NextGen
Annual Report

Fiscal Year 2023

U.S. Department of Transportation

Federal Aviation Administration

CONTENTS

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 the transformation of the NAS.

EXECUTIVE SUMMARY

The Next Generation Air Transportation System (NextGen) is the FAA modernization initiative to transform the U.S. National Airspace System (NAS). Most of the modernized infrastructure is in place, and NextGen has delivered more than $9.5 billion worth of total benefits between 2010 and 2022, with future benefits expected to grow substantially. Through NextGen, the NAS has evolved from a ground-based system of air traffic control into a satellite-based system of air traffic management using advanced automation and information-sharing. This annual report documents NextGen's progress and plans in fiscal year 2023.

Improvements in communications, navigation, surveillance, automation, and information management are the foundation for the modern airspace system. Other enhancements, such as in environment and safety, support the improvements. The FAA must balance sustaining current NAS operations with investments in NextGen priorities. We continue to assess the consequences of delays and funding shortfalls caused by the pandemic on programs, particularly Data Communications (Data Comm), Time Based Flow Management, Terminal Flight Data Manager (TFDM), and System Wide Information Management, even as we mark significant milestones for these initiatives.

In 2023, the FAA activated initial Data Comm en route services at five more air traffic control centers and enabled the first increment of full en route services at 12 facilities, allowing pilots on some transcontinental routes to digitally accept certain clearances from terminal and en route controllers on their entire flight. In 2023, the FAA also increased the amount of Performance Based Navigation flight procedures and routes available, which can reduce travel distance and time, and increase flight path predictability. Arrival procedures with an optimized profile descent were added for 11 airports, bringing the total number of airports with the procedures to 64. The FAA published 30 new and 24 amended T-Routes as part of the Alaska Aviation Safety Initiative and made 169 new Q-Routes available along the East Coast. Reduced airspace separation criteria allow for greater airspace throughput and can enable more expeditious flight paths. Six additional en route centers enabled the track-based display mode technology to use Automatic Dependent Surveillance–Broadcast surveillance for a 3-nautical-mile (NM) separation standard instead of 5 NM below 23,000 feet in certain airspace.

Enhancements to the En Route Automation Modernization system expanded the automated coordination of flight data and aircraft control with Canada, and upgrades to the Advanced Technologies and Oceanic Procedures system optimized flight trajectories and improved system safety for oceanic traffic. The FAA also implemented more of TFDM Build 1, enabling a total of five towers to use this technology to improve efficiency on the ground and in the terminal airspace. The NextGen Weather Processor and Common Support Services–Weather programs completed system development testing ahead of schedule and began key site installation.

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

NextGen innovations in communications, navigation, surveillance, automation, and information management have transformed National Airspace System operations, fulfilling the FAA's mission to ensure a safe and efficient aerospace system.

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

The FAA is operationalizing NextGen to move us closer to regular use of Trajectory Based Operations (TBO), which is an air traffic management method for strategically planning, managing, and optimizing flights throughout the operation. A regional operating area approach, spanning multiple air traffic facilities and airports, is being taken by the FAA for initial TBO implementation, which comprises a series of operational milestones. Regional operating areas of focus are the Northeast Corridor, Mid-Atlantic, Northwest Mountain, Southwest, and parts of the Southeast.

More equipage by aircraft operators and increasing use of NextGen technologies by the workforce are important to realizing the full benefits potential of NextGen. From planning to implementation and operationalization, the success of NextGen depends on the FAA's productive collaboration with other government agencies, industry, academia, research partners, and stakeholders from local communities.

Over the years of NextGen modernization, new kinds of aircraft have entered the NAS, and the changes are continuing rapidly with unmanned aircraft systems, advanced air mobility aircraft, and other emerging aircraft and spacecraft. The FAA continues to safely integrate these new users into the NAS alongside traditional aircraft. The Remote Identification rule has set mandates for drones that require FAA registration and are operating in U.S. airspace. Also, the FAA transitioned DroneZone to the FAA Cloud Service, expanded Low Altitude Authorization and Notification Capability access to the Department of Defense, and completed the Airborne Collision and Avoidance System X for small drones.

As NextGen progresses, the FAA is looking ahead to the next iteration of airspace modernization that is focused on information-sharing. At the heart of continued NAS transformation is the harnessing of data in decision-making to make flights more efficient and improve the safety of our skies. NAS modernization will take advantage of the ongoing information revolution with increases in telecommunication, computational power, and storage, along with new technologies that secure and learn from accumulated data.

INTRODUCTION

The Next Generation Air Transportation System (NextGen) is the FAA modernization initiative to transform the U.S. National Airspace System (NAS). NextGen embodies changes to technologies, procedures, and policies, and is expected to give the FAA the flexibility to adapt to future airspace needs. This report is a singular document about NextGen's progress and plans during fiscal year 2023. Whenever possible and unless stated otherwise, the data cutoff is September 30, 2023. The report responds to 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.

History

NextGen was born in the Vision 100—Century of Aviation Reauthorization Act passed by the 108th Congress in late 2003, after the FAA, based on forecasts of increased air traffic, realized that its air traffic control system was rapidly becoming obsolete and required changes. The act established the Joint Planning and Development Office (JPDO) to create a unified vision of what the U.S. air transportation system should deliver for the next generation and beyond. The FAA started delivering key parts of NextGen in 2008. By 2011, the NextGen Mid-Term Concept of Operations marked the beginning of a transition from the legacy system to the next-generation NAS.

NextGen enables the FAA to transition to a new method of managing air traffic called Trajectory Based Operations (TBO). TBO ensures that stakeholders and automation systems on the ground and flight deck will have a shared understanding of not just where an aircraft is but also where it will be and when at critical points along its flight path. Throughout the transformation, the FAA has worked to develop and test a new infrastructure that will accommodate state-of-the-art enabling technologies and capabilities, which is the foundation for continually improving and accommodating air transportation into the future.

NextGen Today

NextGen innovations in areas such as data networking, digital communications, and weather forecasting, are fulfilling the FAA's mission to ensure safe and efficient skies and airfields. NextGen systems help determine the optimal travel plan based on destination, weather, and traffic, enabling shorter, more precise flight paths. On the ground, aircraft and surface vehicles are tracked electronically, enabling more efficient taxiing. NextGen means less time sitting on the ground and holding in the air. NextGen technology and procedures shave minutes off flight times, saving money and supporting a better flight experience.

As NextGen continues to mature, the FAA still manages the legacy NAS while pivoting to the NAS modernization of the future. This hybrid NAS environment makes the FAA mission more challenging. Some operators still rely on legacy NAS technologies. The FAA continues to deploy NextGen services as operator equipage and federal resources allow. Meanwhile, we are working on future NAS modernization to accommodate new entrants of all types in airspace involving a continuous exchange of data. The FAA continues to work with all stakeholders to make strategic investments and create an agile infrastructure that maintains safety, ensures efficiency, and facilitates access for new entrants.

Benefits

Air traffic controllers, aircraft operators, and passengers benefit from the enhanced safety, efficiency, and capacity of airspace modernization.

The FAA annually updates the value of implemented NextGen benefits. Our estimates show that NextGen has delivered more than $9.5 billion worth of total benefits between calendar years 2010 and 2022 from about 20 NextGen capabilities through more than 200 implementations across the country. NextGen improvements in communication, navigation, and

NextGen capabilities implemented through calendar year 2022 provided $9.5 billion in benefits for the aviation community.

* Per DOT guidance, the FAA values benefits using not only aircraft operating cost savings, but also passenger travel time savings.

surveillance are the sources for nearly $5.3 billion in benefits, automation accounts for about $2.3 billion, and reduced separation standards take credit for an estimated $1.9 billion. NextGen continued to deliver value during the pandemic but at lower levels because of fewer flights. NextGen implementations also slowed during the pandemic due to the FAA's focus on operating the NAS and personnel safety, and multiple programs have been delayed and are being replanned.

NextGen benefits are calculated by analyzing performance before and after implementing NextGen capabilities. They have been measured in detail since 2010 and accrue each year. In 2016, the FAA started examining many of these benefits in partnership with the industry through the Joint Analysis Team (JAT) under the NextGen Advisory Committee (NAC). The JAT was created to increase the transparency of benefit estimates and reach an agreement on benefit values and measurement methodology. Outside of the JAT, the FAA has completed post-operational benefit analyses using JAT methodologies for more than 10 capabilities across 60 sites.

Total achieved benefits measured so far represent key implementations, which will continue to produce benefits. They are an initial portion of the expected future benefits.

Future benefits are driven by more implemented capabilities and procedures, continued equipping of aircraft by operators, and by growth in travel demand.

The FAA expects benefits to continue to grow from previously implemented capabilities and the ongoing implementations of Data Comm en route services and Terminal Flight Data Manager. NextGen remains a valid investment with substantial future benefits.

Collaboration

From planning to implementation and operationalization, the success of NextGen depends on cooperation among the FAA, other government agencies, and the aviation community. The FAA works with its labor unions to prepare employees for change. We interact with other government agencies through collaborative bodies to coordinate policy and share information, working primarily with the departments of Commerce, Defense, Homeland Security, and Interior; NASA; the National Transportation Safety Board; the National Geospatial-Intelligence Agency; the Environmental Protection Agency; and the Advisory Council on Historic Preservation to advance NAS modernization.

The FAA partners with universities and industry to advance aviation technologies and educate a new generation of professionals through the FAA Air Transportation Centers of Excellence. The centers' research focus includes general aviation safety, advanced materials for commercial aircraft, alternative jet fuels, unmanned aircraft systems (UAS), and commercial space transportation. Federally sponsored research and development facilities, such as MITRE's Center for Advanced Aviation System Development, also support FAA research for NextGen decision support systems and TBO concepts.

Besides interacting with the aviation industry stakeholders through research partnerships, the FAA also engages with them through trade associations, conferences, communities of interest, technical work groups, and advisory committees.

Advisory Committees

Three federal advisory committees, consisting of members from government, industry, community organizations, and academia representing broad points of view, provide independent advice and recommendations to the FAA for NextGen implementation, advanced aviation, and future research.

- The NextGen Advisory Committee seeks to resolve issues and challenges involving concepts, requirements, operational capabilities, the associated use of technology, and operational considerations that affect the future of the air traffic management system and the integration of new technologies. Furthermore, the NAC recommends consensus-driven standards for FAA consideration related to the modernization of the air traffic management system that the FAA may choose to adopt.
- The Advanced Aviation Advisory Committee takes on issues that improve the safety and efficiency of integrating advanced aviation, including UAS and advanced air mobility (AAM) aircraft, into the NAS.

It enables communities to inform how UAS, AAM, and other advanced aviation may operate in ways that are compatible with those communities.

- The Research, Engineering, and Development Advisory Committee (REDAC) considers aviation research needs in five areas: airport technology, NAS operations, human factors, aviation safety, and environment and energy. The REDAC also assists in ensuring the coordination of corollary research conducted outside of the FAA.

International

The FAA's leadership within, and collaboration with, the international aviation community achieves results in greater interoperability of avionics, communications, and operational methods. As the global leader in aerospace, the United States maintains international agreements with countries around the world. The FAA and its international partners work through the International Civil Aviation Organization (ICAO), which is the aviation technical body of the United Nations, to adopt international aviation standards that lead to a globally connected and harmonized air traffic management system.

The FAA participates on all expert panels considered necessary for international harmonization to help direct global air traffic modernization and mitigate operational risks, and we have led the revision of the global air traffic management roadmap described by the ICAO Global Air Navigation Plan, defining the 20-year outlook of world aviation systems. At the 41st ICAO Assembly in Montreal in 2022, the United States presented the FAA's NAS modernization vision document, which describes a future that builds upon NextGen and TBO, as our response to the global roadmap. The United States also proposed that ICAO establish an AAM advisory group and expand the scope of the trust framework panel for the secure exchange of digital information.

The FAA interacts directly with regional groups on air traffic management modernization through partnerships, such as agreements with the European Union, Japan, and Singapore for joint research and development of future air traffic systems. We actively work toward global interoperability across the Atlantic and Pacific oceans with the Single European Sky Air Traffic Management Research (SESAR) 3 Joint Undertaking and Japan's

Collaborative Actions for Renovation of Air Traffic Systems (CARATS) program.

In June 2023, the FAA joined Aeronautical Radio of Thailand, Civil Aviation Authority of Singapore, Japan Civil Aviation Bureau, and Boeing to sign a declaration of intent on Multi-Regional TBO, signaling a commitment to make TBO a global reality. The FAA and its Multi-Regional TBO partners completed a six-day live flight demonstration that month showcasing how sharing and coordinating trajectory information across multiple countries could reduce fuel burn and carbon dioxide emissions by up to 10 percent, minimize delays and disruptions, and cut travel costs and time.

Local Communities

The FAA engages local communities and airports by participating in committees, task forces, standards bodies, and public meetings to better understand problems and identify solutions. Public involvement continued through the pandemic and post-pandemic period, even with limits on travel and in-person gatherings because the FAA offered virtual access using remote meeting technology.

Joint Commitments

Through the NAC, the FAA and industry collaborate in program planning and prioritize industry investments as a vital component of NextGen's long-term success. Joint collaboration has proven helpful in improving operational capabilities, mitigating risk, and delivering benefits within the NAS.

The NextGen Priorities Joint Implementation Plan, developed in collaboration with industry stakeholders through the NAC, contains a set of commitments that FAA and industry stakeholders jointly agreed to track as high-priority milestones along the path to operationalizing NextGen. The plan identified 128 FAA and 88 industry commitments across the following focus areas: Data Comm, Performance Based Navigation, surface and data sharing, multiple runway operations, and Northeast Corridor.

The FAA is assessing the consequences of delays and funding shortfalls caused by the COVID-19 pandemic on programs, particularly Data

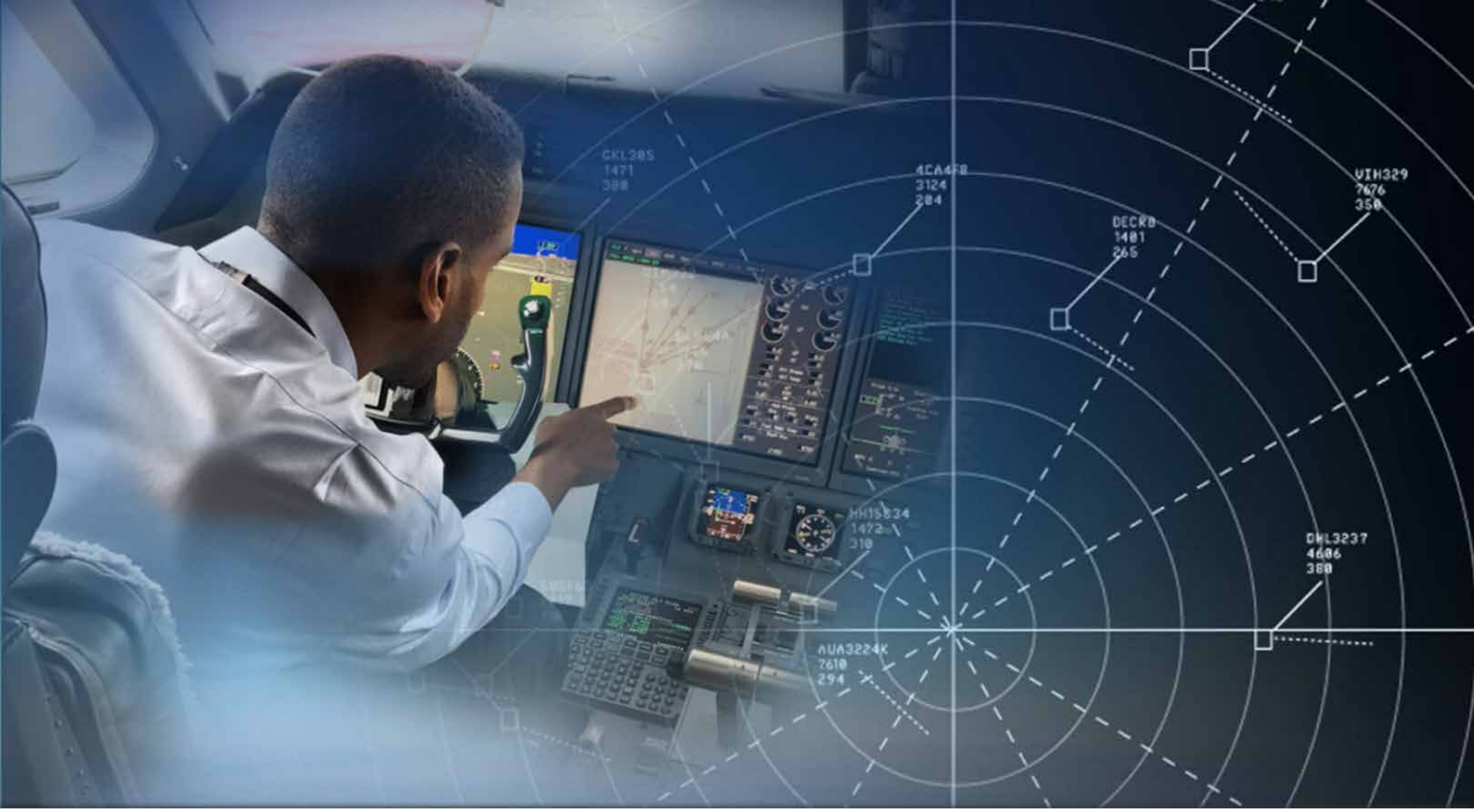
Comm, Time Based Flow Management (TBFM), TFDM, and System Wide Information Management (SWIM). The pandemic interrupted the complex choreography of engineering, implementation, training, and program management resources necessary to operationalize NextGen.

The NAC's consensus-based advice helped to inform our recovery strategy and balance between NAS operational sustainment and NextGen investments. While the FAA continues to validate updated timelines, interdependencies, and budget considerations post-pandemic, we are committed to completing the remaining milestones in the joint implementation plan. Thus, the FAA has extended the current plan, published on June 25, 2019, indefinitely to document our progress.

Equipage

Although the FAA has delivered most of the changes to technologies, capabilities, and operations envisioned under NextGen, the mixed equipage environment creates challenges for air traffic controllers to apply a NextGen improvement uniformly within an operating location. The United States cannot attain the full value of NextGen until more aircraft operators install the appropriate combination of equipment and train enough pilots to use the new technologies and procedures, boosting the number of flights in the NAS that can use the advanced capabilities.

A NAC working group developed an aircraft minimum capabilities list for communication, navigation, surveillance, and resiliency as a comprehensive guide aircraft operators can use for fleet planning. Investments from the aviation community in suitable aircraft equipment are as important to realizing the full potential of NextGen as FAA equipment, and we continue to encourage aircraft operators, equipment manufacturers, and other industry stakeholders to maximize NextGen benefits through increased equipage.



NAS MODERNIZATION

NextGen is delivering benefits as it is becoming operational across the NAS, leading to a new way of managing air traffic known as TBO. Improvements in communications, navigation, surveillance, automation, and information management provide the foundation for the modern airspace system. Other enhancements, such as in environment and safety, support the improvements. A fully operational system will implement NextGen capabilities at the right places in the NAS, with operators using aircraft equipped according to the minimum capabilities list. This increased use of NextGen capabilities will achieve maximum benefits.

Communications

Data Comm supplements voice communications with digital messages using an air-to-ground data link and is a NAC priority area. Aircraft avionics and air traffic control automation systems are integrated to form a Data Comm application known as Controller Pilot Data Link Communications (CPDLC). With Data Comm, NAS efficiency and throughput increase, thereby cutting delays, fuel consumption, and engine exhaust emissions.

The Data Comm program marked an operational milestone with the first coast-to-coast flight using CPDLC on March 17, 2023. An aircraft leaving Raleigh-Durham International Airport received a CPDLC departure clearance from the control tower and the pilots exchanged 24 CPDLC messages with seven en route centers during the nearly 5-hour trip to Seattle-Tacoma International Airport.

Tower Service

Data Comm started with tower service, which provides CPDLC departure clearances, in 2016 and is now available at 65 airports. Controllers can issue these instructions with a single data transmission, revise them as many times as necessary when plans change, and send them to reroute multiple aircraft. Pilots view the message on a flight computer and acknowledge it with the push of a button, which reduces read-back errors and communication time. Controllers can deliver many CPDLC messages in the time required to speak one clearance. This process reduces gate delays and improves taxi-out times and airport traffic flow.

The number of operators using Data Comm has more than doubled since 2016 to 110 domestic and international air carriers as well as several dozen business jet operators. During the week of June 12, 2023, 10 towers experienced record high Data Comm operations, with more than 77,000 eligible weekly flights, which exceeded the pre-pandemic high of 62,000 flights. More than 15.5 million flights serving 2.1 billion passengers have been cleared with CPDLC. Measured benefits of CPDLC tower service through April 2023 include an estimated:

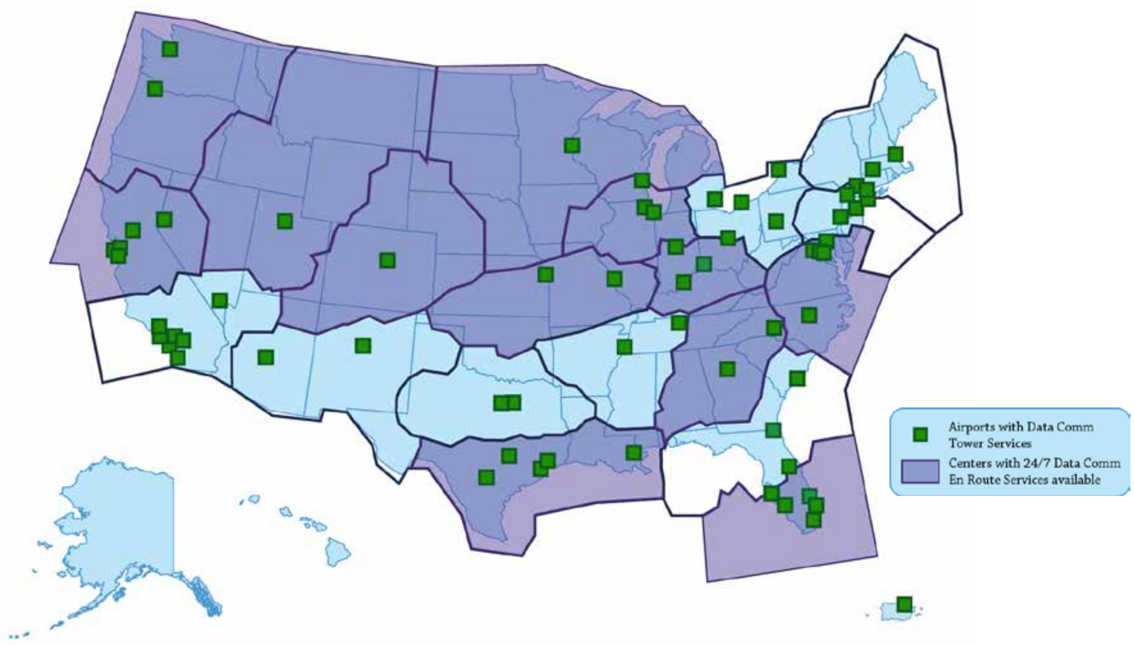
- 4.1 million minutes of communication time saved
- 3 million minutes of airspace-user time saved

- 180,400 read-back errors avoided
- 46,200 tons of carbon dioxide emissions prevented

En Route Services

Messages available for initial en route services are acknowledging the transfer of communications and initial check-in, altimeter settings, altitudes, speeds, crossing restrictions, airborne reroutes/go button, controller-initiated reroutes, and direct-to-fix navigation. Full en route services are more complex and offer additional messages to further streamline the exchange of communications and clearances sent by controllers to pilots.

The FAA activated Data Comm for Atlanta, Denver, Houston, Salt Lake City, and Seattle en route centers in 2023, joining Chicago, Indianapolis, Kansas City, Miami, Minneapolis, Oakland, and Washington centers with the capability. The first increment of full en route services, which enables speed and block altitude messages, is also available at these 12 operational facilities. The FAA plans to deploy initial en route services to the remaining eight centers by spring 2025 and expand full en route services to all facilities by 2027.



Data Comm services are available for equipped aircraft at 65 airports and in airspace served by 12 en route facilities.

Adopting en route CPDLC further increases operational efficiency and lowers costs for airspace users while enhancing safety. From March 2019 through April 2023, the Data Comm program supported the delivery of more than 26 million en route messages to 25 different commercial aircraft types and 31 operators. Benefits through April 2023 for en route CPDLC include 2 million minutes of communication time saved and 539,000 read-back errors avoided.

Navigation

Performance Based Navigation (PBN) enables aircraft to fly on any desired flight path within the coverage of ground- or space-based navigation aids, within the limits of the capability of self-contained navigation systems, or through a combination of these capabilities. PBN is a NAC focus area and has been the standard for airspace navigation in the NAS, primarily using GPS satellites, during normal conditions since 2015. Ground-based navigation aids remain as a backup when GPS satellite service is unavailable.

Although only equipped aircraft can fly PBN procedures and routes using area navigation (RNAV) or required navigation performance (RNP), the FAA ensured that unequipped aircraft can still access the airspace. As a main element of TBO, increased use of PBN routes and procedures is supported by air traffic control decision support systems that improve the predictability of aircraft arrival times along the route.

Flight Paths

In busy or congested areas, PBN provides predictable and repeatable flight paths because GPS provides more precision in the specification and execution of flight paths. PBN procedures can decrease the amount of communication necessary between pilots and air traffic controllers, reducing the chances of read-back errors and giving them more time to concentrate on other tasks.

Pilots flying an RNAV arrival procedure with an optimized profile descent can glide at near-idle engine speed with minimal level-off segments from the top of their descent to the runway. Last year, the FAA implemented these arrivals at 11 airports, bringing the total number of airports with the procedures to 64. The FAA estimates that the industry will annually save

Aviators began using runway lighting in the 1920s and the ILS in the 1930s, and improved versions of these ground-based landing aids remain part of today's National Airspace System. NextGen introduced Performance Based Navigation approach procedures using WAAS for low-visibility operations.

more than 90,000 gallons of fuel and will reduce greenhouse gas emissions by 27,000 tons on average by using this procedure.

Other PBN procedures include an RNP approach using GPS with the Wide Area Augmentation System (WAAS) to enhance the accuracy and integrity of position estimates. More than 150,000 aircraft in the NAS are equipped with WAAS, and more than 4,800 published WAAS procedures serve an estimated 2,500 airports. RNP procedures published as "authorization required" add onboard performance monitoring and alerting. They give the highest level of precision for more challenging environments with obstacles. Equivalent lateral spacing operations, or ELSO, is possible because of PBN departure procedures. ELSO increases capacity by enabling more aircraft to take off from the same runway during the same period.

For en route airspace, T-Routes and Q-Routes flown by aircraft equipped for RNAV provide a PBN alternative to conventional Jet and Victor routes. The more direct, shorter flight distances save time and fuel. In 2023, the FAA published 30 new and 24 amended T-Routes as part of the Alaska Aviation Safety Initiative, and pilots can navigate these routes at lower altitudes to better avoid icing conditions. The FAA also activated new Q-routes and a new sector along the East Coast that will reduce congestion, simplify flows, and reduce reroutes. These improvements will enhance safety and are projected to save nearly 40,000 flying miles and 6,000 minutes of travel time annually. Fewer converging points and more simple flows also enhance safety. These routes operate above 18,000 feet and extend offshore over the Atlantic Ocean and Gulf of Mexico.

The FAA has published 406 PBN routes and 9,478 PBN departure, arrival, and approach procedures as of August 2023. Between 2010 and 2022, the FAA orchestrated new routes, procedures, and airspace changes at 11 metroplexes to optimize air traffic flows in some of the nation's most congested airspace. The FAA works with the aviation community to develop PBN procedures based on the airport, airspace, air traffic, reaction from residents, and costs versus benefits.

Adjacent Operations

Future NAS-wide implementation of concepts taking advantage of PBN is managed by the Integrated NAS Design and Procedures Planning program. The program's initial project is Established on Required Navigation Performance (EoR), a separation standard using a PBN instrument approach procedure that shaves miles off of flights during simultaneous operations at airports with parallel runways. The FAA approved EoR as a national standard in 2016 for simultaneous independent operations, and it is available as of 2020 at Denver International Airport, George Bush Intercontinental Airport in Houston, and Los Angeles International Airport.

Multiple Airport Route Separation (MARS) extends the EoR concept from runways to airports. MARS will enable expanded use of RNP and new access to airports and runway configurations. Phase 1 human-in-the-loop testing and the safety analysis report were completed in 2023. The FAA plans to establish a new national standard for MARS or a site-specific waiver to the current national standard in 2024 and begin MARS operations at key sites soon after.

Resiliency

As more aircraft operators equip for and use satellite-enabled PBN, the legacy ground-based infrastructure is expected to decrease. The NextGen Distance Measuring Equipment (DME) program provides an RNAV backup for aircraft equipped for DME navigation during satellite service disruptions. Redundant coverage will enable aircraft to continue flying PBN routes and procedures in the event of single DME failures. This capability will minimize pilot and controller workload during interrupted satellite service while maintaining the capacity and efficiency enabled by PBN. The FAA is installing more than 120 new DME stations through 2035 to support en route and terminal traffic across the nation. In 2023, the FAA built two new

DME stations, joining eight systems that were installed in previous years.

Surveillance

ADS-B

Automatic Dependent Surveillance–Broadcast (ADS-B) uses GPS satellites, aircraft systems, and ground stations to accurately track and monitor aircraft in real time. ADS-B provides greater coverage than radar. The FAA completed the ground station network in 2015 and required aircraft flying in a large portion of controlled U.S. airspace to be equipped to transmit a signal (ADS-B Out) by 2020. European regulatory bodies; countries such as Canada, Australia, and New Zealand; and large portions of Southeast Asia have also mandated ADS-B for international interoperability and standardization of ADS-B around the world.

Aircraft equipped for ADS-B Out send a signal at least once per second, providing the aircraft's position and other information to air traffic controllers and surrounding aircraft equipped to receive a signal (ADS-B In) for shared situational awareness. The improved update rate allows for more frequent position reports and expands the airspace in which controllers can reduce the required minimum separation. In 2020, the FAA began using ADS-B for a 3-nautical-mile (NM) separation standard reduced from 5 NM in some of the en route airspace below 23,000 feet. In 2023, six additional en route centers deployed the track-based display mode technology, which allows controllers to apply the reduced separation. Seventeen centers now use ADS-B for 3 NM separation. The change increased efficiency for commercial operators, reducing delays, fuel consumption, and engine exhaust emissions.

ADS-B Out technology is also used for airport surface surveillance and detection, and in areas such as the Rocky Mountains and Gulf of Mexico that have limited or no radar coverage. With optional ADS-B In equipment, which consists of a receiver, data processor, and cockpit display, pilots can receive real-time traffic, flight, and weather information services at no extra cost to enhance safety.

ADS-B In Applications

NextGen's ADS-B In Retrofit Spacing (AIRS) evaluation analyzes the feasibility and value of three ADS-B In applications that help pilots and controllers manage spacing between aircraft.

- CDTI-Assisted Visual Separation (CAVS) takes advantage of the Cockpit Display of Traffic Information (CDTI). After acquiring the traffic to follow "out the window," flight crews can rely on CAVS information for continuous visual observation during approaches to the same runway under visual meteorological conditions. It is expected to reduce go-arounds due to traffic flying too close on the final approach.
- CDTI-Assisted Separation on Approach (CAS-A) is similar to CAVS except that pilots can acquire the traffic to follow on the CDTI with no "out the window" acquisition required. In addition, pilots can continue flying at lower ceiling thresholds and with reduced spacing along the approach path during certain weather conditions to enable higher throughput.
- Initial Interval Management (I-IM) enables pilots to more efficiently manage spacing between aircraft in en route airspace to increase throughput. During an I-IM operation, flight-deck interval management avionics calculate and display the appropriate speed to the flight crew to precisely achieve and maintain an air traffic control-issued spacing goal relative to a lead aircraft.

The FAA partnered with American Airlines and Aviation Communications & Surveillance Systems to collect data on these ADS-B In applications. A final report on each application will be completed in 2024.

Future Plans

In 2023, the FAA completed analyses about the future of surveillance, which are outlined in three documents. The Surveillance Services Concept of Use expresses the need for, and uses of, the existing and emerging surveillance capabilities. The concept of use gives a basis for developing performance requirements and considers future surveillance needs. The Surveillance Vision shares the view for the future of surveillance in the NAS based on upcoming needs and emerging capabilities and operations. The

Surveillance Services Requirements document supports the surveillance strategy by developing what is needed to meet the surveillance vision.

Automation

The FAA has implemented new automation systems that air traffic controllers use to ensure the safe separation of aircraft in the NAS. The En Route Automation Modernization (ERAM) system and Standard Terminal Automation Replacement System (STARS) enable controllers to work more productively and support NextGen with modern software architectures that serve as the foundation for new air traffic management capabilities. Additionally, Advanced Technologies and Oceanic Procedures (ATOP) is the U.S. oceanic air traffic control workstation.

The FAA has also deployed automated decision support systems. The Traffic Flow Management System (TFMS), Time Based Flow Management (TBFM), and Terminal Flight Data Manager (TFDM) help controllers and air traffic managers respond more effectively to changing conditions, accommodate user preferences, and resolve traffic flow constraints. Each system has specific roles and tools. Together, they help to manage traffic in an integrated and collaborative way to maximize efficiency and reduce delays. These systems are central to TBO.

En Route

ERAM operates at 20 en route centers across the country, where controllers manage high-altitude air traffic. It is on its way to facilities in Alaska and Hawaii. En route controllers can track as many as 1,900 aircraft at a time with ERAM, which is 800 more than possible with the previous system. ERAM can process data from 64 radars versus the 24 the legacy system handled, extending coverage beyond facility boundaries.

With most of the original ERAM equipment more than 10 years old, the FAA is working on software enhancements as well as its third major technology refresh. Software enhancements are scheduled for completion in 2024 and the technology refresh in 2026. The FAA plans on improving en route sector operations through enhanced trajectory modeling, increasing conflict detection and resolution capabilities to support separation management, and increasing support for PBN. The program will also upgrade flight data management and system support functions. In 2023, the FAA expanded automated coordination of flight data and aircraft control with Nav Canada. More enhancement and sustainment projects are slated for ERAM.

Terminal

STARS replaced the legacy system at more than 200 FAA and Department of Defense (DoD) terminal radar approach control facilities, and 600 FAA and DoD air traffic control towers. The FAA also installed and maintains more than 100 systems at STARS support sites, including operational support facilities and the FAA Academy. STARS also is receiving technology refreshes and software updates.

New automation systems enable FAA staff to use new capabilities to ensure safe and efficient air traffic flow. STARS replaced ARTS at terminal radar approach control facilities and associated control towers.

Oceanic

The ATOP program replaced the original oceanic air traffic control system, updated procedures, and modernized the oceanic automation systems for the Anchorage, New York, and Oakland en route centers. ATOP allowed controllers to safely handle airline requests for more efficient tracks and altitudes over long oceanic routes, therefore reducing flight time over the ocean. It also allowed the FAA to meet international commitments of reduced aircraft separation standards, thereby increasing capacity and efficiency for customers and reducing carbon emissions. An enhancement underway will bring new capabilities, including changes to support continued growth and new functionality to better support TBO, international interface improvements, and coordination among controllers. In 2023, the FAA implemented the first piece of a multi-year enhancement at all three oceanic centers, as well as completed interim milestones for the remaining enhancement parts. Once they are fully implemented, the ATOP enhancement will optimize flight trajectories, decrease controller workload, reduce costs, and improve system safety.

Traffic Flow Management System

TFMS assists with planning and executing traffic management initiatives, which are used to balance demand with capacity in the NAS. The initiatives contribute to the safe and orderly movement of air traffic. TFMS runs custom applications on commercial hardware. Its suite of tools is used to optimize airspace capacity and fleet performance as well as the efficiency of individual flights. At the Air Traffic Control System Command Center, staff works strategically with airspace users to consider the effects of individual actions on the whole. TFMS is also used in en route centers and some large terminal radar approach control facilities in collaboration with other stakeholders, including the airlines, general aviation, and military, to provide general awareness of the airspace system.

In 2010, TFMS replaced the legacy Enhanced Traffic Management System, which existed since the 1980s. It has reduced delays, travel time, and fuel expenses; increased throughput while reducing errors; and solidified the traffic flow managers, controllers, and aviation industry operators as a collaborative decision-making community.

TFMS has been continually updated and enhanced. It is at the end of its lifecycle and is scheduled to be replaced by Flow Management Data and Services (FMDS) in 2029. FMDS will provide a traffic flow management automation system with a modernized architecture that will increase reliability and reduce response time. A microservices architecture will provide flexibility to the FAA for implementing capabilities and leveraging enterprise services, as well as separating the data from the services and applications. FMDS is expected to have many advantages. The new architecture and infrastructure will allow TFM activities to scale to projected air traffic growth. With an architecture designed for flexibility, extensibility, and security, FMDS will provide a foundation for future traffic flow management capabilities that can leverage new technologies and operate in a more interconnected operational and technical environment. Its consistent suite of shared services will eliminate duplicate functions, and the user interface will increase efficiency and reduce opportunities for error.

Time Based Flow Management

TBFM maximizes NAS throughput by using time to manage departing and approaching air traffic in congested airspace and at airports. Its core function is to create a time-ordered sequence of aircraft, referred to as a schedule, within common or converging traffic flows over a defined point in the airspace to ensure appropriate aircraft spacing. The scheduled times allow for traffic flow merging while minimizing coordination, reducing the need for vectoring and holding. TBFM is preferred to miles-in-trail restrictions when departure or arrival flows are subject to traffic management initiatives. TBFM supports aircraft use of available PBN procedures because it allows aircraft to remain on their 3D flight path defined by the PBN procedure, enabling flight-specific efficiency. TBFM capabilities are superior because they make better use of available capacity and enable trajectory adjustments needed for merging and spacing to be taken at more fuel-efficient altitudes.

TBFM tools increase efficiency by allowing aircraft to fly PBN approach procedures. TBFM capabilities enable an increased rate of departures and arrivals in areas where runway demand is high and near its capacity. The result is fewer delays, and reduced fuel consumption and engine exhaust emissions. The FAA completed TBFM deployment to 20 en route centers in June 2014 in one year. TBFM is also adapted for use at 28 terminal radar approach control facilities and the towers at many major airports.

The FAA continues to target opportunities to expand and improve workforce use of the TBFM suite of tools. In 2023, the FAA tested the integration of TBFM and TFDM to support surface management and merging of departure flows into airborne flows. The agency is also expanding the use of TBFM capabilities across the NAS, including departure management capabilities for Florida airports and improved arrival capabilities for Austin-Bergstrom International Airport and Harry Reid International Airport in Las Vegas.

The FAA partners with industry, research and development organizations, airlines, and other countries to promote information-sharing in the National Airspace System.

Terminal Flight Data Manager

TFDM introduces the use of electronic flight data and detailed flight data exchange in the tower to improve efficiency on the ground and in the terminal airspace. It will modernize control tower equipment and processes, and it will streamline the sequence of departing aircraft, leading to improved situational awareness, reduced delays, and a better travel experience.

TFDM improves surface traffic management with better electronic flight data and collaborative surface decision support tools. The system will offer a surface metering capability, runway balancing, and other surface management tools to improve surface traffic flow management. It will use SWIM to share data among controllers, aircraft operators, and airports to better manage departures and arrivals on the airport surface, improve awareness of demand to and from the airport, and improve the efficiency of surface and terminal operations. The surface scheduling capabilities will better predict when departures and arrivals will operate on the airport surface, integrate other traffic management initiatives, and provide the ability for air traffic control to better manage flows to and from the airport. The surface metering capability will manage the number of aircraft taxiing and waiting to depart, reducing emissions and fuel consumption and increasing the efficiency of surface operations. A departure scheduler with live data from air traffic systems and flight service providers will enable collaborative decision-making. TFDM will replace several existing systems, leading to improved efficiency and cost avoidance.

As part of the agency's commitments to the NAC in the surface and data-sharing focus area, the FAA deployed some TFDM capabilities to select NAS facilities, which yielded early benefits. TFDM is deploying to 49 airports in two configurations through 2029. Configuration A brings full functionality to 27 large, high-density airports with improved electronic flight data exchange, electronic flight strips, full number of decision support tools, traffic flow management data exchange and integration, advanced airport management tools, and surface metering capabilities. Configuration B is planned for 22 airports and includes electronic flight data, traffic flow management data exchange, and airport management tools.

TFDM software capabilities will be deployed in two builds. Build 1, a preliminary version, is limited primarily to electronic flight strip capabilities and initial flight data interfaces. The Build 1 key site is Cleveland, which began operating in October 2022. Four more Build 1 sites were deployed in fiscal year 2023. Build 2 is the final TFDM software version that includes all electronic flight strip capabilities, the suite of surface management tools, and additional interfaces. Charlotte is the Build 2 key site, with initial operating capability scheduled for 2024. The FAA will upgrade all Build 1 sites to Build 2 by 2025.

Integrated Information Management

Air traffic management systems must communicate with each other to provide pilots, dispatchers, and controllers with the information necessary for safe and efficient flights. Integrated information management removes barriers to information access to get the right information to the right people at the right time. More secure information can be shared with greater efficiency, agility, and resiliency within the FAA and between the FAA and other NAS users for collaborative decision-making and to meet new air traffic management requirements for TBO.

SWIM

SWIM enables a single point of access for relevant and reliable aeronautical, flight and flow, surveillance, and weather information in near real-time. It delivers the infrastructure, standards, and services needed to optimize the secure exchange of meaningful data across the NAS and the aviation community. Users within and outside of the NAS can respond faster and more accurately to changing conditions. SWIM eliminates the number and types of unique computer interfaces formerly needed to access data from different sources. SWIM helps to reduce implementation and operating costs and increase agility for the aviation community.

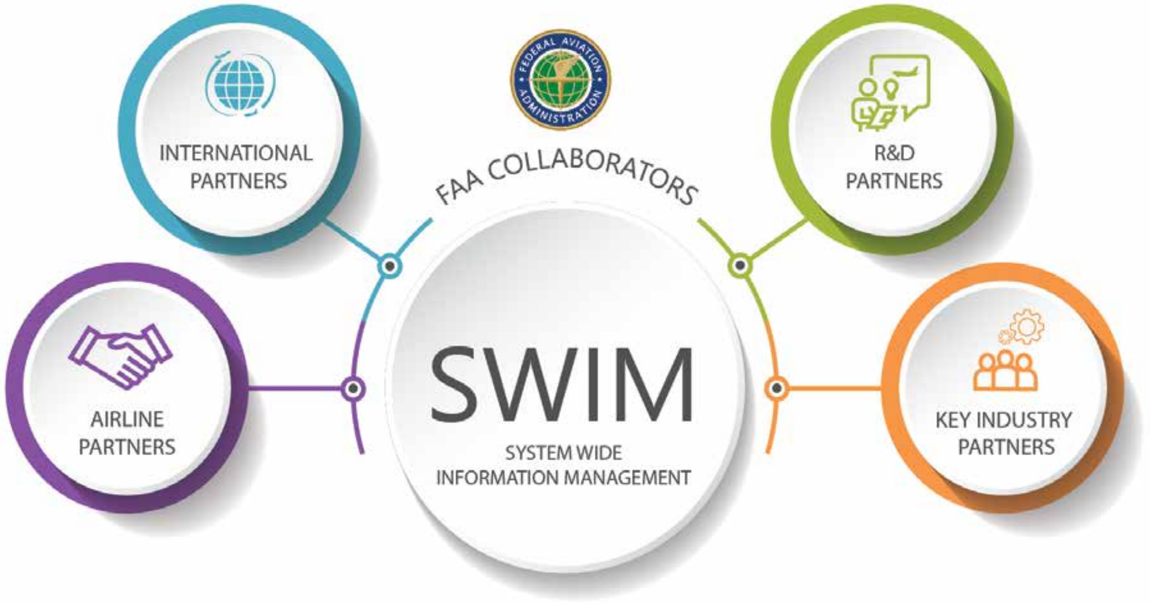
At the end of 2023, 15 FAA programs and several external organizations, including airlines, were providing data for more than 100 services sent via the SWIM network. More than 800 consumers are registered to access the information; of those, about 400 are regular users.

The FAA is implementing SWIM in segments. A set of NAS services is developed and integrated via SWIM in each segment. Enterprise infrastructure is added to support the implementation of capabilities associated with the segments. Systems distributing information via SWIM can request and receive information when they need it, subscribe for automatic receipt, and publish information as appropriate. SWIM capabilities delivered in earlier segments include enterprise service monitoring, identity and access management, NAS common reference service, the SWIM Terminal Data Distribution System, and the SWIM Flight Data Publication Service. Hardware and software enhancements as well as technology refreshes in subsequent segments enable the SWIM capabilities to support the evolving and expanding information environment.

Cloud Integration

A scalable and reliable cloud environment supports the future anticipated growth of services and evolving data exchange scenarios. The SWIM Cloud Distribution Service (SCDS), deployed in 2019, provides non-sensitive NAS data in near real-time without the inconvenience of connecting to the NAS Enterprise Security Gateway. Instead of waiting months to access data through the old method of registration, SCDS lets users dig into tailored data within 72 hours of a basic online account setup. Operating costs are lower, and the service adjusts bandwidth to support data flow. SCDS enables more data to move to meet the needs of more users.

SCDS leverages an externally hosted cloud infrastructure service and has about 230 users actively extracting data from more than 700 subscriptions across the available data services. The NAS Data Release Board approved SCDS products for public release, and the information is not intended for NAS operational use.



The FAA partners with industry, research and development organizations, airlines, and other countries to promote information-sharing in the National Airspace System.

SWIFT Portal

Evolving from the SCDS, a portal named SWIFT (SWIM-Industry FAA Team) deployed in 2021 to further improve the collaboration between the FAA SWIM program and industry. SWIFT provides a single interactive place for the SWIM community for customizable, real-time access to SWIM.

SWIFT offers a collaborative environment for outreach activities related to FAA information services shared via SWIM. Users can discover SWIM data products before subscribing, interact with the SCDS, check the status of SWIM services, connect with other users on the community forum, and get help when needed. An easier and quicker way to request an account is among the improvements provided by the fourth version of the portal, which the FAA released in 2023.

Collaboration

SWIM creates opportunities for collaboration within government and with the aviation industry, research and development partners, and the international community. These interactions will enable the SWIM program to provide the information technology infrastructure necessary for the NAS to share information, increase interoperability, and encourage the reusability of information and services. The availability of data has created a new information ecosystem. Companies are using information from SWIM to develop products for the aviation community that lead to a better experience for the flying public.

Information Management Services

Beyond the gateway for information-sharing that SWIM provides, the FAA is enhancing data management services, maturing concepts, and developing applications for the new information exchange environment.

For example, the Aeronautical Common Services (ACS) integrates, standardizes, and improves the distribution of aeronautical information via a shared platform. Consumers can access static aeronautical information, such as airports, navigation aids, and airspace, through a webpage. An airspace conflict detection service lets consumers see if a specified airspace and schedule will clash with another. The FAA updates to ACS in 2023 are part of the Aeronautical Information Management Modernization program.

Common Support Services–Flight Data (CSS-FD) is the system that will modernize flight information management and update exchanges between all types of operators and the FAA. CSS-FD will enhance flight planning and filing, and flight data management and publication to facilitate quick and agile access to common flight information. It is a key step to achieving TBO by enabling globally consistent, performance-based 4D management by sharing and managing flight information, including the 4D trajectory.

The CSS-FD Phase 1 initial investment decision was completed in 2022, and a final investment decision for Phase 2 is scheduled for 2026. In 2023, four airspace users tested several use cases, including filing flight plans, responding to live NAS constraints, evaluating alternate solutions with trial flight plans, and obtaining current flight plan status using a simulated CSS-FD interface as part of a risk-reduction activity. Their participation demonstrated CSS-FD capabilities and netted feedback that led to increased engagement and buy-in from the participants.

Other projects underway include maturing Flight and Flow Information for a Collaborative Environment (FF-ICE), exchanging digital taxi instructions, and connecting aircraft using commercial broadband internet communication services instead of aviation-specific infrastructure. FF-ICE provides a collaborative decision-making environment, enabling the sharing of appropriate data across a wide set of participants. It creates greater coordination across air traffic management communities, increasing situational awareness and supporting the larger performance target of enabling TBO. Initiatives like FF-ICE and others facilitate information exchange between airborne and ground systems as the need increases for higher levels of accuracy and predictability for TBO.

Zero Trust Framework

For digital identity in network communications, the trusted framework provides policy and technical interoperability to protect against cyberattacks 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.

The FAA is working with ICAO and its 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.

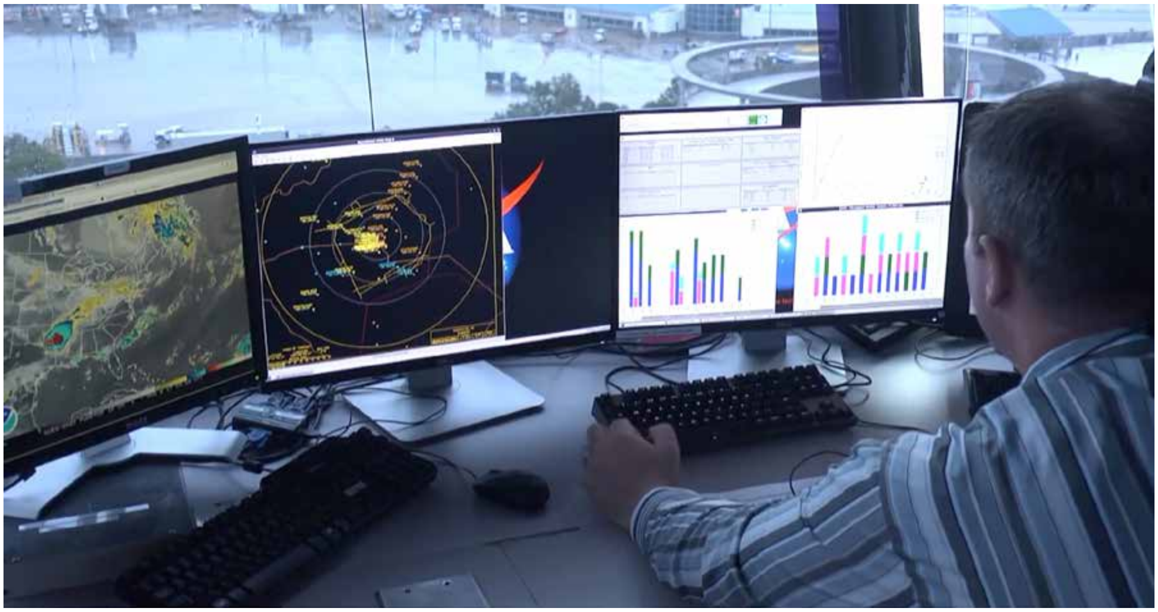
The FAA program will define a solution for harmonized identity management, a certificate policy, a governance structure, and an identity master trust agreement. It will work on these tasks as it works with the international community to develop the Global Resilient Aviation Interoperable Network (GRAIN) for exchanging global information at a compatible protection level based on shared risk. Operational implementation support documentation is scheduled to be available as soon as 2024.

Weather

The NextGen Weather program is working to reduce the effects of weather on aviation, resulting in safer, more efficient, and predictable NAS operations. The FAA collaborates with the National Oceanic and Atmospheric Administration (NOAA) and NASA to improve the collection, processing, distribution, and display of aviation weather data, particularly hazardous weather data.

Processing

The NextGen Weather Processor (NWP) program will replace the legacy systems and bring new capabilities. NWP will use sophisticated algorithms to create current and predicted high-quality aviation-specific weather information. The processor produces improved weather mosaics and predictions that support the optimal selection of aircraft routing and precise spacing for departing and arriving aircraft. The increased accuracy of observations and predictions enables the best use of available airspace. NWP capabilities are expected to decrease aircraft diversions, delays, and



Controllers view current weather conditions and forecasts, such as displayed on the monitor on the left, to direct pilots away from the safety risks posed by bad weather.

cancellations. The NWP program completed system development testing ahead of schedule and began key site installation in 2023, with completion on track for 2024.

Disseminating

Products created by the NWP, NOAA's NextGen Information Technology Web Services, and other weather sources available to FAA and NAS users will be published through Common Support Services–Weather (CSS-Wx). It will become the single provider of weather data, products, and imagery within the NAS using standards-based weather dissemination via SWIM that reduces FAA development and operational costs and achieves enterprise-wide efficiency.

CSS-Wx increases the availability of weather information. Air traffic controllers and managers, pilots, flight dispatchers, and other aviation stakeholders can easily access weather observations and predictions to enable collaborative and dynamic NAS decision-making. CSS-Wx will supply weather data for air traffic control decision support systems, improving the quality of traffic management decisions and reducing controller workload during severe weather. Controllers will be able to use NWP mosaics, enabling more precise and timely information to respond to pilot requests to deviate around hazardous weather.

The system will provide weather information via web services. It will filter weather information by location and time with the ability to provide the user with weather data for a specific geographic area. Weather information will be presented in common, standardized formats, and can be stored, archived, and retrieved. CSS-Wx began key site installation in 2023 and is on track to be completed in 2024.

Runway Operations

Closely spaced parallel operations (CSPO) refer to the simultaneous approaches and departures of aircraft pairs to airports with parallel runways less than 4,300 feet apart. CSPO is part of the multiple runway operations focus area of the NAC. As air traffic increases, the need grows to safely maximize throughput performance at the busiest airports with parallel runways and in the most active arrival/departure airspace. The CSPO program explores concepts to increase airport capacity through reduced separation standards, expanded applications of dependent (when diagonal spacing is required) and independent runway operations, and enabling operations in lower visibility conditions.

CSPO changes improve flight safety by protecting aircraft from lateral path deviation. These operations can reduce delays, fuel consumption, and engine exhaust emissions. When visibility is limited, runway throughput for departures may increase by reducing separation standards. Improved flight deck capabilities also allow reduced separation for dependent approaches, leading to increased arrival capacity in instrument meteorological conditions.

The FAA has revised separation standards at airports with dependent and independent parallel runways during the past decade. For instance, at eight airports with runways spaced between 2,500 feet and 3,600 feet apart, the agency reduced the diagonal spacing requirement from 1.5 NM to 1 NM.

The FAA is analyzing several CSPO-enabling activities to permit revised runway spacing and airport design standards. These potential revisions are based on new research and analysis and are possible through the application of advanced technology and performance-based procedures. A procedure change for dependent departures was incorporated into the air traffic controller handbook for 2023.

Wake Recategorization

Air disturbances—specifically, wake vortices—generated by the lead aircraft can disrupt trailing planes flying too close behind and could result in a turbulent and unsafe ride. Air traffic controllers traditionally separated aircraft using static standards set by maximum certified gross takeoff weight. Although that is a safe practice, FAA research and high-quality wake behavior data showed opportunities to improve efficiency with revised separation categories using aircraft performance metrics. The FAA Wake Recategorization (Wake Recat) program allows some aircraft to follow others at a closer distance without a decrease in safety, increasing throughput benefits to airports and the aviation system.

Wake Recat is one of the activities under the NAC multiple runway operations focus area. The initial phase changed how the FAA categorized aircraft into six categories. In Phase 2, the FAA approved separation standards between 125 pairs of aircraft, providing options for local air traffic facilities to use based on typical operations at their locations. The FAA implemented the new standards airport by airport based on the types of aircraft that normally operate at the locations. Depending on the mix of aircraft, airports saw as much as an average 10 percent increase in throughput, which means more aircraft today can take off and land with shorter wait times on taxiways and runways.

Wake Recategorization allows aircraft to safely follow each other at a closer distance to increase throughput. (Photo courtesy of Volpe)

In 2022, the FAA completed the last site implementation of Consolidated Wake Turbulence standards that were developed from previously identified wake separation standards. These standards harmonized separation reductions at 93 terminal radar approach control facilities and 330 air traffic control towers, ushering in efficiency gains at many constrained airports.

For the final phase of Wake Recat, the FAA is developing dynamic wake separation enhancements for decision support tools that factor in wind conditions to allow a safe reduction in wake separation standards during certain favorable atmospheric conditions. The program is also developing a resource en route controllers can use to determine wake risk when aircraft-to-aircraft separation buffers are reduced. In 2023, the FAA conducted a dynamic wake solution simulation to determine the feasibility and complexities of the concept and how it affects controller workload and situational awareness.

Remote Towers

A remote tower can enhance safety at small and rural airports where it may be too costly to construct and sustain a traditional control tower and acquire equivalent air traffic control services. The FAA’s goal is to approve remote tower systems as non-federal equipment that airport operators may purchase for their non-federal or FAA-contracted control tower. The federal government does not plan to procure this capability for FAA-staffed facilities, and remote towers are not intended to reduce jobs or replace the role of the air traffic controller.

Technology demonstrations since 2014 have informed the remote tower business case and the development of a system design approval process along with associated criteria and standards. Two airports were the host of initial trials.

In 2023, the FAA began constructing a centralized test bed in Atlantic City, NJ, which is scheduled for completion in 2024. Equipment will be located at the National Aerospace Research and Technology Park and Atlantic City International Airport. The centralized test bed will evaluate the FAA Remote Tower Pilot Program. The test bed enables the FAA to understand the full capabilities of remote tower systems using an FAA-controlled test location versus multiple and geographically dispersed test locations. Operational testing and design approval activities are more efficient with this setup.

Environment and Energy

The Continuous Lower Energy, Emissions, and Noise (CLEEN) program is the FAA’s principal effort to develop environmentally beneficial technologies for aircraft and engines, and sustainable aviation fuel. Through the CLEEN program, the FAA and aviation industry share costs to enable the industry to expedite the integration of new technologies. The result will be a fleet of aircraft that consumes less fuel, produces fewer emissions, and creates less noise, which supports a NextGen goal of reducing the environmental effects of aviation while sustaining growth along with the U.S. goal of achieving net-zero emissions by 2050.

The CLEEN program is implemented in 5-year phases. To receive funding, industry partners need to match or exceed the dollars provided by the FAA. Through the first two phases, the industry has contributed $388 million compared to the FAA contribution of $225 million. After the successful first and second phases, the FAA started a third phase in 2021. Among the goals are reducing the noise and emission levels for civil supersonic airplanes.

Safety

NextGen continues to participate in programs critical to maintaining or improving flight safety by ensuring the safe introduction of new capabilities and non-traditional operations into the NAS. NextGen includes a safety portfolio that enables the FAA to explore, develop, and mature NextGen safety concepts, programs, and capabilities.

Enterprise Safety

The interconnected nature of NextGen when introducing new technologies into the NAS presents complex safety challenges that call for integrated safety risk management. The NextGen Enterprise Safety staff guide safety risk management (SRM) on NextGen activities, which is composed of research and development; flight tests, trials, and demonstrations; and aviation weather product implementation. The staff manages a unique assortment of enterprise-level SRM tools and resources. This collection leverages model-based systems engineering principles to provide robust, data-driven, and reliable safety risk analysis, and reinforces risk-based decision-making.

Integrated SRM explores safety risks from a NAS enterprise framework to identify potential safety gaps inherent in NextGen’s capabilities. It identifies safety issues by assessing risk across organizations, programs, and systems. It relies on FAA-wide collaboration to capture the most relevant safety information to assist with decision-making.

Safety Transformation

The System Safety Management Transformation (SSMT) program develops data analysis and modeling capabilities that help determine how NAS-wide operational improvements will affect safety and evaluate potential safety risk mitigation. SSMT consists of three tools:

- Airport Surface Anomaly Investigation Capability (ASAIC) is a risk-based tool to identify and assess selected surface/runway safety events and metrics.
- Safety Information Toolkit for Analysis and Reporting (SITAR) is a risk-based tool to identify and assess candidate terminal and en route safety events and metrics.
- Integrated Safety Assessment Model (ISAM) provides a standard measurement using the best available data for baseline and predictive risk assessment by modeling safety barriers, precursors, and influencers in the NAS.

The value of SSMT lies in its ability to answer questions about how safety is affected by new actions. It establishes a method to integrate anomaly detection into safety analyses, training, and safety risk management initiatives.

SSMT establishes a common platform and offsets limitations in communication between organizations. Stakeholders have timely access to safety event detection algorithms, metrics, and event visualization and replay. SSMT also provides a consistent and standard analytical environment. In 2023, a NAS-wide dashboard for airport hot spots was enabled in ASAIC, and a new user interface in SITAR enables users to define parameters for aircraft positions in time and space.

Information Analysis and Sharing

Aviation Safety Information Analysis and Sharing (ASIAS) is a collaborative initiative that advances aviation safety by taking advantage of data from across the industry to discover and mitigate emerging risks before they result in an incident or accident. ASIAS serves as a central conduit for the exchange of safety information among its stakeholders, providing a valuable resource for the aviation community. The ASIAS vision is to establish a comprehensive network of safety information sources shared by stakeholders supporting the global air transportation system.

In 2023, the ASIAS partnership grew to include 47 commercial carriers, more than 150 corporate/general aviation operators, 15 flight training entities, and seven rotorcraft operators, among many other participants. More than 650 accounts are registered on the ASIAS web portal. ASIAS databases contain more than 32 million digital flight records and hundreds of thousands of Aviation Safety Action Program and Air Traffic Safety Action Program reports. This year, more than 20 individual safety analyses are underway, including for non-towered airports for general aviation and loss of control in rotorcraft.

TBO

TBO is an air traffic management concept that provides a common understanding of planned aircraft flight paths in 4D for all stakeholders. The sharing of a 4D flight trajectory among systems and stakeholders is the core tenant of TBO. Expected benefits are improved flight efficiency,

ASIAS enables a wide range of aviation stakeholders to report safety information, providing the capability to discover and mitigate emerging risks before they result in an incident or accident.

increased airspace and airport throughput, and improved operational predictability and flexibility.

TBO is a major goal of NextGen, and its implementation in the NAS is evolving through four phases: infrastructure, initial, full, and dynamic. Current capabilities from the NextGen infrastructure have enabled TBO to advance to the initial operations. The full and dynamic phases will build upon initial operations as new capabilities become available.

TBO will enhance strategic planning and management of NAS operations through the use of time-based management and PBN with support from enabling technologies that expand and automate the sharing of information affecting the trajectory. Time-based management involves the use of flight-specific crossing times at defined points along the flight trajectory.

The sharing of the 4D trajectory represents a common reference for the time an aircraft is expected to be at key points between the origin and destination. The initial trajectory, determined before departure, is updated based on the aircraft's actual position and in response to emerging operational conditions and operator inputs. The exchange of predicted trajectories helps with operational predictability, which enables better decision-making and can increase the use of PBN routes and procedures.

The FAA has demonstrated global leadership through the international harmonization of NextGen technologies, leading the world toward TBO. ICAO has developed a global air traffic management operations concept, which details the envisioned TBO that global air navigation service providers plan to offer. The FAA's efforts to transition the NAS to TBO are in concert with the global TBO concept.

Initial TBO

Initial TBO, or iTBO, is using NextGen capabilities to achieve a fundamental change to integrated departure and arrival operations. Implementation priorities are managed by considering operational needs, potential benefits, integration risks, opportunity costs, and other FAA priorities, such as safety and sustainment initiatives, and workforce training. Integrating TBO capabilities within an operating area requires a high degree of coordination across facilities and programs. Initial TBO implementation is underway in several NAS operating areas, which group interdependent air traffic facilities serving key airports of interest.

Northeast Corridor

The Northeast Corridor (NEC), the nation's busiest airspace and a NAC focus area, spans from Boston to Washington, DC. Congestion and delays there affect the entire country. The focus airports for iTBO are in New York and Philadelphia. The NEC received tower Data Comm, a modernized PBN route structure along the Atlantic coast, and TBFM integrated departure management capabilities.

Planned capabilities include en route Data Comm, improved route management capabilities, and expanded use of TBFM. TFDM is also planned for implementation at many NEC airports.

Mid-Atlantic

The Mid-Atlantic operating area is focused on Hartsfield-Jackson Atlanta and Charlotte Douglas international airports. With initial TBO, these airports now regularly use time-based management capabilities for arrivals, modernized PBN departure and arrival procedures, and en route Data Comm services.

Planned NextGen capabilities include enhanced en route Data Comm and integrated departure management capabilities. Charlotte is a planned key site for the implementation of TFDM automated surface management capabilities (Configuration A), and Atlanta will eventually receive the system. Finally, Charlotte airspace will receive an airspace modernization that will complement time-based management system implementations and enable additional benefits.

Northwest Mountain

The Northwest Mountain region is focused on flows into and out of Denver International Airport. Data Comm tower and en route services are in place. Additionally, TBFM extended metering for arrivals and updated PBN procedures have been implemented for Denver, resulting in a more even distribution of delays and enabling equipped aircraft to stay on their PBN arrival and approach procedures. Integrated departure management capabilities were implemented at Denver and other nearby airports. Aircraft operators reported to the NAC that these improvements have increased the use of PBN approach procedures and improved predictability.

TFDM is scheduled to deploy to Denver, and departure scheduling will be implemented at nearby facilities. Salt Lake City Center will undergo airspace modernization, which will complement TBFM use and enable additional benefits.

Southwest

The Southwest region's initial TBO implementations are directed at Los Angeles International Airport and Harry Reid International Airport in Las Vegas, which regularly use time-based management for arrivals. Integrated departure management capabilities and Data Comm tower service are in place for most major towers in those areas. Los Angeles received a new spacing tool for arrivals, which has increased the use of EoR. An updated TBFM extended arrival metering design was implemented for Las Vegas arrivals, leveraging the metroplex project navigation improvements completed in 2021.

Planned NextGen capabilities include en route Data Comm, an updated TBFM metering design for Los Angeles arrivals, and TFDM implementation at Los Angeles and Las Vegas airports.

Other Operating Areas

The FAA is evaluating and prioritizing opportunities for expanded implementation of initial TBO, and recent achievements have been the result of emerging operational needs. The FAA introduced initial TBO capabilities in the Southeast operating area in 2023 to improve departure management and alleviate congestion due to rapid post-pandemic traffic growth and competing airspace use. TBFM departure management capabilities began operating for Miami, Fort Lauderdale, and other nearby airports to better coordinate and integrate traffic demand out of multiple airports.

The FAA expanded the use of time-based management and a controller spacing tool to help manage increasing post-pandemic traffic growth for arrivals to Austin-Bergstrom International Airport. Also, expanded time-based management capabilities were implemented for integrated

Trajectory Based Operations are expected to improve flight efficiency, increase airspace and airport throughput, and improve operational predictability and flexibility.

management of departures from the Southeast operating area bound for Chicago O'Hare International Airport.

Change Management

Successful implementation of TBO requires the deployment of sound technology and procedures plus new air traffic management techniques and strategies for air traffic controllers, air traffic managers, pilots, and flight dispatchers. All stakeholders must clearly understand the objectives for TBO and commit to its success.

The workforce needs to be prepared for and engaged in the changes in the NAS. The FAA has developed and is implementing a vigorous change management strategy to help prepare the workforce for TBO. This strategy includes leadership mobilization, consistent communication and coordination, integrated evolution planning, training, and alignment of processes.

ADVANCED AVIATION

Over the years of NextGen modernization, new kinds of aircraft have entered the NAS, and the changes are continuing rapidly with UAS, advanced air mobility, and other emerging aircraft and spacecraft. The challenge for the FAA is safely and securely integrating them into the NAS alongside traditional aircraft.

UAS

FAA involvement with drones predates NextGen, with the first airworthiness certificate for a civilian drone issued in 2005. UAS are uncrewed aircraft and the equipment necessary for the safe and efficient operation of these aircraft. The FAA has assisted the growing number of drone operators with registration, authorization, detection and collision avoidance, and security. The Integration of Civil Unmanned Aircraft Systems in the National Airspace System Roadmap (Version 3, 2020) gives a comprehensive look at the progress of UAS integration into the airspace.

Registration

DroneZone is the FAA website for UAS that are required to be registered. The platform was built using modern and cost-effective cloud-based tools, services, and development practices. The FAA transitioned to the FAA Cloud Service in 2023. In the years ahead, the agency plans on enhancing current products and developing new products to improve customer service.

Authorization

The Low Altitude Authorization and Notification Capability (LAANC) is an automated system the FAA uses to approve flights for operators of small UAS in controlled airspace at or below 400 feet. It simplifies how pilots seek permission to fly, improves awareness of where drone pilots can fly, and lets air traffic controllers know when and where drones are operating. In 2023, access expanded to the DoD.

Collision Avoidance

The Airborne Collision Avoidance System X (ACAS X) is a technology intended to mitigate the safety risk of flying in airspace with various aircraft while minimizing unnecessary alerts. ACAS has different subsets, including ACAS sXu for small UAS and ACAS Xr for rotorcraft. The FAA completed the ACAS sXu project in 2023. The next step for ACAS Xr is the development of minimum operational performance standards that will be documented with RTCA to allow technical transfer to the aviation industry and availability for operators to equip their aircraft.

Remote Identification

The Remote Identification rule has set mandates for drones that require FAA registration and are operating in U.S. airspace. The rule lays the foundation for safety and security needed for more complicated drone operations. Remote ID helps the FAA, law enforcement, and other federal agencies locate the control station when a drone appears to be flying in an unsafe manner or where it is not allowed to fly. The FAA's supporting services for Remote ID follow a LAANC-like model of data exchange with internal users and other government agencies called DISCVR, or Drone Information for Safety, Compliance, Verification, and Reporting.

Space Operations

New procedures, along with increased application of NextGen technologies, enable the FAA to safely and efficiently integrate space operations into the NAS, clearing the way for routine access to low Earth orbit and beyond. For example, upgraded decision support system capabilities, such as TFMS, take advantage of common formats for processing and transferring information. The Space Data Integrator (SDI), which feeds information

As commercial space operations continue to grow, the FAA keeps working to accommodate spacecraft safely and efficiently with other air traffic in the National Airspace System.

voluntarily provided by space operators into TFMS, allows the FAA to track a spacecraft in near real-time by receiving telemetry data such as speed, position, and altitude. The SDI capability improves situational awareness and assists the FAA in efficiently managing air traffic during space operations.

In fiscal year 2023, the FAA safely managed more than 100 commercially licensed space launches and reentries. At some launch sites, airspace closure times have dropped from an average of more than 4 hours per launch in 2018 to about 2 hours. Currently, airspace is routinely reopened as quickly as 3 minutes after a spacecraft safely travels through a designated hazard area.

To enable even more efficient and less disruptive integration of space operations, the FAA is establishing a community of interest to develop standards for exchanging launch and reentry data because multiple government and industry organizations receive, collect, and use commercial space operations data. Extra NAS space integration capabilities projects will further identify and prioritize needed services for air traffic management, mature real-time hazard area generation in radar and oceanic nonradar environments, and increase understanding of reentry communication blackouts.

FUTURE VISION

New opportunities and innovations ahead will increase the connectivity of traditional and new aircraft types, with greater amounts of information becoming available to NAS users. As NextGen progresses, the FAA is looking ahead to the next iteration of airspace modernization that is focused on information.

NAS Modernization

The FAA NAS vision for the future will be interconnected on communication networks, flexible to accommodate changes in operations, and include all stakeholders. NAS modernization will take advantage of the ongoing information revolution with increases in telecommunication, computational power, and storage, and new technologies that secure and learn from accumulated data. Finer quality data gathered from aircraft and ground sources will give planners more detailed models of operations, which in turn will lead to better decision-making. A richer data environment also enables predictive analytics to probe deeper and find more subtle variations in patterns that could indicate a safety risk. NAS modernization improvements will enable the FAA to deliver capabilities faster and improve safety and operational efficiency for aviators and the public.

Fundamental to this NAS modernization is orienting information technology operations toward the primacy of data, and how artificial intelligence and machine learning are applied to data. This focus will allow us to shift from infrastructure investment to data management and decision-support applications.

The FAA will collaborate with government, industry, academic, and international partners to align with the common NAS modernization vision. This vision builds on the NextGen foundation in three pillars: diverse operations, infrastructure, and integrated safety management.

Diverse Operations

Future NAS operations will be diverse. Collaboration will be foremost within traffic management services that integrate the increased number and variety of aircraft and new missions into the NAS. Data from operations will enable more accurate estimates of the state of the NAS and confident prediction of the future state of air traffic. Increased agility in systems and services will allow the NAS to adapt as needs evolve. The NAS modernization vision is the first step toward the future and provides the objectives for a new unified concept across all types of operations, taking advantage of innovation and information to accelerate the evolution of the NAS.

Infrastructure

Evolving infrastructure will take advantage of information technology by leveraging commercial assets, services, and new technologies to support operations across diverse traffic management services. The public-private infrastructure will enable traffic management services that are available at all times and places. They will be resilient to unanticipated changes and agile to respond to future user needs.

Integrated Safety Management

With the growth of available data, the NAS will be able to assure in-time safety through continuous modeling, monitoring, and verification. Artificial intelligence will be involved in decision-making. The system will detect anomalies and correct for spikes in risk. Compliance within each organization's safety management system will assure interoperability across a variety of new interactions between public and private services, air and ground systems, and automated and manual control functions.

Automation Evolution Strategy

The Automation Evolution Strategy establishes computing infrastructure resources, furnishes supporting software platforms, and institutes the mission software. The envisioned NAS service-based architecture includes a computing resources layer that allows for the rapid availability of infrastructure and improved resiliency, a software platform layer of enterprise services and tools that programs can use and reuse to accelerate the development and deployment of capabilities, and a mission software layer to host aviation-specific applications and services in the cloud. This "systems of applications" pathway creates a web of connected technologies that benefit the whole network, where many small applications work together to create flexibility.

The FAA demonstrated that computers could support controller decision-making when we first applied computer automation techniques to flight data processing systems in the early 1960s. Even with the nascent technology, the FAA recognized the power of harnessing data for decision-making, and we adapted and increased reliance on automation to enhance aviation safety and efficiency. NextGen delivered integrated information management capabilities that provide the data, information services, standards, and a system-wide information management environment. The ability to tailor that data is at the heart of our Automation Evolution Strategy, as the FAA prepares for future NAS operations.

Modern technology has accelerated data acquisition and processing, potentially giving NAS users the capability to translate mountains of data into more meaningful and actionable information, allowing for more accurate predictions and more efficient flights. To take full advantage of this data-rich environment, the FAA is evolving our automation into a new microservices-based architecture, one that can support modern development and operations processes, and leverage cloud computing technologies. And we are rolling out these advancements one step at a time, without sacrificing safety-critical services.

APPENDIX A

Work Plan Through 2028

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. It also documents the 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 airspace users.

Appendix A contains:

- Descriptions of the NAS Enterprise Architecture (EA), NAS Segment Implementation Plan (NSIP), and NextGen portfolios
- A detailed work plan by NextGen portfolio showing related increments through 2028
- A roadmap to Trajectory Based Operations (TBO)

NextGen is the FAA's comprehensive overhaul of the NAS, enabling operational improvements and enhancing services to 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 are already benefiting aviation stakeholders and travelers through reduced operating costs and time savings.

Architecture and Implementation

To identify how to transform the NAS, the FAA uses the NAS EA to describe the evolution of air traffic control through the implementation of new infrastructure, technologies, and services. The EA also contains roadmaps to help guide the identification, tracking, and maturation of concepts that will further advance the NAS.

The EA helps us transform the NAS by communicating system responsibilities and enhancing NAS operations. This architecture facilitates 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 to increase efficiency

Supporting the NAS EA is the 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.

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

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 the right of access to the air traffic management (ATM) resources needed to meet their specific operational requirements and can safely share the airspace with different users.

The global ATM system should ensure equity for all users who have access to a given airspace or service.

- **Capacity:** Maximizes the number of takeoffs and landings that an airport can handle in a given period, under certain conditions, 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 effects 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 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:** Enables airspace users and ATM service providers to give consistent and dependable levels of performance. Predictability is essential to users as they develop and operate their schedules.
- **Safety:** Enables uniform safety standards and risk and safety management practices to 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.

Portfolios

As outlined in the NSIP, the FAA organizes operational improvements into 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 in increments as the capability 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 identified.

Portfolio Descriptions

Portfolio milestones are included in the detailed work plans section.

Improved Surface Operations: Improved airport surveillance information, cockpit displays for increased situational awareness, and the deployment of a departure management decision support system 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 aircraft on their final phase of flight will be accomplished through a combination of procedural changes, improved aircraft capabilities, and improved precision approach guidance. Procedural changes also allow for more efficient profiles.

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

Performance Based Navigation (PBN): Improvements in aircraft navigation provide an opportunity to increase efficiency and flexibility. The PBN portfolio addresses ways to leverage area navigation and required navigation performance to improve flexibility for point-to-point operations and access to airports.

Time-Based Flow Management (TBFM): System efficiency will be enhanced by leveraging the legacy Traffic Management Advisor decision support system capabilities. Further improvements will 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 efficiency.

Collaborative Air Traffic Management (CATM): NAS users and FAA traffic managers using advanced automation manage daily airspace and airport capacity issues caused by 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, for example, by tailoring reroutes to specific flights.

Separation Management: Controllers have tools and procedures to manage aircraft in an environment of mixed navigation equipment and varying wake performance capabilities. Aircraft separation assurance is the cornerstone of air traffic control operations. Separation management in the NAS is accomplished by using procedures, automation, or both.

On-Demand NAS Information: This portfolio ensures airspace and aeronautical information is consistent 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 effects to a level that does not limit 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 efficiency, capacity, and flexibility. This portfolio develops aircraft technologies and sustainable aviation fuels to reduce the impact of aviation on the environment and supplies the modeling tools necessary to conduct environmental analyses and ensure compliance with the National Environmental Policy Act.

System Safety Management: The FAA and industry will use policies, processes, and analytical tools developed and implemented to ensure that changes introduced with NextGen maintain or enhance safety while delivering benefits.

NAS Infrastructure: Capabilities in this portfolio involve the transformation or improvement of infrastructure that supports multiple portfolios. The portfolio includes a technical refresh of infrastructure that is indirectly rooted in operational improvements. It contains capabilities in these categories: communications, information management, weather, facilities, and aircraft collision avoidance.

Detailed Work Plans

This section describes detailed work plans for the portfolios. The portfolios list current operations (CO), operational improvements (OI), and the corresponding increments that show the current state and the evolution over time to move toward the NextGen vision and meet future demand. An OI's earliest and latest dates range from its earliest associated increments to the latest implementation dates. Once all increments associated with an OI are completed, the OI achieves operational availability and becomes a CO. A current operational environment (COE) describes the current state of FAA service delivery to NAS users. These portfolio components are associated with the years in which activities occur. The dates and timelines included in the tables are only for planning purposes and are based on information from the February 2023 NSIP baseline.

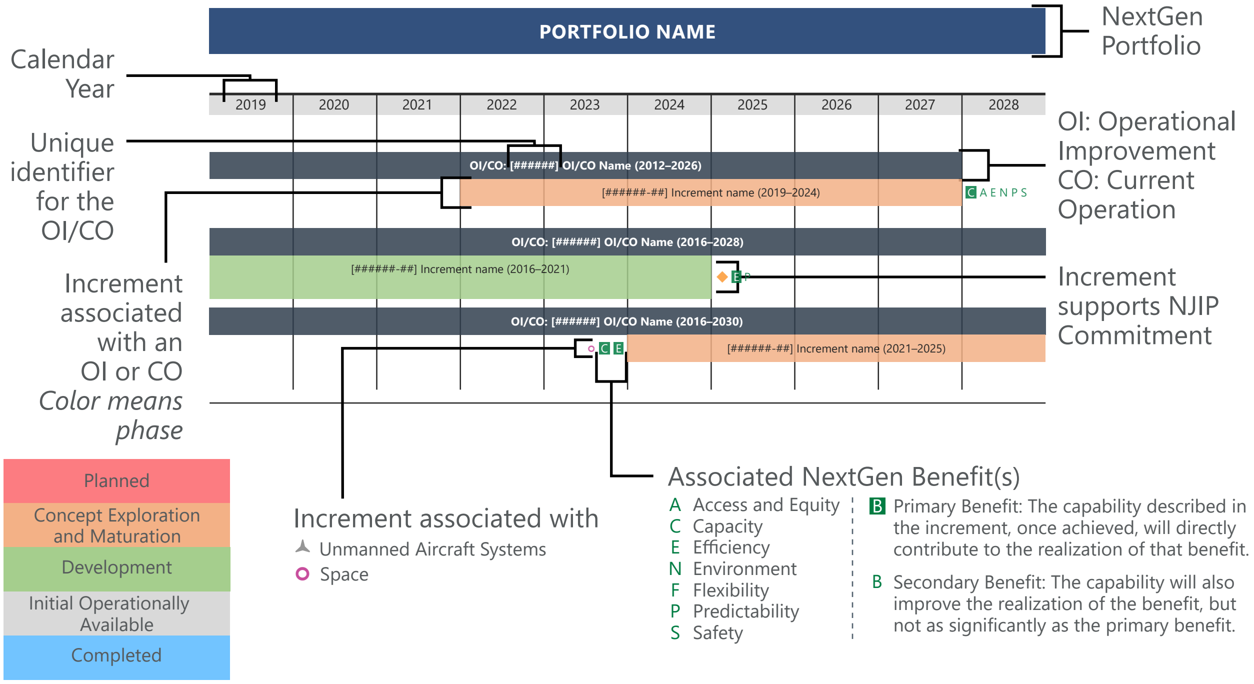
The COVID-19 pandemic delayed the complex choreography of engineering, ongoing recurrent and new training for air traffic controllers, and program management assets necessary to expand the capabilities of NextGen. The FAA has reduced activities that are not directly tied to safely operating the NAS. The results are fewer planned NextGen implementations because of budget, training, and infrastructure maintenance challenges. Still, benefits continue to accrue and will increase as air traffic re-emerges, and FAA implementation activities fully resume.

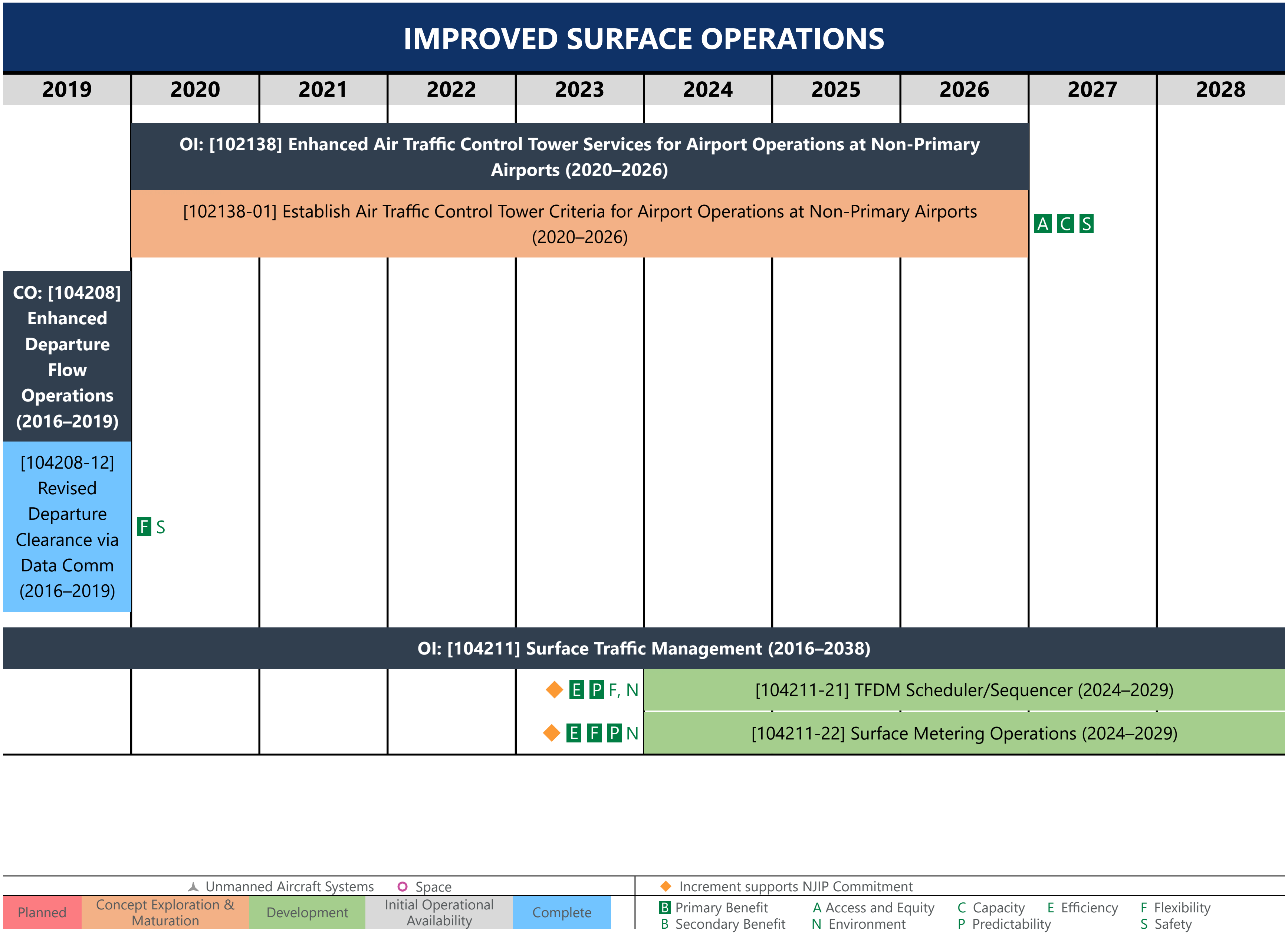
Portfolios also identify increments associated with unmanned aircraft systems, space transportation, and commitments in the NextGen Priorities Joint Implementation Plan (NJIP). FAA commitments are capabilities the industry and the FAA have negotiated as key capabilities that will benefit the industry and improve NAS operations.

See the graphic below for how to read the detailed work plans.

Appendix B defines the airport identifiers and acronyms, initialisms, or abbreviations associated with each operational improvement, current operation, or segment.

How to Read Detailed Work Plans





IMPROVED SURFACE OPERATIONS

2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028

OI: [102138] Enhanced Air Traffic Control Tower Services for Airport Operations at Non-Primary Airports (2020–2026)

[102138-01] Establish Air Traffic Control Tower Criteria for Airport Operations at Non-Primary Airports (2020–2026) A C S

CO: [104208] Enhanced Departure Flow Operations (2016–2019)

[104208-12] Revised Departure Clearance via Data Comm (2016–2019) F S

OI: [104211] Surface Traffic Management (2016–2038)

◆ E P F, N [104211-21] TFDM Scheduler/Sequencer (2024–2029)

◆ E F P N [104211-22] Surface Metering Operations (2024–2029)

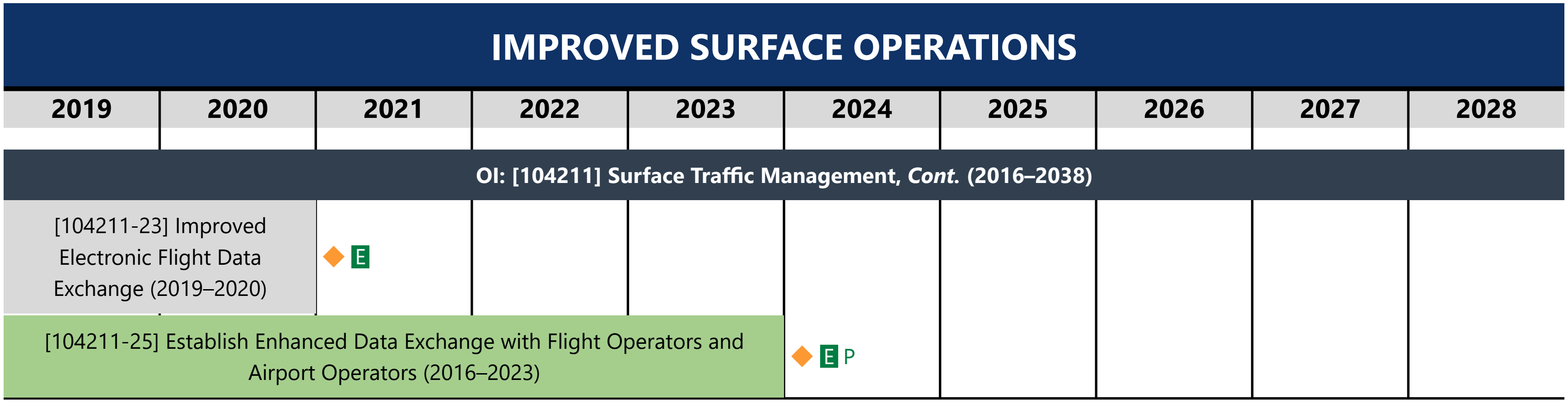
Unmanned Aircraft Systems ○ Space

Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

◆ Increment supports NJIP Commitment

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

IMPROVED SURFACE OPERATIONS



2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
OI: [104211] Surface Traffic Management, *Cont.* (2016–2038)									
[104211-23] Improved Electronic Flight Data Exchange (2019–2020)		◆ **E**							
[104211-25] Establish Enhanced Data Exchange with Flight Operators and Airport Operators (2016–2023)					◆ **E** P				

⅄ Unmanned Aircraft Systems ○ Space

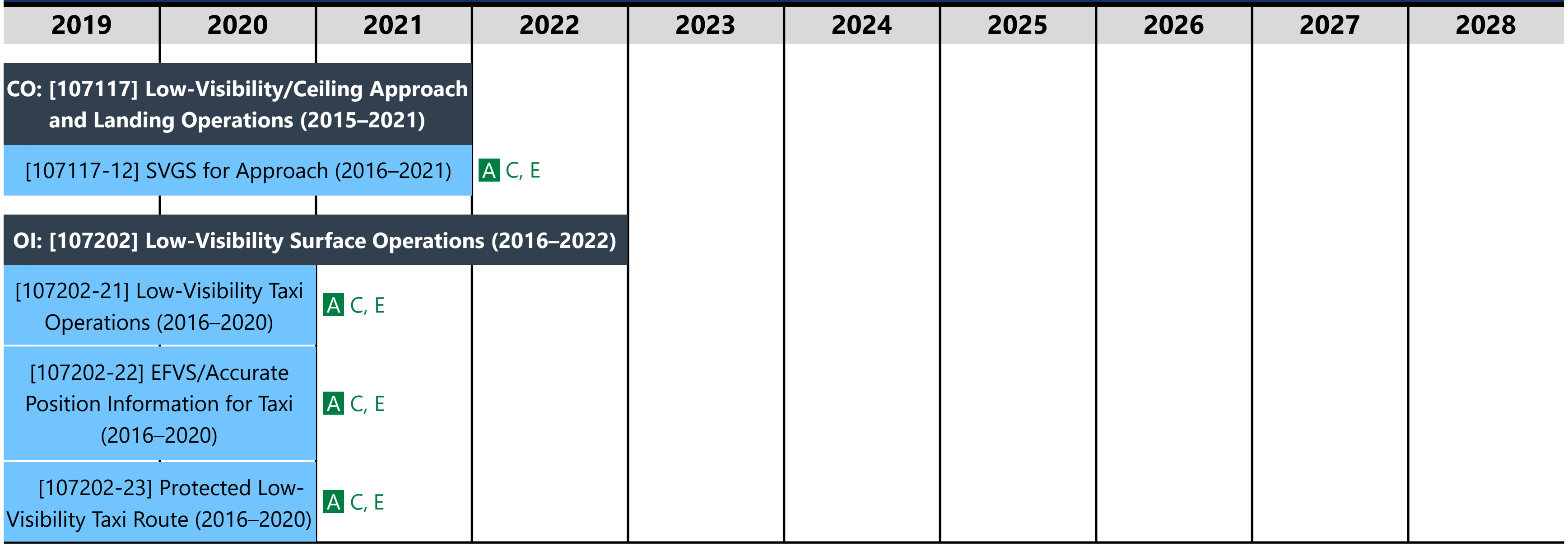
Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

◆ Increment supports NJIP Commitment

B Primary Benefit A Access and Equity C Capacity E Efficiency F Flexibility

B Secondary Benefit N Environment P Predictability S Safety

IMPROVED APPROACHES AND LOW-VISIBILITY OPERATIONS



⅄ Unmanned Aircraft Systems ○ Space

🟥 Planned | 🟧 Concept Exploration & Maturation | 🟩 Development | ⬜ Initial Operational Availability | 🟦 Complete

◆ Increment supports NJIP Commitment

B Primary Benefit
B Secondary Benefit

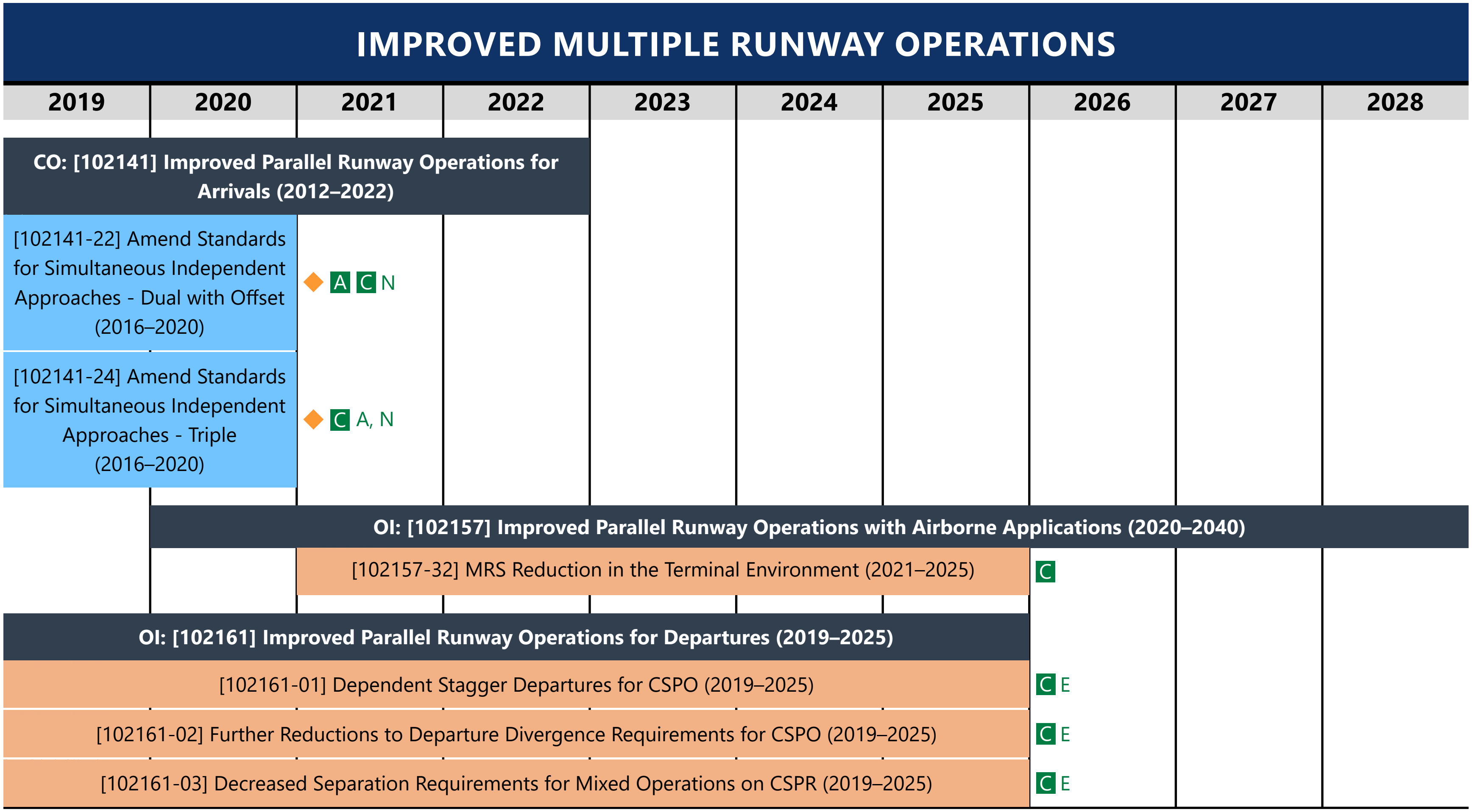
A Access and Equity
N Environment

C Capacity
P Predictability

E Efficiency

F Flexibility
S Safety

IMPROVED MULTIPLE RUNWAY OPERATIONS



2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028

CO: [102141] Improved Parallel Runway Operations for Arrivals (2012–2022)

[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

OI: [102157] Improved Parallel Runway Operations with Airborne Applications (2020–2040)

[102157-32] MRS Reduction in the Terminal Environment (2021–2025) C

OI: [102161] Improved Parallel Runway Operations for Departures (2019–2025)

[102161-01] Dependent Stagger Departures for CSPO (2019–2025) C E

[102161-02] Further Reductions to Departure Divergence Requirements for CSPO (2019–2025) C E

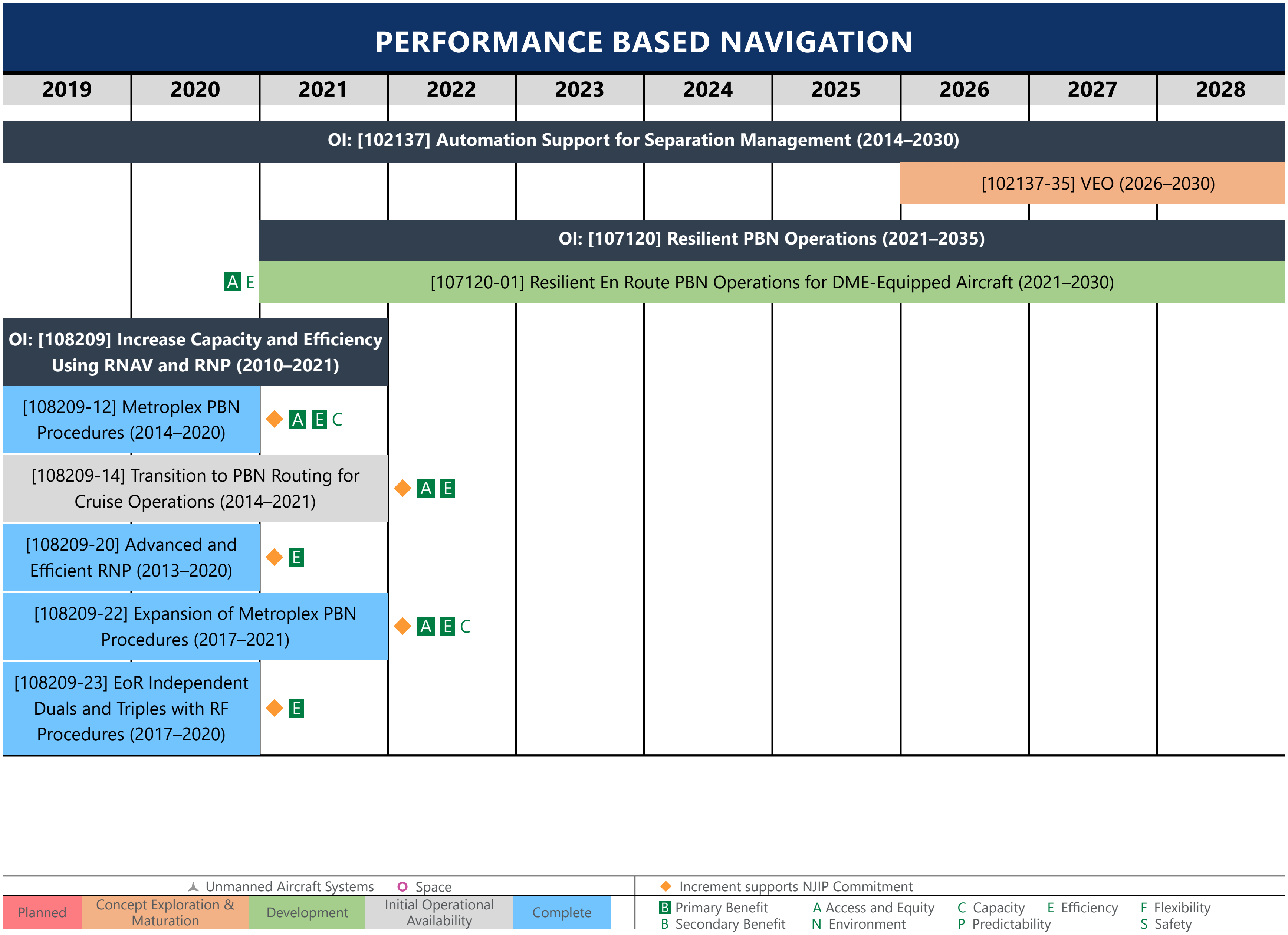
[102161-03] Decreased Separation Requirements for Mixed Operations on CSPR (2019–2025) C E

⅄ Unmanned Aircraft Systems ○ Space

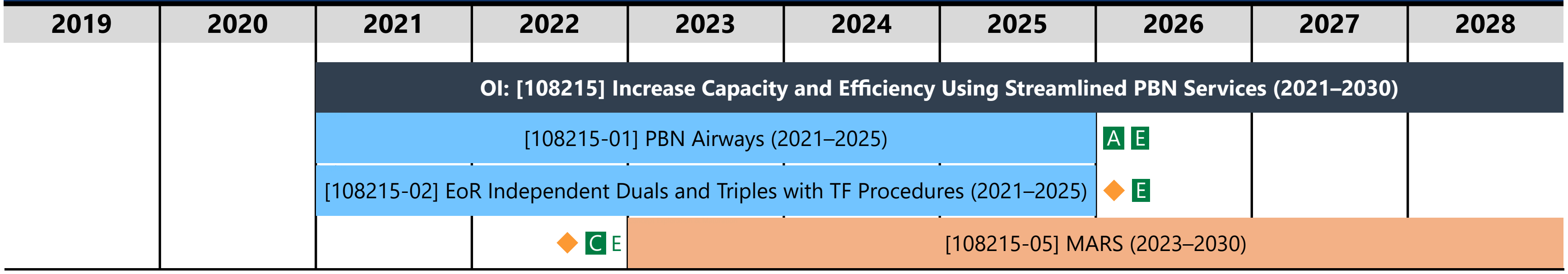
Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

◆ Increment supports NJIP Commitment

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


PERFORMANCE BASED NAVIGATION
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
OI: [102137] Automation Support for Separation Management (2014–2030)
[102137-35] VEO (2026–2030)
OI: [107120] Resilient PBN Operations (2021–2035)
A E
[107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021–2030)
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
[108209-22] 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 Operational Availability
Complete
◆ Increment supports NJIP Commitment
B Primary Benefit
B Secondary Benefit
A Access and Equity
N Environment
C Capacity
P Predictability
E Efficiency
F Flexibility
S Safety

PERFORMANCE BASED NAVIGATION



Unmanned Aircraft Systems ○ Space

◆ Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

B Primary Benefit
B Secondary Benefit

A Access and Equity
N Environment

C Capacity
P Predictability

E Efficiency

F Flexibility
S Safety

TIME-BASED FLOW MANAGEMENT

OI: [104117] Improved Departure Scheduling into Overhead Streams (2015–2035)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
[104117-11] IDAC (2014–2019)	◆ **E** C, N								
		[104117-21] Expansion of the IDAC (2021–2025)					**E** C, N		

⅄ Unmanned Aircraft Systems ○ Space

Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

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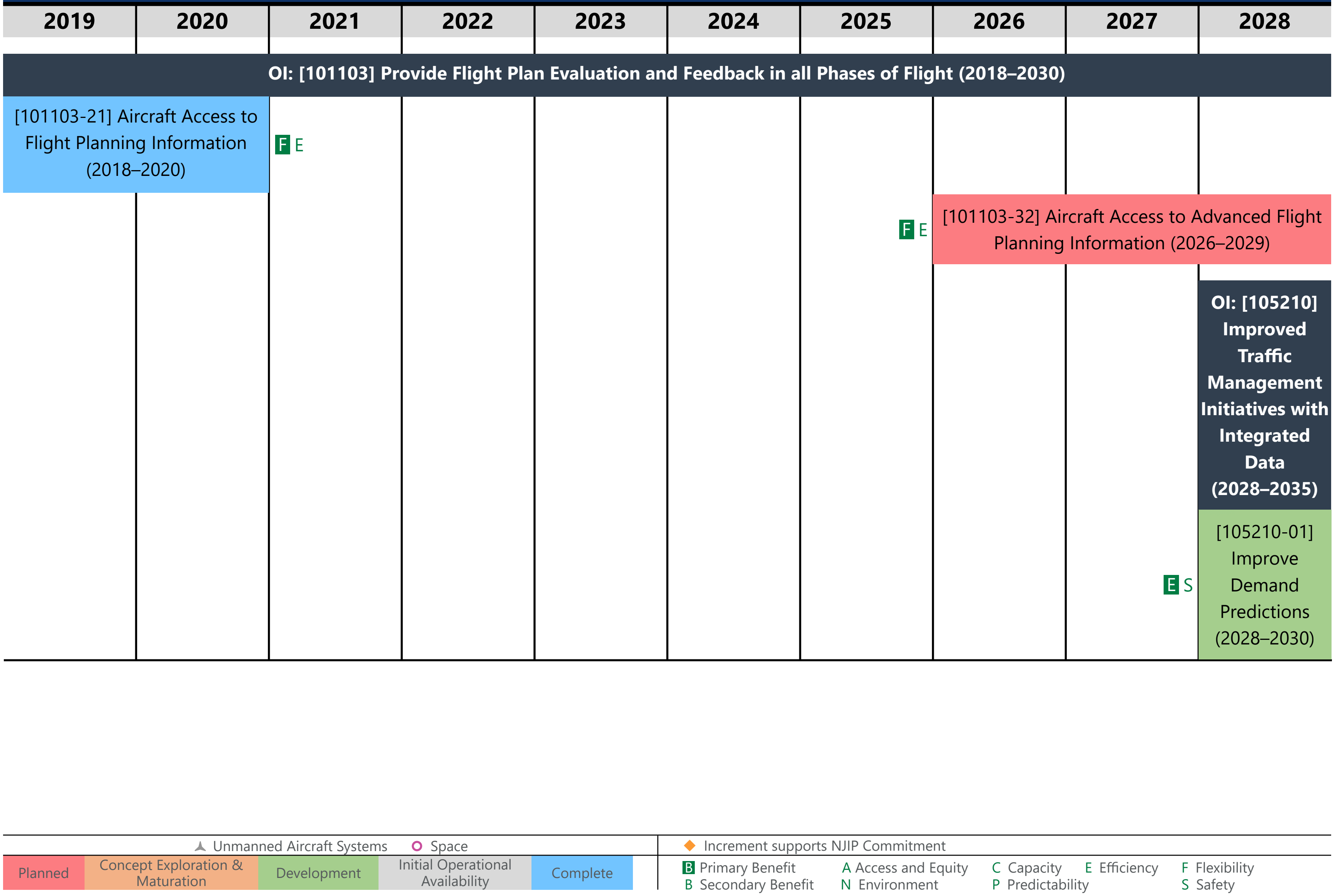
COLLABORATIVE AIR TRAFFIC MANAGEMENT



COLLABORATIVE AIR TRAFFIC MANAGEMENT

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
									OI: [105210] Improved Traffic Management Initiatives with Integrated Data, *Cont.* (2028–2035)
									C E [105210-03] Improved Integration of Traffic Flow Management Operations (2028-2030)
									OI: [105211] Automated Analysis of Flow Strategies (2028-2037)
									P [105211-01] Integrated Departure Route Planning (2028–2030)

⅄ Unmanned Aircraft Systems ○ Space

◆ Increment supports NJIP Commitment

Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

B Primary Benefit
B Secondary Benefit
A Access and Equity
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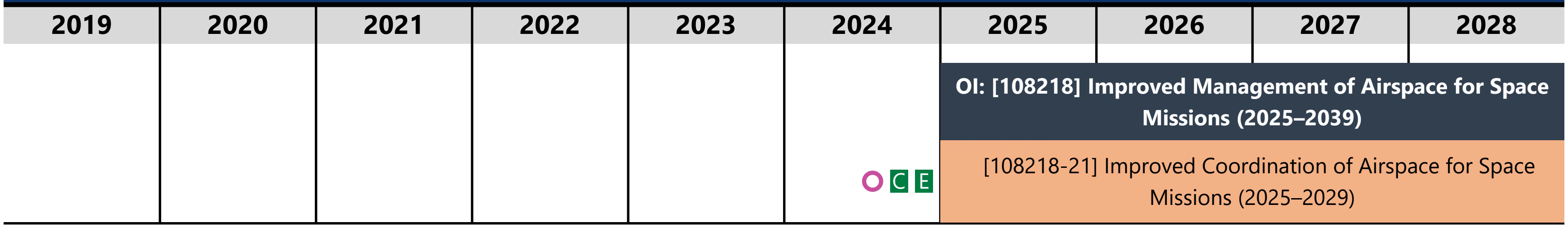
COLLABORATIVE AIR TRAFFIC MANAGEMENT



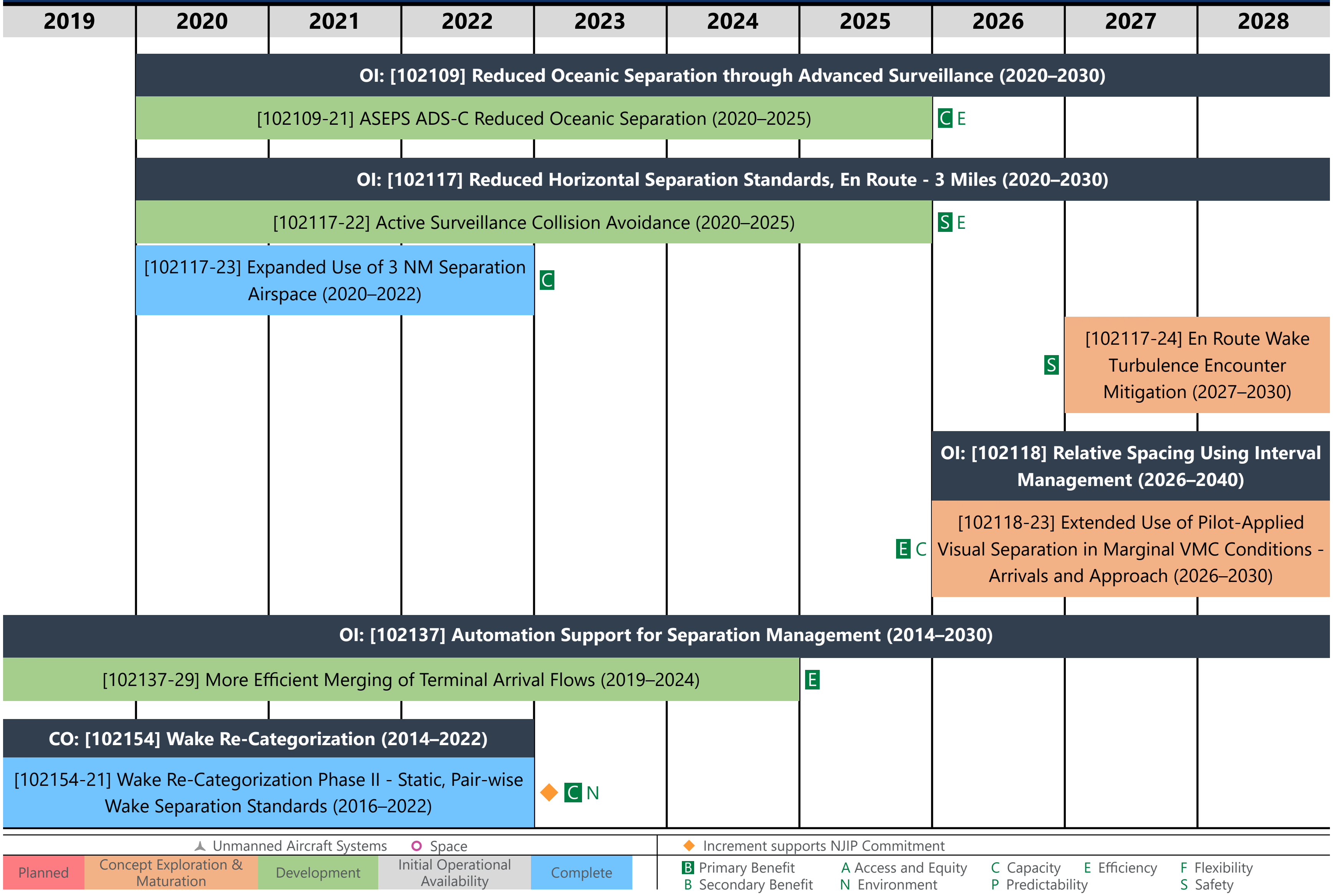
⅄ Unmanned Aircraft Systems ○ Space

◆ Increment supports NJIP Commitment

Planned	Concept Exploration & Maturation	Development	Initial Operational Availability	Complete

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

SEPARATION MANAGEMENT



OI: [102109] Reduced Oceanic Separation through Advanced Surveillance (2020–2030)

[102109-21] ASEPS ADS-C Reduced Oceanic Separation (2020–2025) **C** E

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

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

[102117-23] Expanded Use of 3 NM Separation Airspace (2020–2022) **C**

S [102117-24] En Route Wake Turbulence Encounter Mitigation (2027–2030)

OI: [102118] Relative Spacing Using Interval Management (2026–2040)

E C [102118-23] Extended Use of Pilot-Applied Visual Separation in Marginal VMC Conditions - 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) **E**

CO: [102154] Wake Re-Categorization (2014–2022)

[102154-21] Wake Re-Categorization Phase II - Static, Pair-wise Wake Separation Standards (2016–2022) ◆ **C** N

⅄ Unmanned Aircraft Systems ○ Space

◆ Increment supports NJIP Commitment

🟥 Planned	Concept Exploration & Maturation	Development	Initial Operational Availability	Complete

B Primary Benefit
B Secondary Benefit
A Access and Equity
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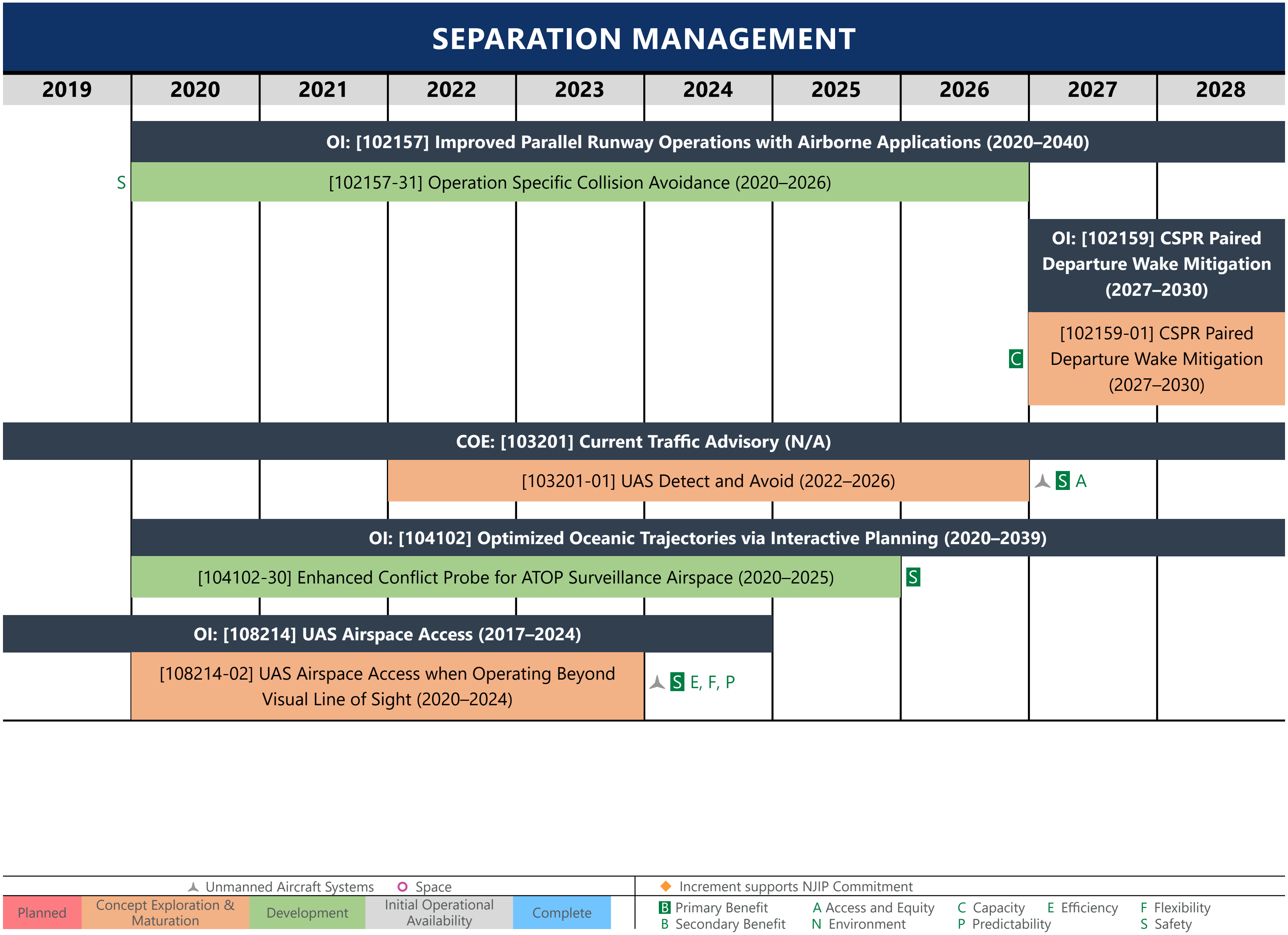
F Flexibility
S Safety

SEPARATION MANAGEMENT



OI: [102157] Improved Parallel Runway Operations with Airborne Applications (2020–2040)

S [102157-31] Operation Specific Collision Avoidance (2020–2026)

OI: [102159] CSPR Paired Departure Wake Mitigation (2027–2030)

C [102159-01] CSPR Paired Departure Wake Mitigation (2027–2030)

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

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

OI: [104102] Optimized Oceanic Trajectories via Interactive Planning (2020–2039)

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

OI: [108214] UAS Airspace Access (2017–2024)

[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 Operational Availability 🟦 Complete

◆ Increment supports NJIP Commitment

B Primary Benefit
B Secondary Benefit

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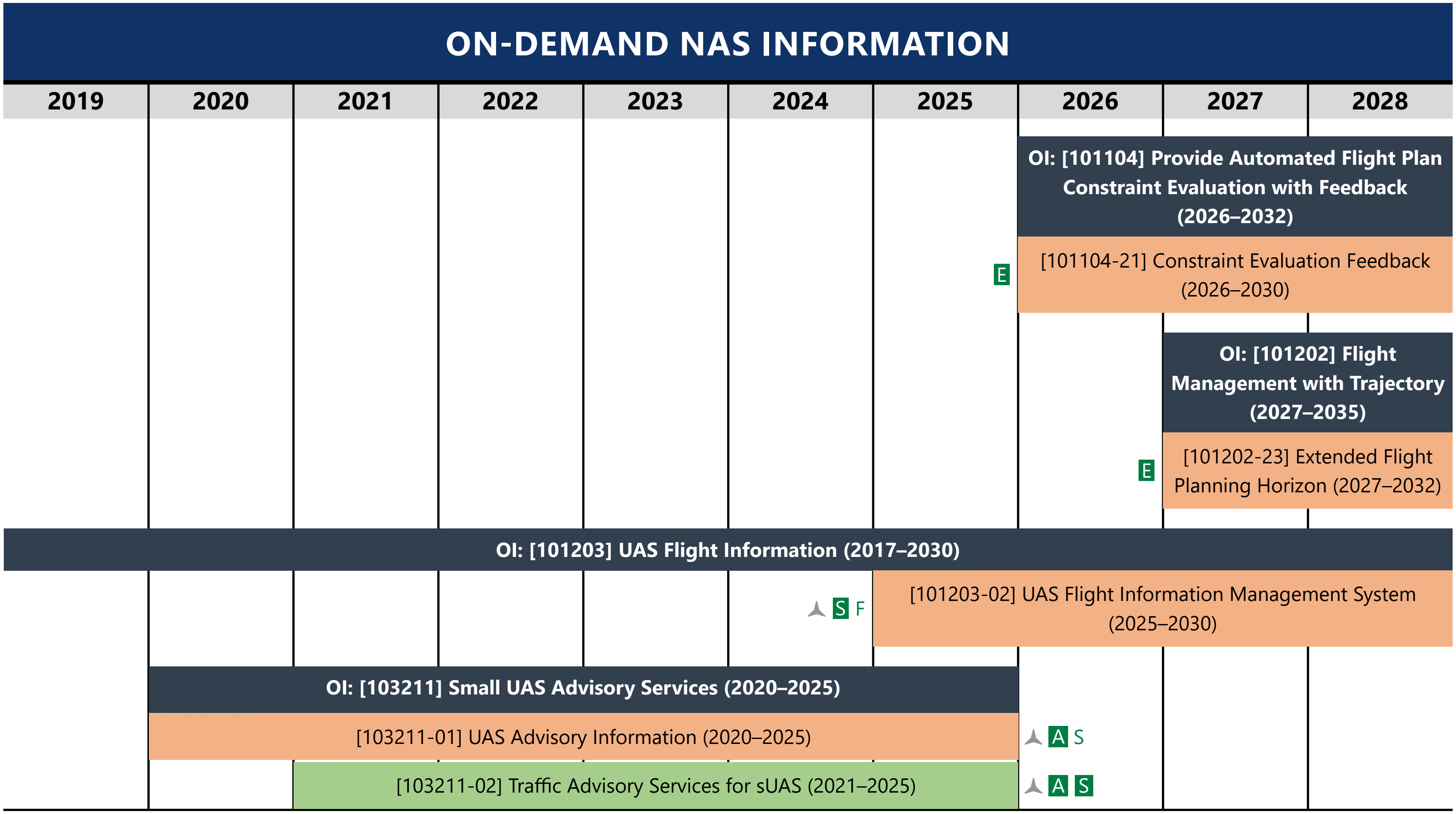
ON-DEMAND NAS INFORMATION



OI: [101104] Provide Automated Flight Plan Constraint Evaluation with Feedback (2026–2032)

E [101104-21] Constraint Evaluation Feedback (2026–2030)

OI: [101202] Flight Management with Trajectory (2027–2035)

E [101202-23] Extended Flight Planning Horizon (2027–2032)

OI: [101203] UAS Flight Information (2017–2030)

✈ 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

✈ Unmanned Aircraft Systems ○ Space

◆ Increment supports NJIP Commitment

🟥 Planned
🟧 Concept Exploration & Maturation
🟩 Development
⬜ Initial Operational Availability
🟦 Complete

B Primary Benefit
B Secondary Benefit
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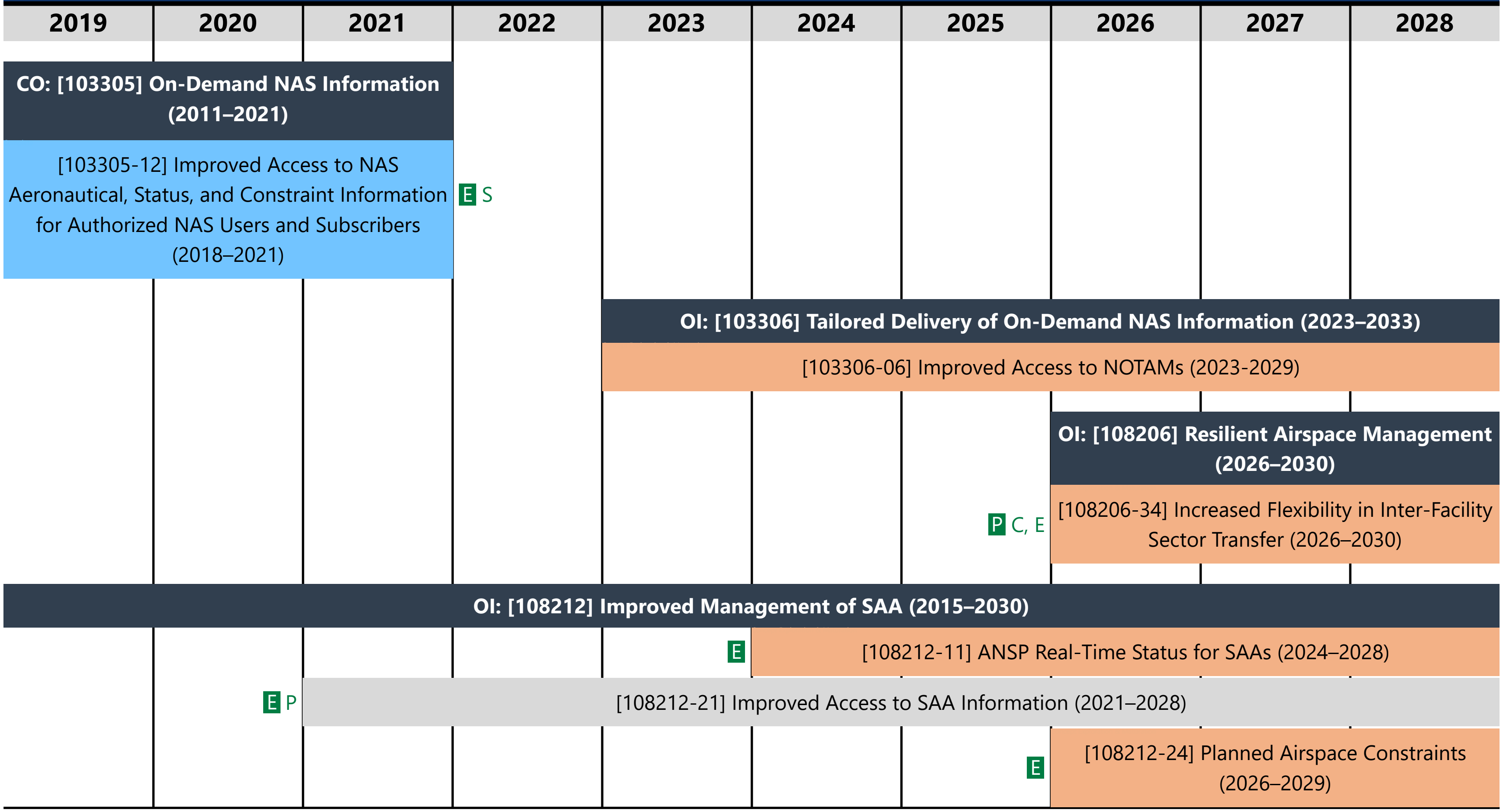
S Safety

ON-DEMAND NAS INFORMATION



CO: [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

OI: [103306] Tailored Delivery of On-Demand NAS Information (2023–2033)

[103306-06] Improved Access to NOTAMs (2023-2029)

OI: [108206] Resilient Airspace Management (2026–2030)

P C, E [108206-34] Increased Flexibility in Inter-Facility Sector Transfer (2026–2030)

OI: [108212] Improved Management of SAA (2015–2030)

E [108212-11] ANSP Real-Time Status for SAAs (2024–2028)

E P [108212-21] Improved Access to SAA Information (2021–2028)

E [108212-24] Planned Airspace Constraints (2026–2029)

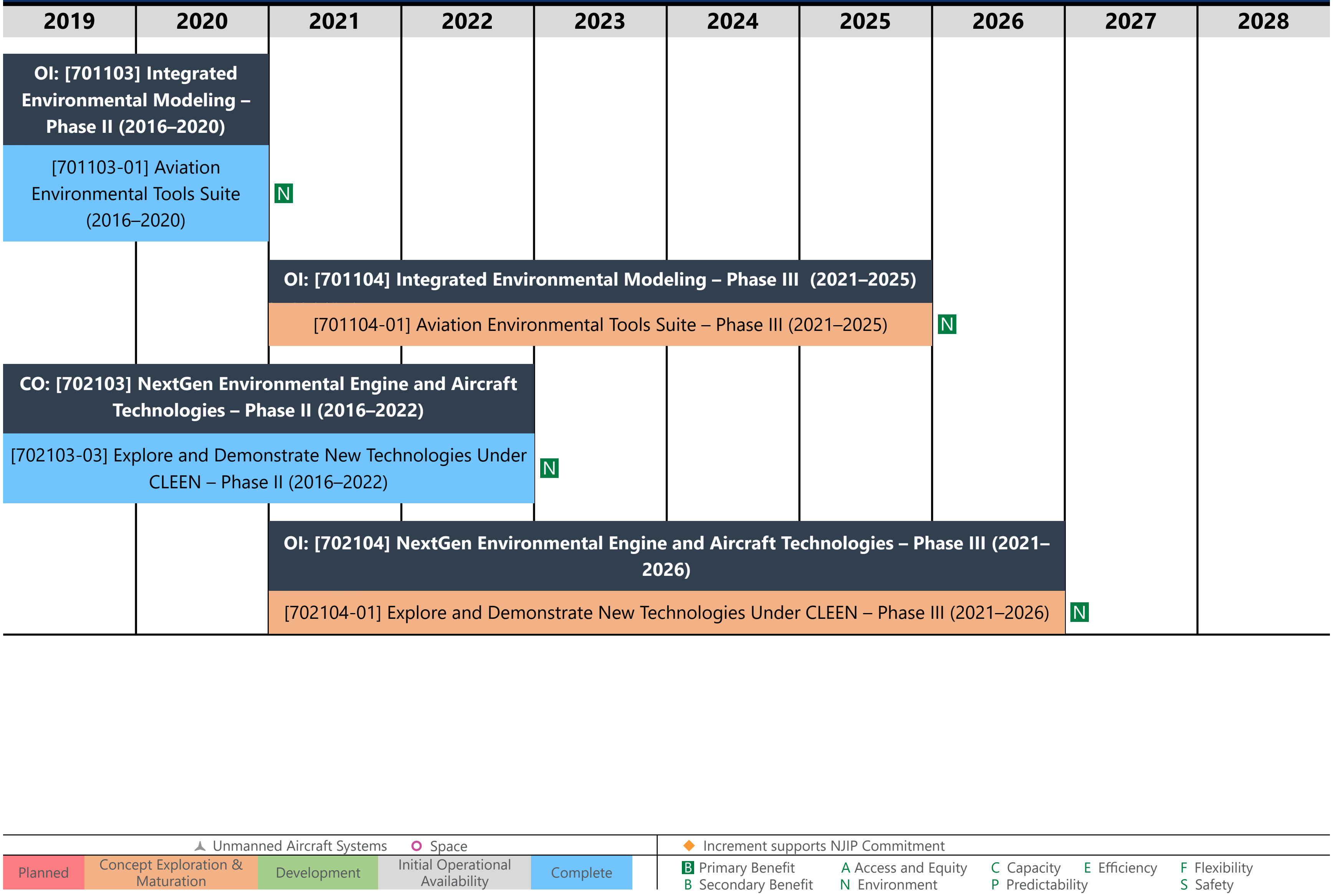
⅄ Unmanned Aircraft Systems ○ Space

Planned	Concept Exploration & Maturation	Development	Initial Operational Availability	Complete

◆ Increment supports NJIP Commitment

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

ENVIRONMENT AND ENERGY



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: [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 (2021–2026)

[702104-01] Explore and Demonstrate New Technologies Under CLEEN – Phase III (2021–2026) N

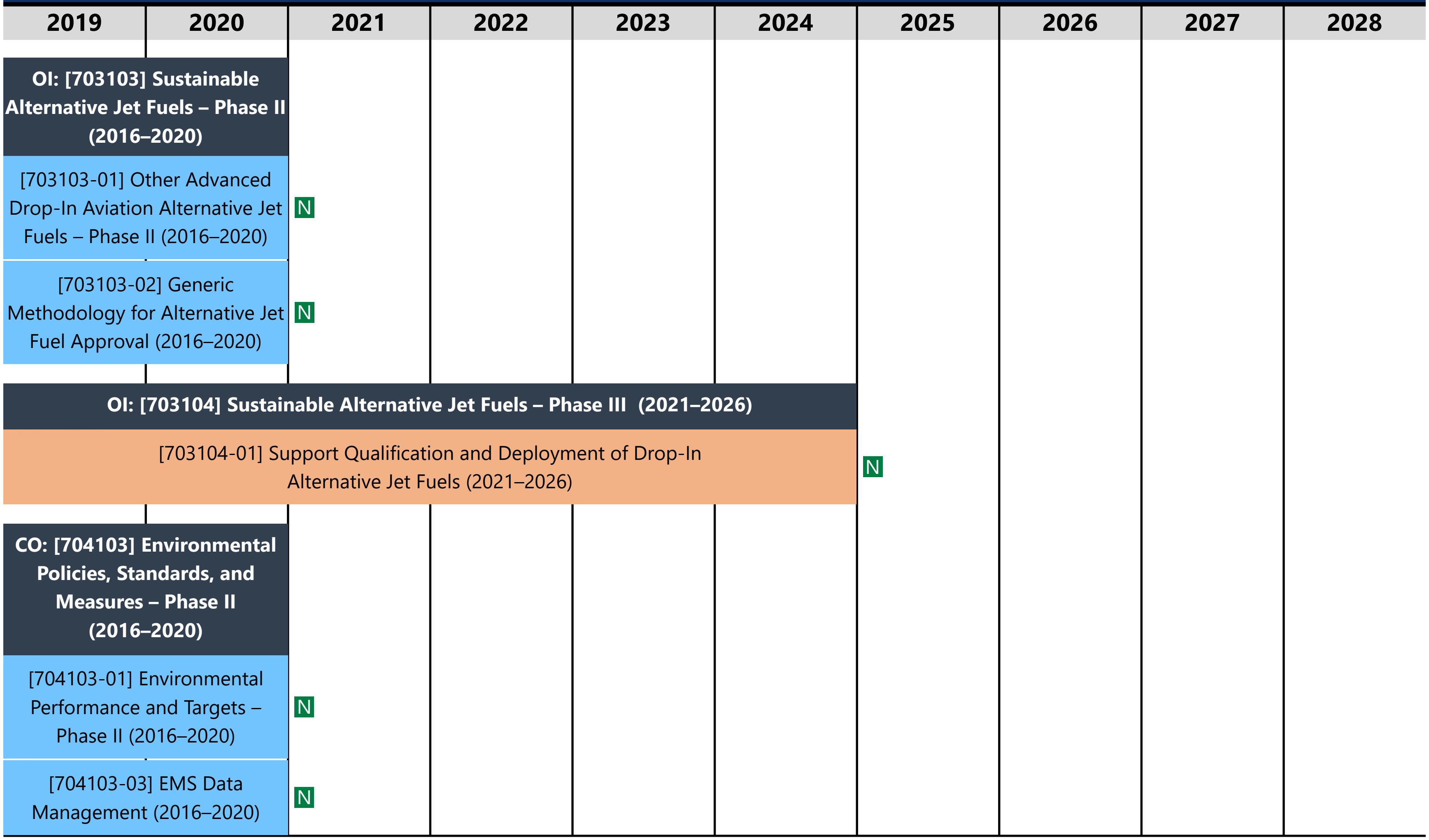
⅄ Unmanned Aircraft Systems ○ Space

Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

◆ Increment supports NJIP Commitment

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

ENVIRONMENT AND ENERGY



OI: [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 (2021–2026)

[703104-01] Support Qualification and Deployment of Drop-In Alternative Jet Fuels (2021–2026) N

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

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

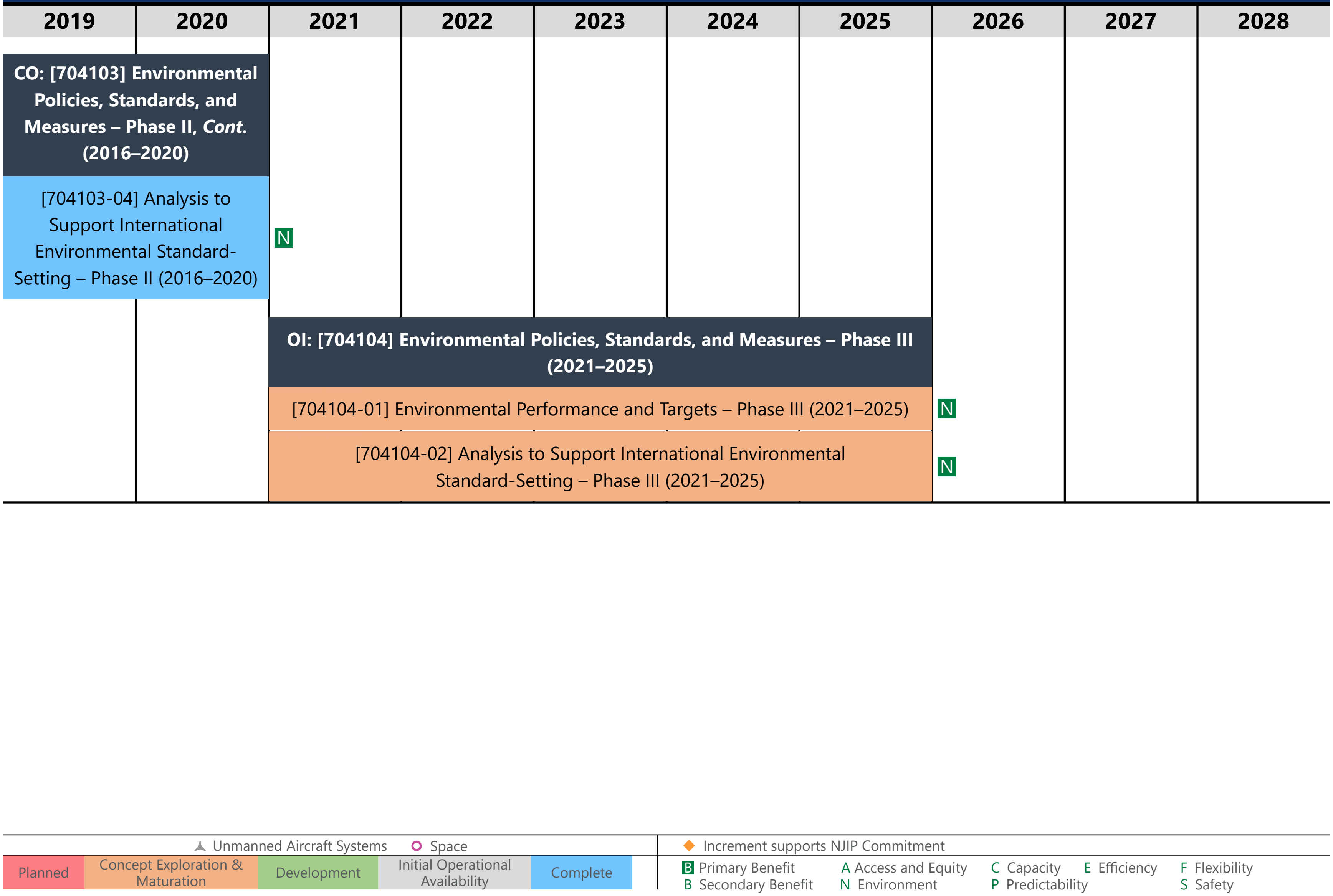
[704103-03] EMS Data Management (2016–2020) N

⅄ Unmanned Aircraft Systems	○ Space
◆ Increment supports NJIP Commitment	

Planned	Concept Exploration & Maturation	Development	Initial Operational Availability	Complete

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

ENVIRONMENT AND ENERGY



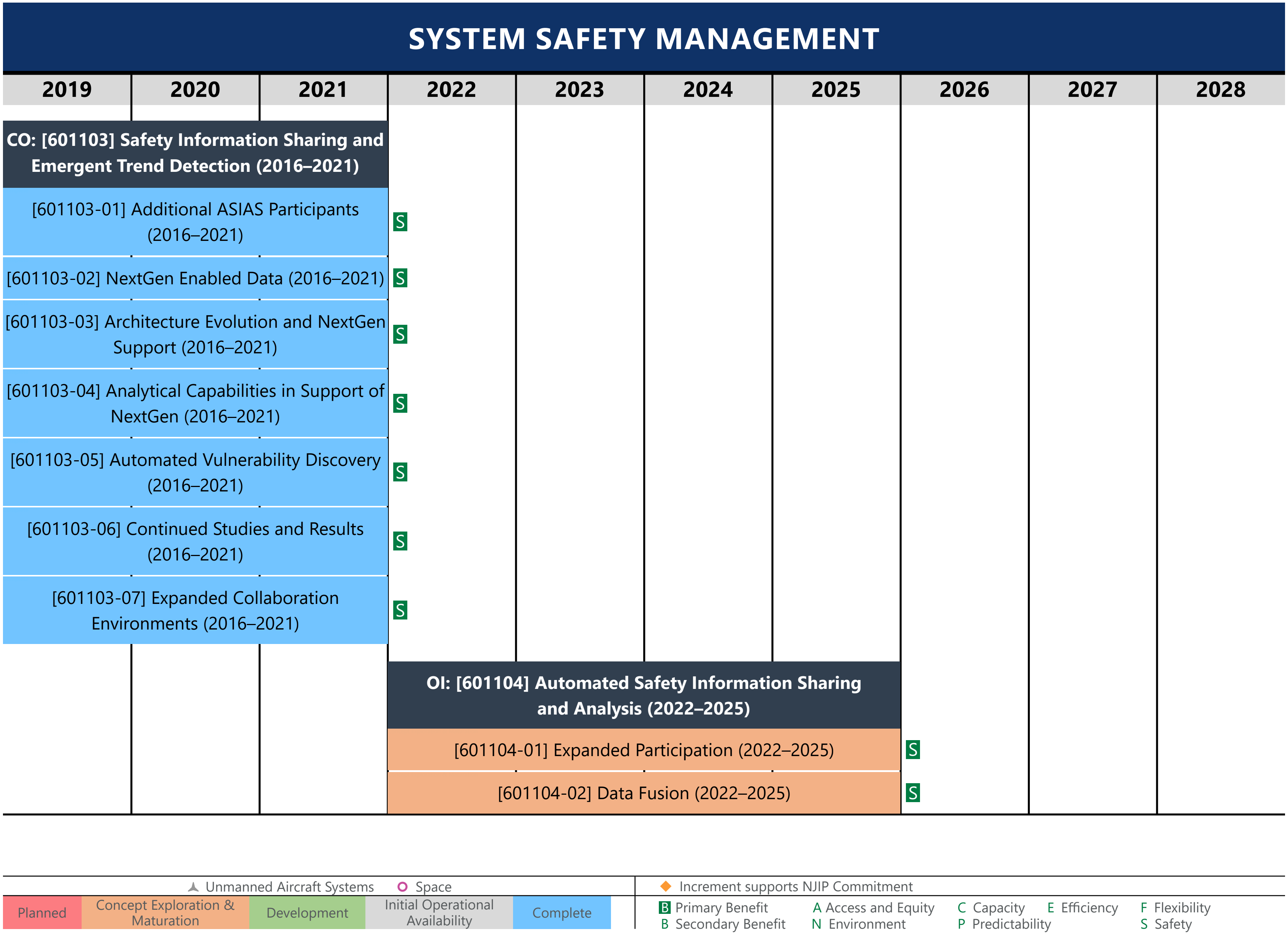
CO: [704103] Environmental Policies, Standards, and Measures – Phase II, *Cont.* (2016–2020)

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

OI: [704104] Environmental Policies, Standards, and Measures – Phase III (2021–2025)

[704104-01] Environmental Performance and Targets – Phase III (2021–2025)

[704104-02] Analysis to Support International Environmental Standard-Setting – Phase III (2021–2025)



SYSTEM SAFETY MANAGEMENT

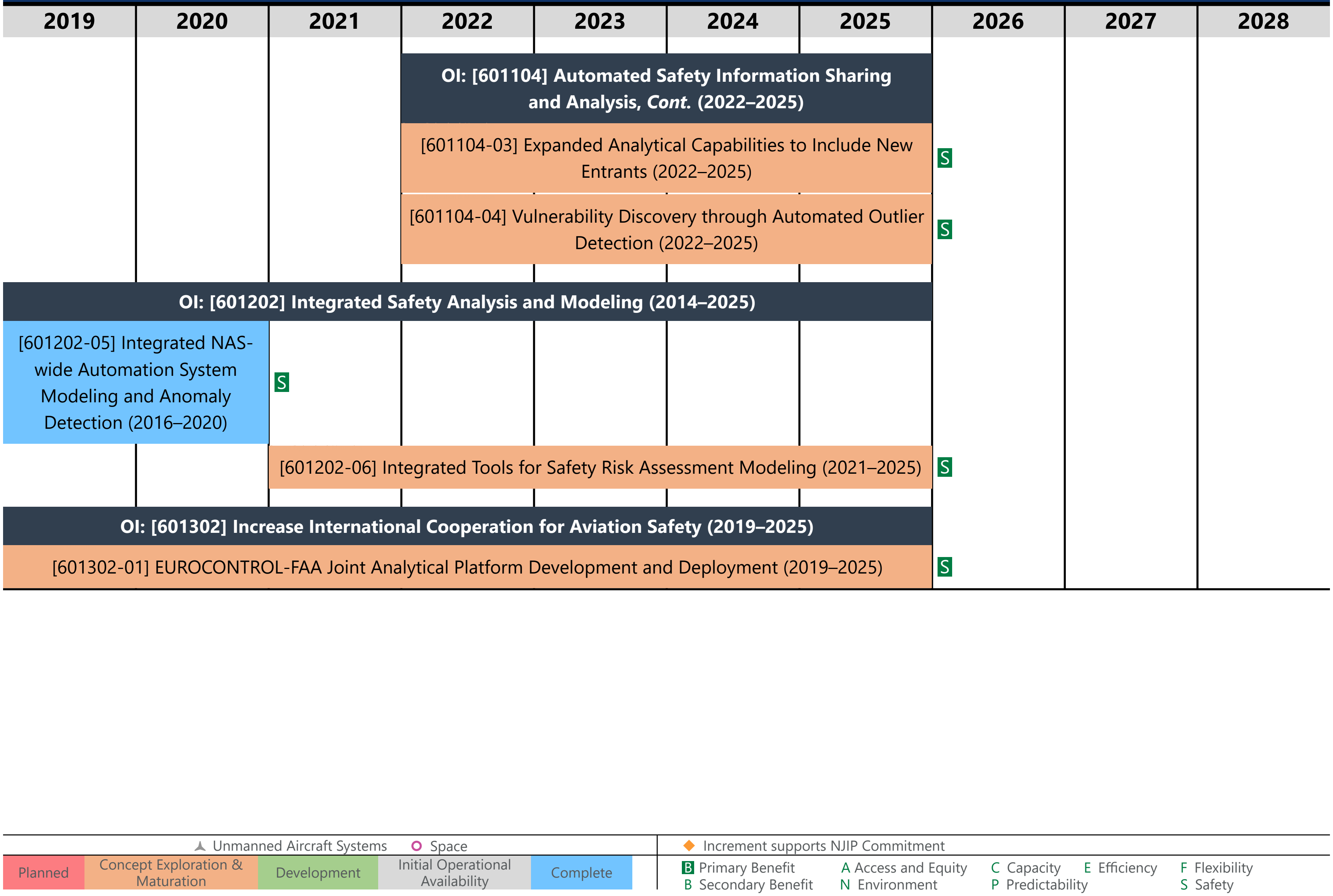
CO: [601103] Safety Information Sharing and Emergent Trend Detection (2016–2021)

- [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

SYSTEM SAFETY MANAGEMENT



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

[601104-03] Expanded Analytical Capabilities to Include New Entrants (2022–2025) S

[601104-04] Vulnerability Discovery through Automated Outlier Detection (2022–2025) S

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

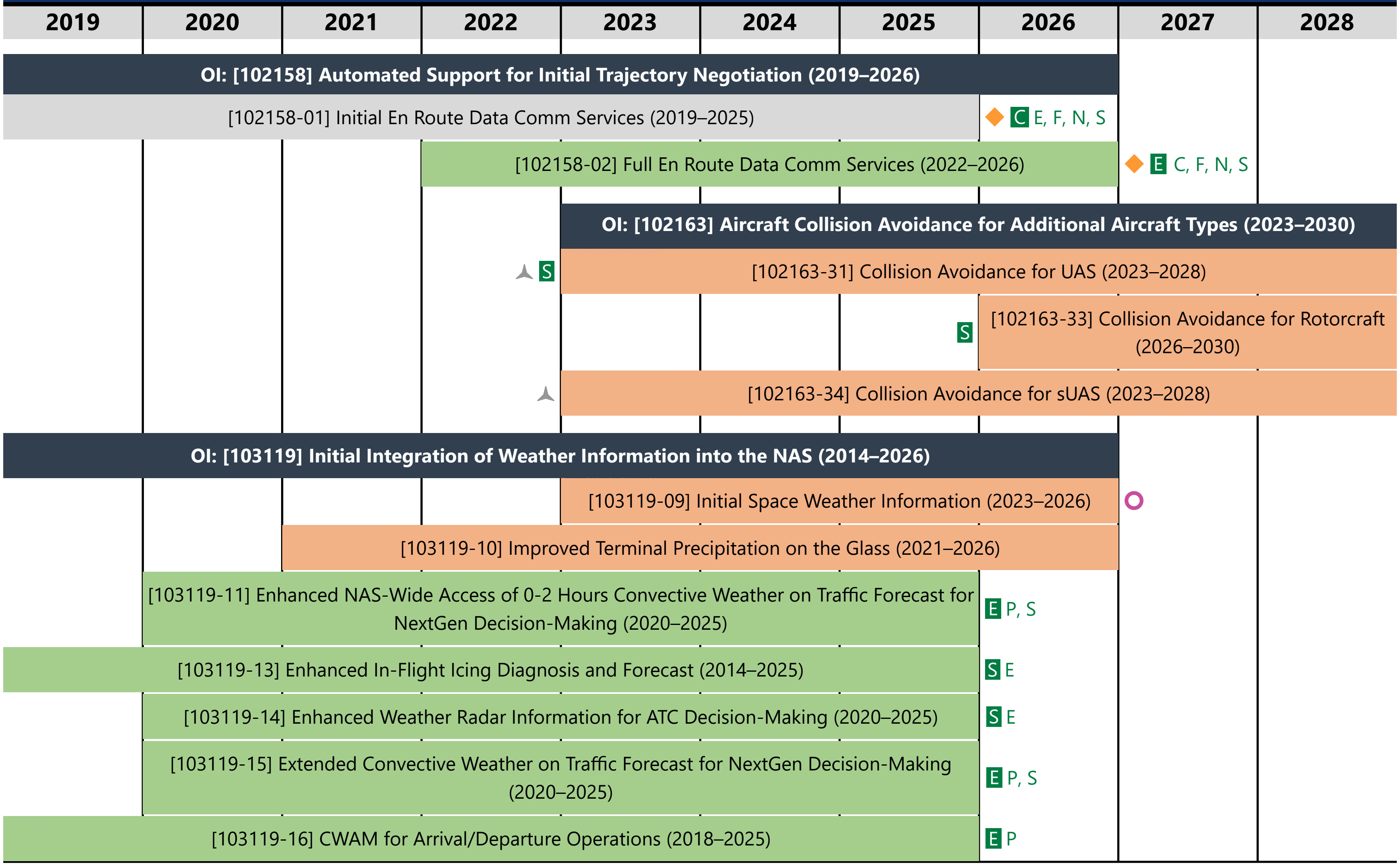
[601202-05] Integrated NAS-wide Automation System Modeling and Anomaly Detection (2016–2020) S

[601202-06] Integrated Tools for Safety Risk Assessment Modeling (2021–2025) S

OI: [601302] Increase International Cooperation for Aviation Safety (2019–2025)

[601302-01] EUROCONTROL-FAA Joint Analytical Platform Development and Deployment (2019–2025) S

NAS INFRASTRUCTURE



OI: [102158] Automated Support for Initial Trajectory Negotiation (2019–2026)

- [102158-01] Initial En Route Data Comm Services (2019–2025) ◆ **C** E, F, N, S
- [102158-02] Full En Route Data Comm Services (2022–2026) ◆ **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)
- ✈ [102163-34] Collision Avoidance for sUAS (2023–2028)

OI: [103119] Initial Integration of Weather Information into the NAS (2014–2026)

- [103119-09] Initial Space Weather Information (2023–2026) ○
- [103119-10] Improved Terminal Precipitation on the Glass (2021–2026)
- [103119-11] Enhanced NAS-Wide Access of 0-2 Hours Convective Weather on Traffic Forecast for NextGen Decision-Making (2020–2025) **E** P, S
- [103119-13] Enhanced In-Flight Icing Diagnosis and Forecast (2014–2025) **S** E
- [103119-14] Enhanced Weather Radar Information for ATC Decision-Making (2020–2025) **S** E
- [103119-15] Extended Convective Weather on Traffic Forecast for NextGen Decision-Making (2020–2025) **E** P, S
- [103119-16] CWAM for Arrival/Departure Operations (2018–2025) **E** P

✈ Unmanned Aircraft Systems ○ Space

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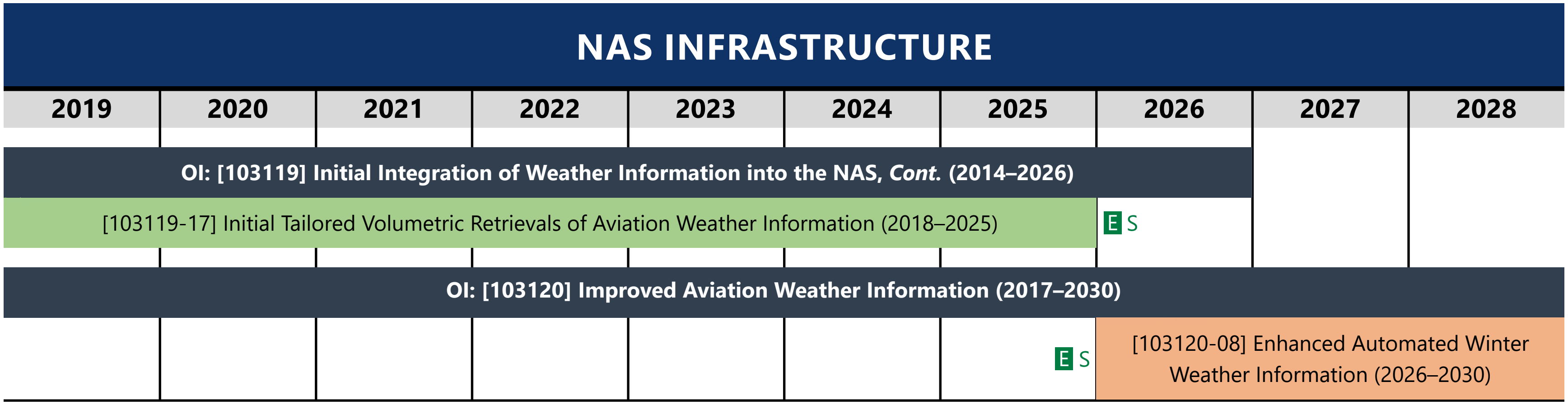

NAS INFRASTRUCTURE

OI: [103119] Initial Integration of Weather Information into the NAS, *Cont.* (2014–2026)

[103119-17] Initial Tailored Volumetric Retrievals of Aviation Weather Information (2018–2025) E S

OI: [103120] Improved Aviation Weather Information (2017–2030)

E S [103120-08] Enhanced Automated Winter Weather Information (2026–2030)

▲ Unmanned Aircraft Systems ○ Space

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Trajectory Based Operations

The path to TBO integrates deployed capabilities with new software applications and systems to deliver on the vision for TBO.

As the FAA moves toward TBO, the agency is assembling the building blocks to change how we operate. While the NSIP and its operational improvements and increments show details, the path to TBO conveys a higher-level view of the themes in which operational changes and the associated dependent technical capabilities are being developed and deployed. The result is a temporal representation of the initial operational availability of the capabilities associated with TBO.

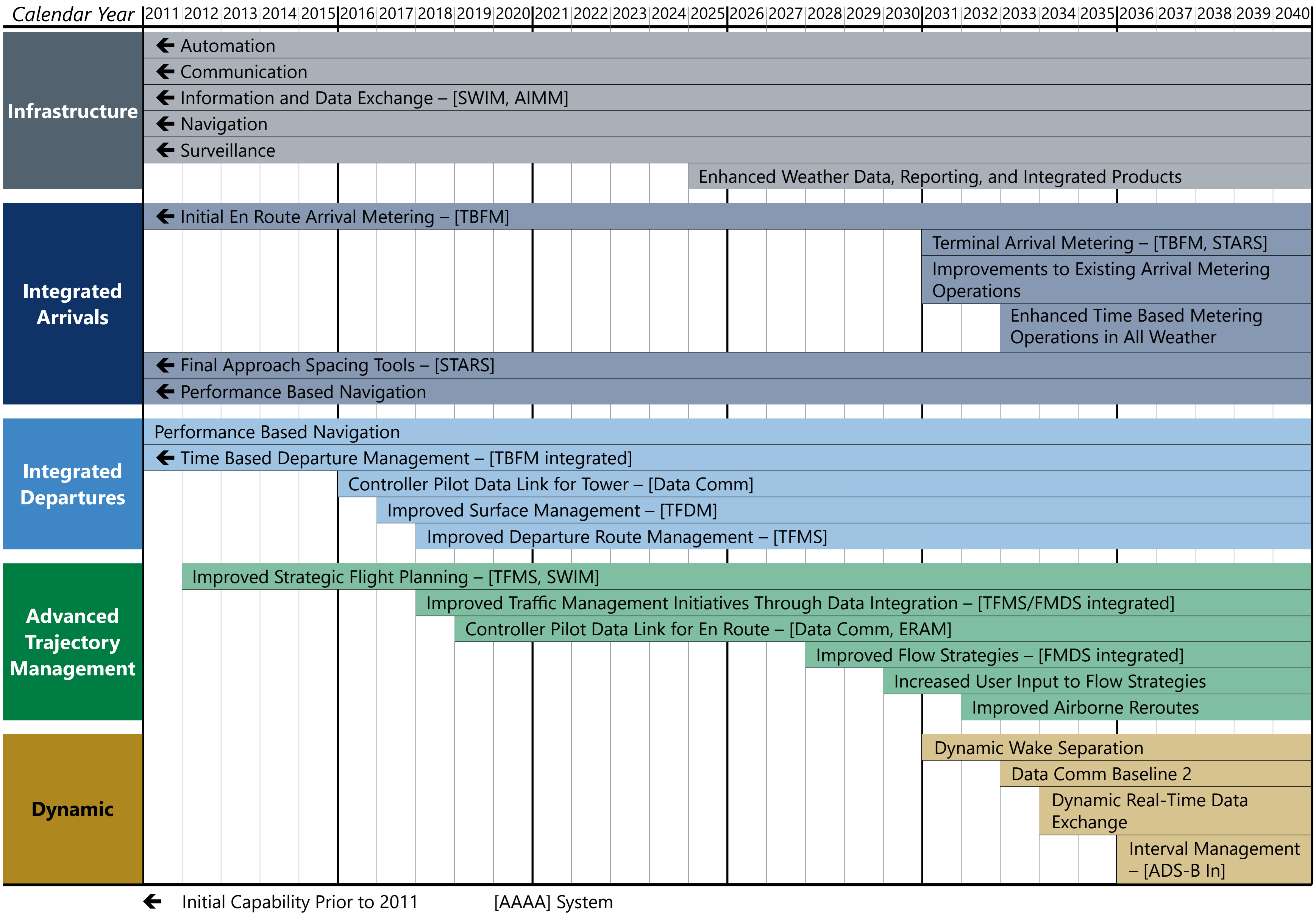
The capabilities listed in the Path to TBO chart are organized into five themes:

- Infrastructure domains related to TBO
- Integrated arrivals, including the procedures and time-based management capabilities necessary for TBO
- Integrated departures focused on the surface and departure phases, including the procedures and time-based management capabilities necessary for TBO
- Advanced trajectory management and negotiation that is strategic and tactical. It includes changes planned for traffic management synchronization across the NAS.
- Dynamic changes for the final phase of TBO. These capabilities are in the earliest stages of planning and concept development.

Beyond 2023

NextGen fundamentally changes aviation communications, navigation, and surveillance. It provides the integrated information environment to enable the transition to a future NAS that will enable the next iteration of airspace modernization.

Path to TBO



The integrated TBO capability will deliver the envisioned operational improvement. Capabilities in the shaded boxes represent when additional features will be available. Black arrows on the left side of the Year 2011 indicate that the initial capability was deployed before 2011. The information is based on the February 2023 NSIP.

APPENDIX B

ABBREVIATIONS, ACRONYMS, INITIALISMS

3D	Three-Dimensional
4D	Four-Dimensional
AAAC	Advanced Aviation Advisory Committee
AAM	Advanced Air Mobility
ABRR	Airborne Rerouting Capability
ACAS sXu	Airborne Collision Avoidance System for Small UAS
ACAS X	Airborne Collision Avoidance System X
ACAS Xr	Airborne Collision Avoidance System for Rotorcraft
ACS	Aeronautical Common Services
ACSS	Aviation Communication & Surveillance Systems
ADS-B	Automatic Dependent Surveillance–Broadcast
AI	Artificial Intelligence
AIMM	Aeronautical Information Management Modernization
API	Application Programming Interface
ASAIC	Airport Surface Anomaly Investigation Capability
ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air Traffic Control

ATM	Air Traffic Management
CARATS	Collaborative Actions for Renovation of Air Traffic Systems
CAS-A	CDTI-Assisted Separation on Approach
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
COE	Centers of Excellence
CPDLC	Controller Pilot Data Link Communications
CSP	Constraint Satisfaction Point
CSPO	Closely Spaced Parallel Operations
CSS-FD	Common Support Services–Flight Data
CSS-Wx	Common Support Services–Weather
Data Comm	Data Communications
DISCVR	Drone Information for Safety, Compliance, Verification, and Reporting
DME	Distance Measuring Equipment
EA	Enterprise Architecture

ELSO	Equivalent Lateral Spacing Operations
EoR	Established on Required Navigation Performance
ERAM	En Route Automation Modernization
FAA	Federal Aviation Administration
FF-ICE	Flight and Flow Information for a Collaborative Environment
FIM	Flight Deck Interval Management
FMDS	Flow Management Data and Services
GRAIN	Global Resilient Aviation Interoperable Network
IAM	Identity and Access Management
ICAO	International Civil Aviation Organization
IM	Interval Management
ISAM	Integrated Safety Assessment Model
ISRM	Integrated Safety Risk Management
JAT	Joint Analysis Team
JPDO	Joint Planning and Development Office
LAANC	Low Altitude Authorization and Notification Capability
LAX	Los Angeles International Airport
MARS	Multiple Airport Route Separation
ML	Machine Learning

NAC	NextGen Advisory Committee
NAS	National Airspace System
NCR	NAS Common Reference
NEC	Northeast Corridor
NESG	NAS Enterprise Security Gateway
NextGen	Next Generation Air Transportation System
NJIP	NextGen Priorities Joint Implementation Plan
NOAA	National Oceanic and Atmospheric Administration
NSIP	NAS Segment Implementation Plan
NWP	NextGen Weather Processor
OI	Operational Improvement
PBN	Performance Based Navigation
REDAC	Research, Engineering, and Development Advisory Committee
RNAV	Area Navigation
RNP	Required Navigation Performance
SCDS	SWIM Cloud Distribution Service
SCM	Single Center Metering
SDI	Space Data Integrator
SESAR	Single European Sky Air Traffic Management Research

SFDPS	SWIM Flight Data Publication Service
SITAR	Safety Information Toolkit for Analysis and Reporting
SMS	Safety Management System
SRM	Safety Risk Management
SSMT	System Safety Management Transformation
STARS	Standard Terminal Automation Replacement System
STDDS	SWIM Terminal Data Distribution System
SWIFT	SWIM-Industry FAA Team
SWIM	System Wide Information Management
TBFM	Time Based Flow Management
TBM	Time Based Management
TBO	Trajectory Based Operations
TFDM	Terminal Flight Data Manager
TFMS	Traffic Flow Management System
TMA	Traffic Management Advisor
TRACON	Terminal Radar Approach Control
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems
XM	Extended Metering

U.S. Department of Transportation

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