flight-deck capabilities like Flight Management System (FMS) time of arrival control and other avionics in the context of TBM operations for additional flight efficiencies and improved flight-crossing time accuracy.

[FY20] CAASD is continuing to partner with the FAA on the successful execution of the iTBO implementation strategy. Key work areas include performing data-driven analyses to address operational issues, conducting analyses to inform iTBO operating area integrated TBM/PBN designs, developing a training roadmap to outline key decisions and investments, supporting FAA workforce engagement activities, and developing key artifacts to educate industry stakeholders on the anticipated impacts to their processes and operating models. CAASD will also define an integrated benefits story for iTBO to better

inform site-specific expectations and success.

CAASD will complete analyses to further clarify evolving ATM roles and responsibilities and will develop an enterprise-level concept of use to inform testing, training, and communications.

CAASD will continue to work closely with the FAA in the methodical tracking and resolution of iTBO implementation risks. CAASD will complete a series of analyses to resolve operational integration risks. These will include two air traffic laboratory simulations with key stakeholder participants—one focused on assessing iTBO interoperability for the NEC operating area and the other on mitigating flight-deck operational integration risks.

CAASD will complete technical analyses to ensure systems perform in a manner that enables iTBO benefits, including evaluating performance of TBFM predictions for departure trajectories and improving the adaptation process so arrival and departure profiles are more aligned with the flight's FMS execution. CAASD will also continue to mature key TBO-enabling capabilities and concepts through a variety of analyses, including human-factors evaluations and requirements and system allocation analyses, to mature and move some candidate capabilities through final investment decision-making milestones. Looking further out, CAASD will develop a refined TBO 2025+ vision and strategy for achieving harmonized flow-management operations that incorporates new entrants' mission needs.

[FY21–FY23] The FAA envisions CAASD will continue as an integral partner across the FAA in executing the iTBO implementation strategy and addressing field transition issues at the current three targeted operating areas and later for additional selected operating areas. CAASD will further mature TBO-enabling capabilities and concepts for challenges related to sustaining TBO in variable operating conditions, enabling real-time airborne trajectory negotiation, and using more sophisticated and tailored flight trajectories. CAASD will also help the FAA develop plans for delivering increased flexibility benefits to operators and for accommodating management of new entrants. CAASD will perform TBO risk mitigation analyses and perform cross-domain interoperability assessments to validate key assumptions and mitigate TBO implementation risks. CAASD will complete activities and analyses to measure TBO success criteria, address field transition needs, and develop innovative workforce training designs that leverage improved methods for achieving skillset evolution. The FAA also expects it will draw upon CAASD's technical and operational expertise to inform TBO pre-implementation system testing.

Enterprise Information Display System

In collaboration with the FAA, CAASD is developing key products, architectural analyses, and human factors and safety risk management evaluations to provide a platform for improved enterprise information for all NAS users by the 2024 timeframe.

The Enterprise Information Display System (E-IDS) will provide FAA operational and support personnel across the NAS with information that supplements and complements the information provided on their primary displays (e.g., radar displays), such as meteorological information, approach procedure charts, and Notices to Airmen. E-IDS will replace legacy Information Display Systems (IDS) with a common NAS-wide platform. The new platform will be integrated into the FAA Service Oriented Architecture (SOA) infrastructure using modern data exchange mechanisms, communication systems, and technological advancements to promote efficiency and NAS resiliency.

[FY19] To inform the FAA's Final Investment Decision (FID) on E-IDS, expected in July 2020, CAASD provided input to key engineering documents, interface documents, and air traffic, data administration, and maintenance concepts. CAASD developed the architectural details, including the enterprise information architecture and flows, support for

external users' access to E-IDS information, and static information and support capabilities to be hosted on the Enterprise Information Management (EIM) platform. CAASD provided cross-domain analysis to ensure the requirements met the intended operational need. CAASD also developed analyses for the preferred alternative to determine architectural implications and performance requirements and assessed the potential severity of risks associated with system failures as inputs to the concept and requirements documents. As part of the E-IDS Human Factors working group, CAASD developed scenarios and storyboards to provide illustration and methodologies for the user-interface requirements. As part of this activity, CAASD also updated the notional demonstration based on feedback from FAA operational experts. CAASD developed safety scenarios to inform the understanding of the potential safety risks and hazards. These scenarios were presented at E-IDS safety working group meetings. CAASD helped make significant progress toward the 2024 timeframe.

[FY20] CAASD is finalizing key engineering specifications, interface documents, and air traffic, data administration, and maintenance concepts in preparation for the FAA's E-IDS FID. CAASD will continue to provide cross-domain reviews to ensure their alignment and that the requirements meet the intended operational need. CAASD will also provide requirements analyses as a member of the Requirements Control Board. As part of the E-IDS working

groups, CAASD will continue to develop air traffic human factors and data administration-related topics and update the notional demonstration to finalize the lower-level requirements and prepare for the Solution Implementation phase. CAASD will complete the safety scenarios to inform the safety panel and inform the development of the preliminary hazard assessment. After FID, CAASD will provide systems engineering and human-factors expertise during Solution Implementation.

[FY21–FY23] The FAA envisions that CAASD will continue to provide systems engineering and human-factors expertise for the Solution Implementation Phase in preparation for the first E-IDS Initial Operating Capability (IOC) occurring in the 2024 timeframe.

Separation Management

The FAA is executing a pre-implementation program that will develop and mature emerging NextGen separation management concepts and capabilities to inform automation support for enhanced en route, terminal, and oceanic operations.

Separation management is defined to include all ATC-automation capabilities that assist controllers in maintaining safe aircraft separation while optimizing use of airspace system capacity. This effort has focused on developing the necessary specifications for En Route Automation Modernization (ERAM) to provide benefits in the following three areas:

1. **Airspace Access Control:** This area is focused on increasing flexibility and support in the dynamic management of airspace access for increased flight efficiency and throughput. This capability is termed Flexible Airspace Access Control (FAAC). It supports system-wide, consistent knowledge of Special Activity Airspace (SAA) schedule and status; automatic processing of Temporary Flight Restrictions (TFRs) and stationary Altitude Reservations (ALTRVs) as dynamic SAAs; and release areas to enable airspace use within SAA during disruptive events.
2. **Trajectory Accuracy and Schedule/PBN Adherence:** In this area, trajectory accuracy, flight efficiency, and aircraft safety are improved through support for the entry of controller intent into the automation, and improved adherence to scheduled arrival times and PBN procedures as separation problems arise. This set of capabilities is termed "Keep Intent and Time" (KIT).
3. **PBN Descent Procedure Execution:** Support for fully and safely realizing the fuel-savings benefits of Optimized Profile Descents (OPDs) using Descend Via clearances.

[FY19] CAASD conducted analyses and operational assessments to help draft and mature the necessary artifacts for en route automation changes. Specific contributions included:

Airspace Access Control: Concepts for FAAC were refined and the related shortfalls defined. Additionally, potential high-level interaction and data flows between the ERAM FAAC capabilities and other NAS systems were described.

Trajectory Accuracy and Schedule/PBN Adherence: Concept development for KIT continued, and a successful laboratory assessment of KIT in three en route sectors was conducted.

PBN Descent Procedure Execution: Concepts and specific shortfalls for enhancements to support PBN descent procedure execution were developed. Specific concepts and algorithm enhancements examined included:

- ERAM trajectory modeling enhancements to predict FMS Vertical Navigation (VNAV) and speed behavior for a PBN procedure descent
- Associated ERAM Conflict Probe and Likelihood algorithm changes due to the PBN constraints and uncertainties associated with a Descend Via clearance

[FY20] CAASD continues to conduct analyses and operational assessments to mature the necessary artifacts for en route automation changes. In addition, CAASD will develop concepts for cross-domain (terminal and oceanic) separation management automation capabilities that assist controllers in maintaining safe aircraft separation while optimizing use of airspace system capacity.

[FY21–FY23] CAASD will continue to conduct analyses and operational assessments to mature the necessary artifacts for en route automation changes and reduce risk in their acquisition. Initial acquisition activities will begin for promising concepts identified for follow-on en route enhancements and cross-domain applications that increase flight efficiency and maintain safe separation.

Northeast Corridor Airspace and Procedures

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

The FAA committed to meet NEC airspace and procedure implementation milestones through December 2021. Additionally, the FAA will introduce key capabilities needed to achieve iTBO, as well as future concepts and airspace and procedures enhancements.

[FY19] In FY19, CAASD assisted with achieving NEC milestones directed at improving NEC operations through innovative airspace and procedure solutions. CAASD worked with the FAA to execute a systematic process for evaluating, designing, and implementing proposed airspace and procedure solutions. CAASD collaborated on environmental review, community engagement, and design and implementation strategies to ensure an integrated approach to

developing and implementing airspace and procedure solutions. CAASD also developed a noise baseline to enable rapid screening to assess potential environmental risks. For multiple initiatives, CAASD analyzed site-specific data to identify near-term design opportunities and potential benefits and engaged stakeholders to educate them on planned initiatives, capabilities, and technologies. Finally, CAASD explored future concepts to identify additional opportunities beyond the existing NEC milestones, including use of Multiple Airport Route Separation (MARS), which has high potential to deconflict the operations at the closely spaced airports in the NEC.

[FY20] In FY20, the FAA and CAASD continue to advance implementation of mature airspace and procedure solutions. Less mature concepts are being evaluated to assess operational benefits and risks. CAASD's noise baseline model is providing a robust platform to evaluate individual proposals and refine the NEC environmental and community engagement strategies. CAASD is also continuing to assess additional opportunities to enhance NEC operations, further exploring deconfliction opportunities such as MARS and noise mitigation opportunities identified through ongoing noise compatibility studies at the four primary New York airports. Further, CAASD is 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 those concepts to address operational needs beyond the NEC.

[FY21–FY23] Going forward, CAASD will partner with the FAA to meet NEC commitments, implement beneficial airspace and procedure solutions, and evolve NEC operations to initial TBO. CAASD will help the FAA institutionalize use of benefits-enabling technologies that are foundational for transitioning to TBO. CAASD will also continue to refine NEC environmental review, community involvement, and design and implementation strategies to implement airspace and procedure solutions to address the operational needs in the NEC.

Surface Operations and Departure Flight Management Efficiency

To improve operational efficiency of departure management, the FAA will use new technologies and procedures—including electronic flight data, surface queue management, and runway load balancing—as part of the Terminal Flight Data Manager (TFDM) program.

Electronic flight data will reduce manual coordination and communication between ATC facilities and ensure up-to-date flight information is available quickly. Using "virtual queues," surface queue management will reduce the long physical queues of aircraft waiting to depart, thus reducing fuel burn and surface congestion. Runway load balancing will improve the sequence of flights requesting access to ATC-managed areas, resulting in improved taxi times to the departure runway. Additionally, the TFDM program will integrate multiple traffic management initiatives (TMI) to ensure no additional wait time is assigned to flights in the virtual queue.

[FY19] CAASD tested, conducted analyses of, and recommended refinements to TFDM system requirements. CAASD also analyzed interface requirements and integration between TFDM, Traffic Flow Management System (TFMS), TBFM, the System Wide Information Management (SWIM) system, and the Tower Data Link System (TDLS). CAASD's expertise and analysis helped determine how new systems could replace the functionality of the Departure Sequencing Program (DSP) tool used to manage departures in the New York area. The work included independent assessments and reviews on vendor contract requirements for testing, integration, and surface scheduling and metering.

[FY20] The FAA envisions CAASD's analysis will inform and

expedite the operational transition and integration of the technology and procedures. CAASD's laboratories will be used to study the evolution of departure management to provide a more comprehensive time-and-trajectory-based operational view.

[FY21–FY23] CAASD will provide analysis to the FAA to inform and successfully deploy the next phase of TFDM technologies. CAASD's analysis will provide input to operational procedures and processes for usage of surface metering and advanced-surface scheduling. CAASD's laboratories will continue to be used to study the evolution of departure management within a TBO operational view.

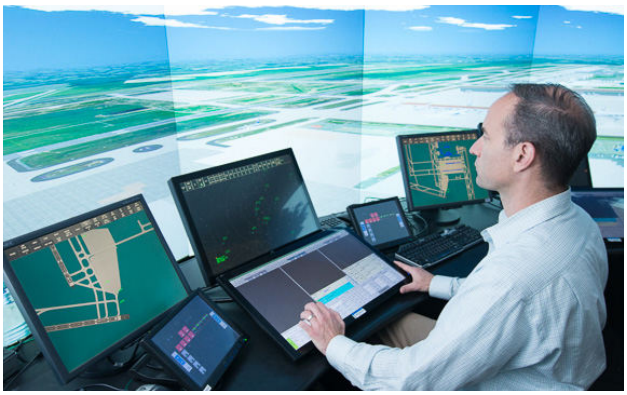
Remote Towers

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.

[FY19] Previously, CAASD examined the costs of remote tower services compared to conventional towers. In FY19, CAASD worked with the FAA to streamline its processes for assessing the new technology, with the goal of reducing operational testing time and cost. CAASD developed a strategy for FAA remote tower cost savings by assessing several alternatives and identifying where the FAA should focus its initial implementation efforts (i.e., on-site single-airport locations). CAASD identified further potential cost savings by developing alternative ways for the FAA to use its Designee program to certify remote tower systems. The use of designees for routine certification tasks allows the FAA to focus its limited resources on safety critical certification issues and new, novel technologies. CAASD also proposed a framework for the FAA to assess the visibility performance of remote tower video cameras during the siting phase, thus reducing risk during deployment and avoiding long and costly operational testing. Finally, CAASD worked with the U.S. Air Force to plan a repeatable operational assessment of remote tower technology at Air Force airfields and leveraged lessons learned to inform the FAA's remote tower pilot program.

[FY20] The FAA envisions CAASD will focus on needed analysis, data, and strategies for implementing remote towers at additional sites, including technology evaluations, technical maturity assessments, policy development, as well as certification and training processes. This includes additional support to the FAA's remote tower pilot program and the U.S. Air Force's ongoing assessment.

[FY21–FY23] The FAA envisions CAASD will continue to support the FAA's remote tower pilot program by leveraging its previous efforts to develop a tower siting tool that incorporates performance of remote tower video cameras. For FY21-23, the FAA anticipates using this tower siting tool for certification of video camera systems as part of sites 3-6 for the remote tower pilot program.



Runway Length Evaluation for Airport Development

When considering runway construction, airport planners rely on FAA Advisory Circular (AC) 150/5325-4B – Runway Length Requirements for Airport Design, which specifies the methodology for determining recommended runway lengths. For large aircraft, this has traditionally been based on a set of predefined charts and airplane manufacturers' Airport Planning Manuals (APMs) that may not fully encapsulate the operational reality.

Through a multi-phase effort, the FAA Office of Airports and CAASD are exploring the use of actual flight-track data and aircraft-performance modeling to determine recommended runway lengths. The new approach will create a software application that facilitates faster decision making that is better aligned with actual performance for reduced cost and improved safety.

[FY19] CAASD worked with the FAA and industry to extract the takeoff and landing runway length properties of many observed flights and augmented the observed data with aircraft performance models to satisfy regulatory planning requirement. This was done to create a new methodology and supporting dataset for recommended runway length estimation. The new methodology and supporting data will be incorporated into a software application that will enable more accurate and flexible analyses, such as what-if questions when there is a shortage of available space. In FY19, CAASD wrote requirements for the software application and developed a Tableau-based prototype.

[FY20] CAASD is refining the prototype through extensive testing by the FAA and industry stakeholders and plans to publish it for use by airport planners.

[FY21–FY23] As new data becomes available, CAASD plans to provide periodic updates to the data set supporting recommended runway length estimation. In collaboration with the FAA sponsor, CAASD will address any residual shortcomings uncovered through lifecycle of the tool for recommended runway length estimation in its interface design or underlying algorithms.

Flight Procedure Assessments

For more than a decade, CAASD has been working with the FAA to create modular software criteria engines to allow users to design and evaluate 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. As of FY20, CAASD has developed 14 criteria engines and integrated them within the FAA's IFP design tool, Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS), which has allowed the FAA to retire expensive legacy systems and provides evaluation capabilities for most IFPs in the NAS. In addition, these criteria engines have been used to enable fully automated IFP evaluations within decision support tools to improve common IFP design and maintenance tasks.

[FY19] CAASD, in partnership with the FAA's TARGETS maintenance contractor, developed criteria assessment and automation functions for conventional, ground-based approach procedures. With this capability, more than 90 percent of procedure types can be evaluated in an automated fashion, enabling additional efficiencies in the design process, such as direct digital procedure upload and storage. CAASD also successfully completed the technology transfer of two criteria engines to the FAA's TARGETS maintenance contractor for ongoing support. Additionally, CAASD continued development of tools to automate the periodic review of IFPs and to automate the evaluation of proposed obstacles for impact on existing IFPs. Lastly, CAASD began research into ways to automate the design of optimal IFPs by combining the criteria engine output with optimization techniques.

[FY20] CAASD is working on designing a new criteria engine to allow for the design and evaluation of ground-based Standard Instrument Departures (SID). This task involves working with the FAA to understand existing criteria and to identify and clarify any current gaps. The completion of this capability will increase the coverage of procedure types in the NAS to more than 95 percent. In addition, CAASD is working 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. CAASD is also expanding the capabilities of the automated periodic review, transitioning the operations to FAA IT infrastructure, and building a prototype automated IFP design system within TARGETS.

[FY21–FY23] The FAA envisions CAASD will work on automation of additional flight procedure types, such as advanced required navigation performance (A-RNP) or helicopter approaches, as well as added functionality, such as PBN transition to Conventional Approaches and enhanced terrain assessments leveraging higher-resolution data. Criteria engine technology transfers will continue, with a goal of transferring two engines per year to the FAA's TARGETS maintenance contractor. Additionally, CAASD will continue development of automated IFP design capabilities to transition IFP design and maintenance tasks from being human-designed/computer-validated to computer-designed/human-validated. These capabilities will help enable a more responsive and efficient future state of the NAS.

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 NAVAIDs.

By transforming the NAS to a PBN operation and optimizing airspace and procedures, the FAA is providing more efficient and more predictable flight paths, reducing pilot/controller communications, and reducing maintenance and infrastructure costs. CAASD has partnered with the FAA since the program's inception, characterizing operational issues, providing subject matter expertise on proposed design concepts, performing aviation data analyses, and conducting both fast-time and real-time ATC simulations. In addition, CAASD has delivered highly complex post-implementation analyses to assess the results of the implementations. CAASD developed analysis capabilities and methodologies that were independently reviewed and accepted by the Joint Analysis Team of the NextGen Advisory Committee. Further, as Metroplex redesigns often involve changes to flight paths, associated environmental issues must also be considered. CAASD worked closely with the FAA and other aviation stakeholders to establish enhanced community involvement processes.

[FY19] In FY19, CAASD conducted post-implementation analyses of the recently implemented Atlanta and Cleveland/Detroit Metroplex projects, identifying over $6 million in annual fuel savings. CAASD also participated in project closeout activities, collecting lessons learned and best practices to inform future efforts. For the remaining sites (South/Central Florida, Denver, and Las Vegas) of this sunsetting program, CAASD performed analyses, modeling, strategic planning, and systems engineering activities, including human-in-the-loop simulations, assessment of TBFM adaptations relative to best practices, documentation of best practices for procedure design, and documentation of analytical methods for benefits estimation.

[FY20] In FY20, the FAA and CAASD are applying the lessons learned from the first eight implementations to the three remaining metroplex sites, which will implement in FY20 and FY21. CAASD will also work to prepare for what comes after Metroplex, capturing design best practices and lessons learned, codifying them into software to help standardize future procedure designs, and identifying opportunities to streamline future procedure development processes.

[FY21–FY23] The Metroplex program will be completed in FY22, but the FAA is planning additional improvements to increase capacity and efficiency using streamlined PBN services, with a focus on optimizing procedures based on new technologies and capabilities such as TBO. CAASD's lessons learned and best practices from Metroplex design and implementation, knowledge of PBN/TBO integration considerations, and expertise in new entrants and NextGen capabilities will enable the FAA to continue to implement beneficial airspace and procedure improvements across the NAS.

Data Communications

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 capabilities are being introduced into the NAS to enable exchange of four-dimensional trajectories (4DT)—longitude, latitude, altitude, and time—and aircraft intent information enabling trajectory-based operations.

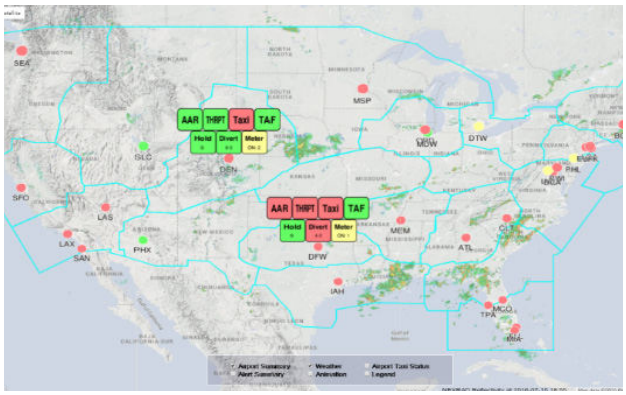
[FY19] To support FAA investment decision making for enhanced Future Air Navigation System (FANS) services, CAASD led significant research and validation activities to mature the operational and functional definitions for a set of enhanced FANS services that build on the initial en route data communication services entering operations in 2019. To that end, CAASD developed operational use cases and conducted assessments using in-house human-in-the-loop laboratory experiments to examine the operational feasibility of enhanced FANS services in a TBO environment. In addition to the new operational uses of FANS, CAASD worked with the FAA and industry to adopt industry internet standard protocols (i.e., Internet Protocol [IP]) for application in the data communications operational environment. This includes network and subnetwork protocols, mobility solutions, and security management options to improve data communications security and system performance.

[FY20] CAASD continues to mature FANS operational use cases and will conduct additional assessments and experiments 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 will also provide 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 will draft a strategy for validation and implementation planning of IP standards for air/ground data communications in the NAS.

[FY21–FY23] As the FAA moves toward a final investment decision on additional en route data communication services, CAASD will continue to mature and validate the integration of enhanced FANS services with TBO and PBN to enable flight-specific and system-wide benefits. CAASD will continue to identify ways to advance and expand data communication for aeronautical applications and will support the maturation of associated standards through validation and implementation in the NAS.

NAS Operations Dashboard

Working with the FAA, CAASD continues critical research focused on day-of and real-time Traffic Flow Management (TFM) monitoring and alerting in support of NAS operations. CAASD is addressing the most difficult air traffic congestion issues and is working to advance increasingly proactive TFM actions designed to reduce inefficiencies and prevent delays from accruing across the NAS.



This work is also targeted on improving TFM-related operational metrics to facilitate the expansion of ATM partnerships and collaboration between the FAA and NAS stakeholders. By leveraging the power of real-time data through the FAA's SWIM capability and other sources, CAASD seeks to provide a high-level system-performance view of real-time operations at and around the FAA's Core 30 airports.

[FY19] The FAA requested that the NAS Operations Dashboard (NOD) be available to airlines for collaboration throughout the NEC. The real-time operational information provided by NOD enabled collaborative discussions among aviation stakeholders, provided access to information otherwise available only in disparate locations, and accelerated the identification of operational problems. A new feature added to the dashboard in FY19 provides route availability information and any restrictions imposed on aircraft flight plans involving those routes.

As a field evaluation capability in FY19, NOD provided operational benefits to the Air Traffic Control System Command Center (ATCSCC), ATC facilities in the NEC, and Airline Operations Centers (AOCs) with access to the dashboard.

[FY20] CAASD is expanding NOD research into other critical operational areas, such as displaying departure route conditions around the New York metropolitan area, Chicago, and Denver. Showing the status of departure routes (open, impacted, or closed) in real time enables departure load balancing that will provide significant operational benefit to ATC facilities and airlines. CAASD is researching the metrics and information being distributed through the SWIM service related to TBFM to identify data that can be visualized to improve ATCSCC situational awareness.

For FY20, the work is increasingly coupled with the FAA's Planning, Execution, Review, Training, and Improvement (PERTI) process. CAASD is currently studying how the NOD can add value to that process and provide NAS decision makers a more comprehensive and customized real-time view of the state of air traffic operations around the Core 30 airports. With that in mind, CAASD is working with the FAA on the use of an advanced monitoring and alerting research platform designed to couple the NOD and PERTI automation (data sharing) to improve planning and day-of NAS situational awareness. This includes monitoring and alerting within the research platform (NOD/PERTI) to provide timelier NAS responses to critical decision windows, data-driven operational triggers, and system

metrics. Plus, this work continues to look at improving the NOD operational view, which includes information on holding, diversions, airport throughput, miles-in-trail restrictions, surface activity, significant weather, use of TBFM, pathfinder and alternative route collaboration, and other important operational factors.

[FY21–FY23] CAASD will continue exploration of opportunities to utilize SWIM and other data sources for operational situational awareness. CAASD will work to integrate timely and accurate information into a research platform (NOD/PERTI) in a manner that facilitates increasingly effective FAA and NAS stakeholder collaboration. This research platform will ensure that TFM-related collaboration metrics are operationally relevant, actionable, and timely. As more information is gathered from SWIM and other data sources, additional capability improvements and collaboration opportunities will emerge. In addition, collaboration with FAA Systems Operations Performance Analysis division (AJR-G) will focus on the outline for an initial technology transfer of the NOD/PERTI platform. The expectation is that in FY21 this dashboard will be transferred to the FAA. CAASD will then utilize the NOD/PERTI research platform as an investigative collaboration platform for future monitoring and alerting research.

Flight Operations Data Sharing

Today, TMI from multiple sources can impact a flight. A new program for airport surface departure management, the TFDM, introduces an additional TMI to improve surface departure management while ensuring no additional delay is allocated to a flight already involved in a TMI.

An essential component of integrated departure scheduling is the incorporation of up-to-date departure readiness information. Most flight operators already provide this information to traffic management demand prediction engines. However, GA operators do not have a way to electronically exchange departure-readiness information. That negatively impacts operations within the NAS.

[FY19] CAASD examined operational performance related to departure readiness information sharing under varying levels of operator participation. CAASD's analysis suggested that, with the introduction of TFDM surface metering, flights participating in data sharing will experience less surface wait time than flights that do not. Additionally, CAASD explored the use of mobile technologies to enable GA flight operators to also exchange flight operations data with the FAA.

CAASD collaborated with National Aeronautics and Space Administration (NASA) in Airspace Technology Demonstration-2 (ATD-2) research. The demonstration leveraged CAASD's mobile technology research prototype to enable information sharing between GA operators and NASA, which broadened stakeholder participation and contributed additional accurate and predictable schedules. Additionally, CAASD conducted analyses to define architecture proposals for two-way information sharing between airspace users and the NAS to support integrated departure scheduling. One proposed architecture would allow GA pilots to submit departure readiness information by using an electronic flight bag.

[FY20] CAASD continues to support integrated departure scheduling by exploring and demonstrating methods for enabling the broader exchange of departure-related data among flight operators, the FAA, and other stakeholders. In FY20, CAASD will continue its collaboration with NASA ATD-2 in Charlotte Douglas International Airport (KCLT). CAASD will also work with NASA and the FAA as they expand the ATD-2 research effort to the Dallas Fort Worth (DFW) metroplex as part of ATD-2 Phase 3. This phase of the research presents some additional challenges as the DFW metroplex has a large GA-traffic population that may increase the uncertainty the automation must address.

[FY21–FY23] Integrated departure scheduling will continue to evolve. The FAA envisions CAASD will identify differences between the FAA's Tower Flight Data Manager system and the findings identified in the CLT and DFW demonstrations. In addition, CAASD will improve the data exchange architecture to allow broader stakeholder participation.

Mobile Applications for Pilot and Controller Communications

On busy days, air traffic controllers and flight service specialists deliver up to 15,000 Instrument Flight Rules (IFR) departure clearances via voice communications to pilots across the U.S. Each clearance takes one to five minutes, creating significant pilot and controller workload. Additionally, potentially misunderstood oral communications can introduce flight safety risks. Additional tasks—such as IFR release and cancellation for approximately 4,000 daily IFR flights at non-towered airports—are conducted orally, with no vision for how these might be conducted more efficiently.

The FAA addressed the clearance delivery issues at the nation's busiest towered airports through the introduction of text-based IFR clearance delivery to suitably equipped aircraft. However, many aircraft and lower-volume airports are not equipped with data-communications capabilities. CAASD is researching the viability of pilots and controllers using mobile devices—such as smartphones and tablets—to exchange text-based IFR departure clearances at all airports and departure releases and cancellations at non-towered airports.

[FY19] CAASD matured the Mobile IFR Services concept and socialized the concept through engagement with key FAA stakeholders using a tabletop exercise, prototype development, and multiple prototype demonstrations. CAASD conducted demonstrations for FAA personnel, industry, and the flying public. Through these efforts, CAASD identified issues in existing NAS systems that must be overcome to support Mobile IFR Services. CAASD also developed a roadmap for examining and establishing end-to-end safety and data assurance in mobile device data exchange of Mobile IFR Services information.

[FY20] CAASD will continue to conduct a full end-to-end, ATC-to-pilot analysis of the functions proposed in the Mobile IFR Services concept to identify additional issues in existing NAS systems that must be overcome to support Mobile IFR Services. Recommendations for addressing each issue will characterize what aspects of the NAS infrastructure are limiting or constraining the innovation and describe how those limitations can be overcome. CAASD will further define and design the Mobile IFR Services architecture and system requirements to accommodate additional services that require a secure connection between pilots of manned or unmanned aircraft and air traffic controllers or NAS systems.

[FY21–FY23] The FAA envisions making Mobile IFR Services available to a broad set of pilots and airports. Using CAASD analysis, the FAA will establish the necessary backend infrastructure and, where required, define/acquire services to enable controller functionality. The FAA will also develop ACs and procedures to make Mobile IFR Services available to users. Industry will incorporate the pilot-side capability into mobile applications. Pilots will acquire the capabilities and incorporate them into their flight procedures. And CAASD will complete its research and technology transfer to industry.

Mobile Applications for Pre-Departure Information Exchange

The FAA is investing in new surface automation capabilities and transitioning to more TBM techniques to balance demand and capacity at busy airports and along busy airspace corridors in the NAS.

These capabilities rely on accurate demand predictions, which can be improved when flight operators provide up-to-date information about when their flights will be ready to depart. The FAA has been coordinating with the airlines to obtain this information from AOCs via the FAA's SWIM. The GA community currently does not have a way to provide similar departure-intent information to the FAA. Including this data can improve overall schedule predictability and reduce demand uncertainty around congested NAS resources. Similarly, flight operators do not always have insight into the expected demand at the airport.

CAASD is researching the use of mobile technologies to include the GA community in surface and departure management initiatives, specifically to collect departure readiness information and to provide GA flight operators with flight-specific schedule and constraint information and airport departure demand information.

[FY19] In FY19, CAASD began testing a prototype research application for operators of unscheduled flights (e.g., GA, Business Aviation [BA]) that provides users with

a mechanism to view departure demand predictions and submit departure readiness information. The application was tested at three locations: McCarran International Airport (KLAS), Henderson Executive Airport (KHND), and Dallas Love Field (KDAL). The test effort at KDAL is being conducted within the context of NASA's ATD-2 activities.

CAASD was also engaged with operators at Charlotte Douglas International Airport (KCLT), facilitating collection of departure-readiness information from GA and BA operators within the context of NASA's ATD-2 project. At KCLT, pilots receive surface schedule and constraint information in return for their submission.

[FY20] CAASD continues field test activities at the current set of test sites and expanding the research to at least one additional airport that experiences traffic management challenges due to high volumes of GA traffic. Multiple reports describing the application, the test efforts, and findings from the test efforts are scheduled for delivery.

[FY21–FY23] TThe FAA envisions that the departure information exchange capability will be available to a broad set of GA flight operators by the time the FAA's TFDM system begins deployments. TFDM, the FAA's solution for surface-based TFM, will benefit from receiving better-planned departure times from flight operators. The FAA also envisions that the information exchange capability will be integrated into existing flight planning tools and applications flight operators already use as part of their flight planning workflow. CAASD, in collaboration with the FAA, will work with industry to facilitate a technology transfer of the findings and capabilities of this research, matured through a multi-year research effort.

FAA Enterprise Networking Services (FENS)

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 services. However, the potential risk of these new technologies must be explored and tested with FAA systems to identify and resolve any technical or operational issues before issuing the final FENS Request for Proposals (RFP).

Transition from the FTI network to FENS will impact multiple programs that depend on voice, flight data, and surveillance data communications. Careful planning is needed to manage transition risk and avoid negative impacts to critical NAS services.

[FY19] CAASD provided insights to the FENS investment analysis that led to the Initial Investment Decision milestone. CAASD worked with FAA and industry to analyze industry responses to the FENS draft Screening Information Request (SIR) releases. Based on these interactions and technical expertise, CAASD proposed revisions to performance and cybersecurity requirements, policies, and evaluation criteria. CAASD provided recommendations

on transition strategies to reduce risk associated with transition activities and agency-specific requirements. CAASD developed risk-reduction testing methodologies for wireless and shared Multi-Protocol Label Switching (MPLS) technologies. CAASD also developed a FENS white paper to help guide FAA on FENS acquisition issues. The white paper addressed key issues, including using shared infrastructure for FAA NAS systems and use of shared infrastructure by other government and private industries. It also identified how FAA addressed past Surveillance and Broadcast Services (SBS)/Automatic Dependent Surveillance-Broadcast (ADS-B) outages and introduced new cybersecurity technology solutions, including the idea of using a zero-trust model to meet FAA future needs.

[FY20] CAASD continues to work with the FAA in achieving a successful implementation of the FENS program. This will include identifying themes from industry engagements, revising security policies that might inhibit the use of commercial technologies and services, and identifying improvements to streamline FAA telecommunications business processes. CAASD will help the FENS program by focusing on the development of innovative program strategies, outreach and change management activities, and requirements refinement. CAASD will contribute to the revision of cybersecurity policies and requirements that constrain FENS from fully leveraging innovative technologies from industry, such as the use of shared infrastructure, and carrier ethernet 4th-and 5th-generation wireless networks. CAASD will participate in assessment of final SIR responses as they become available.

[FY21–FY23] CAASD will work with the FENS program as it goes through source selection and transition. CAASD will provide technical advice to the FENS source selection process. After contract award, CAASD will participate in transition planning and critical outreach messaging to field organizations across the FAA who must work with the FENS vendor to achieve an efficient and swift transition from FTI to FENS. CAASD will continue to participate in risk-reduction activities including testing, transition analysis, and assessment of the winning FENS bidder solutions to ensure they meet FAA safety, security, and performance requirements.

Navigational Aid Rightsizing

Global Navigation Satellite System (GNSS) applications and services are foundational to NextGen. As the FAA enables PBN, aircraft dependence on legacy ground-based navigation systems is reduced. However, those systems are not obsolete. Instead, their role changes to support resiliency by serving as backup navigation capabilities when satellite-based services are interrupted. As a backup to GPS-based navigation, these ground-based navigation systems can be fewer in number, allowing the FAA to pursue cost savings through decommissioning.

[FY19] CAASD worked with the FAA in planning and defining the service-volume enhancements for the ground-based NAVAID infrastructure. CAASD reviewed and analyzed existing Distance Measuring Equipment (DME) sites, assessed backup DME navigation coverage, and performed analysis to identify new DME sites needed to fill area navigation (RNAV) coverage gaps in Class A airspace. CAASD collaborated with military stakeholders to revalidate their legacy navigation infrastructure needs and services provided by the FAA. CAASD consolidated the requirements and inputs from the NextGen DME and Very High Frequency Omni Directional Range (VOR) Operational Network (MON) program to inform the FAA's navigation infrastructure sustainment strategy and contributed to the FAA's PBN Strategy and Navigation Programs Roadmap related to these efforts. In addition, CAASD formulated concepts,

defined key decisions, and conducted data analysis needed to develop an acquisition strategy for legacy ground-based navigation system sustainment. CAASD analyzed results and reviewed methodologies to streamline legacy systems and services and identified opportunities for NAVAID decommissioning.

[FY20] To further assess the ground-based navigation system need, CAASD is evaluating ILS facilities in FY20. In doing so, CAASD is leveraging the FY19 analyses and recommended criteria provided in FY19 to rationalize the number of ILS facilities the FAA should maintain in the U.S. CAASD will integrate the considerations of various FAA offices and aviation stakeholders to help formulate a consensus position that maintains acceptable levels of safety, efficiency, and affordability. The resulting criteria will be a guide for determining which runways need to retain ILS and where divestment may be possible. In addition, CAASD will conduct a data analysis to inform the critical decisions that will lead to a reliable, resilient, and robust overall timing service for FAA systems.

[FY21–FY23] The FAA envisions CAASD will provide technical and operational expertise to guide implementation of these streamlined navigation services. VOR discontinuation will occur in concert with new DME installations, while service-volume changes will impact both sets of services. In addition, the FAA will assess ILS installation and continue activities to sustain the remaining ground navigation infrastructure through the DME, VOR, and Tactical Aircraft Control and Navigation (TACAN) (DVT) program. During all these activities, CAASD will continue to help build consensus and deliver modeling and data analysis to help the FAA restructure the U.S. ground-based NAVAIDs..

Automatic Dependent Surveillance-Broadcast In Applications

Air traffic modernization in the NAS has largely focused on techniques and tools that bring demand into conformance with usable capacity. This is accomplished primarily through the application of delay. While better coordination of merging traffic flows and advisories that reduce guesswork have helped improve usable capacity, current limitations with accurate time-based delivery of aircraft have remained an impediment to increasing usable capacity.

Arrival capacity also degrades when flight crews can no longer accept visual separation clearances that would otherwise allow closer final spacing between aircraft during visual separation operations.Improvements in communication, navigation, and surveillance 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 expanded use of TBO. ADS-B In-enabled applications, 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. These are key components of NextGen and will help mitigate growth in NAS-wide delays and projected airport-capacity shortfalls.

[FY19] CAASD played major roles in maturing the avionics standards documentation for the full suite of IM and CA applications within RTCA Special Committee (SC) 186. CAASD performed technical analysis and human-in-the-loop research to inform the requirements and resolve open questions within the committee. CAASD also helped author the concept of operations for the first phase of ADS-B In applications (termed "Phase A") and brought to bear research that examined the integration of flight deck-centric applications with ground-based metering operations in the terminal area.

[FY20] CAASD is helping to finish the ADS-B In avionics standards in preparation for final publication. CAASD is also helping to mature the ADS-B In Phase A concept of operations and develop the ground automation requirements to enable these operations. In addition, CAASD has been tasked to validate the general feasibility and acceptability of IM operations to dependent-parallel runways in a metering environment from ATC and flight-crew perspectives. This will inform FAA concept and requirements documents for ADS-B In operations that will be implemented after Phase A.

[FY21–FY23] The FAA will focus on developing the ATC automation functions and computer-human interfaces for those capabilities needed to enable ADS-B In Phase A operations. This work includes working with the FAA's vendors to review requirements, prototype solutions, and test plans. The FAA will also work toward an Operational Benefits Validation at a key site, involving the integrated use of the ground systems to initiate and monitor ADS-B In operations and the flight-deck systems to conduct the ADS-B In operations. In parallel, the FAA team will begin initial investment activities in support of the Phase B investment, which more fully integrates IM applications into a TBM environment. CAASD will continue to play a role on the FAA ADS-B In team, making key contributions towards concept maturation, testing, and collecting and analyzing data gathered during the field evaluations.

Environmental Policy and Concepts

Opposition to aircraft noise has continued to grow, and in recent years it has impacted the FAA's ability to implement critical NextGen improvements. The implementation of airspace and procedure improvements is taking longer and costing more, and needed safety enhancements and operational efficiencies are being delayed or stopped completely. CAASD has partnered with the FAA over the last several years to address these obstacles and has developed a three-pronged approach to understand the issues and opportunities, engage with communities and stakeholders, and mitigate the noise concerns.

[FY19] In FY19, CAASD developed enhanced noise screening capabilities to accelerate FAA decision making and created prototype data capabilities to understand and visualize operational and environmental trends. CAASD also explored future concepts such as TBO and Established-on Required Navigation Performance (RNP) to understand emerging environmental issues and develop strategies to address them. Lastly, CAASD developed scenario-based guidance to promote standardized, repeatable, and scalable community engagement activities across the NAS.

[FY20] In FY20, CAASD is partnering with the FAA to identify near-term opportunities to increase the use of existing Noise Abatement Procedures (NAPs) to proactively build goodwill with communities. CAASD is continuing to enhance noise-screening methodologies to accelerate FAA decision making and provide critical noise information earlier in the airspace and procedure design and implementation process. CAASD is also providing visualizations of operational trends to support understanding of these trends and clearly convey them to community stakeholders. Lastly, CAASD is developing a strategic community engagement framework to proactively identify and address emerging noise issues before they become implementation obstacles.

[FY21–FY23] CAASD will continue to partner with the FAA to address the environmental obstacles to NextGen implementation. CAASD will help the FAA make data-driven environmental decisions based on analysis of operational and environmental impacts, options, and tradeoffs. CAASD will work with the FAA to conduct community engagement to consider community input and justify decisions. Lastly, CAASD is developing a strategic community-engagement framework to proactively identify and address emerging noise issues before they become implementation obstacles.

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 communication, navigation, surveillance, 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 industry's current and forecast aircraft fleet capability. 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.

[FY19] CAASD performed an analysis of current and planned aircraft capability, with a focus on capabilities to support PBN, use of ADS-B, data communication, low-visibility operations, and safety enhancements.The analysis examined current and forecasted equipage rates in the air transport, air taxi, foreign carrier, BA/GA, and helicopter categories.

[FY20] CAASD continues to work with the FAA and industry stakeholders to collect, synthesize, and analyze aircraft avionics equipage and capabilities. Additionally, CAASD will assess emerging avionics systems in UAS and non-Air Transport aircraft that may impact future Air Transport Capabilities in order to inform FAA policies and plans for aircraft technology evolution.

[FY21–FY23] The FAA envisions CAASD will continue to gather and use fleet capability information to assess opportunities, challenges, and risks associated with enabling future operational capabilities and related policy decisions.

Small Unmanned Aircraft Systems Risk Analysis

The FAA is seeking quantitative risk assessment methods to enable UAS to safely access airspace and avoid highly-restrictive operational or technical waivers to gain NAS access.

The agency's current focus is on small UAS (sUAS) operational approvals under Code of Federal Regulations (CFR) Title 14 Part 107. In the not-too-distant future, the FAA will require proposed UAS operations beyond the boundaries of Part 107 (i.e., under Part 91 and Part 135) to use quantitative methods for assessing UAS integration risk. The FAA also seeks quantitative means of evaluating proposed rulemaking to address specific UAS operational integration.

CAASD developed a cross-FAA line-of-business (LOB) framework to assist the FAA's UAS integration efforts with two models providing quantitative data support in FY18. The first model, the sUAS Airworthiness Assessment Tool (sAAT), assessed the risk of collision with people on the ground, and is now called the Ground Collision Risk Assessment (GCRA). The GCRA quantifies the risk of fatality by factoring in characteristics of both the sUAS vehicle and its intended operational mission. The second model, the Volumetric Collision Risk Assessment (VCRA) tool, is an air-collision risk model that uses historical data to access the likelihood of sUAS colliding with manned aircraft. The U.S. Navy has validated the VCRA for its UAS air-collision risk assessments.

[FY19] CAASD continued to mature the GCRA and VCRA in FY19. CAASD adapted the VCRA tool from high-altitude macro-airspace to low-altitude small-airspace assessments with provisions for visualization. The tool's algorithms use CAASD-maintained FAA air-traffic data for a specific location and time of day. CAASD provided versions of the air and ground risk model to the Civil Aviation Authority of Singapore (CAAS) for its operational UAS risk assessment and approval. The FAA used both models in risk assessments for the UAS Integration Pilot Program (IPP). In addition, CAASD developed a quantified means to assess the UAS risk to moving vehicles on the U.S. road system.

CAASD provided technical contributions for maturing the UAS risk assessment approach within the Joint Authorities for Rule Making on Unmanned Systems (JARUS) Specific Operational Risk Assessment (SORA) methodology international recommendation. In addition to CAASD's participation in JARUS SORA development, CAASD adapted the SORA for the FAA to use within its Safety Management System (SMS). CAASD led a cross-LOB team to develop an Operational Risk Assessment Prototype (ORAP) based on SORA principles, and FAA System Operations Services (AJR), Air Traffic Organization (ATO), and Aviation Safety (AVS) risk definitions to derive requirements to quantitatively assess qualitative UAS integration risk. As a cross-LOB capability, the prototype is at the center of CAASD's

holistic-risk framework for UAS integration.

[FY20] The FAA identified CAASD personnel as subject matter experts for UAS airworthiness and integration risk assessments in adopting provisions of the risk assessment framework across LOB initiatives. SMS guidance analytics and high-performance computing enhancements to the risk assessment prototype will continue from FY20–FY22.

To address the FAA's UAS airworthiness initiatives, CAASD will use the ground and air risk models to identify the FAA's airworthiness data requirements, recommend an FAA approach to automatic function certification, and explore airworthiness means of compliance requirements for FAA UAS certification.

[FY21–FY23] CAASD will partner with the FAA and UAS industry to continue to develop existing and new UAS integration requirements, quantitative analytical results, and data-driven concepts for accelerating FAA adoption of new risk-related technologies.

UAS Strategic Alignment and Enterprise Planning

The UAS industry continues to drive mission growth and evolve enabling technology. Partnering government agencies are establishing UAS policy and guidelines within their domains of authority, and the global aviation regulatory community continues to define UAS doctrine. The FAA must provide paths to domestic approval that meet the pace of industry and inform the policy of U.S. and international regulators. CAASD provides significant technical and strategic contributions to three primary FAA forward-looking planning guides: the UAS Implementation Plan (UASIP), the UAS Integration Research Plan, and the ATO UAS Services Plan.

[FY19] CAASD continued to provide technical contributions and strategic alignment to the UASIP development. In support of the UASIP - a comprehensive plan representing the intent of the FAA - CAASD provided a broad range of technical and operational skillsets to collect, analyze, normalize, deconflict, and distill UAS-related activities, plans, and other inputs from across all FAA organizations involved with unmanned systems. Identified dependencies and gaps were highlighted and addressed by responsible offices. The FY19 UASIP was finalized in December 2018. The FY19 UASIP was finalized in December 2018. The FY20 UASIP has been coordinated throughout the FAA's LOBs and is awaiting the FAA Administrator's signature.

The UAS Integration Research Plan requires similar technical contributions and strategic alignment with FAA-published roadmaps, NAS strategies (i.e., PBN, NextGen, future surveillance planning, etc.), rulemaking timelines, and industry and other government agency research initiatives. CAASD engaged in outreach to identify existing and planned research efforts, define expected outcomes, and discover potential overlaps or gaps to inform FAA research planning and assignment. The FY19 UAS Integration Research Plan is scheduled to clear Agency approvals within the first quarter of FY20.

The ATO UAS Services Plan was initiated in 2018. Through rapid analytics and multiple levels of engagement with the FAA, CAASD provided a baseline of UAS-specific activities, timelines, estimated levels of effort, dependencies, and gaps across the ATO Service Units. These activities were mapped to known strategic plans (i.e., UASIP) and enabled ATO UAS leadership to make informed decisions on its priorities and goals for ATO UAS services.

In FY19, CAASD coordinated across the Service Units to execute the activities identified in the Services Plan, align them with other FAA efforts, and conduct ATO resource, operational, and economic impact analytics of integrating UAS into national airspace. The ATO UAS

Services Plan was transitioned to the ATO UAS Leadership Team (ULT) and is a living document owned and executed by the ATO ULT.

[FY20] CAASD continues to look across the FAA enterprise for opportunities to address current and anticipated challenges of UAS integration and provide holistic recommendations to help the FAA establish strategic guidance and plans.

[FY21–FY23] The FAA envisions CAASD will partner with the UAS industry to continue to develop strategies that lead to government and industry partnerships, collaboration, and a safe and efficient future for all aviation stakeholders

Small Unmanned Aircraft Systems Routing Operations

The FAA is executing the UAS IPP, the Partnership for Safety Program (PSP), and the UAS Traffic Management Pilot Program (UPP) to enable routine approval of UAS operations in the U.S., including beyond-visual-line-of-site (BVLOS) operations and other operations beyond the limitations of CFR Title 14 Part 107.

To enable routine FAA approval, an airworthiness approval process, airspace access requirements, and operating procedures must be developed. sUAS operating at low altitudes (i.e., a few hundred feet above ground level) in Class G uncontrolled airspace are conducting many operations. Industry trends suggest significant growth in sUAS operations beyond the pilot's visual line of site, including operations in controlled airspace.

[FY19] CAASD contributed technical expertise to FAA partnerships by assisting with flight testing and analyses for each phase of research. CAASD provided analysis on safety, policy, standards development, flight approval processes, and data collection to refine a scalable and

repeatable process toward enabling routine sUAS operations and—where safely practical—away from waivers, Certificate of Waiver or Authorizations (COAs), exceptions, and exemptions.

CAASD also partnered directly with U.S. state governments to explore regional solutions to UAS challenges. While these were individual efforts, each body of research required CAASD to provide depths of expertise in NAS infrastructure, FAA-regulatory statutes, other government-agency statutes, FAA-operational policy, procedures, tool suites, and data-exchange architecture to promote harmonization and true integration of UAS operations across the nation.

iFinally, CAASD partnered with other nations to bring U.S. expertise to the global UAS market. Countries such as Singapore and New Zealand leveraged the FFRDC's expertise to pursue UAS research, learn U.S. aviation practice, and contribute to global-unmanned integration.

[FY20] In FY20, the UAS remote ID rule will be published and the first pilot deployments of compliant technologies will take place. This rule will provide electronic identification requirements for UAS operators, service suppliers, and manufacturers. It is also expected that regular BVLOS operations will continue to expand through waivers, exemptions, or a combination thereof, building on the learnings from the IPP. CAASD will continue to play a key role as technical advisor and trusted partner to the FAA in enabled safe expansion of UAS operations, providing expertise in testing, surveillance, command and control (C2), process development, certification, data analytics, safety analysis, and BVLOS best practices.

[FY21–FY23] The FAA envisions CAASD will continue contributing to the development of BVLOS operations in the NAS via the IPP to ultimately enable routine approval of

UAS operations in the NAS, including BVLOS operations, operations over people, and other operations beyond the limitations of Part 107.

It is expected that CAASD will continue to support the Department of Transportation-FAA government industry partnerships as well as partnerships with local governments to enable safe expansion of UAS operations in the NAS. This may include additional working partnerships between the FAA and state and local governments as well as cooperation with other countries. Ultimately, it is expected that CAASD will be a principal contributor to the development of repeatable, scalable solutions that will allow the FAA to approve consistently safe and increasingly significant and numerous operations of UAS in the NAS.

New Entrants Airspace Access

Airspace demand is increasing, along with the operational diversity of the users seeking access. NAS horizons are expanding by both altitude and mission types. Operators are using innovative technologies to provide new services (e.g., drone delivery, on-demand air mobility, commercial space launch and reentry, and high-altitude telecommunications). These new technologies and operations will have to be integrated with existing operations while continually improving the safety and efficiency of the NAS.

Creating a path for safe and effective integration of all users in the NAS requires an ability to characterize anticipated performance characteristics and demand profiles for new entrants and legacy operations. It also requires an in-depth understanding of relevant airspace access regulations, current NAS capabilities, and planned improvements.

Over the last several years, CAASD has partnered with the FAA to understand the issues and opportunities, engage with a broad set of stakeholders, and highlight what can be done in the near term to accelerate safe and effective airspace access for a diverse set of operations (from low-altitude UAS to unmanned free balloons in the stratosphere to commercial space operations at even higher altitudes).

[FY19] CAASD assessed how current NAS capabilities

and best practices can (or cannot) adequately support operations above flight level (FL) 600. This built on previous work, which assessed and prioritized a range of traffic management service options in the airspace above FL600 using a framework developed by ICAO. In FY19, CAASD identified gaps, currently available solutions, and NAS changes needed to support near-term above-FL600 operations. CAASD also provided recommendations for accelerating above-FL600 airspace access in the near term by leveraging existing NAS capabilities.

[FY20] As part of the licensing process for commercial spaceport launch/reentry sites, the Air Traffic Office provides the Office of Commercial Space a memorandum of assessment outlining a proposed site's potential impacts on the NAS, as well as any possible operational issues or constraints. In FY20, CAASD is partnering with multiple LOBs across the FAA to develop a standardized process that will generate consistent and transparent content at levels appropriate to the FAA and site applicants. This work will leverage previous CAASD efforts that resulted in a process for assessing the airspace at a proposed commercial spaceport site at the local, facility level, which also included the development of a TARGETS plug-in to enable faster airspace-related site assessments.

[FY21–FY23] Going forward, there will continue to be a need for understanding and mitigating airspace issues associated with the integration of new entrants into the NAS. There will be a need to understand how the diverse set of performance characteristics and mission types associated with new entrants will inform airspace needs, access, and equity. CAASD's ongoing work in this area is anticipated to provide the data-driven, evidence-based information needed by the wide range of stakeholders associated with new entrants.

Space Launch and Reentry Vehicle Operation in the NAS

The number of space launch and reentries is increasing. Both established and new operators are entering the commercial-space marketplace to help companies populate satellite constellations. NASA continues to conduct space science, experimentation, and exploration, while the Department of Defense (DOD) maintains U.S. national security. Soon, space tourism operations will build additional demand for access to space through the NAS. Current procedures, processes, and technical capabilities are insufficient to meet this growing demand. The FAA plans to increase its use of new procedures and deploy new automation to efficiently enable these operations while maintaining public safety.

[FY19] CAASD made recommendations to update ATM procedures for space operations. Research was initiated in developing Time-Based Launch Procedures (TBLP) and Dynamic Launch and Reentry Windows (DLRW) to increase efficiency in NAS operations around areas of space operations. TBLP is an FY20 Agency Priority Goal.

CAASD provided input to Acquisition Management System (AMS) artifacts for space-integration enhancements for the initial investment decision and defined preliminary requirements for the FAA's Space Data Integrator (SDI). SDI is a tool that takes telemetry data supplied by a space operator and provides hazard area information to air traffic managers during certain space operations. CAASD also completed shortfall, requirements, and safety analyses for space-integration capabilities. CAASD recommended airspace and policy changes to accelerate safe integration of commercial space operations while considering the impact on NAS users. CAASD leveraged existing research and work with stakeholders to develop community recommendations regarding airspace characteristics most suitable for accommodating spaceport and legacy operations. CAASD delivered a new spaceport assessment plug-in for the FAA's existing TARGETS tool.

CAASD matured the collaborative decision-making and information-sharing concept among all stakeholders during space-operation planning and execution, enhanced and matured the Rapid Impact Assessment (RIA) capability for technology transfer to the FAA, researched the feasibility of using various surveillance systems to track launch/reentry vehicles, and researched methods to improve NAS efficiency during launch/reentry operations.

[FY20] CAASD continues to provide expertise, analyses, and research in support of the AMS process for space-integration enhancements and the operational evaluation of SDI. CAASD, working with a broad cross-section of the FAA, will craft a Space Operations Strategic Vision and

Action Plan for NAS Integration with three-, five-, and ten-year outlooks. Additionally, CAASD will develop new time-based procedures to increase efficiency and reduce delays for aircraft affected by launch/reentry operations. Working with NAS aviation and space operators, as well as select spaceport operators, CAASD will draft procedures enabling TBLP and DLRW. These new procedures dynamically reduce the duration of exclusive airspace use during launch/reentry operations through identification of space launch/reentry operator and site activities. CAASD will also investigate ways to best share and communicate information in support of space operations. Additionally, CAASD will develop a standard process for developing a memorandum of NAS impact for the commercial spaceport site licensing process. Finally, CAASD will provide cross-corporate expertise to the FAA in writing guidance materials for the launch of Tier III Special Nuclear Materials. Finally, CAASD will provide cross-corporate expertise to FAA in writing guidance materials for the launch of Tier III Special Nuclear Materials.

[FY21–FY23] The FAA envisions CAASD will continue contributing to the agency's goal of integrating space operations into the NAS. This includes further refinement of standards and procedures, safety analysis, machine-to-machine data exchange, new ATC and TFM tools, and streamlined licensing and permitting processes. Airspace between 60,000 feet and 328,000 feet (the Karman Line) will see development of new airspace designs, automation capabilities, procedures, and safety requirements to enable integrated use of this airspace by a diverse array of operators.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INNOVATION

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Unmanned Aircraft Systems Approvals

The FAA is exploring various approaches to modernize and streamline its approval processes for commercial UAS operations, such as small package delivery, large cargo transport, and infrastructure inspection. Depending on the type of the proposed operation, granting UAS access to controlled and uncontrolled airspace may require coordination and approvals from multiple FAA organizations. CAASD is helping the FAA define, architect, and manage UAS data and information exchange across the agency.

[FY19] In FY19, CAASD continued its partnership with the FAA Flight Standards (AFS) and FAA Office Information and Technology (AIT) divisions to define requirements for a "one-stop-shop" for UAS registration, airspace authorizations, waivers, and UAS accident reporting data and information. Called "Drone Zone," this cloud-based capability is driven by an agile approach that produces rapid development and frequent releases. In FY19, CAASD continued to be responsible for deriving functional requirements and transitioning them into technical requirements within the FAA infrastructure to advance Drone Zone capabilities and internal FAA data integration.

CAASD also partnered with AIT and ATO to implement the

next generation of COA processing—the COA Application Processing System (CAPS). This capability extended beyond the FAA to DOD users and provided the first phase of an integrated and automated web-based workflow within the FAA's IT architecture. In FY19, the FAA shifted the CAPS technical integration strategy to accommodate integration into the growing FAA cloud-based UAS tool suite. Simultaneously, ATO used CAPS automation to distribute UAS approval decision making deeper into the field to the ATO Service Centers. CAASD provided analytics exploring multiple approaches to satisfying both FAA and DOD needs with minimal operational impact and considering costs and efficiency variables. CAASD also provided technical assistance during the transition.

CAASD has leveraged unmanned traffic management (UTM) and NAS data exchange architectures to identify connectivity, data collection, and information sharing gaps with NAS operational security systems. CAASD has also defined a strategy to systemically address the gaps and inform the requirements that are under development.

CAASD provided a UAS data collection and information exchange schema to IPP aligned with FAA EIM principles. That schema is now in use.

Finally, as an element of CAASD's UAS EIM research for the FAA's Chief Data Officer, CAASD provided a UTM data and information exchange architecture to the UTM Pilot Program that illustrated how certain data and information is proposed to move across the industry and into the FAA. The architecture highlighted data access points and drove discussions on gaps in existing planning and integration challenges with existing FAA systems.

[FY20] CAASD continues to partner with FAA organizations to advance and refine functionality and utility of UAS data and information exchange across the agency. CAASD will evaluate existing system challenges and consider alternative options being developed commercially.

[FY21–FY23] CAASD will continue to actively partner with the FAA to inform policy that enables full data and information integration of UAS operations into the NAS. In addition, CAASD will continue to enhance and develop paths to streamline FAA UAS data collection, processing, and information sharing with the UAS community.

Unmanned Aircraft Systems Command and Control

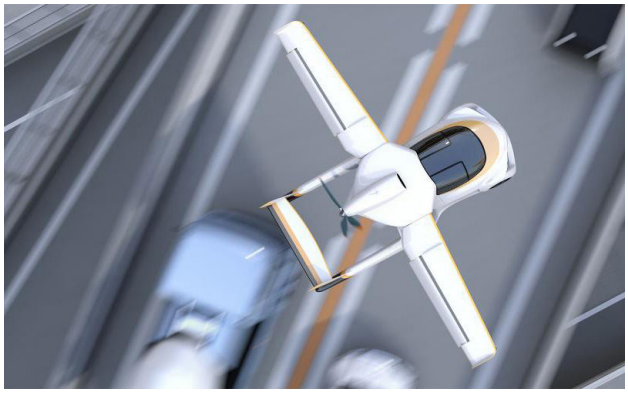
Robust C2 radio links are essential to support safe UAS BVLOS operations. CAASD has worked to identify appropriate C2 link performance metrics, developing modeling and simulation capabilities to predict C2 link performance, and establishing minimum performance requirements for C2 link alternatives.

In FY18 CAASD conducted simulations to learn how efficiently and effectively C2 links that are compliant with FAA Technical Standard Order TSO-C213 can operate in available radio frequency spectrum and how well UAS Control and Non-Payload Communications Terrestrial Link System Radios can do so.

[FY19] CAASD provided technical inputs to RTCA for developing minimum performance standards for various C2 link technology alternatives, including satellite and terrestrial radio networks. This work included helping to update the minimum performance standards established in RTCA DO-362, C2 Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial). CAASD also provided updates to several portions of RTCA DO-377, the minimum aviation system performance standards (MASPS) document for UAS C2 link systems. CAASD provided technical analyses of spectrum planning, satellite communications, network architecture, operational performance assessment, and other issues affecting the future of UAS C2. CAASD also collaborated with UAS IPP participants in C2-related activities.

[FY20] CAASD is continuing to make technical contributions to RTCA for the development of UAS C2 link standards, including both MASPS and MOPS. CAASD's systems engineering work and technical analyses are considering end-to-end functional and performance requirements for various UAS use cases, regardless of the specific communications technologies used. Subject areas include terrestrial systems, multiple-access networking, beyond-radio line of sight (BRLOS) systems, satellite-based systems, and radio frequency (RF) interference analyses in L- and C-bands. CAASD's work will help to ensure the future productive and efficient use of the valuable segments of radio spectrum that have been earmarked for UAS C2. CAASD will continue to collaborate with UAS IPP participants in C2-related activities.

[FY21–FY23] The FAA envisions that CAASD will continue making technical contributions to the FAA's assessment of C2 communications link alternatives. CAASD will also support the FAA in establishing the minimum performance requirements to support the UAS industry's deployment and operations of robust C2 link services for safe large-scale BVLOS UAS operations throughout the NAS.



International Global Navigation Satellite System Standardization

The U.S. GPS, GNSS, and the FAA's Wide Area Augmentation System (WAAS), a Satellite-Based Augmentation System (SBAS), are the "gold standards" throughout the world for civil aviation positioning, navigation, and timing. Not surprisingly, there are now efforts by other nations to develop their own GNSSs and GNSS augmentation systems. However, uncoordinated efforts may interfere with, or even prevent, the navigation services used by international civil aviation.

To ensure successful deployment of enhanced capabilities using multiple frequencies instead of a single frequency, CAASD provides technical advice to the U.S. member of the ICAO Navigation Systems Panel on developing standards and recommended practices for GNSS service providers. CAASD also provides in-depth analyses and extensive content recommendations for MOPS for avionics manufacturers. These efforts ensure internationally harmonized progression in deploying ever-more-capable civil positioning and navigation capabilities, without degrading existing capabilities.

[FY19] CAASD provided technology inputs and contributed on international regulatory issues that enabled ICAO's Navigation Committee to formulate recommendations at the ICAO 13th Air Navigation Conference in Montreal (October 2018) for global usage of multiple constellations. Use of multiple constellations will provide more frequencies from multiple satellite constellations, which will enable positioning performance improvements worldwide. The recommendations were the result of two years of engagement with ICAO members to develop an agreed-upon concept of operations, which will span the next 30 years of dual-frequency, multiple-constellation (DFMC) deployment, adoption, service, and avionics implementation. CAASD's engagement ensured that the U.S., one of 190-plus ICAO member nations, is among the countries leading the worldwide standardization of GNSS for civil aviation.

[FY20] CAASD continues engagement at both the international service and certifications level and at the avionics manufacturer level. CAASD's international engagement will include publication of updated standards and recommended practices for GNSS augmentation systems, plus draft standards for multi-frequency GPS services. This engagement at the avionics manufacturer level will reconcile aircraft avionics standards emerging from the European Organization for Civil Aviation Equipment with standards development by U.S. standards organizations.

[FY21–FY23] The FAA envisions CAASD will provide in-depth technical and operational analyses and position papers to achieve approval for international DFMC GNSS services standards, plus the necessary DFMC GNSS avionics standards for safe, effective, and seamless civil aviation GNSS usage throughout the world.

ACCOUNTABILITY

ADVANCE INFORMATION TECHNOLOGY MODERNIZATION, WORKFORCE IMPROVEMENTS, AND REGULATORY REFORM

Global Data Exchange and Harmonization

The FAA plays a leadership role in improving air traffic safety, 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 analyses that shape global standards, enable collaboration, and align FAA resources to the international harmonization activities that ensure global interoperability.

The FAA, in partnership with the global aviation community, is working to ensure that the NAS is globally interconnected through data exchange and harmonized through standards, procedures, and avionics milestones. ICAO flight planning provisions are dependent on data exchange standards defined within the Flight and Flow Information for Collaborative Environment (FF-ICE) requirements. These requirements define the international data exchange standards for flight planning, flow management, and trajectory management, and are expected to be a cornerstone of TBO.

[FY19] CAASD continued to participate on the ICAO Air Traffic Management and Requirements Panel (ATMRPP), which develops standards and recommended practices, implementation guidelines, and global implementation strategy for the FF-ICE concept. CAASD collaborated with the FAA and other stakeholders on the development of these documents, developed demonstration software, and participated in validation exercises at the Florida Test Bed. These exercises required the use of the Flight Information Exchange Standard, which CAASD evaluated to determine suitability for emerging data serialization standards. Together with the FAA and the Single European Sky ATM Research (SESAR) Joint Undertaking (SJU), CAASD developed the scope of the second release of FF-ICE, in-flight trajectory negotiation, and received endorsement of this scope from the ATMRPP. CAASD developed and investigated various alternatives to leverage existing Airborne Rerouting (ABRR) and the Trajectory Options Set (TOS) for earlier implementation of post-departure negotiation.

[FY20] CAASD is further defining the post-departure negotiation for FF-ICE Release 2, in collaboration with the FAA and the SJU, to provide a seamless transition from Release 1. Capabilities and flight information services developed for pre-departure planning are being leveraged for post-departure negotiation. CAASD is collaborating on validation of approaches to post-departure negotiation through software development and participation in live flights, demonstrations, and tabletops at the Florida Test Bed. CAASD has also been developing scenarios describing the interaction of FF-ICE with existing TFM capabilities and has been investigating approaches for aircraft operators to consider fleet impacts when conducting individual flight negotiation. CAASD is conducting benefits evaluation of trajectory synchronization between FAA flow management systems.

[FY21–FY23] CAASD will provide analysis and validation to support the FAA's goal of global interconnectedness and harmonization. CAASD will provide analysis results to the FAA to support its recommendations to the ICAO working groups that are formulating future data exchange standards and implementation milestones.

Workforce Training Improvements

The FAA is preparing for the future by improving how it recruits and 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's work is helping the FAA to address its ATC workforce hiring and training priorities by drawing upon its change management expertise.

Organizational change management and effectiveness is 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 initial TBO. 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 tailored communications and a communications plan for iTBO.

CAASD works in collaboration with the FAA to define key implementation roles and responsibilities, workforce behaviors, and survey teams to understand how best to empower people and teams 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 aptitude early in the training process, the FAA could improve the selection, placement, and training of ATC students and reduce training costs by reducing failure rates.

To explore the validity and benefits of early aptitude assessment, CAASD is developing and evaluating 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 been evaluating the RVAT prototype with students at the FAA Academy. The results from the initial evaluation phase indicated that the RVAT is a predictor of student success at the academy.

In the next phase, CAASD correlated students' performance during field qualification testing with their performance on RVAT and installed a second prototype, *Scanning, Planning, and Flexibility (SPF) aptitude test*, at the Civil Aerospace Medical Institute (CAMI) and began development of the final prototype - the Filtering and Inductive Reasoning (FaIR) aptitude test.

[FY19] In FY19, data collection and assessment for RVAT and SPF continued. Preliminary, incomplete assessments indicate that both capabilities predict student success in training.

[FY20] In FY20, CAASD is completing the assessment of field qualification training performance data to determine the correlation between RVAT performance and student overall performance in training. CAASD will also complete the initial assessment of SPF data and student performance data to determine whether SPF is predictive of student success at the FAA Academy. Further, CAASD will complete and install the FaIR aptitude test prototype at CAMI and begin evaluation. The FaIR prototype is the third and final aptitude test prototype in the suite, and is designed to assess student information and data filtering and inductive reasoning aptitudes and abilities.

[FY21–FY23] The FAA envisions CAASD will collect performance data from students participating in the evaluation of the three aptitude test prototypes so that the relationship between aptitude test performance, training performance, and ultimately success in achieving certification as an air traffic controller can be finalized. Additionally, CAASD will work in partnership with the FAA to leverage the positive results of the RVAT evaluation to support students throughout training and improve overall training success.

Real-Time ATC 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 student performance is critical to understanding training effectiveness. Specifically, measurement of student performance can be used to identify training content and design shortfalls and to identify specific, targeted training needs and opportunities for individuals to improve their performance.

[FY19] Understanding student performance as a measure of training effectiveness can also support the measurement of the effectiveness of NAS operations and the value and benefits acquired from new operational technology, processes, and procedures. Identifying and collecting objective ATC performance metrics has been a consistent challenge in training. To address this challenge, in FY19 CAASD designed an incremental, multi-year research effort to automate the measurement of ATC operational performance and identify training needs and enhancements for controllers through the definition, collection, assessment, and feedback of data captured during operation.

[FY20] CAASD is developing a concept of operations for the automated, real-time capture, assessment, and feedback of ATC performance data during operation. The development of this concept of operations will be done in collaboration with FAA and National Air Traffic Controllers Association (NATCA) stakeholders. The concept will define the research objectives, identify data sources and uses, and describe the operational functionality. The concept will also include a "use case" to illustrate the approach, uses, and benefits.

[FY21–FY23] Following the development of the concept of operations, CAASD will create a demonstration of the design and user interface that will illustrate the data collection and feedback process. The demonstration will enable the FAA and other stakeholders to visualize the capability's use and potential benefits. The demonstration will leverage capabilities in CAASD's aviation research laboratory and CAASD's extensive ATC training research background and expertise. Based on the success of the demonstration, CAASD will work in partnership with the FAA and NATCA to conduct a field test of the data collection and feedback capability to further illustrate the concept and benefits and to reduce risks to operational integration.

ENHANCING GLOBAL LEADERSHIP

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

GLOBAL HARMONIZATION

INTERNATIONAL HIGHLIGHTS

MITRE'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.

Spain: Arrival-Departure Window Analysis for Madrid Barajas Airport

MITRE, through our sponsor in Spain, Ingeniería y Economía del Transporte, S.A. (INECO), is supporting Enaire (the Air Navigation Service Provider of Spain) in investigating options for improving operational efficiency at Madrid Barajas Airport (Barajas).

Of particular concern is the risk associated with potential midair collisions and wake vortex encounters between departing aircraft and arriving aircraft that execute a missed-approach procedure, where their respective flight paths intersect.

These risks can be mitigated operationally through a controller decision support aid known as Arrival-Departure Window (ADW). This window defines a zone where an arriving aircraft, executing a missed approach, presents a potential risk of collision or wake vortex encounter with a departing aircraft.

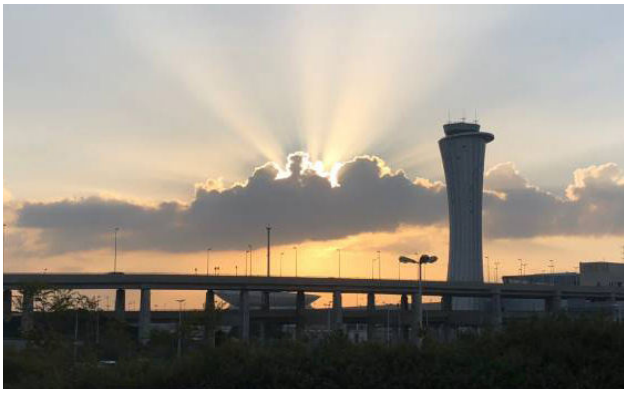
A methodology to evaluate the risk of collision and determine appropriate ADWs was developed by MITRE and has been utilized in the United States to analyze numerous airports with intersecting or converging runway operations. While not required in the U.S., MITRE has extended the application of the ADW development tools to incorporate wake vortex encounter risk. MITRE relied on this methodology, along with aircraft characteristics data and wake vortex models provided by the FAA, to develop ADWs for Barajas.

Since the construction and commissioning of two pairs of parallel runways at Barajas, an ADW has been utilized to mitigate these risks. Enaire asked MITRE to use its modeling tools to determine whether such ADWs are necessary and, if so, whether the current ADWs are appropriate for each of the two runway configurations for which they are applied. MITRE completed its ADW analysis of Barajas in August 2018 and recommended the adoption of ADWs that are less restrictive than those currently implemented by Enaire. The new ADWs will not only increase the operational capacity at Barajas, but will provide a noise benefit in South Flow, by allowing more arrivals to be assigned to Runway 18L rather than Runway 18R, where they currently overfly a residential area just north of Barajas.

Israel: Resolving Air Traffic Capacity Problems in a Small Country

Israel is a small country, about the size of New Jersey, with a single international airport (Ben-Gurion) in the central part of the country between the cities of Tel-Aviv and Jerusalem that effectively serves the whole country.

In recent years, since the signing of an open skies agreement with the European Union, Ben-Gurion has experienced tremendous growth in the number of passengers and commercial flights, to the point that the airport is expected to become saturated within the next few years with no space for further expansion. The Civil Aviation Authority of Israel contacted MITRE to assist them in the determination of aeronautical feasibility to construct a complementary airport in northern Israel—an airport that will likely need to continue to operate as an active military airbase for the defense of the country (a joint military civil airport). The airport would need to absorb the expected overflow of new flights in the long-term once Ben-Gurion reaches saturation.



It is a challenging project given the size of the country, the rapidly expanding new cities to accommodate the increasing population, the numerous airbases within the country, and sensitive airspace restrictions. Noise exposure to surrounding communities at the potential site has also proven to be of considerable importance and sensitivity. MITRE has demonstrated the feasibility of the airport and it is now preparing to assist the nation in the design of a sharply modernized airspace.

Mexico: Air Traffic Flow Management Planning

Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM), the Air Navigation Service Provider of Mexico, currently utilizes an internally developed program to help Air Traffic Flow Management (ATFM) in the proximity of Mexico City International Airport, the busiest airport in Mexico (currently operating above its operational capacity).

In order to ensure the efficient flow of traffic to and from Mexico City, and to the extent possible, MITRE is assisting SENEAM in developing an integrated vision and preliminary plan for ATFM.

MITRE is conducting detailed analyses of the Mexican airspace operational environment to identify existing issues, challenges, and bottlenecks. The results of these analyses will be used to develop a future vision and Concept of Operations (ConOps) for ATFM in Mexico. MITRE will assist SENEAM in making key decisions for deploying advanced ATFM-related tool capabilities to improve air navigation efficiency in the Mexico City area and throughout the nation. MITRE's ATFM project in Mexico is being closely watched by high-level aviation officials and is advancing at a steady pace.

Runway Operations in Asia Pacific

MITRE Asia Pacific Singapore (MAPS) is MITRE's first Research & Development center outside the United States, and it provides a collaborative research platform to explore methods for regional harmonization in aviation and cyberspace, and to facilitate consensus building across a diverse range of stakeholders.

Our advanced technology research laboratory focuses on air traffic management in Singapore to meet the growing demand and unique challenges of the Asia Pacific region. This year, our work included:

- Impact of three runway operations on Changi Airport: We worked with Singapore Airlines, CAAS, and CAG to understand how the transition to three runways operations will affect the airport operator, the home airline, and ai navigation service provision. We examined the impacts and identified possible changes that could alleviate any negative impacts. It was an important role for CAASD in bringing the Singapore aviation stakeholder community together to find solutions that balanced the different needs.
- Changi three runway CONOPS: CAASD brought its expertise in defining triple independent runway operations gained from the U.S. to help Singapore maximize its use of three runways at Changi Airport.

INNOVATION AND ACCELERATION

Partnerships

To support the FAA and accelerate the adoption of new technologies and methods, CAASD partnered 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.

In FY19, CAASD established partnerships with several organizations to further its support of the FAA work program, including:

- An agreement with NASA to partner on an initiative designed to ensure the safety and efficiency of the NAS as the commercial space industry continues to grow.
- A multi-year partnership with the State of North Dakota to support UAS Systems Engineering and Urban Air Mobility testing
- A risk model study for Kittyhawk as they explore mobility in urban and natural environments.

Research and Development

MISSION-ORIENTED INVESTIGATION AND EXPERIMENTATION

The CAASD sponsoring agreement recognizes the importance of innovative, future-looking research and analysis, and established 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 objective thrusts of the MOIE work program include:

1. *Serving as a Catalyst for Transformational Improvements* – 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 to move in a forward direction.
3. *Preparing for the Future* – by ensuring that information, methods, and models have been defined and developed to answer the FAA's emerging needs.

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

During 2019, the research portfolio was comprised of eight independent research and development projects. These projects were conducted to advance the three objectives of the MOIE work program. These research thrusts support the FAA's research goals associated with improving airport

operations, air traffic, and airspace management capabilities; accelerating the use of new technologies for aerospace vehicles, airports, and spaceports; and improving integrated modeling capabilities and system-wide analysis. The FY19 projects included:

1. Using Mobile Technologies to Accelerate Flight-Deck Equipage for Future
2. Applying Blockchain Technologies for the International Flight Object
3. Enabling Efficient and Collaborative Aerospace Operations Management
4. Fostering Innovation through Open Source Software Development Using SWIM
5. Validating Autonomous Control Standards
6. Transforming Analytics through the Integration of New and Disparate Data Sources
7. Enabling the Network Analysis of TBM Operations through Modeling and Simulation
8. Modeling and Simulation for Reliable Long-Term Evolution (LTE)-Based Communications and Information Management

In FY19, CAASD applied findings and capabilities from the

MOIE program to multiple FAA and other MITRE FFRDCs' sponsored projects:

- Autonomous Control Standards project findings were used to update the ASTM F3269 standard (Standard Practice for Methods to Safely Bound Flight Behavior of Unmanned Aircraft Systems Containing Complex Functions)
- The Voice Dialogue Modeling project helped to improve speech recognition capabilities by enhancing the capture of pilot-controller dialogue, enabling the recognition of both words and context.
- The Composable Modeling and Simulation project established a new modeling and fast-time simulation capability that provides flexible components that can be adapted quickly for use in any experiment. This capability was used in developing the FAA's SE2 Benefits Analysis capability in FY19 which is expected to be completed in FY20.
- The RIA modeling and simulation capability, hosted at the CAASD IDEA Lab, is planned for use at Wallops Island as part of MITRE's work with NASA. This work, funded in part through MITRE-internal sponsored research and special initiatives, is expected to have direct value to the FAA.

The FY20 MOIE portfolio will be conducted within the three objective thrusts as outline below:

Serving as a Catalyst for Transformational Improvements

- Electronic Flight Bags to Accelerate and Broaden Equipage for Future Operations
- Using Industry 4.0 Technologies (e.g., AI, Internet of

Things, autonomous systems, cyber-physical systems, etc.) for Certification in a Future Aviation System

- Automated Health Monitoring and Self-Healing for NAS Systems
- Developing In-Time Safety Risk Metrics for Airports

Understanding Future Technologies and Operations

- Performance-Based Separation Methods for Higher Airspace
- Artificial-Intelligences Enabled TFM

Preparing for the Future

- Reconfigurable Fast-Time Aerospace System Simulation

MITRE INNOVATION PROGRAM

In addition to the MOIE program, MITRE provides funding for its internal MITRE Innovation Program (MIP). Within the MIP Aviation and Transportation research portfolio, projects are designed to explore future concepts and capabilities while also aligning with sponsor outcomes and strategies. In FY19, the following milestones were accomplished:

- Completed a system dynamics model of sUAS adoption in the U.S.
- Evaluated the costs of in-flight medical diversions
- Developed operational concepts for integrating Urban Air Mobility vehicles into the NAS
- Collaborated with an airline to develop a decision-support capability for responding to ground delay program
- Improved simulation capabilities for evaluating WAAS performance.

This work advanced the adoption of new capabilities across the aviation community.

Technology Transfer

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

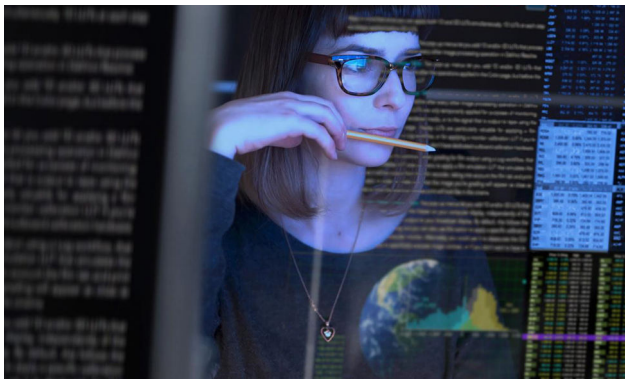
Technology transfer is possible via the following methods:

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

CAASD staff produce innovations that, through their technology transfers, have advanced the state of the art and have had practical application to the safety of ATM. Highlights from FY19 include:

ATC Training and Innovation: Assisting Controllers in the Field

- In-the-field airspace and vector training that aids new and experienced controllers with developing their skills and learning the airspace, operations, and facility Standard Operating Procedures (SOPs)
- Validated Potomac and Miami TRACONs
- In use at New York TRACON by developmental controllers
- Technology transitioned to FAA Safety and Technical Training division (AJI)
- AJI's contractor, RIGIL Corporation, deployed the technology on iPads and is managing the system



Aviation Risk Identification and Assessment

- ARIA is a cornerstone program of the FAA's transition to risk-based decision making; it reduces cost, time, and improves FAA's knowledge of risky events
- CAASD worked with AJI to develop a risk-based identification and reporting capability
- ARIA is being integrated into FAA quality assurance processes for risk events

Technology Agreements/Licenses/ Patents

In FY19, the following technology agreements and licenses were issued for FAA-funded, CAASD-developed technologies:

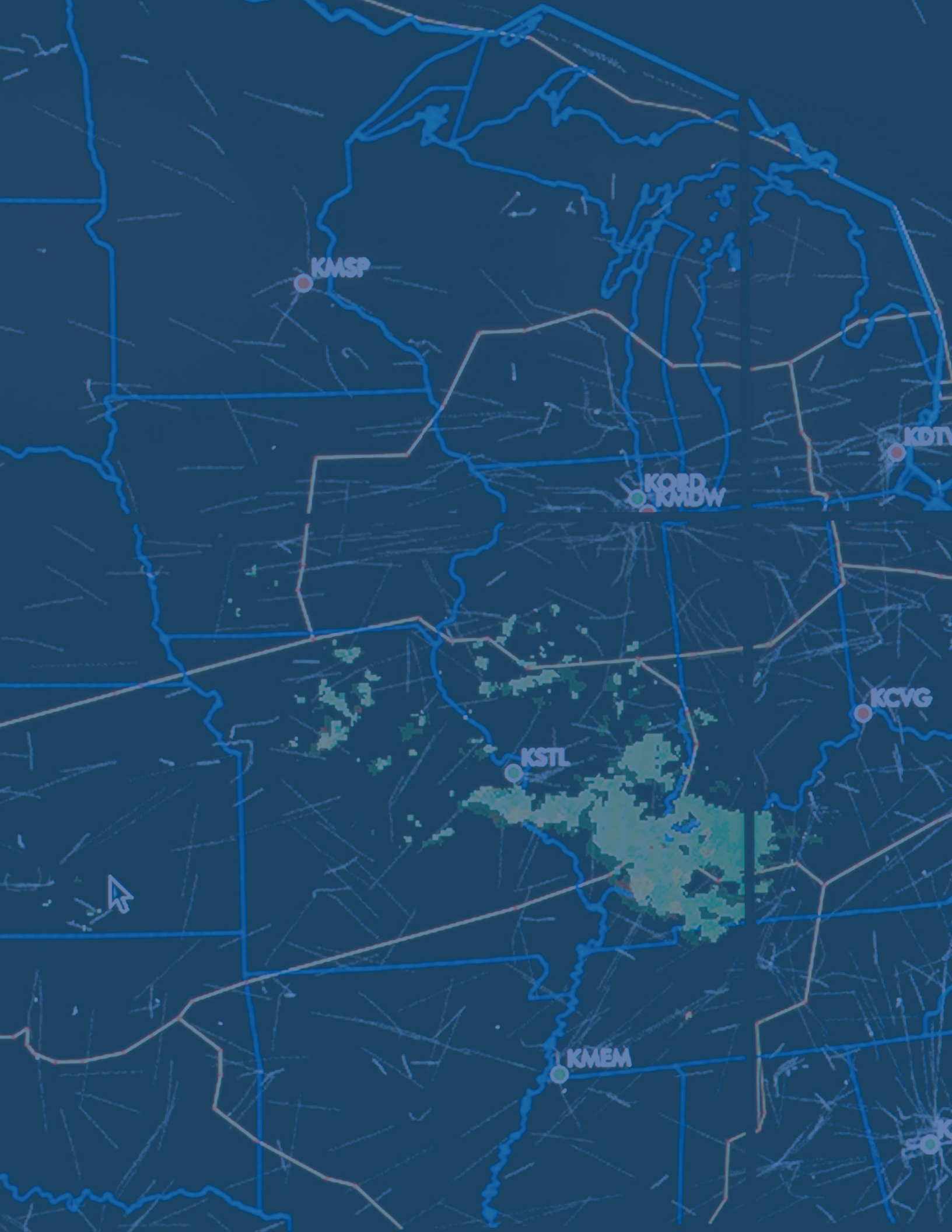
CAASD-developed Technology	FY19 Technology Agreements/Licenses Issued
Assigned Spacing Goal Calculator for Paired Approach	2
Exhaust Plume Analyzer	7
RunwaySimulator	2
sUAS Risk-Based Safety Analysis Model	1
TARGETS	4

The table below shows patents issued to CAASD staff in FY19 and are listed chronologically by issue date (far right column) starting with most recent.

Patent No.	Application No.	Patent Title	Application Date	Issue Date
10,360,801	15/199,218	Systems and Methods for Departure Routing	6/30/2016	7/23/2019
10,321,221	15/978,818	Aviation Intercommunication System to Mobile Computing Device Interface	5/14/2018	6/11/2019
10,318,819	14/988,603	Camera Surveillance Planning and Tracking System	1/5/2016	6/11/2019
10,243,646	14/827,733	Performance-based Link Management for Air Traffic Control	8/17/2015	3/26/2019
10,163,356	15/203,495	Systems and Methods for Displaying Aircraft Separation Information	7/6/2016	12/25/2018
10,140,872	14/988,576	Camera Surveillance Planning and Tracking System	1/5/2016	11/27/2018
10,107,643	14/047,549	Message Filtering Based on Where you are Going, Plan, Intent, Expectation, or Route	10/7/2013	10/23/2018

FFRDC OPERATIONS & STEWARDSHIP

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.


KMSP
KDTW
KORD
KMDW
KCVG
KSTL
KMEM

Integration Demonstration and Experimentation for Aeronautics Lab

The CAASD IDEA Lab enables FAA improvements to current ATM systems and provides an environment to envision the needs and test possibilities for future aerospace and transportation systems.

The lab is a real-time modeling and simulation laboratory 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 human-in-the-loop simulation and visualization to enable the investigation of a broad range of ATM/communications, navigation, surveillance (CNS) concepts.

In FY19, the CAASD Idea Lab conducted 23 evaluations/experiments, requiring over 100 days of data collection. CAASD also conducted 71 project demonstrations, 44 of which were to external FAA and commercial stakeholders.

Aviation Discovery Lab

The CAASD Aviation Discovery Lab provides a unique capability to access any of CAASD's aviation-related data sources from one location. It serves as a collaboration space where analysts and decision makers can work with data in a safe, secure environment collaboratively with government and industry working groups.

The lab focuses on aviation safety analysis and vulnerability discovery through the analysis of aviation data, including sensitive and proprietary airline data. The lab supports the development of the analytical foundation and tools 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 fully integrated with the CAASD IDEA Lab and is the only such facility in the world.

The CAASD Aviation Discovery Lab is an integral part of CAASD's efforts to help the FAA and 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 can be applied to other FAA work areas. Key among these capabilities is working with sensitive airline and air traffic safety data in a protected environment. 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.

In FY19, the CAASD Aviation Discovery Lab conducted 45 demonstrations and government/industry working group sessions in support of ASIAS and CAST. These multi-day sessions leveraged the lab's collaboration capabilities to enable subject matter expert review of analysis findings and drilldown into the identified safety risks, without sensitive 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 (GAJSC) in a timely manner for mitigation.

Key CAASD Capabilities

CONNECTED DATA ARCHITECTURE

CAASD's Connected Data Architecture (CDA) provides a unique capability for CAASD staff to ingest, store, manage, and fuse large amounts of aviation-related data and then access this data from a suite of integrated tools.

CAASD invested in shared and cross-cutting data capabilities across all CAASD Outcomes that support ongoing and emerging business needs to ensure CAASD achieves its strategic missions and aspirations. These data capabilities enable staff to perform timely and in- depth analyses in response to FAA requests and is increasingly able to receive more data types, at faster rates, and in higher volumes.

TRANSPORTATION DATA PLATFORM

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 Transportation Data Platform (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 40 base and derived data services, amounting to 100 Gigabytes (GB) of data per day, 3 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)

Advocacy and Recognition

A key 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 2019 CONFERENCE PARTICIPATION

CAASD participates in a broad range of aviation and aerospace conferences each year to both learn and share. CAASD staff are frequent contributors of technical papers and presentations and are often invited to serve as subject matter experts on educational panels and plenary sessions. Key CAASD technical personnel also are regular keynote speakers. In FY19, in addition to significant participation in educational theaters and panels, CAASD shared technologies and demonstrations at three major domestic aviation conferences (NATCA Communicating For Safety

At the RTCA 2019 Global Aviation Symposium, CAASD communications engineer Dongsong Zeng (second from left) received an Outstanding Leadership Awards for his contributions to Special Committee 214: Standards for Air Traffic Data Communication Services.

(CFS), Air Traffic Control Association (ATCA) Annual Meeting, FAA Managers Association (FAAMA) Gathering of Eagles). In addition, CAASD team members were invited to join both FAA and commercial partners at other conferences (Experimental Aircraft Association [EAA] AirVenture, National Business Aviation Association [NBAA]) to share demonstrations and information on specific projects. Highlights include:

- **ATCA:** Featured integrated flight deck and Pacer demos in the CAASD booth; five presentations in educational theaters
- **FAAMA:** Featured integrated flight deck and NOD demonstrations in the CAASD booth along with providing key demos to FAA leadership
- **EAA AirVenture:** Participated in the NASA booth at their invitation to showcase Pacer and ATD-2 work
- **NBAA:** Participated with the NBAA team in their booth to showcase and sign up GA pilots for Pacer
- **NATCA:** Hosted a booth featuring integrated flight deck and Pacer demos; and participated on the UAS panel.

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 FY19 CAASD-provided content appeared in:

- *FAAMA Managing the Skies*
- *Aviation Today*
- *Aviation Week*
- www.mitre.org.

CAASD has already established additional content partnerships for FY20 to include ATCA publications and the American Association of Airport Executives (AAAE) Airports.

SAFETY MANAGEMENT SYSTEM (SMS) TRAINING COURSES

A 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. SMS is required by ICAO 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 FY19, CAASD held seven training sessions for a total of 44 students.

GLOSSARY

Acronym	Definition
4DT	Four-Dimensional Trajectories
AAAE	American Association of Airport Executives
AAC	Aviation Advisory Committee
ABRR	Airborne Rerouting
AC	Advisory Circular
ADS-B	Automatic Dependent Surveillance-Broadcast
AEB	ASIAS Executive Board
AFS	FAA Flight Standards
AI	Artificial Intelligence
AIT	FAA information technology divisions
AJI	Safety and Technical Training
AJR	System Operations Services
AJR-G	Systems Operations Performance Analysis
ALM	Approach and Landing Misalignment
ALTRV	Altitude Reservations
AMS	Acquisition Management System
AOA-1	FAA's office of the administrator
AOC	Airline Operations Centers
APM	Airport Planning Manual
APM	Airport Planning Manuals
ARIA	Aviation Risk Identification and Assessment
A-RNP	Advanced Required Navigation Performance
ARTCC	Air Route Traffic Control Center
ASAP	Aviation Safety Action Program
ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air Traffic Control
ATCA	Air Traffic Control Association
ATCSCC	Air Traffic Control System Command Center
ATD-2	Airspace Technology Demonstration-2
ATM	Air Traffic Management
ATMRPP	Air Traffic Management and Requirements Panel
ATO	Air Traffic Organization
AVS	Aviation Safety

Acronym	Definition
BA	Business Aviation
BFI	Boeing Field
BRLOS	Beyond Radio Line of Sight
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CA	CDTI Assisted
CAAS	Civil Aviation Authority of Singapore
CAASD	Center for Advanced Aviation System Development
CAMI	Civil Aerospace Medical Institute
CAPS	COA Application Processing System
CAST	Commercial Aviation Safety Team
CDA	Connected Data Architecture
CDTI	Cockpit Display of Traffic Information
CFR	Code of Federal Regulations
CFS	Communicating for Safety
CLT	Charlotte Douglas International Airport
CNS	Communications, Navigation, Surveillance
COA	Certificate of Waiver or Authorization
CRDA	Converging Runway Display Aid
DFMC	Dual-Frequency, Multiple Constellation
DFW	Dallas Fort Worth International Airport
DLRW	Dynamic Launch and Reentry Window
DME	Distance Measuring Equipment
DOD	Department of Defense
DSP	Departure Sequencing Program
DVT	DME, VOR, and TACAN
EAA	Experimental Aircraft Association
E-IDS	Enterprise Information Display System
EIM	Enterprise Information Management
ERAM	En Route Automation Modernization
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
FAAC	Flexible Airspace Access Control
FAAMA	FAA Managers Association
FaIR	Filtering and Inductive Reasoning
FANS	Future Air Navigation System
FEB	FFRDC Executive Board
FENS	FAA Enterprise Networking Services

Acronym	Definition
FF-ICE	Flight and Flow Information for Collaborative Environment
FFRDC	Federally Funded Research and Development Center
FID	Final Investment Decision
FL	Flight Level
FMS	Flight Management System
FOQA	Flight Operations Quality Assurance
FTI	FAA Telecommunications Infrastructure
FY	Fiscal Year
G4	FAA Group of 4
GA	General Aviation
GAJSC	General Aviation Joint Steering Committee
GB	Gigabyte
GCRA	Ground Collision Risk Assessment
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IAT	Issues Analysis Team
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDEA	Integration Demonstration and Experimentation for Aeronautics
IDRP	Integrated Departure Route Planning
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
IT	Information Technology
iTBO	initial Trajectory-Based Operations
JARUS	Joint Authorities for Rule Making on Unmanned Systems
KCLT	Charlotte Douglas International Airport
KDAL	Dallas Love Field
KHND	Henderson Executive Airport
KIT	Keep Intent and Time
KLAS	McCarran International Airport

Acronym	Definition
LOB	Line of Business
LTE	Long-Term Evolution
MARS	Multiple Airport Route Separation
MASPS	minimum aviation system performance standards
MGFI	MITRE Global Flight Informatics
MIP	MITRE Innovation Program
ML	Machine Learning
MMMX	Mexico City International Airport
MOIE	Mission-Oriented Investigation and Experimentation
MON	Minimum Operational Network
MOPS	Minimum Operational Performance Standards
MPLS	Multi-Protocol Label Switching
MTS	MITRE Technical Staff
NAP	Noise Abatement Procedures
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NAVAID	Navigation Aid
NBAA	National Business Aviation Association
NEC	North East Corridor
NextGen	Next Generation Air Transportation System
NG	Next Generation
NOD	NAS Operations Dashboard
NTSB	National Transportation Safety Board
OM	Outcome Manager
OPD	Optimized Profile Descents
ORAP	Operational Risk Assessment Prototype
PBN	Performance-Based Navigation
PBWP	Product-Based Work Plan
PERTI	Planning Execution Review Training and Improvement
PHL	Philadelphia International Airport
PSP	Partnership for Safety Program
QPRB	Quarterly Product Review Boards
RA	Resolution Advisory
RAST	Regional Aviation Safety Team
RF	Radio Frequency
RFP	Request for Proposal
RIA	Rapid Impact Assessment

Acronym	Definition
RNAV	Area Navigation
RNP	Required Navigation Performance
RVAT	Radar Vectoring Aptitude Test
SAA	Special Activity Airspace
sAAT	sUAS Airworthiness Assessment Tool
SBAS	Satellite Based Augmentation System
SBS	Surveillance and Broadcast Services
SC	Special Committee
SDI	Space Data Integrator
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departures
SIR	Screening Information Request
SJU	SESAR Joint Undertaking
SMS	Safety Management System
SOA	Service Oriented Architecture
SOP	Standard Operating Procedure
SORA	Specific Operational Risk Assessment
SPF	Scanning, Planning, and Flexibility
sUAS	small Unmanned Aircraft System
SW	Software
SWIM	System Wide Information Management
SY	Staff Year
TACAN	Tactical Aircraft Control and 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 Collision Avoidance System
TDLS	Tower Data Link System
TDP	Transportation Data Platform
TEB	Teterboro Airport
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
TFMS	Traffic Flow Management System
TFR	Temporary Flight Restrictions
TLO	Technical Liaison Officers

Acronym	Definition
TMI	Traffic Management Initiatives
TOS	Trajectory Options Set
TRACON	Terminal Radar Approach Control
TSO	Technical Standard Order
U.S.	United States
UAS	Unmanned Aircraft Systems
UASIP	UAS Implementation Plan
UFB	Unmanned Free Balloons
ULT	UAS Leadership Team
UPP	UAS Traffic Management Pilot Program
URL	Uniform Resource Locator
UTM	Unmanned Traffic Management
VCRA	Volumetric Collision Risk Assessment
VHF	Very High Frequency
VNAV	Vertical Navigation
VNY	Van Nuys Airport
VOR	Very High Frequency Omni Directional Range
VOR	VHF Omni-directional Range
WAAS	Wide Area Augmentation System

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