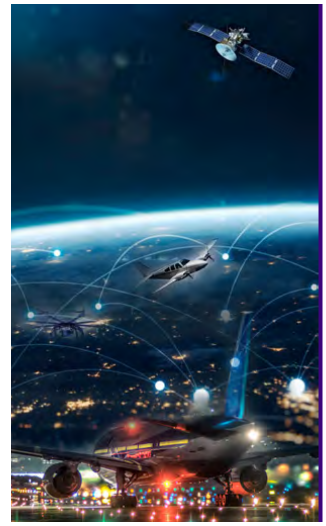
U.S. Department of Transportation
Federal Aviation Administration

NextGen
Annual Report

Fiscal Year 2021



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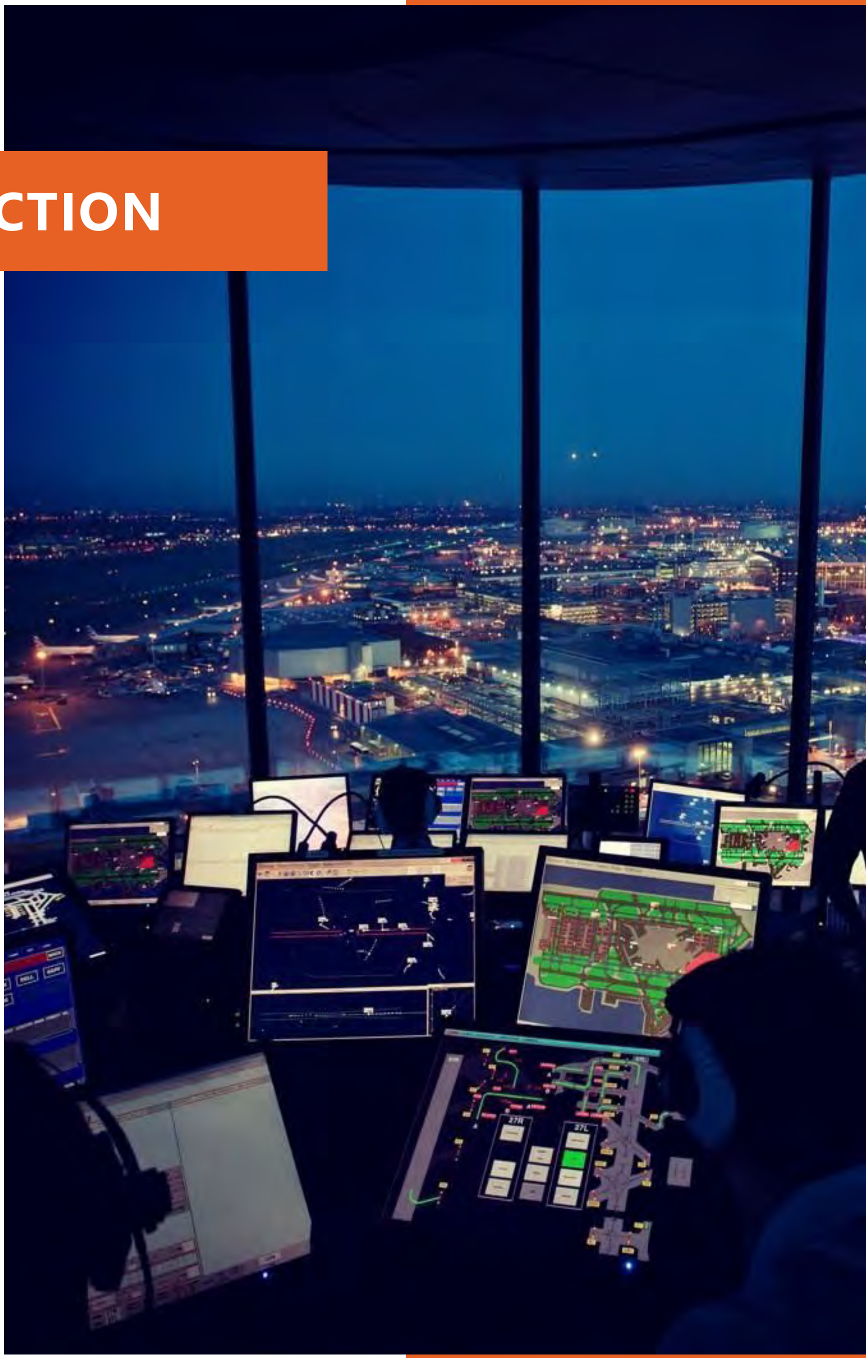
The Next Generation Air Transportation System (NextGen) is a complex network of new and existing technologies, procedures, and policies that collectively work with the completed modernized infrastructure. Although funding for many of the programs described in this document can be traced to congressional authorization for NextGen, some systems funded through other sources enable full realization of the National Airspace System (NAS) transformation. This document also covers these non-NextGen programs, which are important to transformation of the NAS.

INTRODUCTION



The Federal Aviation Administration (FAA) began its second decade of comprehensive airspace modernization with the foundational infrastructure for the Next Generation Air Transportation System (NextGen) in place and a focus on the operational integration required to achieve Trajectory Based Operations (TBO), a long-term goal of NextGen. The FAA adjusted to the restrictions brought on by the COVID-19 pandemic and persevered to continue making progress with airspace modernization where able. This document serves as a singular report on NextGen's progress and plans for fiscal year 2021. Whenever possible and unless stated otherwise, the data cutoff is as of September 30, 2021. The report complies with congressional reporting requirements in the Vision 100–Century of Aviation Reauthorization Act of 2003, FAA Modernization and Reform Act of 2012, and FAA Reauthorization Act of 2018.

NEXTGEN DEFINED

NextGen is the FAA's ongoing multibillion-dollar infrastructure program to modernize the U.S. National Airspace System (NAS), which is the world's busiest and most complex. Through research, innovation, and collaboration, NextGen contributes to defining new standards and further advancing the FAA's global leadership in aviation.

NextGen is not defined as one technology, product, or goal. Rather, NextGen is a series of interlinked programs, portfolios, systems, policies, and procedures that fundamentally change aviation communications, navigation, and surveillance. Within its scope are airport infrastructure improvements, new air traffic management technologies and procedures, and environmental, safety, and security-related enhancements.

NextGen enables a more flexible—yet robust and resilient—aerospace infrastructure that will meet projected demand and support the administration's goals. It improves safety of flight paths, ensuring the safe introduction of new users into aviation, such as commercial space, unmanned aircraft, and advanced air mobility. Moreover, new technologies and procedures reduce the health effects of excessive noise and harmful emissions on vulnerable and overburdened communities. Figure 1 shows how NextGen infrastructure is enabling the transformation of our air traffic management operations. The sections that follow further describe these important innovations.

The FAA engages with the public and shares noteworthy practices with the aviation community to accelerate the adoption of innovative technologies. Many NextGen innovations are the product of knowledge acquired through high-risk, high-reward research, engineering, and development that is driven by policy objectives. We continue to support programs to facilitate sustainable aviation fuel consumption, new aircraft, and improved aviation operational efficiency.

As a global leader in aerospace, we also foster safe innovation and international cooperation in evolving enhanced aviation infrastructure technologies that improve system safety and mobility. The FAA implements programs in a comprehensive, cross-agency portfolio approach that recognizes modernization as an integrated effort instead of a collection of independent programs. We work with stakeholders across government, the private sector, academia, and the international aviation community to develop and deploy new capabilities.

BEFORE AND AFTER NEXTGEN

PAST PRACTICES	ENABLING PROGRAMS	NEXTGEN IMPROVEMENTS
Voice-only communications	Data Communications (Data Comm)	Digital communications
Ground-based routes and procedures	Performance Based Navigation (PBN)	Satellite-enabled routes and procedures
Radar-only surveillance	Automatic Dependent Surveillance – Broadcast (ADS-B)	Satellite-enabled near real-time surveillance
Tactical and reactive air traffic control	Decision Support System (DSS) Automation	Strategic integrated air traffic management
Point-to-point, segmented information sharing*	System Wide Information Management (SWIM)	Enterprise-level information sharing*

* The FAA shares information on SWIM and other channels in accordance with our policy on protecting sensitive unclassified information.

Figure 1. NextGen infrastructure is enabling the transformation of our air traffic management.

COLLABORATION

Successful NextGen implementation requires support and coordination among the FAA, other government agencies, and the aviation community.

FAA WORKFORCE

The FAA workforce is an essential component of NextGen development. Our labor unions collaborate with the FAA at national, regional, and local levels to better understand requirements in a changing aviation system and prepare employees for changes. As we transition to TBO, the FAA workforce is represented in NextGen working groups to provide input on the operational suitability of new technologies and to communicate recommendations.

FEDERAL AGENCY PARTNERS

Our engagement with other federal government agencies through forums and other collaborative bodies allows us to leverage stakeholder expertise while gathering resources to advance NAS modernization. We work primarily with the departments of Commerce, Defense, Homeland Security, and Interior; NASA; the National Geospatial Intelligence Agency; the National Transportation Safety Board; the Environment Protection Agency; and the Advisory Council on Historic Preservation.

FEDERAL ADVISORY COMMITTEES

The FAA collaborates with diverse stakeholders on three federal advisory committees that meet routinely throughout the year to advise us on NextGen implementation, integration of advanced air mobility technology, and aviation research.

NextGen Advisory Committee

The NextGen Advisory Committee (NAC) is a federal advisory committee responsible for responding to specific assignments from the FAA. Membership includes senior executives representing airports, manufacturers, aircraft operators, international stakeholders, labor unions, environmental interest groups, the Department of Defense, and NASA. The committee completes assignments related to concepts, requirements, operational capabilities, associated use of technology, and considerations to operations that affect the future air traffic management system. The NAC also proposes independent, nonbinding, and consensus-driven recommendations to the FAA through a task response process.

Beginning in 2019, the FAA initiated a series of focused engagements with the NAC to explore risk mitigations of specific barriers to successfully implement NextGen. These mitigation-focused and time-limited ad hoc tasks provide a mechanism for the FAA, in partnership with the NAC, to quickly address emerging issues. To date, the FAA has received advice from the NAC via ad hoc teams for Performance Based Navigation, Automatic Dependent Surveillance–Broadcast In, vertical navigation, the minimum capabilities list, and enhanced air traffic services, a congressionally mandated program specified in Section 547 of the FAA Reauthorization Act of 2018.

For more information, refer to the NextGen Joint Implementation Plan (NJIP), which describes implementation activities that align FAA and aviation community priorities, and to the NAC Tasking Ad Hoc Status Report, which describes NAC assignments focused on mitigating barriers to implementation activities described in the NJIP.

Advanced Aviation Advisory Committee

The Advanced Aviation Advisory Committee (AAAC), formerly known as the Drone Advisory Committee (DAC), is a broad-based federal advisory committee that helps the FAA identify challenges and prioritize improvements on unmanned aircraft systems (UAS) and advanced air mobility (AAM) integration issues, interests, and policies. The committee helps to foster broad support for an overall integration strategy and vision. Membership is composed of executives from a cross-section of stakeholders representing various UAS and AAM interests, such as industry and academia, and community advocates who

provide insight on potential impacts of increased drone traffic on communities.

Research, Engineering, and Development Advisory Committee

The Research, Engineering, and Development Advisory Committee (REDAC) is a federal advisory committee that provides advice and recommendations to the FAA administrator on the agency's aviation research portfolio's needs, objectives, plans, approaches, content, and accomplishments. The REDAC also assists in ensuring that present and future FAA aviation research is coordinated with similar research being conducted outside the FAA. REDAC membership comprises a representative body of subject matter professionals from aerospace and related emerging technology-focused corporations, universities, associations, and government agencies.

ACADEMIA AND RESEARCH

Through the FAA Air Transportation Centers of Excellence (COE), the FAA works with universities and industry affiliates to advance aviation technologies. This cooperation is critical for training the next generation of aviation professionals. COE focus areas include UAS, commercial space transportation, alternative jet fuels, aviation emissions, and aircraft noise mitigation. MITRE's Center for Advanced Aviation System Development, a federally funded research and development center, also supports FAA research for NextGen decision support systems and TBO concepts.

INTERNATIONAL

The role of the United States as a global leader in aerospace greatly depends on our ability to communicate and collaborate, as well as research, develop, and implement technologies around the world.

The FAA and its international partners work through the International Civil Aviation Organization (ICAO) to develop a globally connected and harmonized air traffic management system. As the aviation technical body of the United Nations, ICAO provides a forum for its 192 member states to adopt and implement international aviation standards. The FAA provides representatives for all expert panels considered necessary for the international harmonization of NextGen technologies and continues to lead in the development of the global air traffic management roadmap. The roadmap is described by the ICAO Global Air Navigation Plan, which defines the course of world aviation systems for the next 20 years.

We collaborate directly with key international partners and regional groups on relevant air traffic management modernization topics and hold international agreements with the European Union and its Single European Sky Air Traffic Management Research organization, Japan and its Collaborative Actions for Renovation of Air Traffic Systems, and Singapore for joint research and development of future air traffic systems.

Additionally, the FAA engages with potential international partners to support the adoption of U.S. standards as globally accepted standards. We work to develop bilateral relationships to harmonize existing air traffic modernization programs, such as OneSKY (Australia), SIRIUS (Brazil), and New Southern Skies (New Zealand), with NextGen technologies as well as with partners who can leverage technologies regionally, such as Thailand and the United Arab Emirates.

The FAA also continues to participate with the U.S. Trade and Development Agency and Department of Commerce to cooperate with the Association of Southeast Asian Nations, Brazil, and India to ensure U.S. aviation standards are considered in air traffic modernization planning. Our leadership within, and collaboration with, the international aviation community results in greater interoperability of avionics, communications protocols, and operational methods.

LOCAL COMMUNITIES

The FAA's engagement strategy includes working with airports and community leadership through standards bodies, ad hoc committees, task forces, and public roundtables. The goal is to understand specific challenges and determine how to implement changes that could alleviate concerns. We meet community stakeholders where they live, listen to people's concerns, and attempt to find workable solutions.

PANDEMIC RESPONSE

To protect the FAA workforce from exposure to COVID-19, and ensure the safety and continuity of the NAS, the FAA undertook widespread measures beginning in March 2020 that reduced travel and limited access to air traffic control facilities. As a result of the pandemic, the FAA suspended hardware installations, on-site recurring training, and in-person engagements that were not immediately and directly tied to safely operating the NAS. Testing and development of new technologies at the FAA William J. Hughes Technical Center in New Jersey were adapted where possible to limit in-person interaction, and were unable to operate at a normal capacity.

Work on many NextGen programs paused initially as the FAA focused on the immediate priority of employee health and safety. Once we stabilized facility operations, we transitioned some activities to remote system testing, safety panels, and site surveys. We also staged related materials at field facilities in preparation for the resumption of in-person activities.

New capability implementation always requires a complex choreography of engineering, ongoing recurrent and new training for air traffic controllers, and program management. Thus, NextGen implementation activities encountered many barriers as a result of the COVID-19 pandemic. While the FAA prudently restarted some training and on-site activities, the incurred backlog

will require time to resolve. We are continuing to assess the ramifications of the delays and revised implementation milestones for affected NextGen activities.

REPORTING BENEFITS

FAA estimates of NextGen benefits are divided into three categories: current benefits from implemented capabilities, future benefits from implemented capabilities, and future benefits from new sites and new capabilities.

We continue to work with the aviation community to build consensus on data, methodologies, and the value of NextGen improvements. This work influences how we will prioritize future implementations.

Benefits from implemented capabilities represent a portion of expected total benefits. Per the FAA's estimate, NextGen has delivered more than $7 billion in benefits through 2019. The FAA has completed post-operational analyses of more than 20 capabilities at nearly 200 locations by leveraging methodologies developed through the Joint Analysis Team, a government-industry group of experts. We project to produce more than $21 billion in total benefits by continuing to use these capabilities at these sites.

As programs and operators continue to capitalize on the deployed NextGen infrastructure, the FAA expects future benefits to expand with new sites and new capabilities. The pandemic has affected the NextGen implementation schedules and operations demand. While the underlying basis for NextGen improvements to the NAS remains firm, benefit projections are highly linked to implementation and equipage schedules as well as returning demand. As we prepared this report, volatility in these underlying factors did not support projections of future NextGen benefits.

RETURN ON INVESTMENT REPORT

In response to Section 503 of the FAA Reauthorization Act of 2018, the FAA in 2020 prepared a return on investment report for Congress that summarized the cost-benefit analysis for NextGen programs and priorities. The document was included as an appendix to the NextGen Annual Report for Fiscal Year 2020 and planned to be updated for this year’s report. However, restrictions from the pandemic have impeded

ESTABLISHED INFRASTRUCTURE

The FAA focused on establishing a base for implementing the Next Generation Air Transportation System (NextGen) during the first 10 years of the initiative. The modernized infrastructure is now in place, and this section describes some of the systems' capabilities. New digital communications enable more efficient communications between air traffic controllers and pilots. Performance Based Navigation enables shorter, more precise flight paths that allow for more fuel-efficient operations. Satellite-enabled surveillance provides the most accurate aircraft location information to controllers. State-of-the-art automation systems now in use at air traffic control facilities support the FAA staff in managing individual aircraft in the flow to effectively and efficiently use every available slot on our most congested air routes. Enterprise-level integrated information management improves shared decision-making, scheduling, and analysis.

COMMUNICATION

Data Communications (Data Comm) provides a secure digital air-to-ground link. It integrates aircraft avionics and ground air traffic control automation systems to deliver electronic messages that supplement air-to-ground voice communications. This Data Comm application is also known as Controller Pilot Data Link Communications (CPDLC).

Using CPDLC, air traffic controllers and pilots quickly and accurately send, review, and accept a variety of text-like digital messages with a push of a button, thereby reducing read back errors and communication time. Air carrier flight operations centers simultaneously receive the same information as the flight deck, providing decision-makers with shared awareness for faster reaction and agreement to flight changes. Data Comm is expected to save operators more than $10 billion and the FAA about $1 billion in operating costs over the program's 30-year life cycle.

DATA COMM IN THE NAS

Data Comm is operational at 62 air traffic control towers and three en route centers listed below and in Figure 2 as of the end of fiscal year 2021. In November 2021, Cincinnati/Northern Kentucky International Airport became the 63rd facility to activate Data Comm Tower Service. The deployment schedule for the remaining 17 en route facilities was put on hold due to COVID-19 and is being re-planned.

- Albuquerque
- Atlanta
- Austin
- Baltimore-Washington
- Boston
- Buffalo
- Burbank
- Charleston
- Charlotte
- Chicago O'Hare
- Chicago Midway
- Cleveland
- Columbus
- Dallas-Ft. Worth
- Dallas Love
- Denver
- Detroit
- Fort Lauderdale
- Fort Myers
- Houston Bush
- Houston Hobby
- Indianapolis
- Kansas City
- Las Vegas
- Los Angeles
- Louisville
- Memphis
- Miami
- Minneapolis-St. Paul
- Milwaukee
- Nashville
- Newark
- New Orleans
- New York John F. Kennedy
- New York LaGuardia
- Oakland
- Ontario
- Orlando
- Philadelphia
- Phoenix
- Pittsburgh
- Portland
- Raleigh-Durham
- Reno-Tahoe
- Sacramento
- San Juan
- St. Louis
- Salt Lake City
- San Antonio
- San Diego
- San Francisco
- San Jose
- Santa Ana
- Seattle
- Tampa
- Teterboro
- Van Nuys
- Washington Andrews
- Washington Dulles
- Washington Reagan
- Westchester County
- Windsor Locks (Bradley)
- Indianapolis Center
- Kansas City Center
- Washington Center

More than 6,000 aircraft flown by 84 domestic and international air carriers, as well as several dozen business jet operators, are equipped for Data Comm.

More than 9.7 million flights serving 1.3 billion passengers have been cleared with Controller Pilot Data Link Communications (CPDLC). Measured benefits of CPDLC tower service through March 2021 include an estimated:

- 2.5 million minutes of communication time saved
- 135,000 read back errors avoided
- 1.8 million minutes of airspace-user time saved
- 20.5 million kilograms of carbon dioxide emissions prevented

From March 2019 through March 2021, the Data Comm program supported the delivery of more than 5 million en route messages to 22 different aircraft types and 17 operators. Benefits through March 2021 for en route CPDLC include:

- 100,171 read back errors avoided
- 378,195 minutes of communication time saved

DATA COMM IN THE NAS

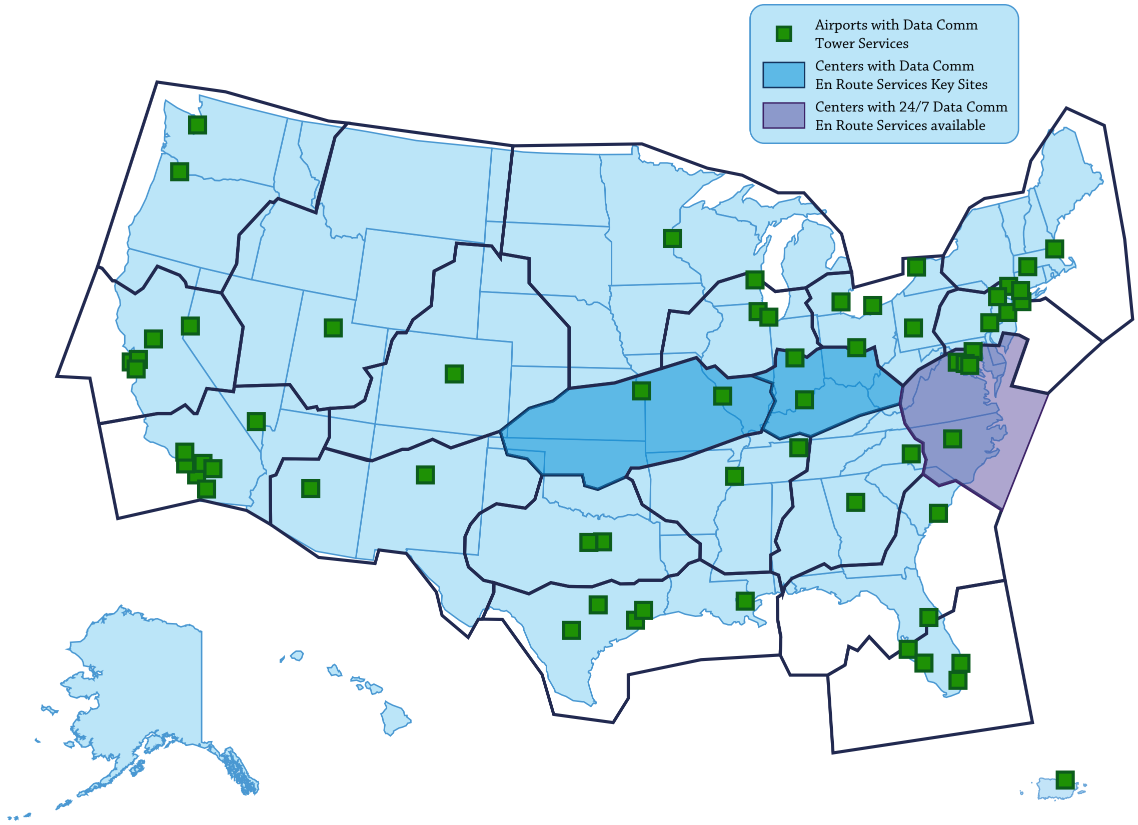


Figure 2: As of the end of the fiscal year 2021, Data Comm is operational at 62 air traffic control towers, and three en route centers. The deployment schedule for the remaining 17 en route facilities is being re-planned due to COVID-19.

TOWER SERVICE

Data Comm has been built from the ground up. Tower service started in 2016 and is available at more than 60 airports. Airports in addition to the original budgeted facilities have requested the service, and Cincinnati/Northern Kentucky International, Palm Beach International, and Jacksonville International airports are the latest to be approved to activate it.

Tower service provides CPDLC departure clearances, which are the instructions pilots receive before takeoff to fly to their destinations. The longer the flight, the more complicated the flight route clearance and pilot read back, which increases the possibility of misunderstanding and errors. CPDLC enables controllers to issue a departure clearance with a single data transmission, send instructions to reroute multiple aircraft at once, and revise clearances as many times as necessary when plans change.

When weather or other factors delay departures, CPDLC revised clearances improve accuracy, timeliness, and air traffic controller and pilot productivity. Controllers can deliver multiple CPDLC messages in the time it would take to conduct one clearance via voice, thereby reducing gate delays and improving taxi-out times and airport traffic flow. During severe weather, some flights have saved more than 90 minutes of delay time.

Since initial development, tower service operations have grown steadily, and controllers have sent more than 8,500 CPDLC departure clearances every day as of early 2020. Despite the pandemic-fueled drop in air traffic, operations bounced back to about 7,100 clearances per day as of March

2021. The number of operators participating has more than doubled since 2016.

EN ROUTE SERVICES

CPDLC progressed to the next phase when initial en route services began at the Indianapolis and Kansas City en route centers in 2019. The Washington en route center started initial en route services in 2020. The technology is scheduled to deploy to the remaining 17 centers across the country. These services include digital messages between the air traffic facility and the flight deck for acknowledging transfer communications and initial check-in, altimeter settings, altitudes, speeds, crossing restrictions, airborne reroutes/go button, controller-initiated reroutes, and direct-to-fix navigation.

Initial en route services help reduce flight delays and provide more efficient routes for aircraft, resulting in enhanced safety, increased operational efficiency, and lower costs for airspace users. Full en route services are more complex and expand upon messages offered by initial en route services. The FAA is planning on full services software development and testing through 2022.

NAVIGATION

Since 2015, Performance Based Navigation (PBN) has defined the standard method of operating in the National Airspace System (NAS) during normal conditions. The FAA has published 322 PBN routes for cruising altitudes and 9,415 PBN departure, arrival, and approach procedures for more than 500 airports.

PBN procedures may not be suitable for every airport or phase of flight. The FAA works with the aviation community to determine the validity of a PBN procedure based on the airport, airspace, air traffic, reaction from residents, and costs versus benefits. Ground-based navigation remains a backup option when GPS satellite service is unavailable.

METROPLEX

Optimization of Airspace and Procedures in the Metroplex, or Metroplex for short, is an FAA program using a systematic, integrated, and expedited approach to implementing PBN routes, procedures, and airspace changes. This program's objectives are to improve predictability and flexibility in transitioning traffic between en route and terminal airspace and between terminal airspace and runways, and segregation of departures and arrivals in the terminal area and en route airspace.

A metroplex is a metropolitan area with commercial and general aviation airports serving at least one large city and a variety of operators, from private pilots of single piston-engine aircraft to air carriers flying jumbo jets. Each metroplex has a unique system of airports, aircraft, geography, and weather patterns. Metroplexes have complex air traffic flows and are among the busiest regions of airspace in the nation.

Each Metroplex project is a multi-year effort that brings benefits to congested airspace near high-traffic airports. Since the start of the first project in 2010, the FAA has completed Metroplex projects for Atlanta, Charlotte, Cleveland-Detroit, Denver, Houston, Las Vegas, Northern California, North Texas, Southern California, and Washington, D.C. The final location, South-Central Florida, has been implemented, and post-implementation activities are scheduled to complete in 2022. Figure 3 lists the 11 implemented Metroplex locations.

The FAA chose these Metroplex sites after recommendations from the aviation community based on traffic levels, operation types, complexity, and history of delays. Study teams composed of air traffic controllers, pilots, airport operations personnel, and FAA technical staff analyze a metroplex's operational challenges and explore opportunities to safely improve regional traffic movement by designing new or modifying existing PBN departure, arrival, and approach procedures. Although only equipped aircraft can fly PBN, the FAA ensures that unequipped aircraft still can access the airspace.

PBN PROCEDURES

PBN procedures in a busy metropolitan area establish consistent flight paths and help maintain an anticipated flow of aircraft to and from an airport.

For example, PBN standard instrument departures provide fixed paths for aircraft from takeoff to en route airspace with minimal level-offs. Standard flight paths simplify navigation tasks for controllers and pilots in all weather conditions. They do not have to issue and follow step-by-step climb and turn instructions.

Another example of how a PBN procedure is making a difference is a standard terminal arrival (STAR) with an optimized profile descent (OPD).

With a STAR OPD, pilots can program the flight management system for optimal speed and altitude requirements for various points along the flight path. Aircraft then glide continuously at near-idle engine speed from the top of the descent to landing with minimal level-off segments. Aircraft stay at higher, more fuel-efficient altitudes closer to the airport, and pilots avoid using speed brakes and frequent thrust adjustments. The procedure also decreases the amount of communication necessary between pilots and air traffic controllers.

METROPLEX IN THE NAS

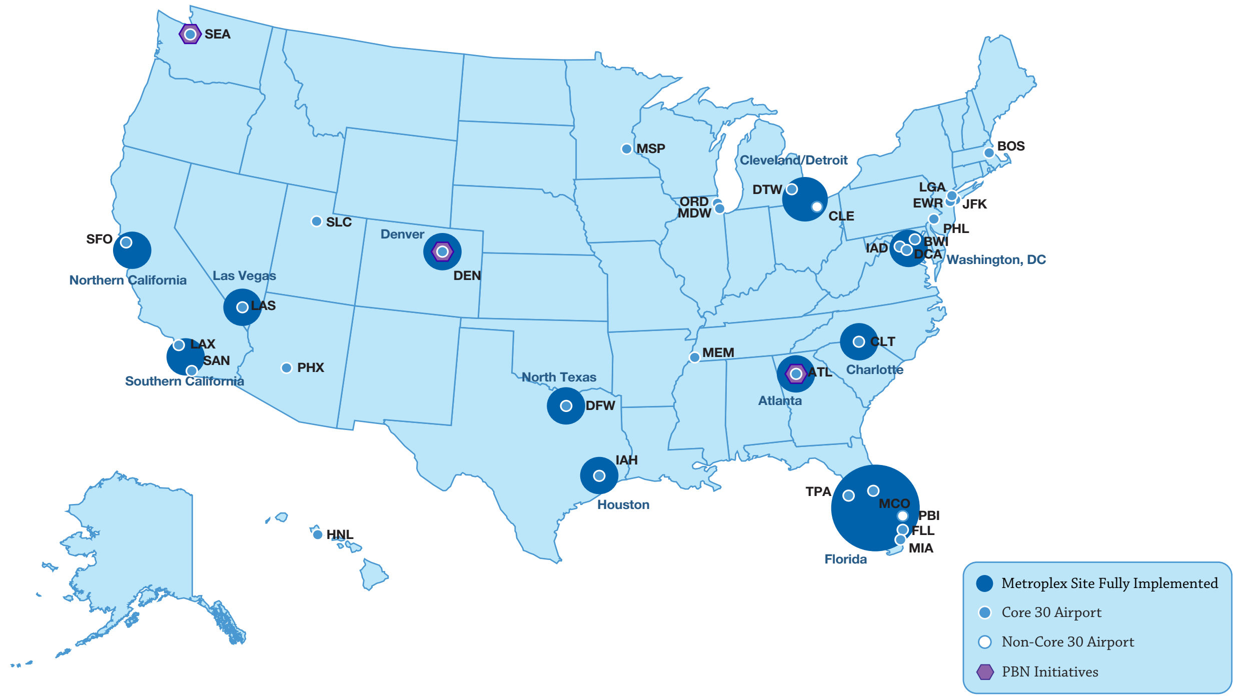


Figure 3: The 11 implemented Metroplex locations are depicted. The FAA considers traffic levels, operation types, complexity, history of delays, and recommendations from the aviation community in selecting the sites.

NEXTGEN DISTANCE MEASURING EQUIPMENT

Area navigation with distance measuring equipment, known as DME/DME RNAV, will become more widely available because the agency needs to maintain an appropriate network of ground infrastructure to support continued PBN operations in the event of GPS service disruptions.

Upon loss or denial of GPS signals, air carrier aircraft will revert to DME/DME navigation to continue RNAV to the destination to fly a conventional ILS approach. DME will enable aircraft to continue using PBN where coverage is provided without requiring aircraft to be equipped with an inertial reference unit. Redundant coverage will allow the aircraft to continue flying PBN routes and procedures in the event of single DME failures. Pilot and controller workload will be minimized during satellite service disruptions while maintaining PBN capacity and efficiency.

Two or more DME range measurements from ground locations relative to an aircraft can provide a position fix, hence the name DME/DME RNAV. Extensive fleet equipage, existing wide deployment of DME ground facilities, and a long history of successful service in the NAS all point to the benefits of DME and its continued use, sustaining area navigation and eventually required navigation performance routes and procedures.

The FAA is installing more than 120 new DME stations through 2031 to support en route and terminal traffic across the nation. By September 30, 2021, new DME stations were installed and operational at eight locations.

SURVEILLANCE

Automatic Dependent Surveillance–Broadcast (ADS-B) transitions the FAA from primarily using ground radar to mainly using GPS satellites with ground stations to track aircraft. The fusion of data from different sources to form a single track

ADS-B TRAFFIC AND WEATHER

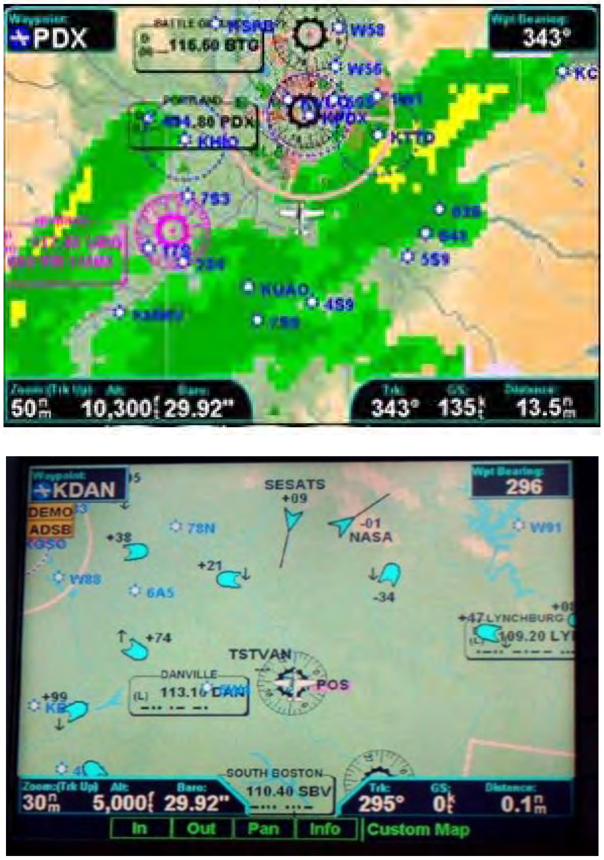


Figure 4: Aircraft equipped for ADS-B In can receive traffic, flight, and weather information services at no additional cost to the operator through Flight Information System–Broadcast (top) and Traffic Information Service–Broadcast displays in the flight deck.

on air traffic displays increases the stability and accuracy of the surveillance presentation when compared to a radar-only mode. Fusion also removes the dependency on a single source and provides greater resiliency during a surveillance system outage.

Real-time precision, shared situational awareness, and advanced applications for pilots and controllers are the hallmarks of ADS-B, now the primary surveillance method for air traffic control across the nation.

ADS-B Out equipment is required to operate in a large portion of the controlled U.S. airspace. ADS-B Out sends a signal to provide aircraft position and other information. As of September 2021, more than 147,000 U.S.-registered civil aircraft (including air carrier, business, and general aviation) and 2,700 international air carrier aircraft are appropriately equipped with ADS-B Out. With optional ADS-B In equipment (Figure 4), pilots can receive real-time traffic, flight, and weather information services at no additional cost to them.

REDUCED SEPARATION

ADS-B Out equipped aircraft transmit their information once per second to air traffic controllers and surrounding aircraft equipped for ADS-B In for shared situational awareness. The improved update rate from ADS-B allows for more frequent position reports and expands the airspace in which controllers are able to provide lowered required minimum separation. These efficiencies save time and fuel, reducing delays and aircraft emissions.

Before ADS-B, surveillance was unavailable in the Gulf of Mexico at low altitudes or beyond 200 nautical miles from the coast. Since the FAA installed ADS-B in the Gulf in 2009, monthly instrument flight rules helicopter traffic tripled due to the improved routing efficiencies and safety benefits of ADS-B. With ADS-B, aircraft traversing the Gulf can safely maintain a minimum separation of as close as 5 nautical miles instead of the 100 nautical miles required under procedural air traffic separation. Moreover, aircraft no longer have to be rerouted over land during weather diversions.

The FAA in 2020 began using ADS-B to enable 3-nautical-mile separation standards in en route airspace below 23,000 feet, resulting in increased NAS efficiency for commercial operators.

AUTOMATION

The FAA acquired new automation systems to accommodate NextGen capabilities. The En Route Automation Modernization (ERAM) platform and Standard Terminal Automation Replacement System (STARS) process surveillance data and aircraft flight plan information. Air traffic controllers use these systems to manage air traffic in their assigned airspace, allowing them to

STARS IN THE NAS

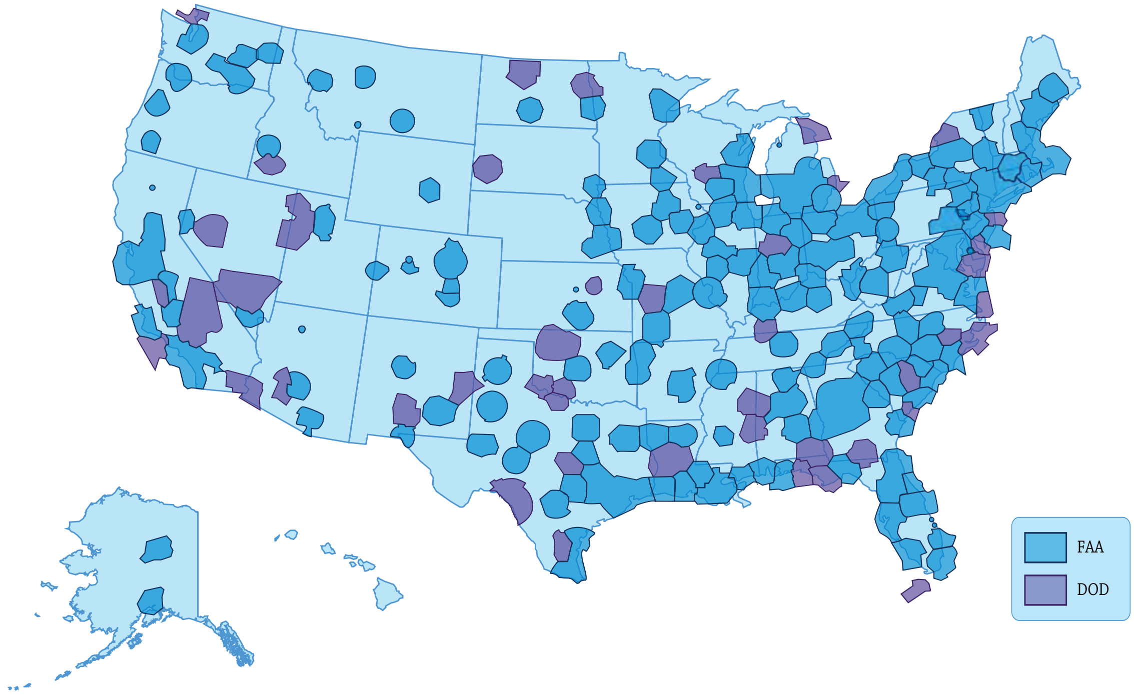


Figure 5: Air traffic controllers at more than 500 FAA and 200 Department of Defense approach control and control tower facilities use STARS to manage aircraft and access flight plan information.

separate, sequence, and vector aircraft; monitor conflict and terrain avoidance alerts; and issue weather advisories. These platforms help controllers handle growing volumes of air traffic.

ERAM replaced the legacy Host computer system at 20 centers in 2015. Several initiatives will replace or enhance original ERAM equipment and capabilities:

- In 2021, the FAA replaced components of ERAM that were nearing their end-of-service life or had degraded performance at Cleveland, Fort Worth, and Minneapolis en route centers as part of the ERAM Sustainment 2 program, and the remaining facilities will be complete by summer 2022.
- ERAM Sustainment 3 refreshes hardware, network equipment, outdated commercial applications, the operating systems at en route centers, and hardware at the William J. Hughes Technical Center. In 2021, the FAA completed system engineering for Sustainment 3 functionality and handed off software for testing.
- ERAM Enhancement 2 provides software enhancements for the en route sector controller team, incorporating enhanced trajectory modeling, increased conflict detection and resolution capabilities to support separation management, and support to PBN.

STARS is a real-time digital processing and display system at terminal radar approach control and air traffic control tower facilities. With the installation of STARS at the Grand Canyon Tower in 2021, the FAA completed the system's nationwide rollout, replacing the legacy Automated Radar Terminal System and incorporating ADS-B as a surveillance source. STARS, operational at more than 500 FAA and 200 Department of Defense facilities (Figure 5), is now in a technical refresh and sustainment cycle. The following programs enable the FAA to maintain system performance levels, respond to the evolving security landscape, and replace obsolete components with modern technology:

- STARS Sustainment 2 provided the engineering to address obsolescence issues with key system components, such as analog video, processors, and the operating system.

- STARS Sustainment 3 will procure hardware and provide the operational deployment of products developed in Sustainment 2.

- STARS Sustainment 4 will provide engineering, development, and deployment activities to replace STARS components that are no longer compatible with current commercial offerings.

DECISION SUPPORT SYSTEMS

The three Decision Support Systems (DSS)—Traffic Flow Management System (TFMS), Time-Based Flow Management (TBFM), and Terminal Flight Data Manager (TFDM)—enable the safe and efficient flow of air traffic in the NAS. DSS help organize and increase the visibility of aviation information, supporting decision-making and enhancing communications between pilots and air traffic control controllers.

Leveraging existing technologies, implementing improvements, and deploying emerging technologies within DSS will increase traffic flow management reliability, efficiency, and flexibility.

Traffic Flow Management System

TFMS provides traffic demand and capacity information to enable decision-makers to manage the NAS. TFMS tools available NAS-wide are:

- Adaptive Compression is used during ground delay programs to adjust scheduling as conditions change.

- Unified Delay Program improves the handling of pop-up flights for ground delay and airspace flow programs, thus increasing the overall equity of delays and the stability of delay times.

- Collaborative Trajectory Options Program enables operators to communicate their route and delay preferences to traffic managers who must manage demand through constrained airspace.

- Airspace Flow Program identifies en route constraints and develops a real-time list of flights that are filed into the constrained area. It distributes “expect departure clearance times” to meter the demand through the area. Metering delivers an aircraft to a specific place at a specific time.

- Reroute Impact Assessment allows traffic managers to model and determine the effect of a proposed reroute. If necessary, they can modify the new route before issuing.

- Corridor Integrated Weather System automatically forecasts and analyzes the weather to support the development and execution of convective weather (e.g., thunderstorms) impact mitigation plans for congested en route airspace.

- Collaborative Airspace Constraint Resolution predicts sector demand and capacity. It identifies a problem and generates congestion resolution plans.

The Airborne Reroute (ABRR) and Pre-departure (PDRR) capabilities connect TFMS and ERAM to allow traffic managers to electronically send aircraft-specific assigned reroutes to air traffic controllers. This is especially beneficial during periods of severe weather when departure routes are rapidly opening and closing, or to mitigate a specific traffic flow problem. In each case, the capability eliminates the need for controllers to type reroutes into the flight plan and provides faster, more accurate, and efficient solutions to flight rerouting problems.

Over the last decade, the expectations for reliability and user requirements have greatly increased for TFMS, with demand exceeding the system’s current architecture. A replacement system, Flow Management Data and Services (FMDS), addresses improvements in architecture, performance, user interface, and how quickly

system improvements can be deployed. The FAA will sustain TFMS until FMDS is operational.

The FAA is researching and developing performance based flow management concepts, including a strategic flow management application to apply advanced technologies in the NAS through DSS.

Time-Based Flow Management

TBFM's core function is to schedule aircraft within a stream of traffic to reach a defined constraint point, which can be a runway, a meter fix, or a slot in the overhead stream. TBFM schedules aircraft to arrive at the constraint point at specified times, creating an orderly sequence of traffic. The scheduled times allow for the merging of traffic flows while minimizing coordination, reducing the need for redirecting an aircraft in flight to a desired point, and efficiently using airport and airspace capacity. TBFM tools include arrival metering, adjacent center metering, coupled scheduling, and extended metering on the arrival side, as well as departure scheduling for departing aircraft.

An enhancement under TBFM extends the scheduling capability into the terminal area through the new Terminal Sequencing and Spacing (TSAS) tool. TSAS provides the same arrival management guidance to terminal controllers as en route controllers. TSAS uses published definitions of arrival and approach procedures as the basis for its sequencing and scheduling. With TSAS, more precise arrival delivery can be achieved.

TBFM's Integrated Departure/Arrival Capability (IDAC) coordinates departure times between airports and informs tower air traffic controllers so they can select from available departure times and plan their operations to meet those times. IDAC uses electronic messaging to request departure times, eliminating the need to place telephone calls from the tower to en route center.

En Route Departure Capability (EDC) using IDAC automation helps determine how long to delay a flight departure and where it will fit in the overhead stream. EDC helps when controllers require additional spacing between flights to manage congestion in another part of the country.

Terminal Flight Data Manager

TFDM supports more efficient airport surface and terminal airspace flow management. It brings several changes:

- Electronic flight strips in the tower replace paper flight strips.
- Collaborative decision-making for the surface includes departure scheduling, departure metering, and other decision support tools.
- Traffic flow management integration connects to TFMS and TBFM through System Wide Information Management (SWIM).
- Systems consolidation replaces multiple legacy systems.

The SWIM Surface Visualization Tool (SVT) shares situational awareness at the airport for traffic management coordinators. Controllers at Terminal Radar Approach Control (TRACON) facilities can easily identify departure congestion and anticipate changes—such as switching runway operations in response to a shift in wind direction—as if they were located in a tower. In 2017, the FAA enhanced SVT to include gate assignment information provided by air carriers. SVT operates at 16 air traffic facilities to support the early implementation of TFDM capabilities. The functions of SVT will be incorporated into and enhanced with the deployment of TFDM.

TFDM will be deployed in two configurations. Configuration A will include electronic flight data, surface surveillance data integration, traffic flow management data exchange and integration, a surface situational awareness display, and full decision support tools. Configuration B includes electronic flight data and, at selected sites, a surface situational awareness display.

TFDM also will use a multi-build strategy for its deployment. Build 1 features full hardware development, electronic flight data exchange, runway assignment predictions, basic load balancing, surface situational awareness viewer via TFMS, and maintenance tools. The Build 1 key site is Cleveland, with initial operating capability projected for late 2022. Build 2 features surface scheduling, surface metering, advanced runway load balancing, and metrics reporting and analysis, through integration with TFMS and TBFM. Charlotte is the Build 2 key site, with initial operating capability projected for late 2023.

TFDM will be implemented at 89 airports through 2030. Full functionality TFDM, configuration A, will be installed at 27 locations and configuration B will be installed in 62 sites.

INTEGRATED INFORMATION MANAGEMENT

Air traffic management within the NAS requires the support of many systems. Those systems must communicate with each other and provide human operators and controllers with the information they need. Integrated information management enables access to information services using standard protocols and preventing using proprietary protocols for system to system exchange. Integrated information management facilitates greater sharing of information. It is more agile and resilient. It breaks down information silos and gets the right information to the right people at the right time.

SYSTEM WIDE INFORMATION MANAGEMENT

SWIM technology comprises the FAA's integrated information management. It provides digital data sharing capabilities and enables the exchange of accurate aeronautical, flight and flow, surveillance, and weather information to internal and external users. It delivers these capabilities with less complexity and expense compared to legacy methods, and provides a common platform where data producers publish information and subscribers access it through a single connection. This new functionality eliminates the number and types of unique computer interfaces needed to access data from different sources.

SWIM is the gateway for information exchange between government, industry, and NAS automation systems, and its common data format enables

SWIM STAKEHOLDERS

Figure 6: Government and industry stakeholders use SWIM exchange aeronautical, flight and flow, surveillance, and weather information through common data formats and streamlined interfaces.

collaboration between the aviation community and governments worldwide (Figure 6). Its enterprise infrastructure enables systems to publish information to users, request and receive information from other NAS services, and support security requirements. SWIM provides governance to NAS programs to ensure services are SWIM compliant and meet all FAA standards, thereby reducing the cost and risk for FAA programs to develop and deploy services. To comply with the FAA's policy of protecting sensitive unclassified information, SWIM has security controls to prevent sensitive information from being transmitted to external users.

One of the first steps to establishing SWIM was creating the NAS Enterprise Messaging Service (NEMS). NEMS is a NAS-based implementation of message-oriented middleware responsible for distributing messages among information consumers and providers. Producers and consumers connect to the NEMS platform to exchange content in a "publish-subscribe" and "request-response" model. This model serves as the foundation for stable and timely movement of information to and from a broad community of users.

SWIM messaging using NEMS allows for flexible and efficient system interactions, eliminating the need for specific producer-to-consumer interfaces. Other core services offered include security, data management, and mediation, which is a SWIM capability that can transform data.

Fourteen FAA programs and several external organizations, including airlines, provide data for 80 services sent via the SWIM network, supporting all phases of flight (Figure 7). More than 800 consumers are registered to access the information, and of those, about 400 are regular users. The availability of data has created a new

SWIM IN THE NAS

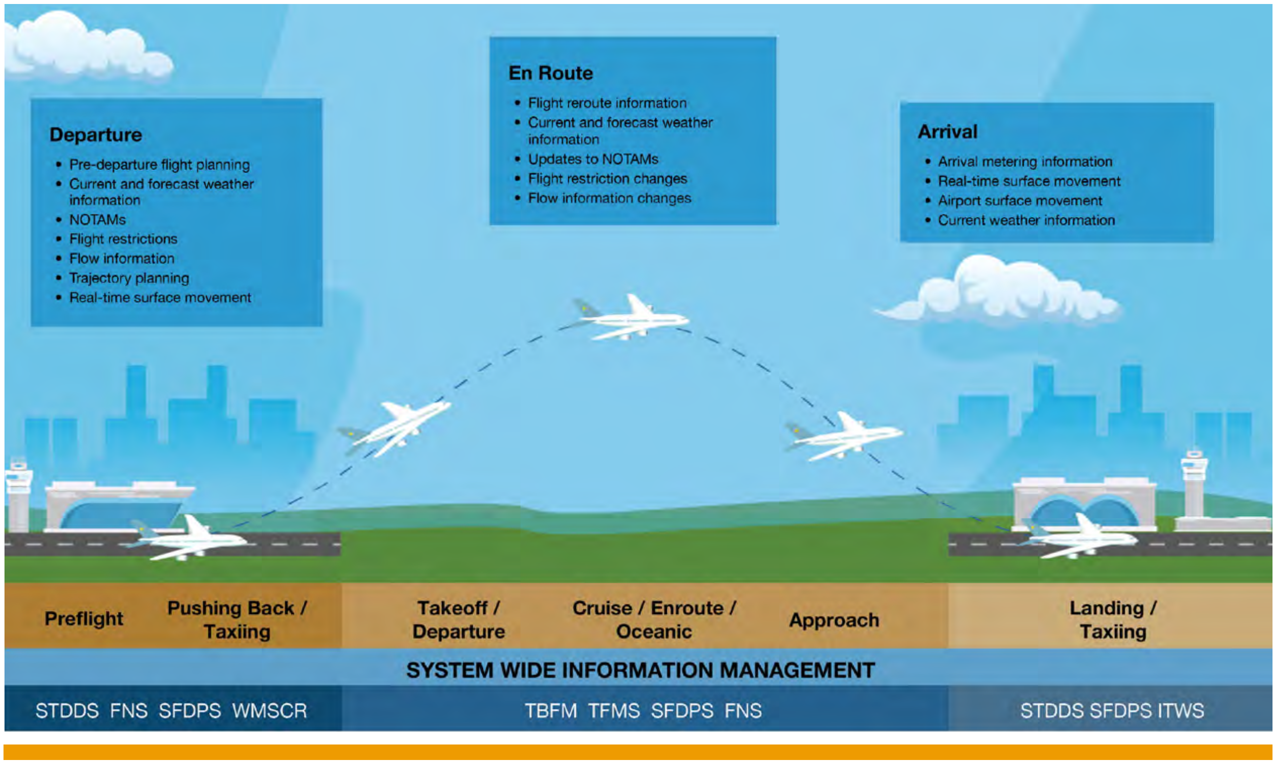


Figure 7: SWIM supports information dissemination for all phases of flight, from gate to gate.

information ecosystem. Companies are using information derived from SWIM to develop value-added products for the aviation community that lead to a better experience for the flying public.

SWIM Flight Data Publication Service

The SWIM Flight Data Publication Service (SFDPS) provides en route flight data from the ERAM system to various consumers. Consumers can access data about flights, airspace, operations, and general messages for use in analytics, business processes, research, and other activities.

The variety of data includes flight plans, flight tracks, beacon codes, and handoff status. The service also disseminates sector configuration data, route status, special activity airspace status, altimeter settings, and data such as the status of ERAM.

Consumers using the data are able to compare predicted and actual departure times, compare control times and actual departure times, determine the busiest departure and arrival fixes, measure the busiest traffic areas, and glean other valuable insights. Among its various features are fast and accurate flight matching, and data that can easily be integrated with applications, such as Google Maps.

SWIM Terminal Data Distribution System

The SWIM Terminal Data Distribution System (STDDS) converts surface and terminal surveillance data collected from ADS-B, radar, or sensors at airport towers and terminal radar approach control facilities into easily accessible information. STDDS uses NEMS to send surface information from airport towers to the corresponding terminal radar facility so traffic management coordinators can assess how to optimally balance demand with capacity.

STDDS enhances data feeds by eliminating redundant or conflicting information. It provides fast and accurate flight matching capability for complete air traffic management situational awareness from surface to cruising altitude, and enables the Surface Visualization Tool. To support safe operations, the tool shows the same information that tower controllers see to air traffic managers in the corresponding terminal radar approach control facility and en route center, as well as other NAS and non-NAS consumers.

The FAA installed STDDS at 38 TRACONs, which draw information from 150 airports. All 38 TRACONs received a technical refresh in 2020, including new hardware and updates to the Terminal Automation Information Service data cap to ensure that flight track data with a correlated flight plan is included in the published data. STDDS recently enhanced its service by implementing track and flight plan data and real-time status and alerts from tower and airport systems. The FAA completed these updates in 2021.

Other STDDS upgrades enhanced terminal information from 118 radar systems for tracks and flight plans below 18,000 feet, as well as added airport surface movement information from 35 airports with Airport Surface Detection Equipment–Model X (ASDE-X), and seven airports with Airport Surface Surveillance Capability (ASSC), with plans to add two more. Airport surface data expanded to include aircraft position reports in the ramp areas at airports with ASDE-X and ASSC. This change will result in more information being available to airlines.

Identity and Access Management

Identity and Access Management (IAM) provides authentication and authorization services to NAS systems using a dedicated FAA public key infrastructure (PKI) to securely identify NAS systems and to protect NAS information.

IAM Authentication certificate services, which began operating in 2017, are available through four U.S. locations on the NAS IP Operational Network and within the four NAS Enterprise Security Gateways.

With IAM Authorization Services, SWIM can centrally manage access privileges to NAS data on the NAS Enterprise Messaging Service platform. This capability reduces cybersecurity vulnerabilities by enforcing proper security policies when creating, managing, and revoking access privileges.

NAS Common Reference

NAS Common Reference (NCR) compiles information from multiple information services to provide consumers with enterprise-level services for NAS status and constraints. Users interface with a single SWIM service to access real-time, correlated data they need for decision-making.

NCR service consists of a geospatial query engine and data aggregation utility that provides common situational awareness for traffic flow management. Approved customers can receive weather, restricted airspace, and other relevant aeronautical traffic management initiatives associated with that particular airspace. The service has been operational since 2021 and is available through the Atlanta and Salt Lake City network enterprise messaging centers.

OPERATIONALIZING NEXTGEN

The Next Generation Air Transportation System (NextGen) incorporates transformative technologies and processes that make air travel even safer and more convenient, efficient, and dependable. However, fielding the right technology is not the sole strategy. Transformation comes from operationalizing these technologies in ways that improve how the Federal Aviation Administration (FAA) provides services and conducts operations. An operationalized NextGen will fully implement NextGen capabilities at the right places in the National Airspace System (NAS), increase aircraft equipage to optimal levels, and raise usage of the deployed capabilities by controllers and pilots to achieve maximum benefits. To modernize the NAS into the 2030s and beyond, we are focusing on operationalizing NextGen.

JOINT COMMITMENTS

NextGen is a large joint investment between the FAA and industry. The FAA has modernized the aviation infrastructure for NextGen and continues to deploy new technologies and procedures. Aviation industry participation and follow-through with commitments are equally important to achieving the full potential of NextGen. Airline business decisions, such as flight scheduling or fleet assignment, also can influence the operational efficiency of the NAS. The FAA and industry have partnered to prioritize and plan programs, and securing industry investment remains a key to NextGen's long-term success.

The NextGen Advisory Committee (NAC) identified mixed avionics equipage as a primary risk for the full realization of NextGen benefits. To mitigate the mixed equipage risk, the NAC developed a minimum capabilities list (MCL) to define optimal aircraft equipage levels. The MCL is based on a review of current fleet operator avionics equipage levels and identifies the core capabilities necessary for current and future NAS operators to take advantage of the benefits from FAA NextGen investments. The NAC also identified a set of supplemental capabilities that may be beneficial to some operators depending on individual business cases and operations.

TRAJECTORY BASED OPERATIONS

Operationalizing NextGen moves us closer to our vision of transitioning air traffic management to Trajectory Based Operations (TBO). TBO is an air traffic management method for strategically planning and managing flights throughout the operation by using time-based management, information exchange between air and ground systems, and the aircraft's ability to accurately navigate in time and space. Expected benefits include enhanced flight efficiency, increased airspace and airport throughput, and improved operational predictability and flexibility. The FAA has demonstrated global leadership through international harmonization of NextGen technologies, leading the world toward TBO.

EVOLUTION

The evolution toward implementing TBO can be described in four general phases:

- Infrastructure deployment of foundational automation, surveillance, weather, and information and data exchange infrastructure to support TBO enabling capabilities and products

- Initial TBO capabilities deployed for use domain by domain with the integration of the capabilities left to the human operator

- Full TBO capabilities delivered to all domains, providing the ability to automate the integration of time-based management data and tools to greatly improve strategic planning and execution

- Dynamic TBO will use advanced aircraft and ground automation to enable flight-specific time-based solutions for reroutes and advanced flight-specific TBO to further optimize operations

TBO CHANGE MANAGEMENT

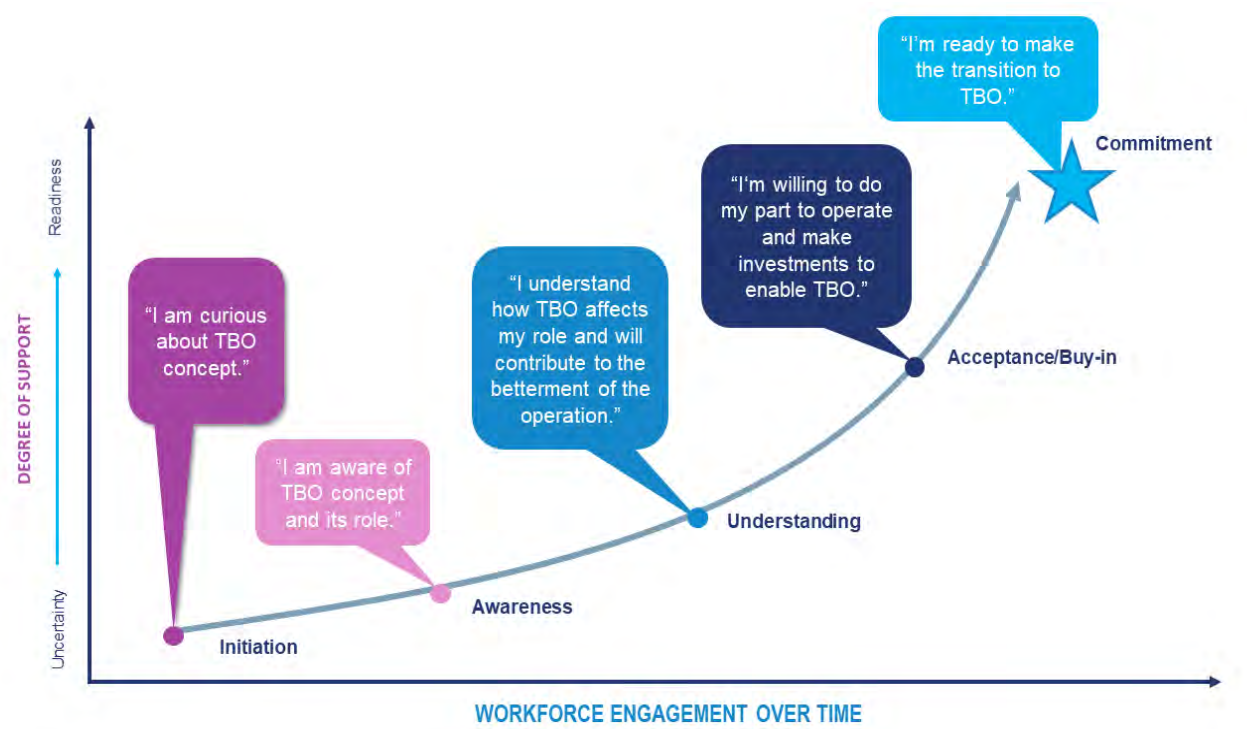


Figure 8: Change management is a progression that starts small and leads to greater workforce engagement to achieve the FAA's commitment to TBO.

INITIAL TBO IN THE NAS

Figure 9: The initial four TBO operating areas—Northeast Corridor, Mid-Atlantic, Northwest Mountain, and Southwest—cut across geography and traditional facility boundaries. TBO implementation requires complex, regional integration to provide airspace users with the right tools at the right place at the right time.

CHANGE MANAGEMENT

TBO is an operational change that will require new time-based techniques for air traffic controllers, air traffic managers, pilots, and dispatchers, and shared FAA and operator collaboration, actions, and investments. The FAA cannot achieve TBO with technology alone. It requires a clear understanding and commitment by all stakeholders—from FAA and industry executives to air traffic staff, pilots, and flight operations team members. We are pursuing a systemic approach to change management inclusive of technology, people and culture, procedures, and policies. Additionally, the FAA seeks to promote new skills for TBO while employees maintain proficiency with conventional techniques. The FAA has developed a change management plan focused on five key areas: leadership mobilization, stakeholder engagement, communication, training/education, and organization/workforce alignment. Figure 8 shows how we can increase readiness and achieve greater commitment for TBO through workforce engagement.

INITIAL TBO

Initial TBO, or iTBO, reflects the collective use of existing and new technologies and capabilities for achieving a fundamental operational change in integrated arrival and departure operations. The FAA is incrementally deploying new capabilities using a sophisticated project plan, beginning with the initial four TBO operating areas depicted in Figure 9. Integration of TBO within an operating area spans across multiple air traffic facilities and requires a high degree of coordination to provide the right tools at the right place at the right time. With TBO, the FAA aims to achieve holistic operational balance while also addressing regional needs and improvement opportunities.

Other progress for iTBO includes restarting training and preparation for Data

Communications en route services, and restarting test and verification activities for Terminal Flight Data Manager (TFDM).

NORTHEAST CORRIDOR

The FAA is progressing toward implementing Atlantic Coast routes to modernize the Northeast Corridor route structure. The Northeast Corridor, the nation's busiest airspace, spans from Boston to Washington, DC. Congestion and delays in the Northeast Corridor affect the entire country.

The FAA implemented departure scheduling from New York and Boston en route centers to Hartsfield Jackson Atlanta International and Charlotte Douglas International airports. This scheduling also includes the Washington en route center and is part of time-based management using Time-Based Flow Management (TBFM). We continue to work on the design for implementing departure and full metering to Philadelphia International and Newark Liberty International airports.

In response to the NAC Performance Based Navigation (PBN) and Opportunities Ad Hoc Task, the FAA implemented the Runway 31 Park Visual procedure at LaGuardia Airport in 2021. We also tested escape routes from Teterboro and White Plains. These initiatives improve flows in and out of the Northeast Corridor.

MID-ATLANTIC

To improve delay distribution for the Mid-Atlantic airspace, the FAA implemented enhanced interfaces between automation systems at Boston, New York, Atlanta, and Jacksonville en route centers for TBFM departure scheduling to Hartsfield Jackson Atlanta International and Charlotte Douglas International airports.

NORTHWEST MOUNTAIN

In response to air traffic operations recovery from the COVID-19 pandemic decline, the FAA restarted extended metering to Denver International Airport from adjacent facilities and

continued to refine Denver en route center's metering system. Testing of the Terminal Sequencing and Spacing (TSAS) tool resumed at the FAA William J. Hughes Technical Center in New Jersey, and Denver terminal radar approach control facility is scheduled to be the first TSAS site in 2022.

SOUTHWEST

The FAA successfully implemented the Las Vegas Metroplex in early 2021, and we are working on TBFM extended metering designs for Las Vegas McCarran International and Los Angeles International airports. Los Angeles International Airport was approved for Established on Required Navigation Performance (EoR) operations in September 2021, and the Southern California terminal radar approach control facility will be the second TSAS site in 2023.

EOR AND MARS

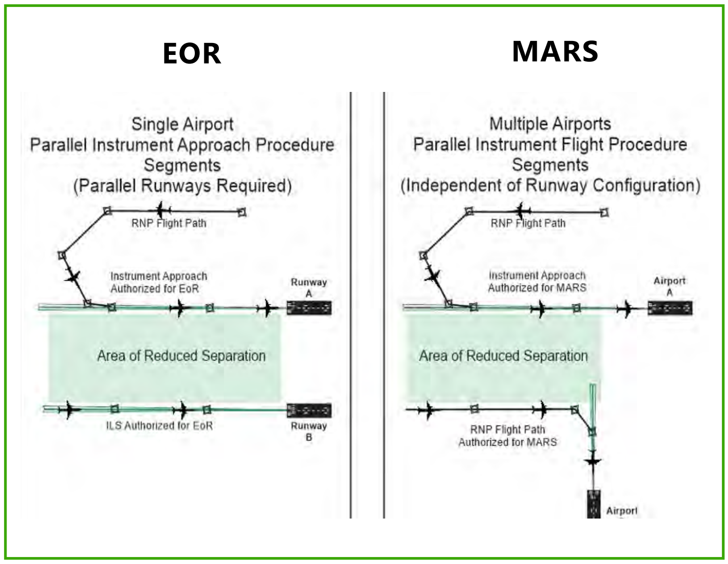


Figure 10: EoR can increase efficiency and capacity by using PBN. The MARS concept extends the single airport EoR application to instrument flight procedures to or from multiple airports in close proximity.

INITIATIVES SUPPORTING TBO

The FAA is fielding and integrating NextGen technologies to improve strategic planning and tactical flow management techniques. Today's air traffic and its future growth require deploying an evolving NextGen modernization with TBO founded on time-based management, Performance Based Navigation (PBN), and other enabling technologies. With the deployment of NextGen automation infrastructure, we can access additional and improved information for flight planning and management. Time-based management will help manage trajectories by scheduling and metering aircraft through constraint points. PBN enables aircraft to more accurately navigate along their trajectories.

Components of the technologies discussed in the previous section of this report are largely in place, providing future opportunities for integrating automation capabilities to deliver full TBO. For example, the delivery of TFDM will enable the sharing of surface information with the strategic and tactical decision support tools, which is fundamental to the implementation of TBO. The capabilities described below may further support TBO.

ESTABLISHED ON REQUIRED NAVIGATION PERFORMANCE

EoR creates a shortcut that is long on benefits. The separation standard, shown in Figure 10, uses a PBN instrument approach procedure to shave miles off of flights near an airport. EoR is designed for equipped aircraft flying into high-traffic-volume airports with parallel runways when they need to turn 180 degrees to line up with the runway. "Established" is to be stable or fixed on a flight path, in this case, stable on the PBN procedure.

EoR uses a required navigation performance (RNP) procedure to establish an aircraft on the approach. The controller clears the aircraft for the approach which allows the aircraft to turn, based on the procedure track, to final independent of or dependent to traffic to parallel runways much earlier in the approach than if the aircraft had to maintain the standard separation of 3 nautical miles horizontally or 1,000 feet vertically.

Aircraft are considered EoR on an initial or intermediate segment of an instrument approach procedure authorized for EoR operations after several steps. An air traffic controller issues an approach clearance, the pilot responds to the controller, and the controller observes the aircraft on the published procedure for an authorized approach to a parallel runway. This process enhances the efficiency of air traffic control to clear RNP approaches.

The benefits of using EoR are extensive. Less distance traveled saves fuel and time, and decreases engine exhaust emissions and noise exposure. PBN procedures increase repeatability and predictability, helping to enable TBO. Stabilized PBN procedures reduce the number of go-arounds after aborted approaches. Fewer radio transmissions between controllers and pilots lower the chances of read back, hear back errors and allow more time to concentrate on other tasks.

EoR at Denver International Airport has been shown to shorten each aircraft's path to the runway by about 6 nautical miles in visual conditions and close to 30 nautical miles in instrument meteorological conditions. Denver was the first airport to conduct EoR for widely spaced independent parallel runways in 2015. Seattle-Tacoma International Airport began limited dependent parallel operations the same year. EoR for widely spaced operations became a national standard in 2016.

George Bush Intercontinental Airport in Houston began widely spaced operations in 2017. Denver and Houston added simultaneous independent approaches for dual and triple runways after the FAA approved it as a national standard in 2018. Los Angeles International Airport began EoR in September 2021, the first site to run pure independent dual parallel runway operations. Dependent parallel runways require a diagonal separation of aircraft, while independent runways allow passing.

The EoR capability provides operational improvements to increase efficiency and capacity using PBN. The FAA plans to mature EoR research by validating variations of the EoR concept in an operational environment. During concept validation, operational lessons learned are captured and potential new research areas are identified.

MULTIPLE AIRPORT ROUTE SEPARATION

Research is underway for an application of monitored procedural separation known as Multiple Airport Route Separation (MARS). The MARS concept (Figure 10) extends the single airport EoR application to instrument flight procedures (IFP) to or from multiple airports in close proximity.

It is a system of authorized IFPs, air traffic control procedures, surveillance, and communication requirements that allow aircraft to fly safely with reduced separation criteria once aircraft are established on a PBN segment of a published instrument procedure to adjacent airports. The MARS concept can be applied to various types of IFP pairings, including approaches, departures, and missed approaches to deconflict flows to and from the airports.

MARS will leverage applicable EoR, closely spaced parallel runway operations, and other related safety analyses. If the safety case results are positive, MARS will enable expanded use of required navigation performance and access into airports and runway configurations that would have previously been denied. Throughput and overall NAS efficiency will increase. Depending on the location, MARS reduces miles flown, resulting in less fuel consumption and decreased engine emissions. MARS intends to use existing controller staffing and resources, and no new software or extra aircraft equipment is required.

The FAA plans to establish a new national standard for MARS or a site-specific waiver to the current national standard in 2023. Safety analyses will continue with controllers involved in testing. The FAA will conduct a benefits analysis in order to continue to investigate the potential of MARS.

INTERVAL MANAGEMENT

Interval Management (IM) is an Automatic Dependent Surveillance–Broadcast (ADS-B) In application that enables more efficient and precise management of spacing between aircraft in en route or terminal airspace.

IM requires FAA investments in air traffic management and decision support automation systems, and operator investments in flight-deck avionics. It also requires new procedures for initiation, execution and cancellation of IM operation. During an IM operation, the Flight Deck Interval Management (FIM) avionics functionality provides speed guidance to the flight crew to precisely achieve and maintain an ATC-issued spacing interval (in time or distance) relative to a lead aircraft.

IM is consistent with the FAA's vision for increased use of time-based management (TBM) of air traffic flows. IM assists controllers with managing arrival compression by reducing the variance in spacing between aircraft, and supports more accurate metering of aircraft through constrained NAS resources. As a result, IM leads to decreased use of vectoring and other deviations from filed procedures, and to increased throughput over today's operations. IM also increases the benefits provided by TBM when the two are used together.

The FAA has partnered with American Airlines and Aviation Communication and Surveillance Systems, LLC, popularly known as ACSS, to certify and install ADS-B In avionics on the airline's fleet of Airbus A321 aircraft. Starting in 2022, the FAA will conduct field evaluation of initial IM operations in Albuquerque en route center's airspace consisting of two clearance types: "cross" and "maintain". For a period of one year, the FAA will gather operational data on use and benefits of initial IM operations, as well as review lessons associated with procedures and training. Once completed, the FAA will share lessons and results from the operational assessment with the operator community.

CDTI-ASSISTED VISUAL SEPARATION

Cockpit Display of Traffic Information (CDTI) technology enables another ADS-B In application called CDTI-Assisted Visual Separation (CAVS). Supported by accurate ADS-B location and velocity data, CAVS allows flight crews to use information on the CDTI as a substitute for continuous visual observation of traffic-to-follow (TTF) during approaches to the same runway under Visual Meteorological Conditions. Once the flight crew has visually acquired TTF and accepted a visual approach clearance, the pilot can use the CDTI to maintain separation during a visual approach even when out the window visual contact is lost.

CAVS operation is transparent to the controllers, and requires no new procedures or phraseology. It is expected to reduce go-arounds due to traffic getting too close on the final approach.

In partnership with the FAA and ACSS, American Airlines started equipping its Airbus A321 fleet with ADS-B In avionics and training its pilots, and commenced CAVS operations in May 2021. For a full year, the FAA and the airline will gather operational data, and evaluate benefits for sharing with the operator community.

The FAA also is working on CDTI Assisted Separation (CAS) on Approach (CAS-A) utilizing the same avionics functionality used for CAVS. Used only between aircraft that are approaching the same runway, CAS-A will not require out the window visual contact, and will continue during operating conditions with lower than currently allowed ceiling thresholds. As such, CAS-A operations are expected to improve airport throughput under applicable conditions.

CAS-A will allow controllers to achieve reduced along-path approach spacing during certain weather conditions by relying on pilot-applied "visual" separation from controller-assigned TTF using the CDTI. CAS-A operations require new phraseology, but does not change any requirements for instrument or visual approach procedures.

INTEGRATED ARRIVAL, DEPARTURE, AND SURFACE TECHNOLOGY

NASA collaborated with the FAA and industry to develop and demonstrate TFDM technology during the Airspace Technology Demonstration-2 (ATD-2) field demonstrations, which led to NASA's transfer of Integrated Arrival, Departure, and Surface (IADS) technology to the FAA in September 2021. The result is better communications between the en route and tower controllers, more precise scheduling of surface departures into constrained overhead flows, and significant improvement in meeting target takeoff times. Figure 11 shows the benefits from the ATD-2 Phases 1 and 2 demonstrations at Charlotte Douglas International Airport.

TFDM provides new tools for air traffic control and new data interfaces to facilitate collaboration with flight operators. However, operators must be equipped to effectively participate in the TFDM concept. Benefits measured during the demonstrations showed that IADS integration into DSS would reduce fuel consumption and emissions and reduce flight delays.

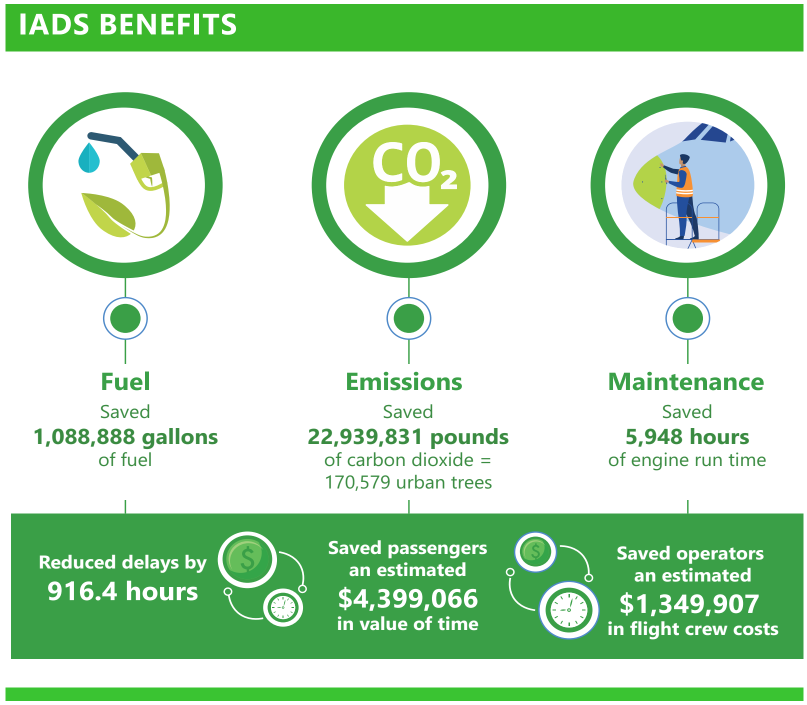


Figure 11: The ATD-2 field demonstration at Charlotte Douglas International Airport between September 29, 2017, and August 31, 2021, showed the IADS technology reduced delays, fuel burn, engine exhaust emissions, and cost to aircraft operators and travelers.

WEATHER PRODUCTS

The biggest cause of air traffic delay is bad weather, and delays translate into real costs for operators and passengers. The NextGen Weather program is a critical part of NextGen—it helps reduce the impact of weather on aviation, resulting in safer, more efficient and predictable day-to-day NAS operations. NextGen Weather is accomplished through collaboration among the FAA, National Oceanic and Atmospheric Administration (NOAA), and NASA.

The NextGen Weather Processor (NWP) and Common Support Services–Weather (CSS-Wx) will establish and disseminate weather products to replace legacy NAS weather systems. In March 2021, the FAA conducted an informal integration test at the FAA William J. Hughes Technical Center in New Jersey and found the interface between NWP and CSS-Wx was functional and stable throughout the test. We did not detect any system failures, and the test demonstrated the delivery of most weather products across the NWP and CSS-Wx interface. The systems will achieve key site initial operating capability in 2024 and are scheduled to be implemented at all planned sites by 2026.

NextGen Weather Processor

The NWP combines information from weather radars, environmental satellites, lightning detection systems, meteorological observations from surface stations and aircraft, and numerical forecast model output from NOAA to generate products for FAA users and NAS stakeholders. The NWP consolidates multiple FAA weather programs with overlapping capabilities into a single NextGen weather system. The NWP is fully automated, identifies aviation safety hazards, and translates weather information needed to predict route blockage and airspace capacity constraints up to 8 hours in advance.

Consumers can view weather products on the NWP aviation weather display, which provides consistent weather information and offers at-a-glance information for en route and terminal users. NWP's new products enable air traffic managers to reduce weather-related delays. Figure 12 shows an example of NWP improvement in echo tops mosaics, which show the tops of actual precipitation. The mosaics are an important product for determining en route airspace availability.

WEATHER MOSAICS

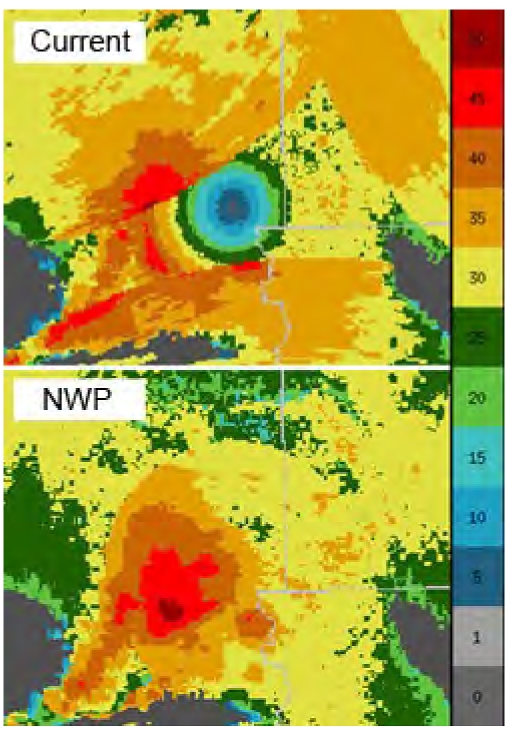


Figure 12: The mosaics represent a map of the top of the radar echoes and are colored in 5,000-foot increments. The current mosaics (top) are range limited, leading to poor high-altitude coverage directly over the center radar and curved artifacts from the other radars. In comparison, the NWP mosaics provide a realistic, artifact-free image that does not exaggerate echo top values at long range. The mosaics help controllers determine en route airspace availability.

Common Support Services–Weather

CSS-Wx is the single provider of weather data, products, and imagery within the NAS, using standards-based weather dissemination via SWIM. CSS-Wx disseminates weather data into air traffic decision support systems, improving the quality of traffic management decisions and reducing controller workload during severe weather. CSS-Wx helps maximize the use of airport capacity by providing more precise information on where adverse weather is located and how it is moving, which allows runways to remain in use longer and reopen quicker following adverse weather.

In addition, CSS-Wx enables airline operations centers and traffic managers to develop better weather mitigation plans and new plans by selecting flight paths that maximize the use of available capacity in weather-impacted airspace.

CSS-Wx publishes weather datasets in geographic standardized formats that are adopted broadly around the world, making weather information more consistent. The system increases the availability of common weather information, filters weather information to provide user-specified subsets, and partners with SWIM to achieve enterprise-wide efficiency.

CLOUD INTEGRATION

As technology advances, information systems will operate at a standard of information assurance well beyond today's levels. Cloud technologies and information-sharing made possible by SWIM will enable the dynamic configuration of applications and information resources to meet the real-time demands of users and service suppliers. Figure 13 depicts how users access the NAS operational network using SWIM cloud services.

SWIM Cloud Distribution Service

The SWIM Cloud Distribution Service (SCDS) provides consumers non-sensitive NAS data in real-time without connecting to the NAS Enterprise Security Gateway, which secures information between NAS and non-NAS systems and networks.

SWIM DISTRIBUTION

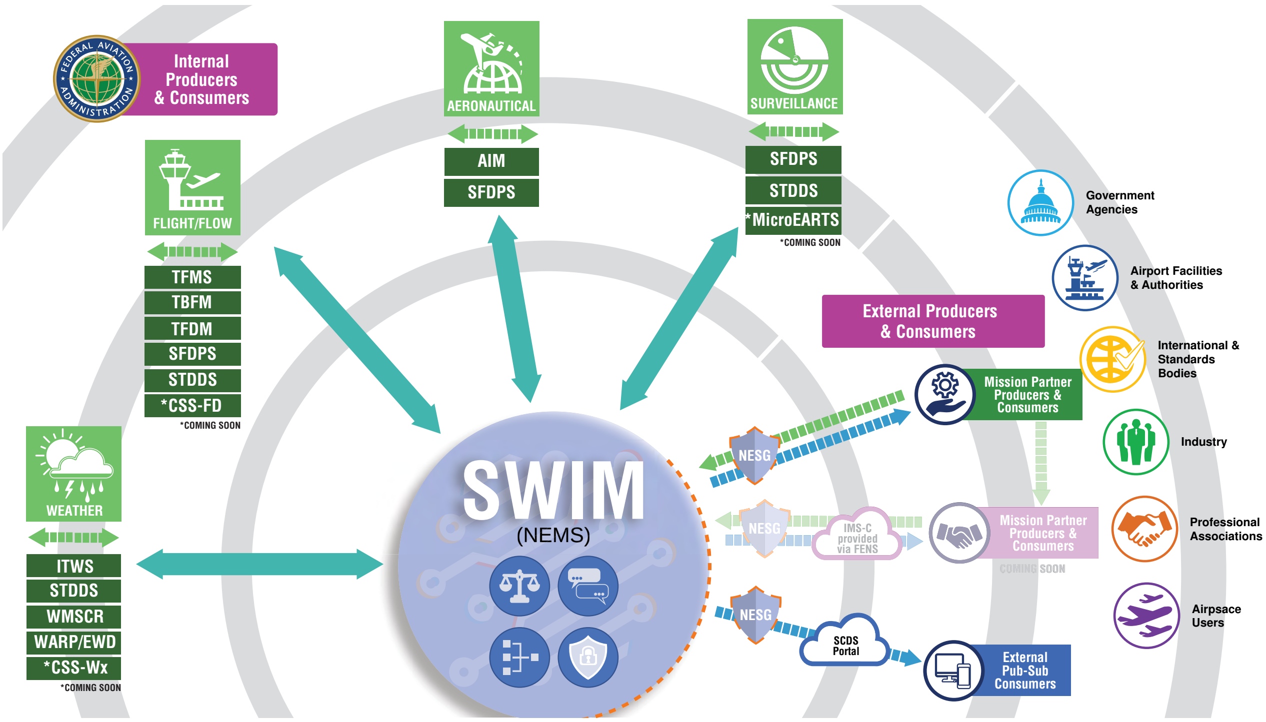


Figure 13: The FAA uses SWIM to collect and disseminate information to internal and external stakeholders. External consumers access subscribed information via NESG and SCDS while internal NAS producers and consumers bypass NESG to access enterprise services.

Data obtained via SCDS is not for operational use. Additionally, all data has been pre-approved for public release by the NAS Data Release Board. Instead of waiting months to access data through the old registration and distribution process, SCDS lets users tap into tailored data within 72 hours of a basic online account setup. Operating costs are lower, and the new service adjusts bandwidth to support data flow. SCDS enables more data to flow through the system, thereby meeting the needs of more users.

A scalable and reliable cloud environment supports the future anticipated growth of services and evolving data exchange scenarios. SCDS leverages an externally hosted cloud infrastructure service and has about 210 users actively pulling data from nearly 580 subscriptions across the available data services.

The SWIM-Industry FAA Team (SWIFT) portal evolved from the existing SCDS and was deployed in 2021. SWIFT is a public forum that offers a collaborative environment for outreach activities related to FAA information services shared via SWIM. The portal is an interactive information-sharing platform providing customizable, real-time access to SWIM.

OTHER ENHANCEMENTS

Other technologies and initiatives contribute to operationalizing NextGen and improving the safety and efficiency of the NAS.

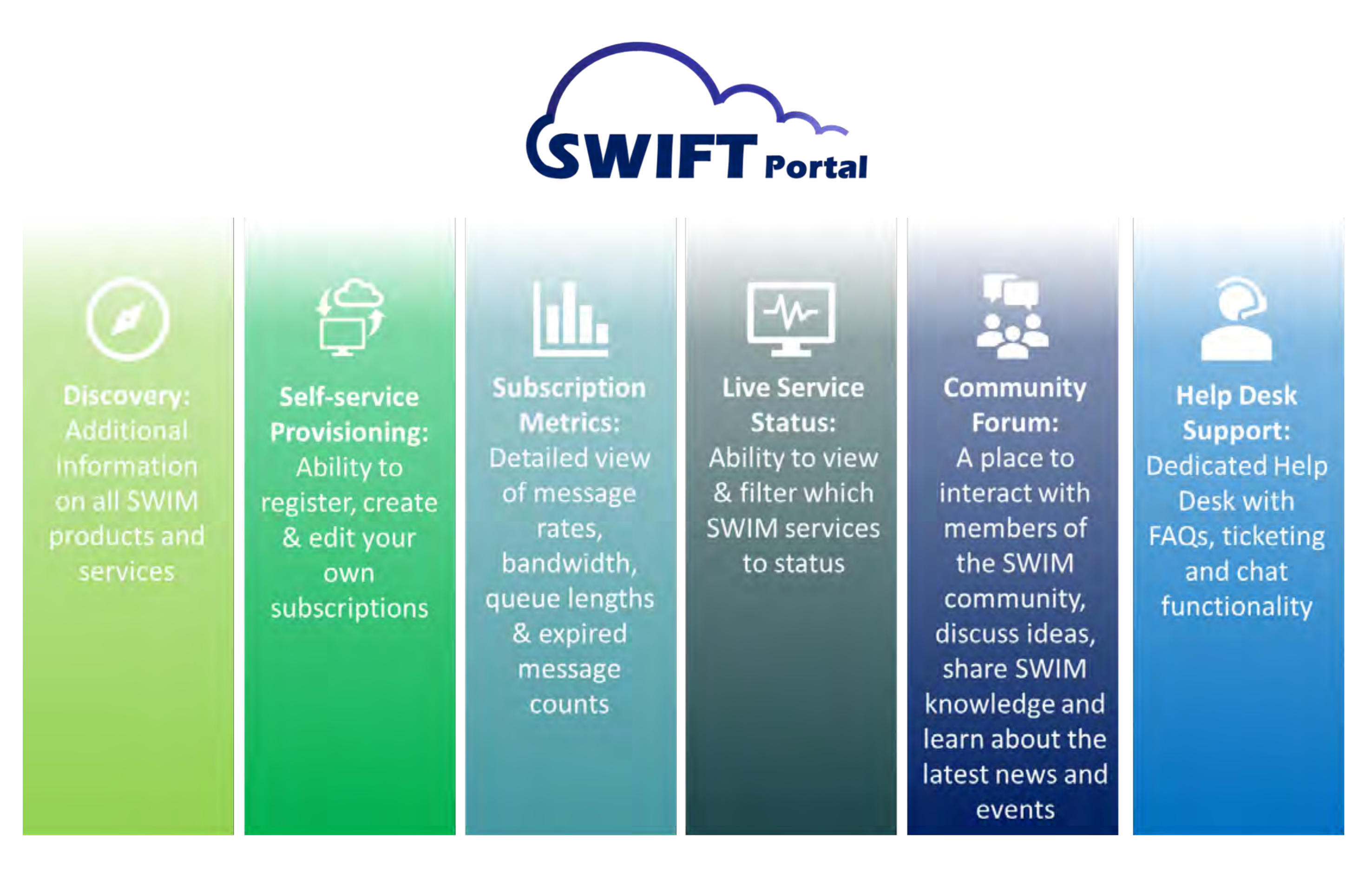
SPACE-BASED ADS-B

New surveillance technologies, such as Space-Based ADS–B (SBA), and enhanced use of existing surveillance sources, present the opportunity to develop new global separation standards approved

SWIFT PORTAL

The SWIFT portal offers users core features:

- Discovery informs users about SWIM data products before subscribing.
- Service status offers the state of SWIM services.
- Client connections assist with troubleshooting and provide insights into previously unavailable information.
- Community forum connects SWIM users to share knowledge and ideas with others and learn what is new with SWIM.
- SWIM Cloud Distribution Service provides users with the ability to request, connect, consume, and manage SWIM Cloud data subscriptions through self-service provisioning.



by the International Civil Aviation Organization (ICAO) in oceanic airspace. These surveillance technologies may present the potential for improving the safety and efficiency of oceanic operations in U.S.-managed airspace.

In April 2021, the FAA completed an operational assessment of SBA in the Caribbean that allowed us to evaluate the SBA technology across a broader range of complex airspace environments. In August 2021, the FAA also completed a non-operational SBA data evaluation looking at applications such as accident investigation, search and rescue, environmental impact analysis, and tracking of commercial space activities. Results from these evaluations will be used to better understand the total value and benefits of SBA technology. Additional work includes an evaluation at all three of the U.S. oceanic air traffic control facilities to assess the benefits in the oceanic environment.

INTERNATIONAL AVIATION TRUST FRAMEWORK

A trusted framework standardizes procedures and protocols for managing and integrating network and service infrastructure to protect against cyberattacks. The policies, technical specifications, and interoperability criteria that multi-organizational participants accept should satisfy the need to protect a specific service.

In the case of digital identity in network communications, the trusted framework provides policy and technical interoperability for the issuers of digital identity credentials, the individuals asserting their identities through the use of the credentials, and the organizations relying on the identity assertions linked to the digital credentials.

We are working with ICAO and our international partners to develop a global trusted framework to create a digital identity management system for internationally federated trusted identities. The objective is to define a global architecture and principles of interconnected networks within a common trust model that allows scalable, technology-agnostic solutions for all aviation stakeholders to exchange data and information.

The FAA, ICAO, and international partners are developing the Global Resilient Aviation Interoperable Network, which is where we will exchange global information at a compatible protection level based on shared risk.

The Enterprise Security Harmonization Proof of Concept activity in July 2021 demonstrated successful interoperability between the United States and Europe using digitally signed SWIM information. The project showed the viability of establishing trust between international certificate authorities and the viability of certificate signing and validation to ensure the integrity of internationally exchanged SWIM messages.

ACCOMMODATING ALL OPERATIONS

As the Federal Aviation Administration (FAA) builds upon the benefits of and continues to operationalize the Next Generation Air Transportation System (NextGen), we also are examining how to adapt our strategies to accommodate increasing air traffic, expanding markets, and changing technology. The FAA continues to evaluate technologies, such as remote towers, for the National Airspace System (NAS). Rapid growth is anticipated in the coming years in drone traffic and space launch and reentry operations. We are working with industry and academia to incorporate new operations into the NAS safely.

Figure 14: Instead of looking through the windows of a tower, controllers look at a wall of video screens depicting the same scene from the remote tower of the Northern Colorado Regional Airport.

REMOTE TOWERS

Remote towers use video technology to monitor aircraft at airports without a traditional brick-and-mortar control tower, some of which have identified missed economic opportunities, such as loss of revenue from landing and other fees, not attracting commercial operators, and lack of job growth.

Remote towers feature enhanced capabilities, such as color cameras with pan-tilt-zoom and night vision features. Capabilities may also include automated identification and display of aircraft and other information on video monitors. Ultimately, the new technologies can enable control tower services at more small and rural airports, improving safety and efficiency without the operational costs associated with a traditional control tower. Figure 14 shows what a controller working with the data feed from a remote tower would see "out the window."

The FAA is evaluating remote tower systems at Leesburg Executive Airport in Virginia and Northern Colorado Regional Airport in Fort Collins. We issued an operational viability decision on the Saab Remote Tower system in September 2021 and authorized the continued provision of air traffic control services using the system at Leesburg. The FAA plans to select more sites to explore how remote tower capability can be expanded to airports that are more complex. The FAA is evaluating proposed technologies, identifying system criteria, and developing a process to approve use of these technologies to provide air traffic services remotely.

Detailed safety analyses will examine whether air traffic controllers can use ground-level remote towers instead of an out-the-window view from a tower cab to safely and efficiently provide visual flight rules airport tower services. Development of technical requirements and a process for system design approval will be critical elements before the FAA can commission and expand remote tower systems.

UAS OPERATIONAL ENVIRONMENT

UAS operations below 400 feet above ground level cooperatively separate through shared situational awareness. Crop monitoring, firefighting support, and package delivery are some of the operations that might take place in this airspace where traditional air traffic services are not provided. These operations will eventually occur under UAS Traffic Management (UTM), which will be a community-based traffic management system where operators and entities providing operational support services are responsible for coordination, execution, and management of operations under established FAA rules. The FAA's DroneZone, Low Altitude Authorization and Notification Capability (LAANC), and Airborne Collision Avoidance System for Rotorcraft (ACAS Xr) are examples of programs that support operations in this environment.

In air traffic management (ATM) controlled airspace up to 60,000 feet, UAS are certified and receive traditional air traffic services where required. Below 18,000 feet, operators follow a mix of visual and instrument flight rules, and an example of UAS uses in this airspace is infrastructure surveillance. At and above 18,000 feet, UAS operations like those that support large cargo delivery and border patrol operate under instrument flight rules only.

UAS operating at and above 60,000 feet in the Upper Class E Traffic Management (ETM) environment are certified and cooperatively separate through shared situational awareness. There is limited coordination with the air navigation service provider for these flights, some of which may be long endurance operations supporting internet services or research.

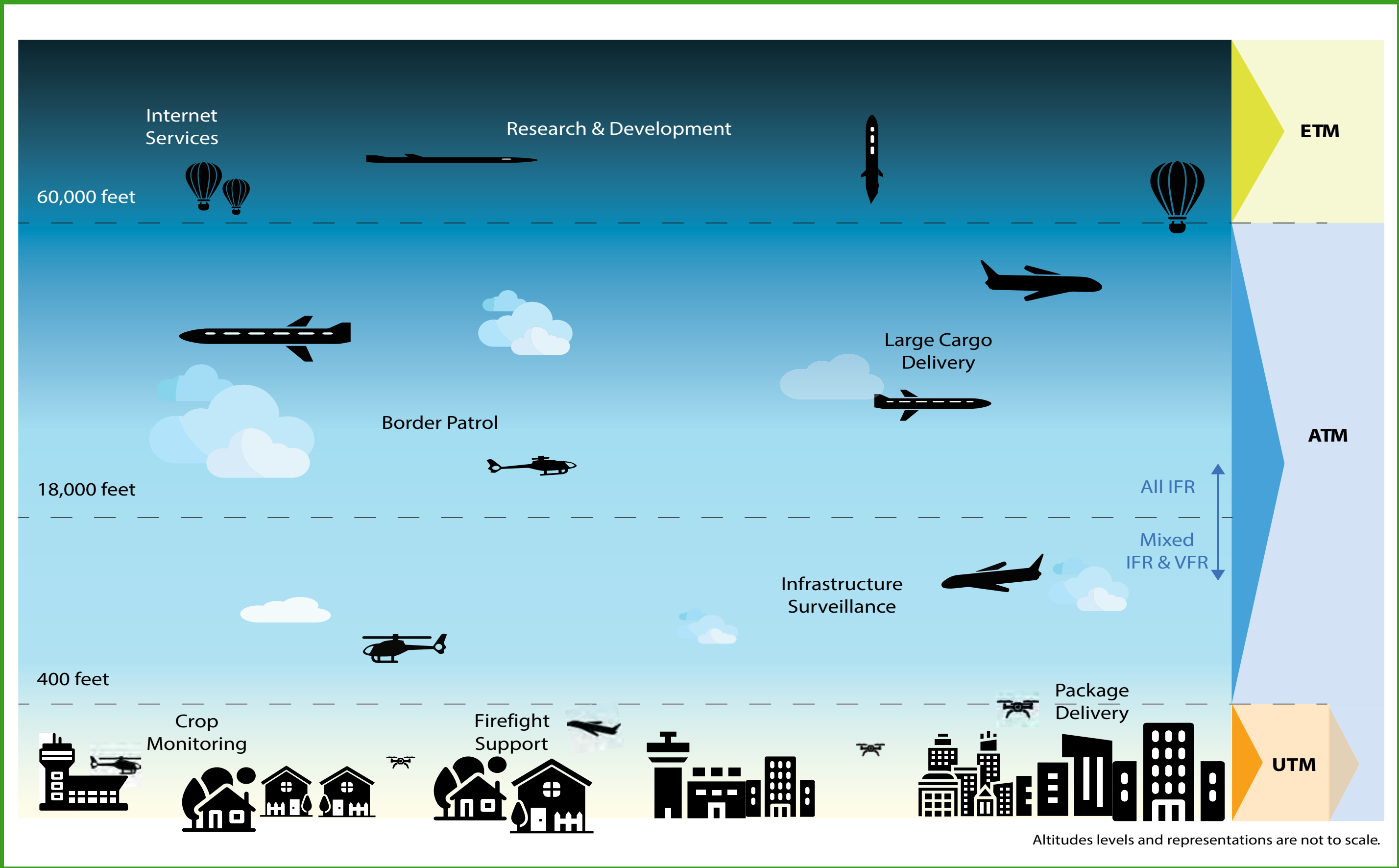


Figure 15: The UAS operational environment includes UTM for operations below 400 feet above ground level, ATM for operations in controlled airspace below 60,000 feet, and ETM for operations at and above 60,000 feet.

UNMANNED AIRCRAFT SYSTEMS

Unmanned aircraft systems (UAS), commonly referred to as drones, are defined as an unmanned aircraft and its associated elements, including communication links and the components that control the unmanned aircraft, that are required for the safe and efficient operation of the unmanned aircraft in the airspace of the United States.

UAS technology and operations continue to expand rapidly in volume, variety, and complexity, affecting the NAS in multiple ways. The FAA is developing rules, policies, and procedures for UAS to operate within the NAS. The UAS programs will form a traffic management ecosystem that will enable UAS operations in the NAS and ensure UAS safely co-exist with crewed aircraft operations and minimize disruptions or delays.

The FAA relies on data from UAS research to inform decisions related to rulemaking, policies, procedures, and standards that are needed to safely integrate UAS into the NAS. Ground collision severity studies have been crucial in our rulemaking efforts for UAS operations over people. Following is a description of the UTM planning and implementation efforts underway.

UAS TRAFFIC MANAGEMENT

The FAA UAS Traffic Management (UTM) capability will allow the seamless operations of small UAS within the NAS below 400 feet (Figure 15). The UTM ecosystem relies on public-private partnership. The private sector provides services that are consistent with published FAA rules and regulations, and the FAA provides complementary capabilities along with the private sector to achieve successful operations of small UAS in accordance with FAA rules and regulations. Following is a description of the UTM planning and implementation efforts underway.

Planning

Planning activities underway include:

- The UTM Pilot Program (UPP) was completed. Packaged artifacts included functional analyses and demonstration reports, which will assist in enabling beyond visual line of sight operations under the UTM ecosystem.
- The FAA initiated a UTM identity access management for another layer of security and enterprise integration capability for better information sharing, data exchange, and data reliability among operators, the FAA, and other stakeholders to achieve safe operations.
- We analyzed needs and alternatives for an enterprise approach to the management of geospatial information for UAS flight over critical infrastructure. This work responds to regulatory requirements for designating drone flight restrictions, UAS volume restrictions, community-based areas of interest, and FAA-recognized identification areas, among other geospatial needs.

Implementation

Our highlights of implementation activities for fiscal year 2021 are:

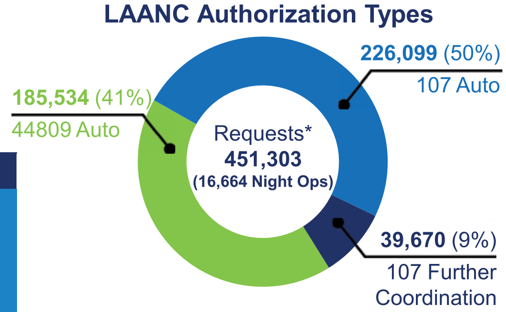
- Enhanced the Low Altitude Authorization and Notification Capability (LAANC) that automates the FAA's ability to grant authorization for small UAS operations in controlled airspace. These enhancements include incremental development of documentation, validation, and security testing. Figure 16 shows key LAANC metrics for calendar year 2021.
- Initiated a UTM identity management service that will implement the requirements, policies, and governance from the International Aviation Trust Framework for UTM. The intent is to create a secure service available to external users.
- Created an application programming interface (API) infrastructure and a suite of API management capabilities. They will support developers in designing, publishing, and documenting APIs in a secure environment for internal and external access to UAS data and business functions. The outcome

LAANC IN THE NAS

LAANC-Enabled Air Traffic Facilities
542
UAS Facility Maps
735

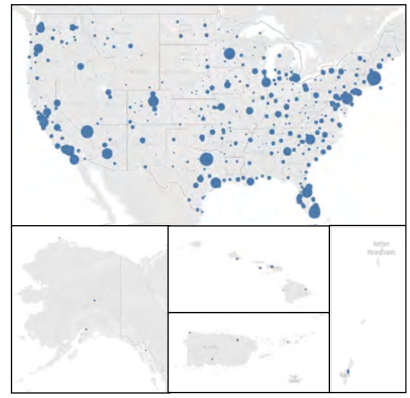
Approved UAS Service Suppliers	
Airbus	DroneUp
AirMap	ETT Aviation
Airspace Link	FlightReady
Aloft	Simulyze
ANRA	Skygrid
ATA	Skyward
Avision	UASidekick
Botlink	Wing

LAANC Authorization Types



Total Authorization Requests (All Time)	
107 Auto	527,316
107 FC	99,897
44809 Auto	338,751
Grand Total	**965,964**

LAANC Proportional Symbol Map



DroneZone authorizations displayed in LAANC are not included

Figure 16: Key indicators for LAANC for calendar year 2021.

will enable a platform for UTM to provide secure data for public and internal users.

- Devised an incremental process that will allow community-based organizations and eligible educational institutions to submit and track applications for FAA-recognized identification areas more effectively. The work will create a dynamic workflow to review their requests and improve communications between the FAA and these groups. The FAA-recognized identification areas capability is an important component for implementing the remote identification rule, where drones in flight provide identification and location information to other parties.

AIR TRAFFIC MANAGEMENT AUTOMATION ENHANCEMENTS

Traditional air traffic management serves mixed traffic using instrument and visual flight rules up to 18,000 feet and instrument flight rules only at and above 18,000 feet (Figure 15). FAA air traffic management automation enhancements will identify changes to NAS automation systems needed for future UAS operations and will support engineering, test and evaluation, and concept analysis.

The agency completed an analysis of UAS operations in air traffic management controlled airspace and found the demand for these operations is well within the parameters of existing automation systems. The UAS automation tripwire report and matrix documents demonstrate how we monitor conditions that prompt an investment analysis for automation systems to support increased demand for UAS airspace access.

Advanced Air Mobility

Advanced Air Mobility (AAM) is a rapidly emerging sector of the aerospace industry that aims to integrate highly automated vertical takeoff and landing aircraft into the NAS safely and efficiently. The AAM sector includes crewed and unmanned vehicle developers and operators. To support future unmanned operations, the FAA is evaluating AAM beyond visual line of sight (BVLOS) operations, focusing on large UAS such as cargo aircraft that fly longer distances.

Working with the UAS community, the effort will evaluate new technologies, along with the need to develop or enhance airspace management systems, and operational procedures to support these operations. As BVLOS operations increase in complexity, the FAA will develop, analyze, test, and evaluate multiple concepts to identify gaps and system impacts of these operations have on communications, navigation, and surveillance services.

We are also working with NASA and other stakeholders to facilitate a live flight trial in Texas to demonstrate AAM BVLOS operations in the NAS. The demonstration will showcase a diverse operational environment that incorporates current and emerging technologies, and a final report will document the technical and functional performance of the flight trial.

Urban Air Mobility

Urbanization increases congestion and environmental stress, offering an opportunity to explore AAM solutions to transportation-related problems. To that end, the aviation industry is exploring the feasibility of crewed and unmanned aerial cargo and passenger vehicles, such as air taxis and air ambulances, under the urban air mobility (UAM) concept. This effort explores the safe integration of UAM operations into the NAS, which may need to operate in UTM and air traffic management environments.

The FAA completed an initial requirements analysis of UAM that reviewed the BVLOS NAS evaluation and other projects to develop initial requirements for UAM operations. The resulting high-level requirements will be documented to describe interactions of UAM systems and potentially those performed by UTM and air traffic management. The project established the groundwork for engineering and research to identify and develop infrastructure and services needed to support UAM operations, following the UAM concept of operations published in 2020.

The initial concepts of internal corridor operations, as well as corridor structure, will be further developed and evaluated. The UAM corridor analysis work performed to date has focused on the size and placement of UAM corridors. Given the operating environments and probable size of UAM and internal operations, this work will determine UAM corridor capacities.

UPPER CLASS E AIR TRAFFIC MANAGEMENT

Upper Class E airspace operations, defined as those at and above 60,000 feet (Figure 15), have historically been limited because traditional fixed-wing aircraft are not designed to fly in thin air in the upper stratosphere. In the future, crewed and unmanned upper airspace operations are expected to increase dramatically in the public and private sectors. We must review and refine, or develop through supporting research, air traffic products, policies, and procedures to ensure the safe operation of vehicles that transition to and operate in Upper Class E airspace.

The FAA is developing an Upper Class E Traffic Management (ETM) concept of operations for proposed operations at and above 60,000 feet. The ETM framework will include overall conceptual principles and assumptions, supporting architecture, information flows and exchanges, and FAA and ETM operator roles and responsibilities.

We will use the concept of operations to develop and evaluate the capability and technical requirements to enable safe and efficient operations in Upper Class E airspace. The work will identify potential requirements and architecture, ensure harmonization between ETM and air traffic management, and develop the necessary system prototypes.

AIRBORNE COLLISION AVOIDANCE SYSTEM X

In collaboration with the airspace users and aviation industry, the FAA has been developing a new collision avoidance system called the Airborne Collision Avoidance System X (ACAS X).

ACAS X has the flexibility to provide a collision avoidance capability for new user classes, reduce

ACAS X IN THE NAS

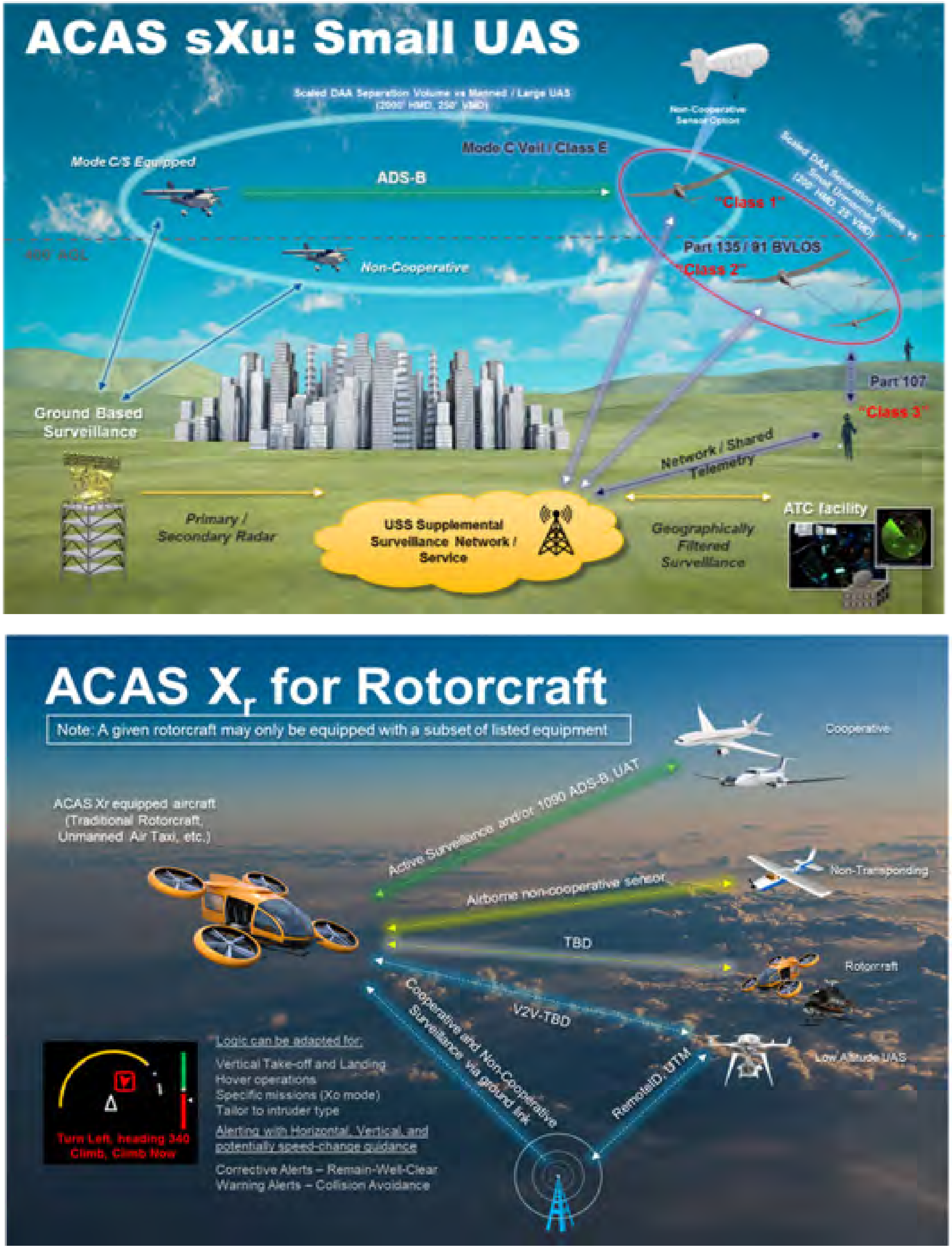


Figure 17: ACAS X provides a collision avoidance capability for two new user classes, small UAS (top) and rotorcraft, to enable future airspace procedures and operations.

unnecessary alerts, support the use of alternative surveillance sources, and enable future airspace procedures and operations. The ACAS program is divided into subsets, including ACAS sXu for small UAS and ACAS Xr for rotorcraft. The outcome is functional and interoperable collision avoidance technologies for different types of aircraft.

Small UAS

The ACAS program completed the ACAS sXu verification and validation capabilities milestone, which will provide stakeholders, including users and vendors, with the toolsets required to verify and validate ACAS sXu implementation into their respective user platforms. Figure 17 illustrates how the technology functions with other airspace users.

The effort provided a detect and avoid (DAA) capability for small UAS, as the previous DAA standards did not address small UAS. Also, collision avoidance research was expanded to develop requirements for a new user class and to ensure future collision avoidance systems are interoperable within the NAS. ACAS sXu requirements and algorithms were developed jointly with standards and development organizations to resolve major scope misalignments and ensure eventual sXu compliance.

Rotorcraft

The ACAS program completed an ACAS Xr integration, test, and characterization milestone required for a test flight scheduled for 2022. This project will address the unique operating environments and performance dynamics of rotorcraft operations and will ensure the safe and interoperable integration of UAM operations in the NAS. Figure 17 shows how ACAS Xr works in notional airspace.

DRONEZONE

The FAA DroneZone is a cloud-based information technology platform. It hosts several applications and the supporting infrastructure that improves the user experience. It also increases the efficiency of internal business processes required for the operation of small UAS.

The goal is to improve public interaction and FAA processes related to small UAS operations under Title 14 of the Code of Federal Regulations, Part 107, and Title 49 of the United States Code, Section 44809. In addition to incorporating the small UAS registration service, the FAA DroneZone also released beta web applications to support the collection and processing of airspace authorizations and waivers, operational waivers, and accident reporting under Part 107.

The FAA is developing a plan to migrate the DroneZone platform to the FAA Cloud Services migration system. The transition will adjust the current UAS data model to the NAS data model standard.

SPACE OPERATIONS

The FAA safely managed 54 commercially licensed-space launches and six reentries in calendar year 2021, compared to 39 launches and two reentries in 2020. This unprecedented number defines a new era of routine commercial space travel. Figure 18 shows the more than a dozen FAA-licensed commercial space launch facilities located across the United States. The emergence of space tourism is expected to propel the space launch and reentry tempo even higher.

INTEGRATION CAPABILITIES

NAS Space Integration Capabilities (NSIC) combines the requirements from Phase 1 of Space Data Integrator with space integration capabilities. The NSIC program automates the delivery of vehicle-related telemetry data to the FAA Air Traffic Control System Command Center, and automates delivery of hazard areas to controller displays. The SDI prototype capabilities at the Command Center allow us to track a space launch or reentry vehicle position in near-real-time as it travels through the NAS. The FAA operationalized the Space Data Integrator Minimum Viable Product in 2021.

U.S. SPACEPORTS

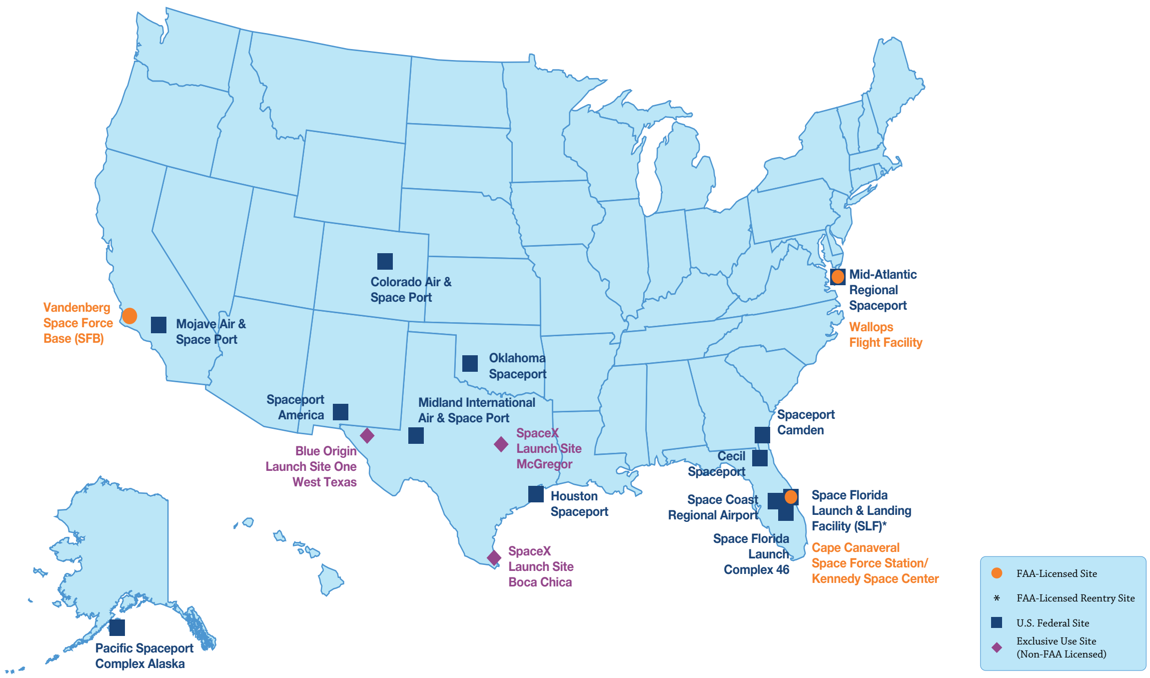


Figure 18: More than a dozen locations across nine states support commercial space launches.

Historically, the FAA closed airspace for extended periods before, during, and after a space launch. The increase in commercial space activity causes airspace to be blocked off more frequently and in more locations across the United States. The FAA and other government agencies, along with industry, airports, international airspace users, and other stakeholders, will benefit from the implementation of NSIC because it will allow the FAA to more dynamically:

- Manage airspace for safety and efficiency
- Manage air traffic during commercial space operations
- Improve situational awareness of the space vehicle's location along the launch or reentry trajectory

NSIC will transform resource-intensive manual processes, such as data transfer by telephone and networks, into automated systems and processes delivering near-real-time or real-time information to enable and enhance air traffic controller and air traffic management decision-making.

HAZARD VOLUMES DEMONSTRATION

Safety is integral to the implementation of space operations. The FAA developed the space operator-generated hazard volumes concept because of the growing number of launch and reentry operations and stakeholders. Private launch and reentry operators use this new approach to provide the FAA with information about debris hazards in airspace. The approach leads to enhanced automation capabilities and increased collaboration with private operators. Ultimately, this will lead to industry growth in commercial space.

Collaboration with SpaceX on their in-flight abort demonstration allowed the FAA to access and display the generated debris field on the appropriate air traffic management automation platform and use this information in strategic and tactical actions during the demonstration.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HOME

FUTURE VISION

The future National Airspace System (NAS) must accommodate emerging users and innovative business models for aviation and aerospace. For example, unmanned aircraft systems and long-endurance balloons fly slower than traditional aircraft. New technologies and traffic management approaches will allow the aviation community to operate differently while increasing safety, maximizing efficiency, and integrating all users into the NAS. As the Federal Aviation Administration (FAA) continues to operationalize the Next Generation Air Transportation System (NextGen), we are also looking toward the future and capitalizing on the momentum from our current modernization initiative to deliver an Info-Centric NAS.

INFO-CENTRIC NAS VISION

The aviation system is experiencing a phase of discovery and rapid innovation for incorporating new vehicles, modes of operation, and business models. Building on the foundation of Trajectory-Based Operations, the Info-Centric NAS will extend many concepts the FAA has been maturing since 2004.

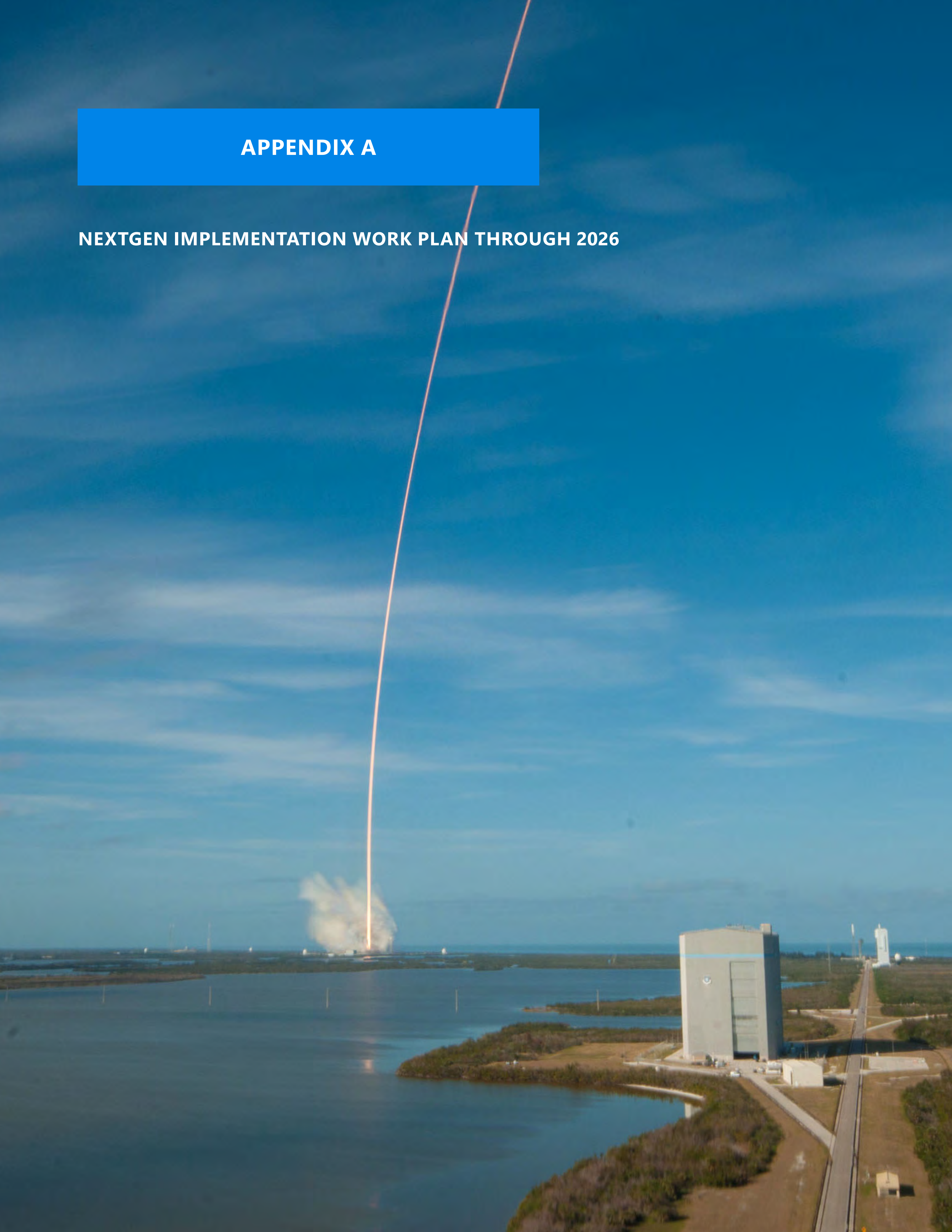
The Info-Centric NAS vision will leverage the NextGen foundation and embrace advanced changing technologies. Advances in artificial intelligence, coupled with abundant data, will help systems to continually refine predictive models supporting decision-making. Machine learning approaches will assist in the effective prediction of potential failures, evolving airspace demand, and predictive maintenance applications.

In addition, the Info-Centric NAS will provide a more flexible, agile, and resilient air traffic management foundation to support continuous change in demand in the aviation community. A key enabler of the future system is improved real-time information connections and sharing, which allow aircraft operators on the ground, in the air, or via autonomous technology to operate with a common picture. Within the fully integrated-information environment, decision-making will be optimally distributed.

The FAA needs to research and leverage advanced and innovative technologies that support NAS operations. Industry, academia, and others in the aviation community continue to collaborate with the FAA to develop the vision for the operating environment beyond NextGen. Working together, we can evolve into the vision for the future airspace system and share in enabling a new era of growth for aviation.

APPENDIX A

NEXTGEN IMPLEMENTATION WORK PLAN THROUGH 2026



APPENDIX A
NextGen Implementation Work Plan Through 2026

Appendix A describes how the FAA plans to modernize the National Airspace System (NAS) through the Next Generation Air Transportation System (NextGen) initiative. The appendix summarizes the structure that our project planners and engineers use to implement NextGen effectively. It also documents the necessary milestones to deliver operational improvements to the NAS. Detailed work plans describe the improvements and include high-priority, ready-to-implement activities to deliver benefits for all airspace users.

This appendix contains:

- Descriptions of the NAS Enterprise Architecture, NAS Segment Implementation Plan, and NextGen portfolios
- A detailed work plan by NextGen portfolio showing related increments through 2026
- A roadmap to Trajectory Based Operations (TBO)

NextGen is the FAA's comprehensive overhaul of the NAS, which will enable operational improvements and enhance services for the aviation community. Most notably, NextGen is transitioning the NAS to TBO, an air traffic management method for strategically planning, managing, and optimizing flights throughout the operation.

The FAA has delivered the foundational elements of NextGen with support from federal agency partners and the aviation community. These capabilities already are benefiting aviation stakeholders and travelers through reduced operating costs and time savings. The FAA plans to complete the implementation of the major components of NextGen by 2025.

ARCHITECTURE AND IMPLEMENTATION

To identify how to transform the NAS, the FAA built the NAS Enterprise Architecture (EA), which describes the evolution of air traffic control through our implementation of new services, technologies, and infrastructure. It documents current and future mission-critical and mission-support systems. The EA also contains roadmaps to help guide identification, tracking, and maturation of concepts that will further advance the NAS.

The EA helps us transform the NAS by clearly communicating system responsibilities while enhancing NAS operations. This architecture eases how we consolidate functions and systems while continuing to satisfy the aviation community's changing needs.

Functions of the EA include:

- Providing a common reference for the FAA to make informed investment decisions
- Aligning aviation systems and technologies we use as an air navigation service provider with the agency's mission
- Helping to identify duplication of effort, show interoperability, and increase efficiency

Supporting the NAS EA is the NAS Segment Implementation Plan (NSIP), our blueprint for developing, integrating, and implementing NextGen capabilities. The NSIP provides the framework for understanding interdependencies among operational improvements, increments, systems, and investment decision points. The FAA defined segments to assist in planning these investments. Figure A-1 shows how TBO phases correspond to the segments in the overall NextGen transformation.

BUILDING THE FUTURE

Overall NextGen Transformation		
Foundational Infrastructure	**Expanding Capabilities**	**Realizing NextGen / Leveraging NextGen**
This period can be considered the foundational infrastructure phase of NextGen.	This period focuses on expanding capabilities and improving the infrastructure laid out in the previous period.	These two periods are for capabilities that require additional maturation or concept development. These are future, and in some cases, near-term capabilities that will benefit the NAS in terms of safety, efficiency, predictability, and flexibility.

Trajectory Based Operations Phases			
Infrastructure	**Initial**	**Full**	**Dynamic**
Deployment of foundational automation, surveillance, weather, and information and data exchange infrastructure to support TBO enabling capabilities and products.	Initial TBO capabilities deployed for use domain by domain with the integration of the capabilities left to the human operator.	Full TBO capabilities delivered to all domains, providing the ability to automate the integration of time-based management data and tools to greatly improve strategic planning and execution.	Dynamic TBO will use advanced aircraft and ground automation to enable flight-specific time-based solutions for reroutes and aircraft sequencing and advanced aircraft-based pairwise trajectory solutions. Information will be integrated and shared further improve NAS operations.

Figure A-1: NextGen Transformations and TBO Phases.

The NSIP serves important, distinct purposes for different NAS users. Program managers, engineers, and acquisition teams use the resource to plan NextGen milestones. External stakeholders, such as advisory organizations, use the plan to identify and prioritize capabilities.

NEXTGEN BENEFITS

Improvements from new technologies, capabilities, and procedures covered in the NSIP provide primary and secondary benefits in one or more of these areas:

- **Access and Equity**: Provides an operating environment that ensures that all airspace users have right of access to the air traffic management (ATM) resources needed to meet their specific operational requirements and that the shared use of airspace by different users can be achieved safely. The global ATM system should ensure equity for all users that have access to a given airspace or service. Generally, the first aircraft ready to use the ATM resources will receive priority except where significant overall safety or system operational efficiency would accrue, or national defense considerations or interests dictate that priority be determined on a different basis.

- **Capacity**: Exploits the inherent capacity to meet airspace user demands at peak times and locations while minimizing restrictions on traffic flow. To respond to future growth, capacity must increase, along with corresponding increases in efficiency, flexibility, and predictability, while ensuring that there are no adverse impacts on safety and giving due consideration to the environment. The ATM system must be resilient to service disruption and the resulting temporary loss of capacity.
- **Efficiency**: Addresses the operational and economic cost-effectiveness of gate-to-gate flight operations from a single-flight perspective. In all phases of flight, airspace users want to depart and arrive at the times they select and fly the trajectories they determine to be optimum.
- **Environment**: Contributes to the protection of the environment by considering noise, emissions, and other environmental issues in the implementation and operation of the aviation system.
- **Flexibility**: Ensures the ability of all airspace users to modify flight trajectories dynamically and adjust departure and arrival times, thereby permitting them to exploit operational opportunities as they occur.
- **Predictability**: Allows airspace users and ATM service providers to provide consistent and dependable levels of performance. Predictability is essential to users as they develop and operate their schedules.
- **Safety**: Uniform safety standards and risk and safety management practices should be applied systematically to the air transportation system. In implementing elements of the system, safety needs to be assessed against appropriate criteria and according to appropriate and globally standardized safety management processes and practices.

NEXTGEN PORTFOLIOS

As outlined in the NSIP, the FAA organizes operational improvements in 11 portfolios to group related initiatives for assessing, developing, and implementing new capabilities. Within a NextGen portfolio, each operational improvement is divided into capabilities that are deployed by increments as the technology or process becomes operational. The incremental capabilities in many cases immediately benefit the aviation community and help develop operational improvements. When all the capabilities are in place, the operational improvement becomes a current operation. Primary and secondary benefits for each increment are also mapped.

PORTFOLIO DESCRIPTIONS

Milestones for these 11 portfolios are included in the section discussing detailed work plans.

Improved Surface Operations: Improved airport surveillance information, cockpit displays for increased situational awareness, and the deployment of a departure management decision support tool are some of the implementations within this portfolio. Improved Surface Operations safety features include surface moving-map displays in the cockpit, while surface movement data exchange and departure routing improvements enhance efficiency.

Improved Approaches and Low-Visibility Operations: Increased access and flexibility for approach operations will be accomplished through a combination of procedural changes, improved aircraft capabilities, and improved precision approach guidance. Additionally, procedural changes allow for more efficient profiles.

Improved Multiple Runway Operations: This portfolio improves runway access through the use of enhanced technology, updated standards, safety analysis, air traffic tools, and operating procedures, which enable increased arrival and departure operations. Improving runway access will increase efficiency and capacity while reducing delays.

Performance Based Navigation (PBN): Improvements in aircraft navigation performance provide an opportunity to increase efficiency and flexibility. The PBN portfolio addresses ways to leverage emerging technologies, such as Area Navigation (RNAV) and Required Navigation Performance (RNP), to improve access and flexibility for point-to-point operations.

Time-Based Flow Management (TBFM): System efficiency will be enhanced by leveraging Traffic Management Advisor (TMA) decision support tool capabilities. Further improvements will be made to enable controllers to accurately deliver aircraft to the terminal radar approach control facility (TRACON) while providing the opportunity for them to fly optimized descents and maintain spacing intervals, further improving capacity and flight efficiency.

Collaborative Air Traffic Management (CATM): NAS users and FAA traffic managers using advanced automation manage daily airspace and airport capacity issues (i.e., congestion, special activity airspace, and weather) by coordinating flight and flow decision-making. The overall philosophy driving the delivery of CATM services is to accommodate user preferences to the maximum extent possible (e.g., tailoring reroutes to specific flights).

Separation Management: Controllers are provided with tools and procedures to manage aircraft in a mixed environment of varying navigation equipment and wake performance capabilities. Aircraft separation assurance is the cornerstone of air traffic control operations. Separation management in the NAS can be accomplished procedurally and/or by using automation support.

On-Demand NAS Information: This portfolio ensures the consistency of airspace and aeronautical information across applications and locations, and is available to authorized subscribers and equipped aircraft. Users will request NAS information when planning flights through services that will allow them to collaborate with air navigation service providers, resulting in improved flow management and efficient use of resources.

Environment and Energy: The FAA's strategic environmental goal is to develop and operate a system that reduces aviation's environmental and energy impacts to a level that does not constrain growth and is a model of sustainability. Noise, air quality, climate, energy, and water quality are the most significant potential environmental constraints to increasing aviation capacity, efficiency, and flexibility. This portfolio develops aircraft technologies and sustainable aviation fuels to reduce the impact of aviation on the environment and the modeling tools necessary to conduct environmental analyses and ensure compliance with the National Environmental Policy Act and other special purpose environmental laws.

System Safety Management: Develops and implements policies, processes, and analytical tools that the FAA and industry will use to ensure that changes introduced with NextGen enhance or do not degrade safety while delivering benefits.

NAS Infrastructure: This portfolio encompasses increments for systems that represent FAA investments or that have cross-portfolio dependencies. As new services are established, the applicable increments that use these services or data from legacy sources will migrate to the new NAS infrastructure. The major focus areas of this portfolio include improved weather information and dissemination, data communications, and information management.

DETAILED WORK PLANS

This section describes the detailed work plans for the 11 NextGen portfolios. The portfolios list operational improvements, current operations, and the corresponding capabilities of each; these portfolio components are associated with the years in which activities occur. The dates and timelines included in the tables are for planning purposes only and are based on information from the January 2021 NSIP baseline.

The rapid spread of the COVID-19 pandemic that began in early 2020, and its effects on aviation and the broader economy, is unprecedented. Much uncertainty remains on how the pandemic will affect milestones, industry commitments, and projected benefits. As of the publication of the NSIP 2021 baseline, programs had assessed some of the impacts, and plans to develop and/or implement NextGen capabilities were adjusted and reflected in the 2021 baseline as much as possible.

Portfolios also are tagged to identify increments that are associated with unmanned aircraft systems or space transportation. Increments that support the FAA commitments identified in the NextGen Priorities Joint Implementation Plan (NJIP) are tagged as well. FAA commitments are capabilities that the industry and the FAA have negotiated as key capabilities that will benefit the industry and improve NAS operations over time. See Figure A-2 for how to read the detailed work plans.

To preserve space in the tables, airport identifiers and acronyms associated with each operational improvement, current operation, or segment are decoded in Appendix B.

HOW TO READ DETAILED WORK PLANS

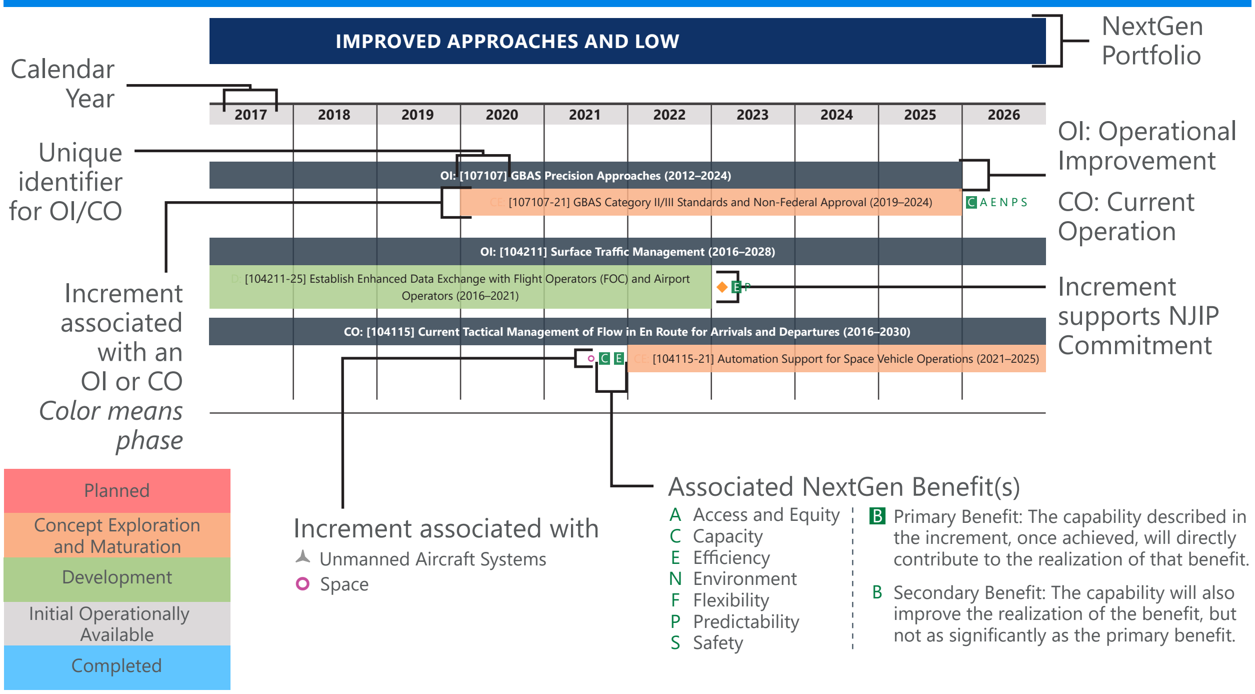


Figure A-2

IMPROVED SURFACE OPERATIONS

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [102138] Enhanced Air Traffic Control Tower Services for Airport Operations at Non-Primary Airports (2017–2022)

[102138-01] Establish Air Traffic Control Tower Criteria for Airport Operations at Non-Primary Airports (2017–2022) — A C S

OI: [102406] Provide Full Surface Situation Information (2011–2017)

[102406-12] Expansion of Surface Surveillance (2013–2017) — ◆ S E

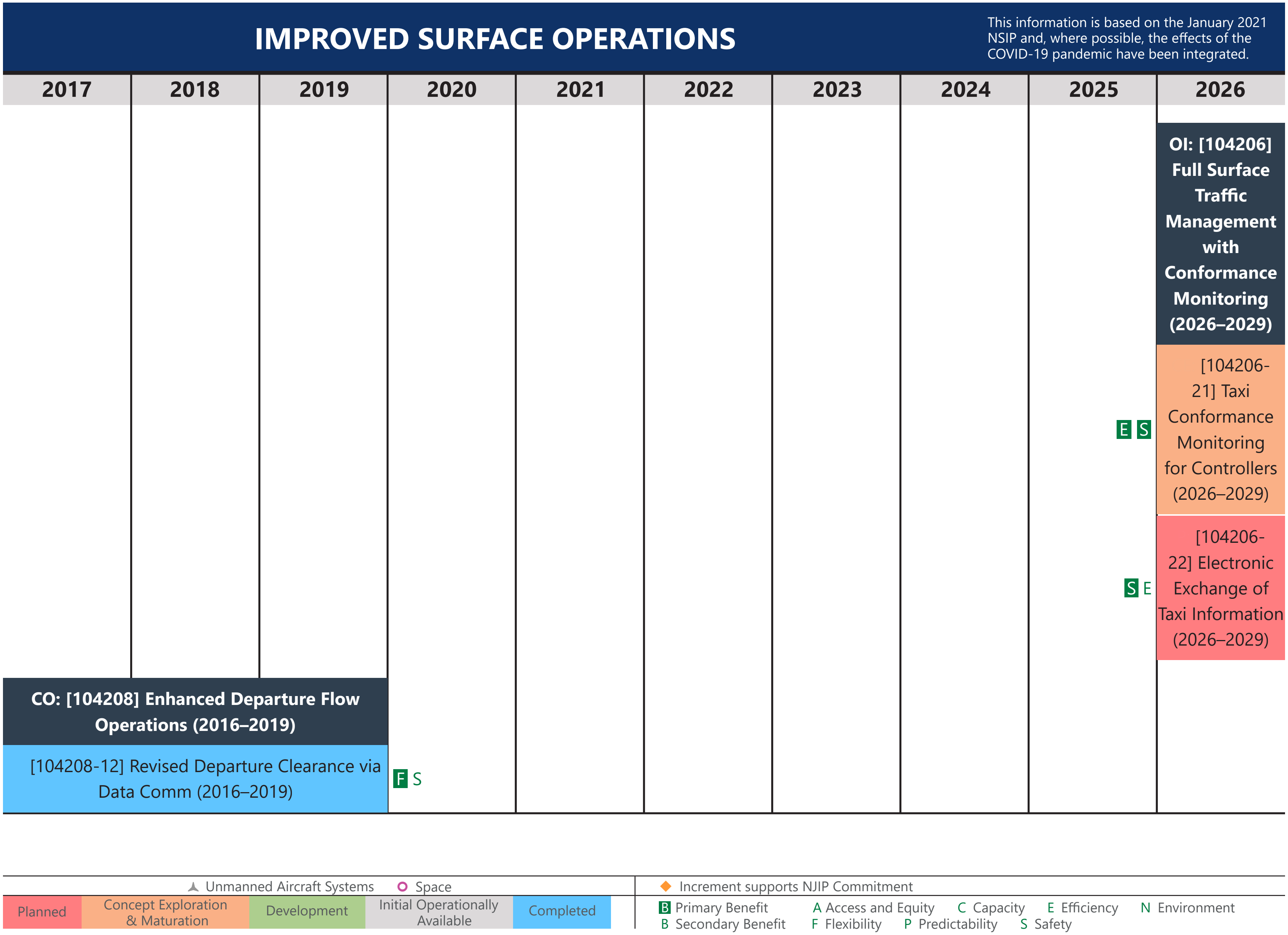
OI: [104117] Improved Management of Arrival/Surface/Departure Flow Operations (2015–2032)

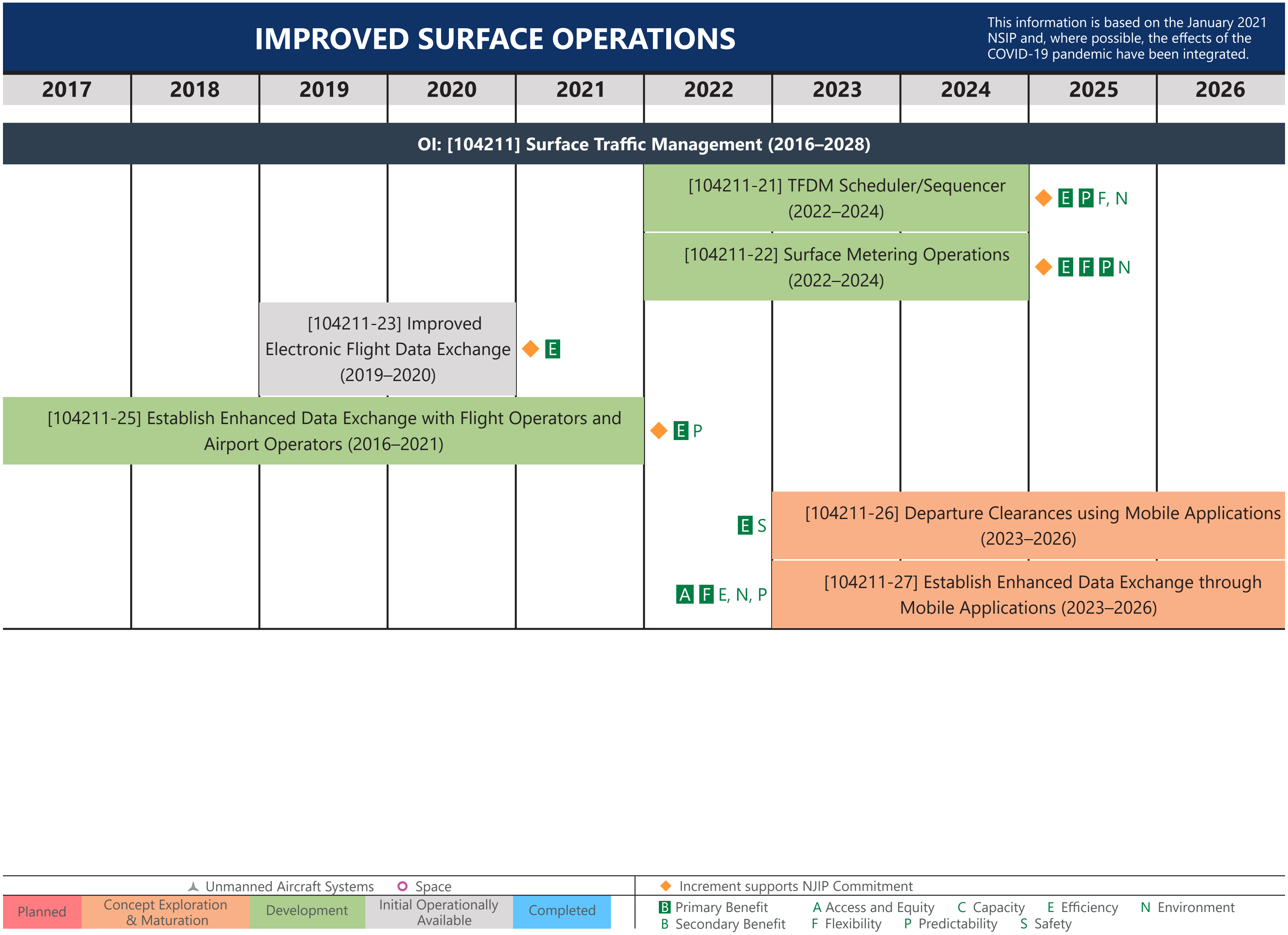
E C, P — [104117-32] Improved Departure Operations using Mobile Applications (2023–2026)

Unmanned Aircraft Systems | Space | ◆ Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment


IMPROVED SURFACE OPERATIONS
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [104206] Full Surface Traffic Management with Conformance Monitoring (2026–2029)
E S
[104206-21] Taxi Conformance Monitoring for Controllers (2026–2029)
S E
[104206-22] Electronic Exchange of Taxi Information (2026–2029)
CO: [104208] Enhanced Departure Flow Operations (2016–2019)
[104208-12] Revised Departure Clearance via Data Comm (2016–2019)
F S
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment


IMPROVED SURFACE OPERATIONS
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [104211] Surface Traffic Management (2016–2028)
[104211-21] TFDM Scheduler/Sequencer (2022–2024)
E P F, N
[104211-22] Surface Metering Operations (2022–2024)
E F P N
[104211-23] Improved Electronic Flight Data Exchange (2019–2020)
E
[104211-25] Establish Enhanced Data Exchange with Flight Operators and Airport Operators (2016–2021)
E P
E S
[104211-26] Departure Clearances using Mobile Applications (2023–2026)
A F E, N, P
[104211-27] Establish Enhanced Data Exchange through Mobile Applications (2023–2026)
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

IMPROVED APPROACHES AND LOW-VISIBILITY OPERATIONS

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [107107] GBAS Precision Approaches (2012–2024)

[107107-21] GBAS Category II/III Standards and Non-Federal Approval (2019–2024) — C A, E, N, P, S

OI: [107117] Low-Visibility/Ceiling Approach and Landing Operations (2015–2021)

[107117-12] SVGS for Approach (2016–2021) — A C, E

[107117-13] EFVS for Landing (2015–2017) — A C, E

OI: [107202] Low-Visibility Surface Operations (2016–2022)

[107202-21] Low-Visibility Taxi Operations (2016–2020) — A C, E

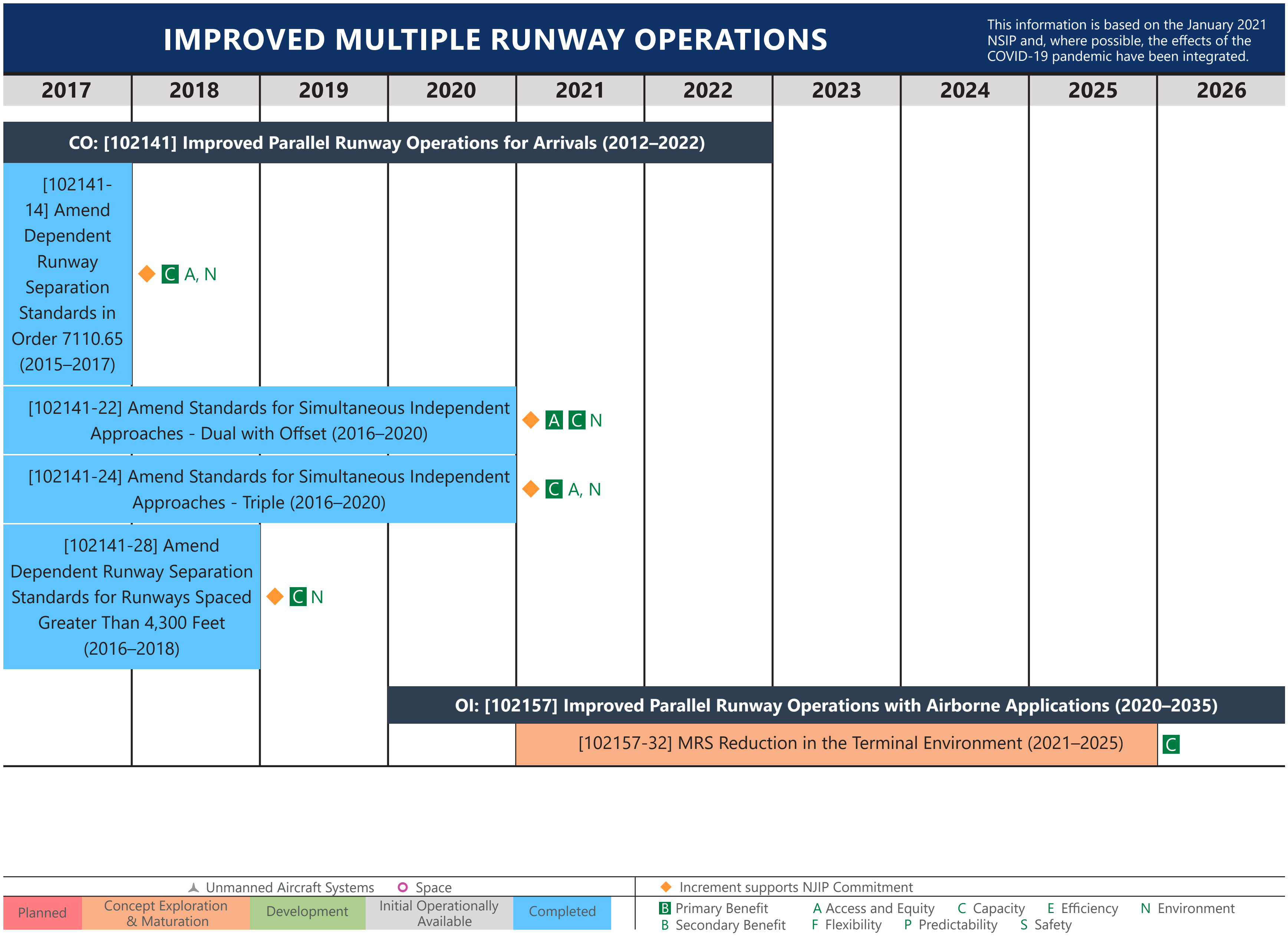
[107202-22] EFVS/Accurate Position Information for Taxi (2016–2020) — A C, E

[107202-23] Protected Low-Visibility Taxi Route (2016–2020) — A C, E

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment


IMPROVED MULTIPLE RUNWAY OPERATIONS
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
CO: [102141] Improved Parallel Runway Operations for Arrivals (2012–2022)
[102141-14] Amend Dependent Runway Separation Standards in Order 7110.65 (2015–2017)
C A, N
[102141-22] Amend Standards for Simultaneous Independent Approaches - Dual with Offset (2016–2020)
A C N
[102141-24] Amend Standards for Simultaneous Independent Approaches - Triple (2016–2020)
C A, N
[102141-28] Amend Dependent Runway Separation Standards for Runways Spaced Greater Than 4,300 Feet (2016–2018)
C N
OI: [102157] Improved Parallel Runway Operations with Airborne Applications (2020–2035)
[102157-32] MRS Reduction in the Terminal Environment (2021–2025)
C
Unmanned Aircraft Systems
Space
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
Increment supports NJIP Commitment
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

IMPROVED MULTIPLE RUNWAY OPERATIONS

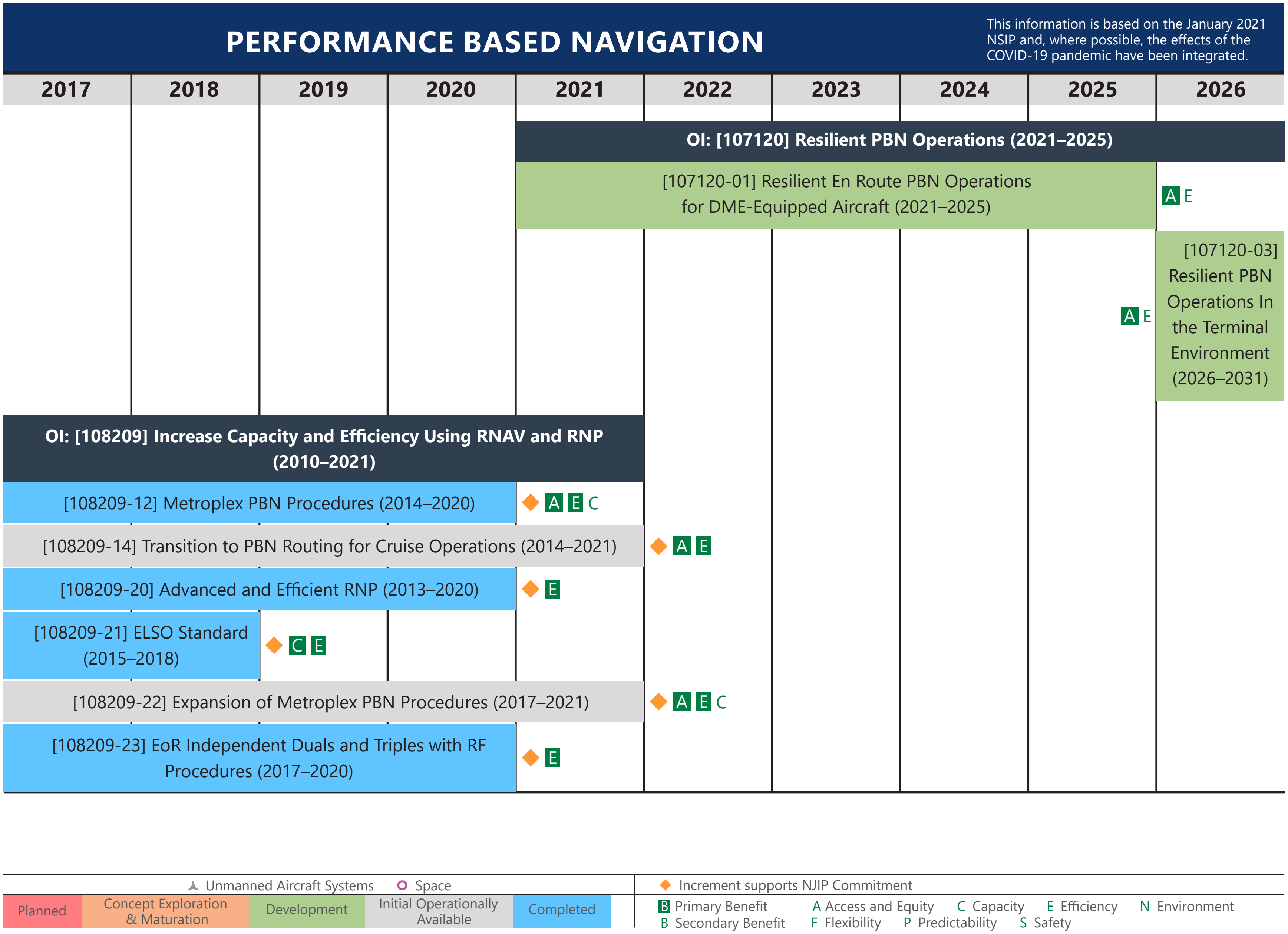
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

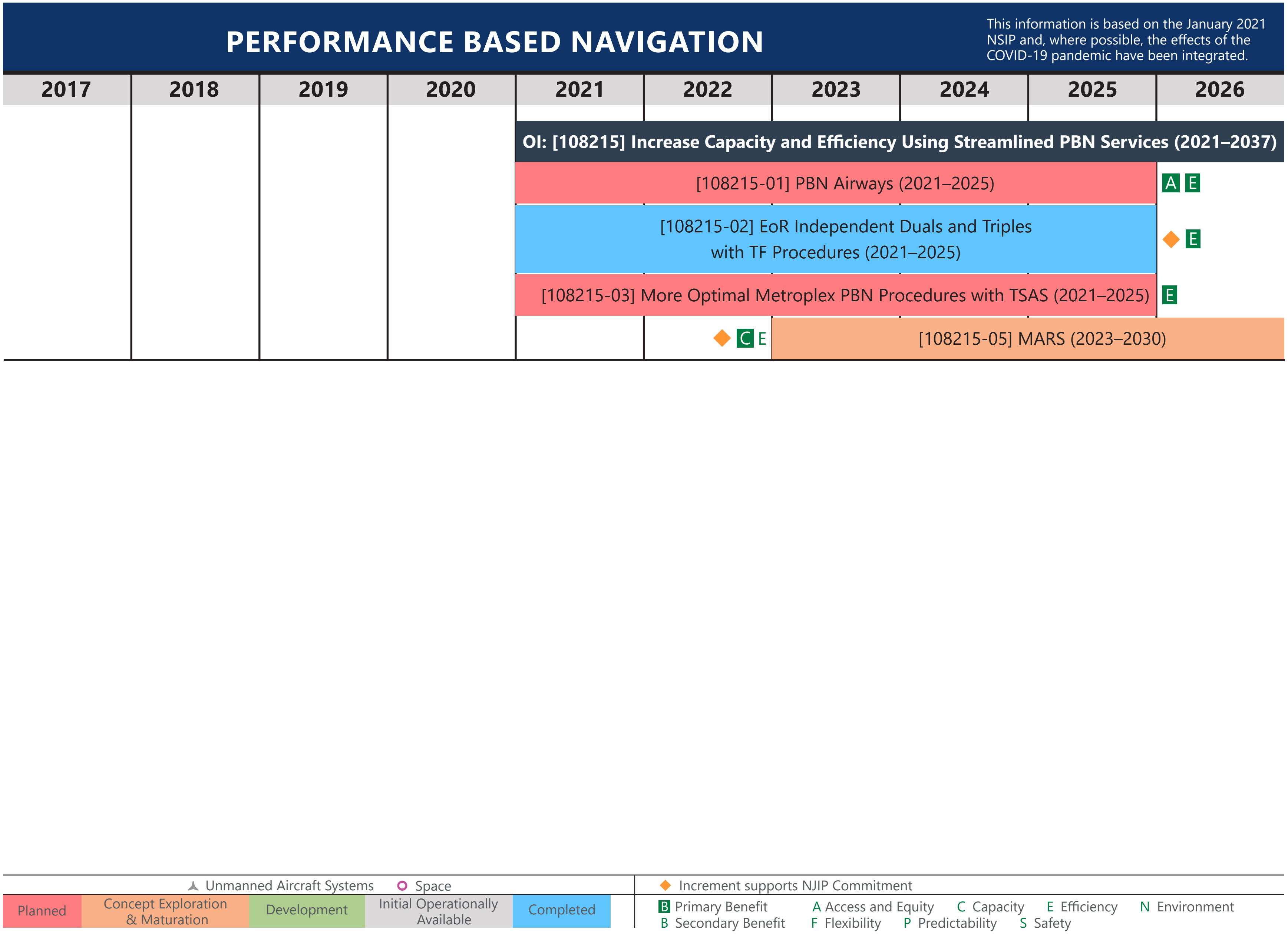
2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
		OI: [102161] Improved Parallel Runway Operations for Departures (2019–2023)							
		[102161-01] Dependent Stagger Departures for CSPO (2019–2023)					C E		
		[102161-02] Further Reductions to Departure Divergence Requirements for CSPO (2019–2023)					C E		
		[102161-03] Decreased Separation Requirements for Mixed Operations on CSPR (2019–2023)					C E		

Unmanned Aircraft Systems   Space   Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit   A Access and Equity   C Capacity   E Efficiency   N Environment
B Secondary Benefit   F Flexibility   P Predictability   S Safety


PERFORMANCE BASED NAVIGATION
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [107120] Resilient PBN Operations (2021–2025)
[107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021–2025)
A E
[107120-03] Resilient PBN Operations In the Terminal Environment (2026–2031)
A E
OI: [108209] Increase Capacity and Efficiency Using RNAV and RNP (2010–2021)
[108209-12] Metroplex PBN Procedures (2014–2020)
A E C
[108209-14] Transition to PBN Routing for Cruise Operations (2014–2021)
A E
[108209-20] Advanced and Efficient RNP (2013–2020)
E
[108209-21] ELSO Standard (2015–2018)
C E
[108209-22] Expansion of Metroplex PBN Procedures (2017–2021)
A E C
[108209-23] EoR Independent Duals and Triples with RF Procedures (2017–2020)
E
Unmanned Aircraft Systems
Space
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
Increment supports NJIP Commitment
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment


PERFORMANCE BASED NAVIGATION
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [108215] Increase Capacity and Efficiency Using Streamlined PBN Services (2021–2037)
[108215-01] PBN Airways (2021–2025)
A E
[108215-02] EoR Independent Duals and Triples with TF Procedures (2021–2025)
E
[108215-03] More Optimal Metroplex PBN Procedures with TSAS (2021–2025)
E
C E
[108215-05] MARS (2023–2030)
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

TIME-BASED FLOW MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [102118] Relative Spacing Using Interval Management (2026–2030)

E [102118-21] Relative Spacing Using Interval Management - Cruise (2026–2030)

OI: [104117] Improved Management of Arrival/Surface/Departure Flow Operations (2015–2032)

[104117-11] IDAC (2014–2019) ◆ E C, N

[104117-21] Expansion of the IDAC (2021–2025) E C, N

P E [104117-22] Arrival Scheduling with Departure Data (2024–2028)

Unmanned Aircraft Systems · Space · ◆ Increment supports NJIP Commitment

Planned · Concept Exploration & Maturation · Development · Initial Operationally Available · Completed

B Primary Benefit · B Secondary Benefit · A Access and Equity · F Flexibility · C Capacity · P Predictability · E Efficiency · S Safety · N Environment

TIME-BASED FLOW MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [104120] Enhanced Time-Based Metering Operations in All Weather (2014–2035)

- P E [104120-21] Sustain Metering in Variable Operational Conditions (2026–2031)

CO: [104123] TBM Using RNAV and RNP Route Assignments (2014–2032)

- E N [104123-21] Lateral Maneuvering for Delay Absorption (Path Stretch) (2025–2029)
- E N [104123-25] OPDs to the Runway Enabled by RTA Capability (2023–2027)

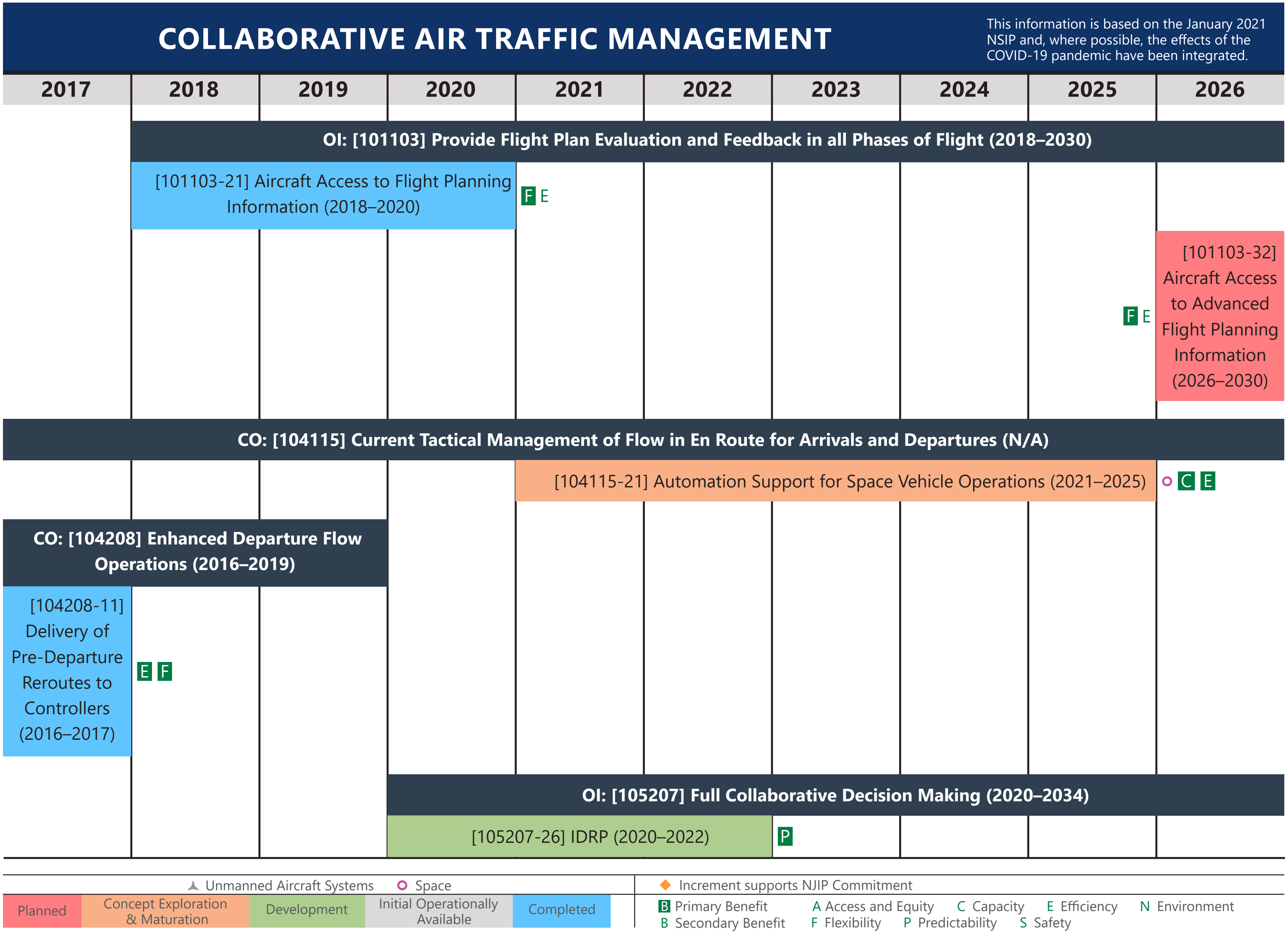
OI: [104128] TBM in the Terminal Environment (2019–2028)

- [104128-24] Initial TBM in the Terminal Environment (2019–2022) E
- E [104128-25] Expanded TBM in the Terminal Environment (2024–2026)

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment


COLLABORATIVE AIR TRAFFIC MANAGEMENT
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [101103] Provide Flight Plan Evaluation and Feedback in all Phases of Flight (2018–2030)
[101103-21] Aircraft Access to Flight Planning Information (2018–2020)
F E
[101103-32] Aircraft Access to Advanced Flight Planning Information (2026–2030)
F E
CO: [104115] Current Tactical Management of Flow in En Route for Arrivals and Departures (N/A)
[104115-21] Automation Support for Space Vehicle Operations (2021–2025)
C E
CO: [104208] Enhanced Departure Flow Operations (2016–2019)
[104208-11] Delivery of Pre-Departure Reroutes to Controllers (2016–2017)
E F
OI: [105207] Full Collaborative Decision Making (2020–2034)
[105207-26] IDRP (2020–2022)
P
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

COLLABORATIVE AIR TRAFFIC MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

CO: [105208] TMI with Flight-Specific Trajectories (2012–2032)

- [105208-21] Airborne Rerouting (2016–2017) — Completed — **E** F
- [105208-26] Access to Airborne Reroute Evaluation, Feedback, and Synchronization (2026–2031) — Planned — **F** E

CO: [105302] Initial Flight Day Evaluation (2011–2018)

- [105302-27] User Input to Improve Departure Predictions (2016–2018) — Completed — **E** P

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

COLLABORATIVE AIR TRAFFIC MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
									OI: [105303] Advanced Flight Day Evaluation (2026–2032)
								E C	[105303-21] Improve Demand Predictions (2026–2028)

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

SEPARATION MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [101202] Flight Management with Trajectory (2017–2035)

- [101202-22] Unique Attributes for UAS Flight Planning (2026–2030) — P

CO: [102105] Current Oceanic Separation (N/A)

- [102105-21] ASEPS ADS-C Reduced Oceanic Separation (2020–2023) — C E

OI: [102117] Reduced Horizontal Separation Standards, En Route - 3 Miles (2020–2030)

- [102117-22] Active Surveillance Collision Avoidance (2020–2025) — S E

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

SEPARATION MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
									OI: [102118] Relative Spacing Using Interval Management (2026–2030)
								E C	[102118-23] Relative Spacing Using Interval Management - Arrivals and Approach (2026–2030)
OI: [102137] Automation Support for Separation Management (2014–2030)									
		[102137-29] More Efficient Merging of Terminal Arrival Flows (2019–2024)							

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

SEPARATION MANAGEMENT

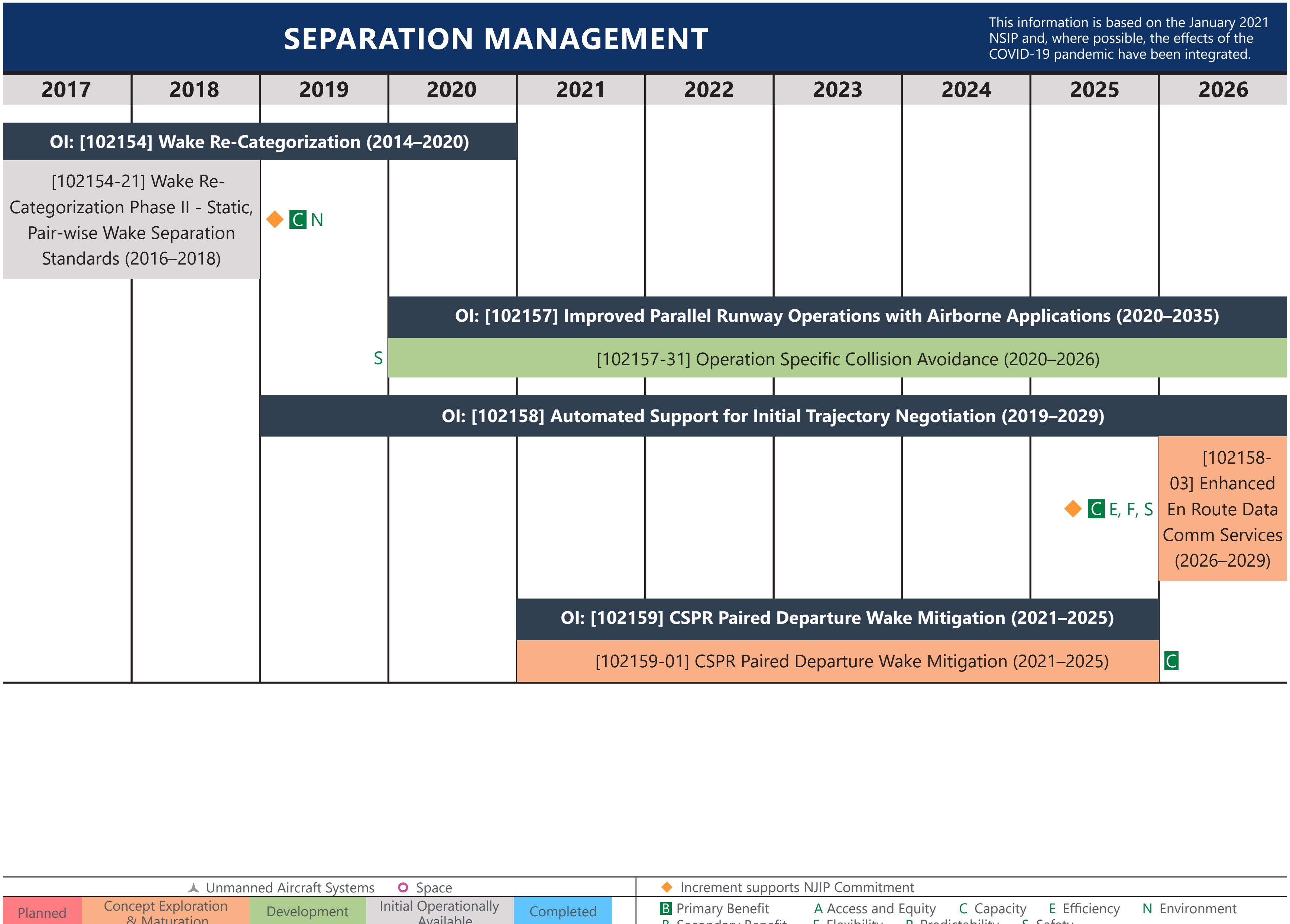
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
									OI: [102148] Time-Based Spacing Using Interval Management (2026–2035)
								E F	[102148-01] Initial Time-Based Spacing Using Interval Management (2026–2030)
							OI: [102152] Dynamic, Pair-wise Wake Turbulence Separation (2024–2030)		
								C	[102152-31] Dynamic, Pair-wise Wake Separation Standards (2026–2030)

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment



SEPARATION MANAGEMENT
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [102154] Wake Re-Categorization (2014–2020)
[102154-21] Wake Re-Categorization Phase II - Static, Pair-wise Wake Separation Standards (2016–2018)
C N
OI: [102157] Improved Parallel Runway Operations with Airborne Applications (2020–2035)
S
[102157-31] Operation Specific Collision Avoidance (2020–2026)
OI: [102158] Automated Support for Initial Trajectory Negotiation (2019–2029)
C E, F, S
[102158-03] Enhanced En Route Data Comm Services (2026–2029)
OI: [102159] CSPR Paired Departure Wake Mitigation (2021–2025)
[102159-01] CSPR Paired Departure Wake Mitigation (2021–2025)
C
Unmanned Aircraft Systems
Space
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
Increment supports NJIP Commitment
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

SEPARATION MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026

OI: [102160] Advanced Automation Support for Separation Management (2025–2030)

C S [102160-02] Controller Tools for Managing Advanced Wake Separation Standards (2025–2030)

CO: [103201] Current Traffic Advisory (N/A)

S A [103201-01] UAS Detect and Avoid (2022–2026)

OI: [104102] Optimized Oceanic Trajectories via Interactive Planning (2020–2032)

E [104102-25] Preferred Oceanic Routes with More Dynamic Special Activity Airspace Information (2026–2031)

[104102-30] Enhanced Conflict Probe for ATOP Surveillance Airspace (2020–2025) S

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

SEPARATION MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

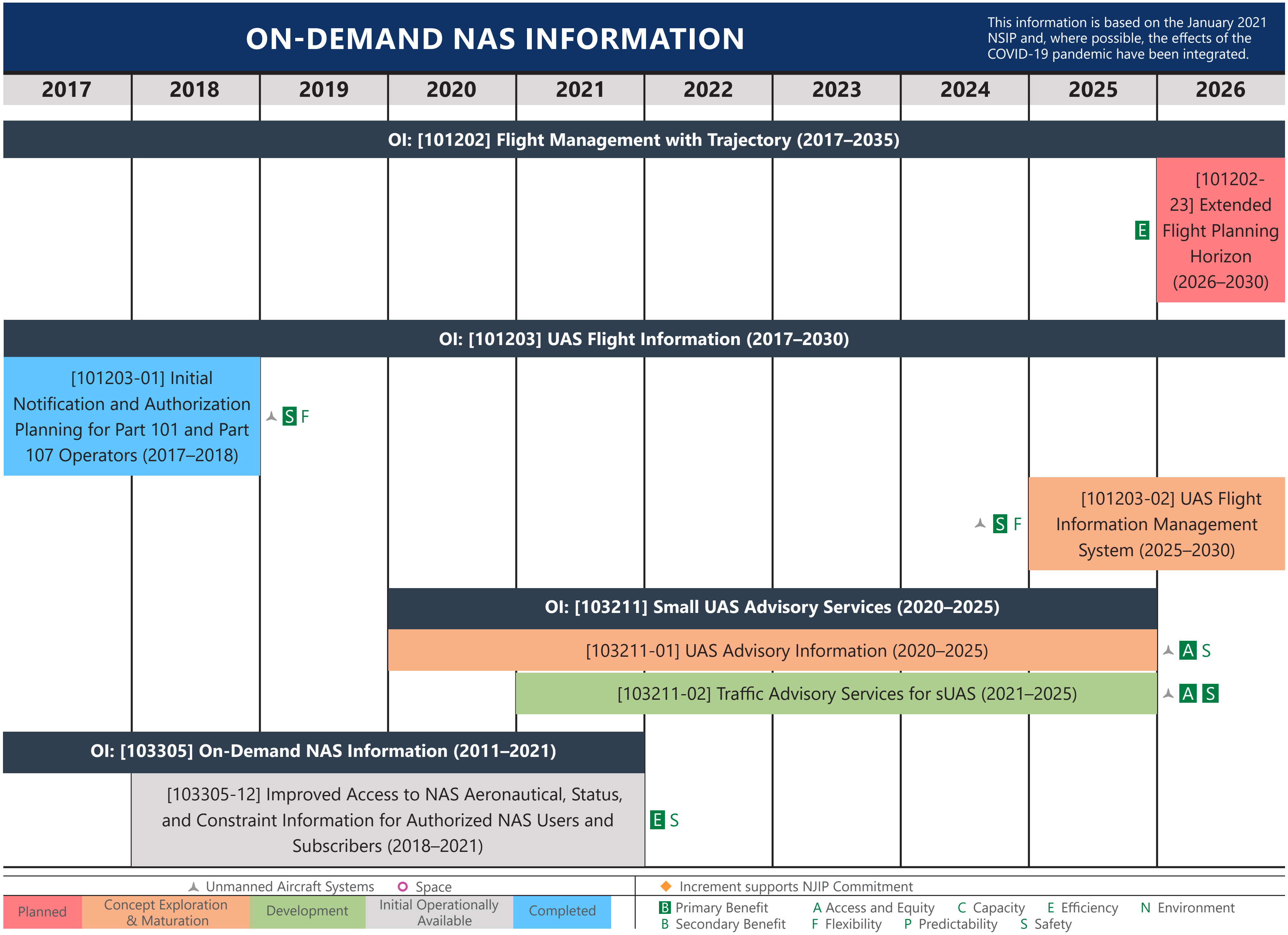
2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
OI: [108214] UAS Airspace Access (2017–2024)									
[108214-01] UAS Airspace Access when Operating within Visual Line of Sight (2017–2018)		S E, F, P							
			[108214-02] UAS Airspace Access when Operating Beyond Visual Line of Sight (2020–2024)					S E, F, P	

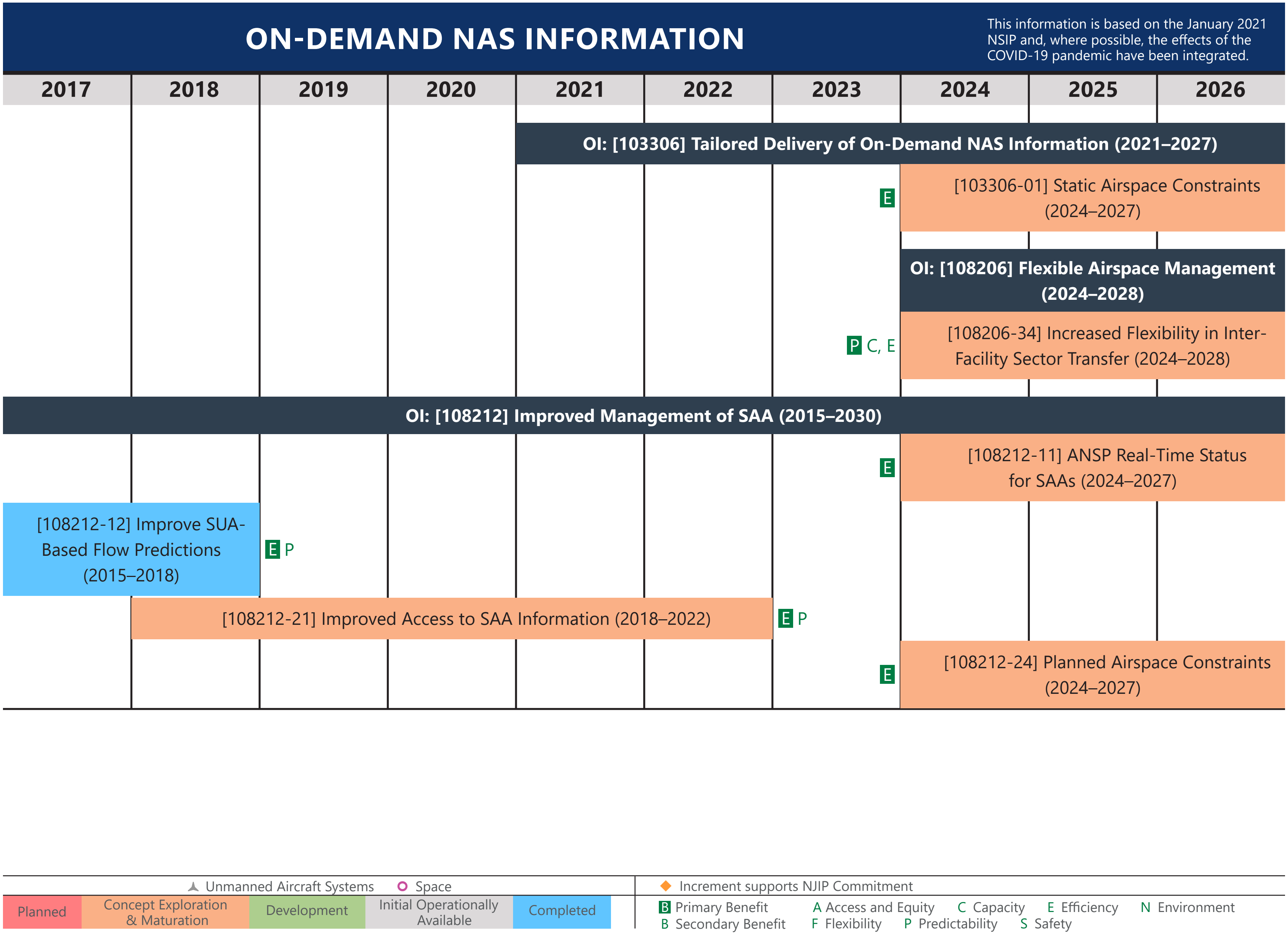
Unmanned Aircraft Systems Space

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

Increment supports NJIP Commitment

B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment


ON-DEMAND NAS INFORMATION
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [101202] Flight Management with Trajectory (2017–2035)
E
[101202-23] Extended Flight Planning Horizon (2026–2030)
OI: [101203] UAS Flight Information (2017–2030)
[101203-01] Initial Notification and Authorization Planning for Part 101 and Part 107 Operators (2017–2018)
S F
S F
[101203-02] UAS Flight Information Management System (2025–2030)
OI: [103211] Small UAS Advisory Services (2020–2025)
[103211-01] UAS Advisory Information (2020–2025)
A S
[103211-02] Traffic Advisory Services for sUAS (2021–2025)
A S
OI: [103305] On-Demand NAS Information (2011–2021)
[103305-12] Improved Access to NAS Aeronautical, Status, and Constraint Information for Authorized NAS Users and Subscribers (2018–2021)
E S
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment


ON-DEMAND NAS INFORMATION
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [103306] Tailored Delivery of On-Demand NAS Information (2021–2027)
E
[103306-01] Static Airspace Constraints (2024–2027)
OI: [108206] Flexible Airspace Management (2024–2028)
P C, E
[108206-34] Increased Flexibility in Inter-Facility Sector Transfer (2024–2028)
OI: [108212] Improved Management of SAA (2015–2030)
E
[108212-11] ANSP Real-Time Status for SAAs (2024–2027)
[108212-12] Improve SUA-Based Flow Predictions (2015–2018)
E P
[108212-21] Improved Access to SAA Information (2018–2022)
E P
E
[108212-24] Planned Airspace Constraints (2024–2027)
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

ENVIRONMENT AND ENERGY

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [701103] Integrated Environmental Modeling – Phase II (2016–2020)

[701103-01] Aviation Environmental Tools Suite (2016–2020) N

OI: [701104] Integrated Environmental Modeling – Phase III (2021–2025)

[701104-01] Aviation Environmental Tools Suite – Phase III (2021–2025) N

CO: [702102] NextGen Environmental Engine and Aircraft Technologies – Phase I (2012–2017)

[702102-07] Ultra High-Bypass Ratio Geared Turbo Fan (2015–2017) N

[702102-08] Ceramic Matrix Composite Turbine Blade Tracks (2017) N

Unmanned Aircraft Systems Space

Planned	Concept Exploration & Maturation	Development	Initial Operationally Available	Completed

Increment supports NJIP Commitment

B Primary Benefit	A Access and Equity	C Capacity	E Efficiency	N Environment
B Secondary Benefit	F Flexibility	P Predictability	S Safety	

ENVIRONMENT AND ENERGY

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

CO: [702102] NextGen Environmental Engine and Aircraft Technologies – Phase I (2012–2017)

[702102-09] Dual-Wall Turbine Blade (2017) N

OI: [702103] NextGen Environmental Engine and Aircraft Technologies – Phase II (2016–2022)

[702103-03] Explore and Demonstrate New Technologies Under CLEEN – Phase II (2016–2022) N

OI: [702104] NextGen Environmental Engine and Aircraft Technologies – Phase III (2021–2025)

[702104-01] Explore and Demonstrate New Technologies Under CLEEN – Phase III (2021–2025) N

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

ENVIRONMENT AND ENERGY

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

CO: [703103] Sustainable Alternative Jet Fuels – Phase II (2016–2020)

[703103-01] Other Advanced Drop-In Aviation Alternative Jet Fuels – Phase II (2016–2020) N

[703103-02] Generic Methodology for Alternative Jet Fuel Approval (2016–2020) N

OI: [703104] Sustainable Alternative Jet Fuels – Phase III (2021–2025)

[703104-01] Support Qualification and Deployment of Drop-In Alternative Jet Fuels (2021–2025) N

CO: [704103] Environmental Policies, Standards, and Measures – Phase II (2016–2020)

[704103-01] Environmental Performance and Targets – Phase II (2016–2020) N

[704103-03] EMS Data Management (2016–2020) N

[704103-04] Analysis to Support International Environmental Standard-Setting – Phase II (2016–2020) N

Unmanned Aircraft Systems · Space · Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit · B Secondary Benefit · A Access and Equity · C Capacity · E Efficiency · N Environment · F Flexibility · P Predictability · S Safety

ENVIRONMENT AND ENERGY

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
				OI: [704104] Environmental Policies, Standards, and Measures – Phase III (2021–2025)					
				[704104-01] Environmental Performance and Targets – Phase III (2021–2025)					N
				[704104-02] Analysis to Support International Environmental Standard-Setting – Phase III (2021–2025)					N

Unmanned Aircraft Systems   Space   Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit   B Secondary Benefit   A Access and Equity   F Flexibility   C Capacity   P Predictability   E Efficiency   S Safety   N Environment

SYSTEM SAFETY MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [601103] Safety Information Sharing and Emergent Trend Detection (2016–2021)

- [601103-01] Additional ASIAS Participants (2016–2021) S
- [601103-02] NextGen Enabled Data (2016–2021) S
- [601103-03] Architecture Evolution and NextGen Support (2016–2021) S
- [601103-04] Analytical Capabilities in Support of NextGen (2016–2021) S
- [601103-05] Automated Vulnerability Discovery (2016–2021) S
- [601103-06] Continued Studies and Results (2016–2021) S
- [601103-07] Expanded Collaboration Environments (2016–2021) S

OI: [601104] Automated Safety Information Sharing and Analysis (2022–2025)

- [601104-01] Expanded Participation (2022–2025) S
- [601104-02] Data Fusion (2022–2025) S
- [601104-03] Expanded Analytical Capabilities to Include New Entrants (2022–2025) S
- [601104-04] Vulnerability Discovery through Automated Trend Detection (2022–2025) S

Unmanned Aircraft Systems | Space

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

Increment supports NJIP Commitment

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

SYSTEM SAFETY MANAGEMENT

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026

OI: [601202] Integrated Safety Analysis and Modeling (2014–2025)

- [601202-01] Automated Operational Anomaly Detection, Analysis and Forecasting Models (2014–2018) S
- [601202-02] System-Wide Integrated Risk Baseline Annual Reports (2014–2017) S
- [601202-03] Tailored, Domain-Specific Baseline and Predictive Risk Models (NextGen Portfolio Support) (2015–2018) S
- [601202-04] Integrated NAS-wide Hazard Identification, Evaluation and Forecasting (2014–2018) S
- [601202-05] Integrated NAS-wide Automation System Modeling and Anomaly Detection (2016–2020) S
- [601202-06] Integrated Tools for Safety Risk Assessment Modeling (2021–2025) S

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

SYSTEM SAFETY MANAGEMENT

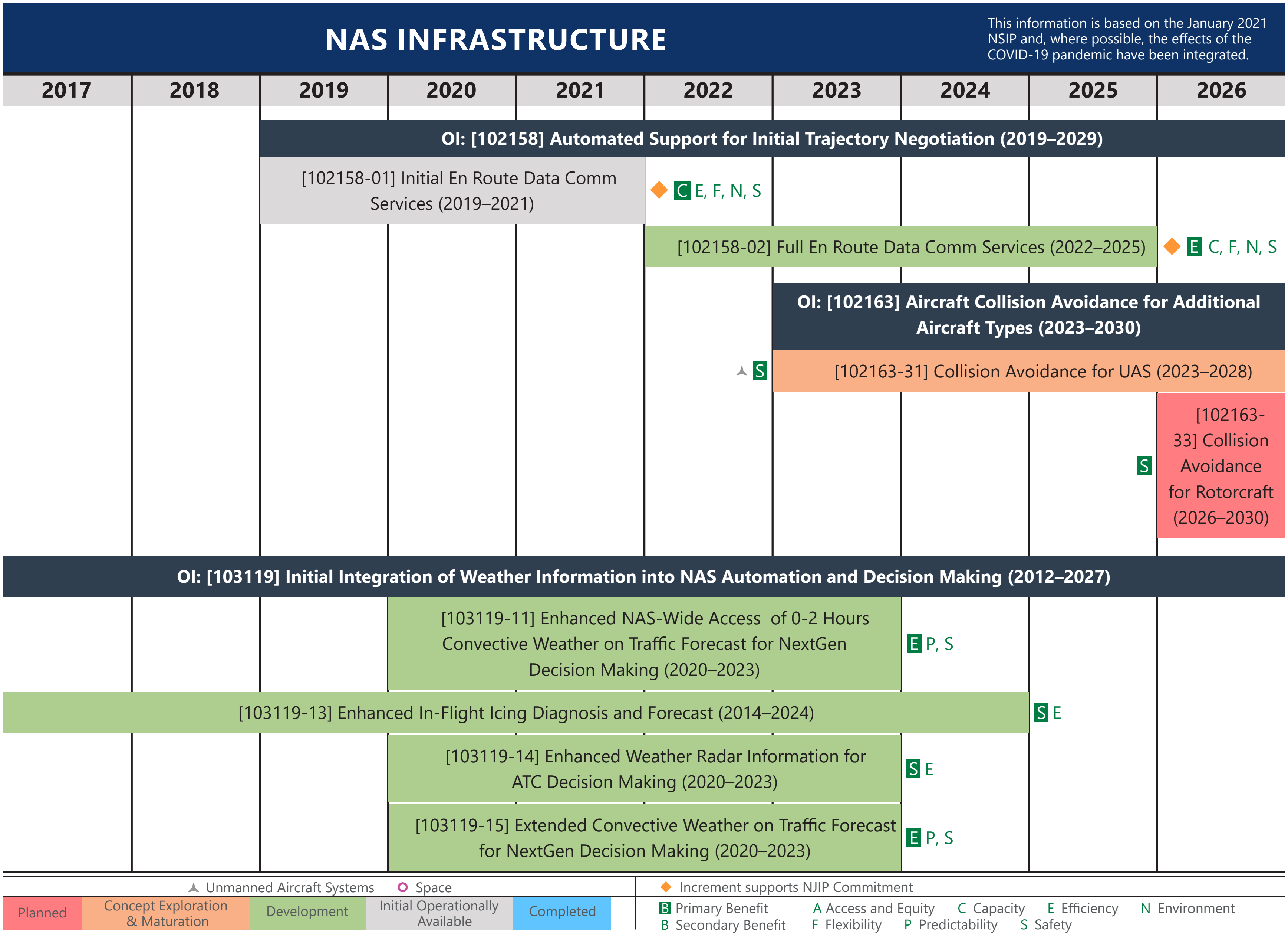
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
		OI: [601302] Increase International Cooperation for Aviation Safety (2019–2025)							
		[601302-01] EUROCONTROL-FAA Joint Analytical Platform Development and Deployment (2019–2025)							S

Unmanned Aircraft Systems Space Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit B Secondary Benefit A Access and Equity F Flexibility C Capacity P Predictability E Efficiency S Safety N Environment


NAS INFRASTRUCTURE
This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
OI: [102158] Automated Support for Initial Trajectory Negotiation (2019–2029)
[102158-01] Initial En Route Data Comm Services (2019–2021)
C E, F, N, S
[102158-02] Full En Route Data Comm Services (2022–2025)
E C, F, N, S
OI: [102163] Aircraft Collision Avoidance for Additional Aircraft Types (2023–2030)
S
[102163-31] Collision Avoidance for UAS (2023–2028)
S
[102163-33] Collision Avoidance for Rotorcraft (2026–2030)
OI: [103119] Initial Integration of Weather Information into NAS Automation and Decision Making (2012–2027)
[103119-11] Enhanced NAS-Wide Access of 0-2 Hours Convective Weather on Traffic Forecast for NextGen Decision Making (2020–2023)
E P, S
[103119-13] Enhanced In-Flight Icing Diagnosis and Forecast (2014–2024)
S E
[103119-14] Enhanced Weather Radar Information for ATC Decision Making (2020–2023)
S E
[103119-15] Extended Convective Weather on Traffic Forecast for NextGen Decision Making (2020–2023)
E P, S
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operationally Available
Completed
B Primary Benefit
B Secondary Benefit
A Access and Equity
F Flexibility
C Capacity
P Predictability
E Efficiency
S Safety
N Environment

NAS INFRASTRUCTURE

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [103119] Initial Integration of Weather Information into NAS Automation and Decision Making (2012–2027)

[103119-16] CWAM for Arrival/Departure Operations (2018–2023) E P

[103119-17] 4-D Tailored Volumetric Retrievals of Aviation Weather Information (2018–2024) E S

[103119-18] Enhanced Turbulence Forecast and Graphical Guidance (2018–2024) S E

[103119-19] Enhanced Ceiling and Visibility Analysis (2012–2024) E S

[103119-21] Enhanced Convective Weather Using Satellite-Based Observation in Offshore Oceanic Airspace (2017–2027) E P, S

OI: [103123] Full Integration of Weather Information Into NAS Automation and Decision Making (2021–2030)

E S [103123-01] Severe Weather to Aircraft Notification (2021–2027)

E [103123-02] Net-Enabled Access to NextGen Common Weather Information Source – Enhanced (2021–2026)

E C, S [103123-03] Enhanced Icing Information (2021–2026)

E C, S [103123-04] Expanded Turbulence Information (2021–2027)

E [103123-05] Generation of Enhanced NextGen Weather Information – Extended (2021–2027)

E S [103123-06] Expanded Ceiling and Visibility Information (2021–2026)

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit | B Secondary Benefit | A Access and Equity | F Flexibility | C Capacity | P Predictability | E Efficiency | S Safety | N Environment

NAS INFRASTRUCTURE

This information is based on the January 2021 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

OI: [103123] Full Integration of Weather Information Into NAS Automation and Decision Making (2021–2030)

- E — [103123-07] Enhanced Weather Products from Improved Satellite Observation Data (2023–2027)
- E S — [103123-08] Enhanced Automated Winter Weather Information (2026–2030)
- Space, E S — [103123-09] Space Weather Information (2023–2026)

OI: [103306] Tailored Delivery of On-Demand NAS Information (2021–2027)

- [103306-04] CSS-Wx (2021–2024) — E S

Unmanned Aircraft Systems · Space · Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operationally Available | Completed

B Primary Benefit · B Secondary Benefit · A Access and Equity · F Flexibility · C Capacity · P Predictability · E Efficiency · S Safety · N Environment

TRAJECTORY BASED OPERATIONS

Many of the current operations or planned operational improvements serve as building blocks for TBO, a principal goal for NextGen and the future NAS. TBO is an air traffic management method for strategically planning, managing, and optimizing flights throughout the operation by using time-based management, information exchange between air and ground systems, and the aircraft's ability to fly precise paths in time and space. TBO allows for more effective flight planning alongside smoother and more predictable operations throughout the NAS.

With TBO, controllers continue to assure separation based on where a flight is and improved predictions of where and when the flight is expected to be at key points. The aircraft's trajectory will be synchronized through automation by using improved and consistent information for better sequencing, which will reduce the need for less efficient rerouting. All flight trajectories competing for the same point in space at the same time will be sequenced to ensure appropriate spacing at those locations.

NextGen's path to TBO (Figure A-4) integrates capabilities that already have been deployed with new hardware and software to deliver on the operational vision. The capabilities are grouped into five themes:

- **Infrastructure**: Improvements to communications, navigation, surveillance, automation, and information exchange infrastructure that we implemented over the past decade. The FAA will continue to introduce new capabilities and enhance existing technologies in these areas to fully implement TBO.
- **Integrated Arrivals**: Operational changes focused on the arrival phase of the operation, including navigation procedures and time-based management capabilities required for TBO. For example, en route arrival metering using TBFM is already in place; terminal arrival metering began operation in 2020. Standard terminal arrival procedures with an optimized profile descent and the Established on RNP separation standard are already available in the NAS.
- **Integrated Departures**: Operational changes at the airport and departure phase of the flight, including navigation procedures and time-based management capabilities necessary for TBO. Departures enabled by PBN and Data Communications (Data Comm) for departure clearances are available at many busy airports. Improvements for surface metering and electronic flight data will be deployed in the next two years to further improve collaborative decision-making between the FAA and aircraft operators.
- **Advanced Trajectory Management**: Operational changes focused on strategic and tactical management of aircraft trajectories. This includes operational changes planned for traffic management synchronization across the NAS. With improved strategic flight planning offered by the Traffic Flow Management System and System Wide Information Management in place, we will improve how we manage flights. In 2019, the FAA improved aircraft access to advanced flight planning information and began initial en route services for Data Comm; additional initial en route services are planned in the next few years.
- **Dynamic**: Operational changes envisioned for the final phase of TBO are in the earliest stages of planning and concept development. These changes are planned to begin in 2025 with dynamic wake separation and in 2026 with interval management, an Automatic Dependent Surveillance–Broadcast In application.

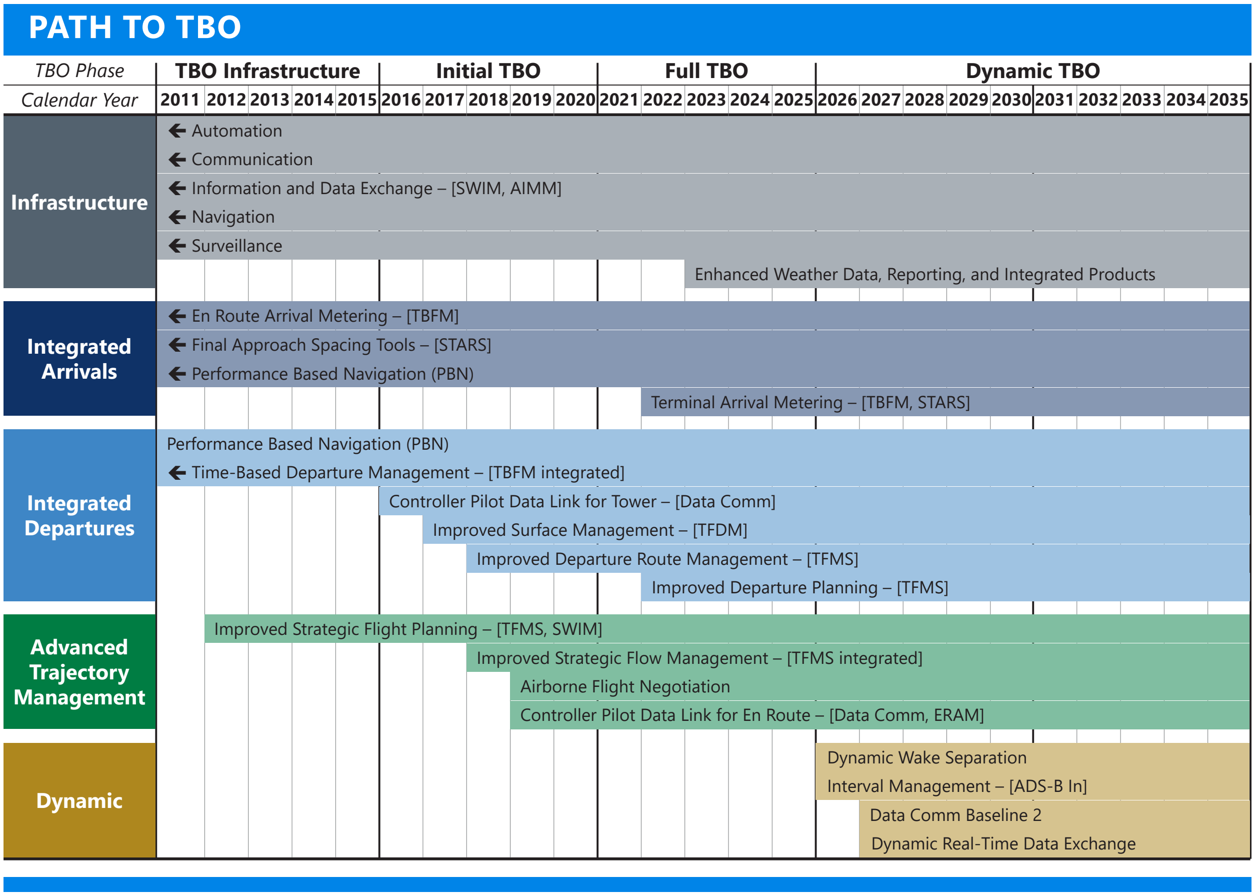


Figure A-4: The integrated TBO capability will deliver the envisioned operational improvement. The capabilities in the shaded boxes represent when additional features will be available. Black left arrows to the left side of the chart indicate the initial capability was deployed before 2011. The information is based on the January 2021 NSIP; the FAA continues to assess the ramifications of delays caused by the pandemic and revised implementation milestones for some of these activities.

TBO implementation will evolve over time and be phased in at targeted locations beginning with the Northeast Corridor. This phased approach ensures that air traffic control facilities receive the right capabilities for their needs in the best sequence and at the correct time.

As the FAA extends TBO to new areas, we will choose from the available capabilities at the time of deployment. For example, if a location is slated for TBO in 2022, the FAA will assess whether integrated arrivals, integrated departures, and some initial advanced trajectory management capabilities, such as en route Data Comm, would provide an operational benefit. We will also determine which of those capabilities should be integrated into the initial TBO deployment for that area.

2021 AND BEYOND

Through NextGen, the FAA is implementing new technologies and air traffic control procedures that transform how we communicate, navigate, and track aircraft in our nation's skies.

APPENDIX B

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

APPENDIX B
ACRONYMS, INITIALISMS, AND ABBREVIATIONS

AAAC	Advanced Aviation Advisory Committee
AAM	Advanced Air Mobility
ABRR	Airborne Reroute
ACAS sXu	Airborne Collision Avoidance System for Small UAS
ACAS X	Airborne Collision Avoidance System X
ACAS XO	Airborne Collision Avoidance System XO variant (variant of ACAS X)
ACAS Xr	Airborne Collision Avoidance System for Rotorcraft
ACS	AIMM Common Service
ADS-B	Automatic Dependent Surveillance–Broadcast
ADS-C	Automatic Dependent Surveillance–Contract
AGL	Above Ground Level
AIM	Aeronautical Information Management
AIMM	Aeronautical Information Management Modernization
ANSP	Air Navigation Service Provider
APDS	Airport Data Service
API	Application Programming Interface
ASDE-X	Airport Surface Detection Equipment–Model X
ASEPS	Advanced Surveillance Enhanced Procedural Separation
ASIAS	Aviation Safety Information Analysis and Sharing
ASSC	Airport Surface Surveillance Capability
ATD	Airspace Technology Demonstration
ATM	Air Traffic Management

ATOP	Advanced Technologies and Oceanic Procedures
AWS	Amazon Web Services
BVLOS	Beyond Visual Line of Sight
CAS	CDTI Assisted Separation
CATM	Collaborative Air Traffic Management
CAVS	CDTI-Assisted Visual Separation
CDTI	Cockpit Display of Traffic Information
CLEEN	Continuous Lower Energy, Emissions, and Noise
CO	Current Operation
CO2	Carbon Dioxide
COE	Centers of Excellence
CPDLC	Controller Pilot Data Link Communications
CSPO	Closely Spaced Parallel Operations
CSPR	Closely Spaced Parallel Runways
CSS-Wx	Common Support Services–Weather
CWAM	Convective Weather Avoidance Model
DAA	Detect and Avoid
DAC	Drone Advisory Committee
Data Comm	Data Communications
DME	Distance Measuring Equipment
DOD	Department of Defense
DSS	Decision Support System
EDC	En Route Departure Capability
EFVS	Enhanced Flight Vision System
ELSO	Equivalent Lateral Spacing Operations

EMS	Environmental Management Systems
EoR	Established on RNP
ERAM	En Route Automation Modernization
ERADP	En Route Airspace Data Publication
ERFDP	En Route Flight Data Publication
ERGMP	En Route General Messaging Publication
ETM	Upper Class E Traffic Management
EUROCONTROL	European Organization for the Safety of Air Navigation
EWD	Enhanced WINS Dissemination
FAA	Federal Aviation Administration
FNS	Federal NOTAM System
FMDS	Flow Management Data and Services
GBAS	Ground Based Augmentation System
GPS	Global Positioning System
H.R.	House Resolution
IADS	Integrated Arrival, Departure, and Surface
IAM	Identify and Access Management
ICAO	International Civil Aviation Organization
IDAC	Integrated Departure/Arrival Capability
IDRP	Integrated Departure Route Planning
IFP	Instrument Flight Procedures
ILS	Instrument Landing System
IM	Interval Management
iTBO	Initial TBO
ITWS	Integrated Terminal Weather Service

LAANC	Low Altitude Authorization and Notification Capability
MARS	Multiple Airport Route Separation
MCL	Minimum Capabilities List
MicroEARTS	Microprocessor En Route Automated Radar Tracking System
MRS	Minimum Radar Separation
NAC	NextGen Advisory Committee
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NCR	NAS Common Reference
NDS	NOTAM Distribution Service
NEMS	NAS Enterprise Messaging Service
NESG	NAS Enterprise Security Gateway
NextGen	Next Generation Air Transportation System
NJIP	NextGen Joint Implementation Plan
NSIP	NAS Segment Implementation Plan
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notices to Air Missions
NPS	NOTAM Publication Service
NSIC	NAS Space Integration Capabilities
NWP	NextGen Weather Processor
OI	Operational Improvement
OPD	Optimized Profile Descent
PBN	Performance Based Navigation
PDRR	Pre-departure Reroute
PIREP	Pilot Report

PUB	Publication
REDAC	Research Engineering, and Development Advisory Committee
RF	Radius-to-Fix
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
RVR	Runway Visual Range
SAA	Special Activity Airspace
SBA	Space-Based ADS-B
SCDS	SWIM Cloud Distribution Service
SFB	Space Force Base
SFDPS	SWIM Flight Data Publication Service
SLF	South Florida Launch and Landing Facility
SMES	Surface Movement Event Service
STAR	Standard Terminal Arrival
STARS	Standard Terminal Automation Replacement System
STDDS	SWIM Terminal Data Distribution System
SUA	Special Use Airspace
sUAS	Small UAS
SVGS	Synthetic Vision Guidance Systems
SVT	Surface Visualization Tool
SWIFT	SWIM-Industry FAA Team
SWIM	System Wide Information Management
TAIS	Terminal Aviation Information Service
TBD	To Be Determined

TBFM	Time-Based Flow Management
TBM	Time-Based Metering
TBO	Trajectory Based Operations
TDES	Tower Departure Event Service
TFDM	Terminal Flight Data Manager
TFMData	Traffic Flow Management Data
TFMS	Traffic Flow Management System
TRACON	Terminal Radar Approach Control
TSAS	Terminal Sequencing and Spacing
TTP	TFDM Terminal Publication
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems
UAT	Universal Access Transceiver
UPP	UTM Pilot Program
USS	UAS Service Supplier
UTM	UAS Traffic Management
V2V	Vehicle to Vehicle
WARP	Weather and Radar Processor
WCS	Web Coverage Service
WFS	Web Feature Service
WINS	Weather Information Network Server
WMSCR	Weather Message Switching Center Replacement

CORE AIRPORTS

The Core Airports are those that have the most significant impact on the operation of the NAS.

ATL	Hartsfield-Jackson Atlanta International Airport
BOS	General Edward Lawrence Logan International Airport (Boston)
BWI	Baltimore-Washington International Thurgood Marshall Airport
CLT	Charlotte Douglas International Airport
DCA	Ronald Reagan Washington National Airport
DEN	Denver International Airport
DFW	Dallas/Fort Worth International Airport
DTW	Detroit Metropolitan Wayne County Airport
EWR	Newark Liberty International Airport
FLL	Fort Lauderdale-Hollywood International Airport
HNL	Daniel K. Inouye International Airport (Honolulu)
IAD	Washington Dulles International Airport
IAH	George Bush Intercontinental Airport (Houston)
JFK	John F. Kennedy International Airport (New York)
LAS	McCarran International Airport (Las Vegas)
LAX	Los Angeles International Airport
LGA	LaGuardia Airport (New York)
MCO	Orlando International Airport
MDW	Chicago Midway International Airport
MEM	Memphis International Airport
MIA	Miami International Airport
MSP	Minneapolis-Saint Paul International/Wold-Chamberlain Airport

ORD	O’Hare International Airport (Chicago)
PHL	Philadelphia International Airport
PHX	Phoenix Sky Harbor International Airport
SAN	San Diego International Airport
SEA	Seattle-Tacoma International Airport
SFO	San Francisco International Airport
SLC	Salt Lake City International Airport
TPA	Tampa International Airport

U.S. Department of Transportation
Federal Aviation Administration

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