U.S. Department of Transportation
Federal Aviation Administration

NextGen Annual Report

Fiscal Year 2022




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 transformation of the NAS.

EXECUTIVE SUMMARY

The Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration's (FAA) ongoing multibillion-dollar infrastructure program to modernize the U.S. National Airspace System (NAS), which is the world's busiest and most complex. NextGen's leading-edge technologies and policies have significantly advanced aviation safety and efficiency, delivering more than $8.5 billion worth of benefits between 2010 and 2021. With air traffic returning to pre-pandemic levels, the potential benefits from NextGen capabilities remain substantial. This report documents our progress and plans for fiscal year 2022.

The FAA has completed most of the NextGen infrastructure, enabling notable improvements in the management of the national airspace. Digital communications enable efficient message exchanges between controllers and pilots; performance-based navigation facilitates shorter, more fuel-efficient flight paths; and satellite-enabled surveillance enhances aircraft location accuracy. State-of-the-art automation systems and integrated information management improve air traffic management efficiency, fostering shared decision-making and analysis.

NextGen capabilities support our goal of Trajectory Based Operations (TBO), an innovative approach to managing air traffic that provides a common understanding of planned aircraft trajectories for all systems and stakeholders. TBO is expected to increase efficiency, throughput, predictability, and flexibility. Initial TBO implementation is underway at four NAS operating areas: Northeast Corridor, Mid-Atlantic, Northwest Mountain, and Southwest. To showcase the technical capabilities of TBO, the FAA, in collaboration with partners, executed five multi-regional TBO scenarios at the Florida NextGen Test Bed. These simulations illustrated how TBO can enhance the efficiency of flights traversing international airspace boundaries.

Despite pandemic obstacles that disrupted the complex choreography of engineering, training, and program implementation crucial to operationalizing NextGen, airspace modernization carried on as restrictions to facilities eased, enabling access where necessary to advance our important programs. We are revising implementation milestones and coordinating reprogramming for affected activities.

In 2022, the FAA brought Data Communications (Data Comm) tower service to Jacksonville and Palm Beach international airports. Minneapolis en route center achieved the initial operating capability milestone for Data Comm initial en route services, and centers in Oakland and Miami began using the technology 24 hours a day, 7 days a week.

We completed the Metroplex program that integrated Performance Based Navigation routes, procedures, and airspace changes at 11 metropolitan areas with the closeout of the South-Central Florida Metroplex project. Houston expanded Established on Required Navigation Performance operations, with aircraft now able to turn on all four available downwind directions. The FAA also completed safety analyses and initial controller training for Multiple Airport Route Separation.

Initial Interval Management operations using Automatic Dependent Surveillance–Broadcast In technology began in Albuquerque en route center's airspace consisting of two clearance types: cross and maintain. We also developed requirements for surveillance services, architecture alternatives, and future technologies to enhance the existing surveillance infrastructure.

To enhance automation capabilities, the FAA finished replacing En Route Automation Modernization components that were nearing their end-of-service life or had degraded performance. The Terminal Flight Data Manager Build 1 began operations at its key site, Cleveland. The FAA added new features, which included enhanced location data, more sophisticated tracking data, wider access to aircraft transponder codes, and access to airport ramp data for the System Wide Information Management (SWIM) Flight Data Publication Service.

The SWIM Terminal Data Distribution System was refreshed at 38 terminal radar approach control facilities with enhancements to the services for surface movement events, tower departure events, terminal automation information, and infrastructure, monitoring, and control. We also completed the SWIM Identity and Access Management's strong authentication capability. The SWIM NAS Common Reference received a connection to the Aeronautical Common Services as well as performance improvements, and the SWIM Industry-FAA Team portal was refreshed. The FAA also advanced projects in information management services, flight deck collaborative decision-making, digitization of airspace constraints, and the International Aviation Trust Framework.

The NextGen Weather program is working to reduce the effect of weather on aviation, resulting in safer, more efficient, and predictable NAS operations. The FAA has also furthered efforts for closely spaced parallel operations, remote tower demonstrations, and safety transformation.

As we are modernizing the NAS through NextGen, the aerospace ecosystem is expanding rapidly. The advanced air mobility, unmanned aircraft systems, and commercial space industries are growing exponentially. The FAA began Phase 2 of the beyond visual line of sight NAS evaluation for drones heavier than 55 pounds in airspace above 400 feet. We also released DroneZone beta web applications to support the collection and processing of airspace authorizations and waivers, operational waivers, and accident reporting, as well as a common logging and monitoring service for Low Altitude Authorization and Notification Capability. We are developing innovative traffic management concepts and evaluating technologies such as a new collision avoidance system to safely incorporate additional future users into the NAS.

From air traffic control to the biggest airliner down to the smallest drone, connectivity is the way of the future in aerospace as we transition to an information-centric NAS, incorporating imaginative technologies into a fully integrated information environment for the U.S. air transportation system.

The FAA in 2022 published “Charting Aviation’s Future: Vision for an Info-Centric National Airspace System.” The vision builds on NextGen 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.

INTRODUCTION

The Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration's (FAA) ongoing multibillion-dollar infrastructure program to modernize the U.S. National Airspace System (NAS), which is the world's busiest and most complex. NextGen is the largest upgrade of air traffic control systems in modern history. Through research, innovation, and collaboration, NextGen contributes to defining new standards and further advancing the FAA's global leadership in aviation. This report is a singular document about NextGen's progress and plans in fiscal year 2022. Whenever possible and unless stated otherwise, the data cutoff is September 30, 2022. 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.

NextGen Defined

NextGen is a series of interlinked programs, portfolios, systems, and policies that fundamentally change aviation communications, navigation, and surveillance. Airport infrastructure improvements, new air traffic management technologies and procedures, and environmental, safety, and security enhancements are within its scope.

NextGen enables a more flexible, robust, and resilient aerospace infrastructure that will meet projected demand and support the administration's goals. It improves the safety of flight paths and ensures the safe introduction of non-traditional users into aviation, such as operators for advanced air mobility and commercial space. Moreover, new technologies and procedures reduce the effects of excessive aircraft noise and engine exhaust emissions on vulnerable and overburdened communities.

The transformation of the NAS is a broad and complex endeavor. The FAA works with stakeholders across government, the private sector, academia, and other nations to develop and deploy new capabilities. The FAA engages with the public on airspace modernization and shares noteworthy practices with the aviation community to adopt new technologies and processes more quickly. As a global leader in aerospace, we also foster international cooperation in evolving aviation infrastructure technologies that improve system safety and mobility.

The FAA follows a comprehensive cross-agency portfolio approach to implementation that recognizes modernization as an integrated effort rather than a collection of independent programs. We continue to support programs that facilitate improved aviation safety and operational efficiency.

Drivers of Change

In the late 1990s, mounting congestion heavily stressed the NAS. Forecasts predicted even more congestion because of greater demand for aviation services. Representatives from government, industry, and the public were concerned about how the NAS could accommodate future air travel demands. After 9/11, security requirements further constrained how people traveled and cargo moved.

In 2003, Congress passed the Vision 100—Century of Aviation Reauthorization Act. 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 JPDO was tasked with developing and coordinating long-term plans and sponsoring cross-agency mission research.

The FAA worked closely with stakeholders to develop the Next Generation Air Transportation System Integrated Plan that defined high-level goals and requirements to transform the NAS. In 2007, the JPDO updated the original vision with the Concept of Operations for NextGen, which identified key research and policy issues that needed to be resolved to achieve our national goals for airspace modernization.

Changes were underway by 2008 when the FAA started to move key parts of NextGen from design to delivery. In 2011, the NextGen Mid-Term Concept of Operations served as a stepping stone from the legacy system to the next generation NAS the JPDO had envisioned.

Throughout the transformation, the FAA has worked to develop and test a new infrastructure that will accommodate state-of-the-art enabling technologies and advanced capabilities, helping to bring research to reality.

Research and Development

To transform the NAS, concepts, capabilities, and systems must be researched, developed, tested, and evaluated before they can be implemented. The FAA William J. Hughes Technical Center in Atlantic City, NJ, is the nation's premier federal aviation laboratory for advancing the NAS and sustaining its continued safe and efficient operations. Every fundamental improvement in the NAS since 1958 has been developed or tested at the Technical Center.

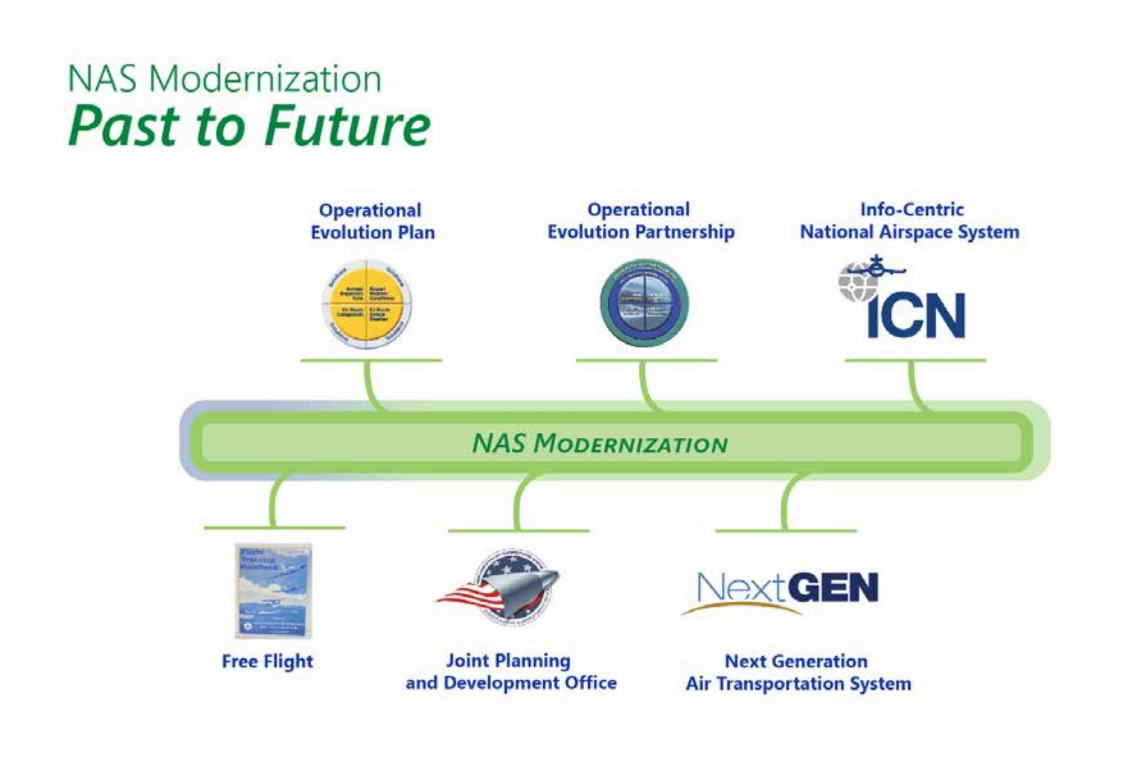
The FAA established the Florida NextGen Test Bed in 2008 to generate industry-driven concepts that advance NAS modernization. It provides a platform where early-stage NextGen concepts can be integrated, demonstrated, and evaluated. In 2012, the FAA designated the North Texas Research Station, a partnership between the FAA and the National Aeronautics and Space Administration (NASA), as a NextGen test facility that operates in all phases of NextGen research.

Additionally, the FAA Air Transportation Centers of Excellence (COE) enable the FAA to work with universities and industry affiliates to advance aviation technologies and grow the next generation of aviation professionals. Located at universities across the United States, COEs contribute to research in focus areas such as human factors, aircraft noise and aviation emissions mitigation, general aviation safety, alternative jet fuels, and unmanned aircraft systems (UAS). Grant recipients are required to match FAA grant awards with contributions from non-federal sources and may contribute more through federal cost-share.

MITRE's Center for Advanced Aviation System Development, a federally funded research and development center, supports a variety of FAA research, such as NextGen decision support systems and Trajectory Based Operations concepts.

Where We Are Today

The FAA has completed most of the NextGen infrastructure, providing us and the aviation community with the necessary flexibility to handle projected air traffic demand. NextGen has integrated leading-edge technologies and policies to make air travel safer and more efficient. As a result, the important functions of managing our national airspace have improved.



Modernization of the National Airspace System (NAS) has been an ongoing endeavor since 1937, when the Bureau of Air Commerce launched a two-year comprehensive airways modernization and extension program. A more recent initiative was Free Flight in the early 2000s. The Operational Evolution Plan and the Operational Evolution Partnership built upon Free Flight. The Joint Planning and Development Office formed in 2003 to establish NextGen and the NextGen Implementation Plan in 2008. After NextGen, the Info-Centric NAS will carry on the legacy of NAS modernization, with capabilities beginning operations around 2035.

The FAA is delivering benefits to aircraft operators and the traveling public through:

- Digital communications that enable more efficient and timely information exchange between air traffic controllers and pilots

- Performance-based navigation that enables shorter, more precise flight paths that can save fuel and reduce engine
- exhaust emissions
- Satellite-enabled surveillance that more accurately shows aircraft location information to air traffic controllers and other pilots
- State-of-the-art automation systems to increase the efficiency of air traffic management at every phase of flight
- Enterprise-level integrated information management that improves shared decision-making, scheduling, and analysis

In addition to delivering more benefits and innovative capabilities across the NAS, the aviation industry expects to increase aircraft equipage and pilots’ use of deployed capabilities as we operationalize NextGen.

Pandemic Response

The FAA implemented unprecedented measures at the beginning of the COVID-19 pandemic to protect FAA employees. We suspended activities that were not immediately and directly tied to safely operating the NAS, which interrupted the complex choreography of engineering, ongoing recurrent and new training for air traffic controllers, and program management assets necessary to expand NextGen capabilities. Those measures continued to influence the implementation of many NextGen initiatives through 2022.

Work on some NextGen programs transitioned to remote system testing and development, safety panels, and site surveys. The FAA prudently resumed some training and on-site activities, and the agency is continuing to work through the resulting backlog and assessing the full ramifications of delays from the pandemic. The agency is also revising implementation milestones and coordinating reprogramming for affected NextGen activities.

Total NextGen benefits are measured from more than 20 NextGen capabilities through more than 200 implementations across the nation.

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

Reporting Benefits

The FAA estimates NextGen has delivered more than $8.5 billion worth of total benefits between 2010 and 2021 from about 20 NextGen capabilities through more than 200 implementations across the nation.

Return on Investment Report

NextGen benefits have been measured in detail since 2010 and accrue each year. They are calculated by analyzing performance before and after implementing NextGen capabilities. 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. The JAT was created to increase the transparency of benefit estimates and reach an agreement on benefit values and measurement methodology.

Beyond 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 but are a small portion of the expected future benefits. Cumulative increases result from continued benefits from previous implementations plus new implementations. Future benefits are driven by growth in travel demand, more implemented capabilities and procedures, and continued equipping of aircraft by the industry for required navigation performance and Data Communications.

With air traffic returning after the pandemic, the potential benefits from NextGen capabilities remain substantial.

The FAA will continue to leverage methodologies developed through the JAT and validate NextGen benefits through demonstrations, trials, and initial deployment of new systems and capabilities at existing and new sites. Aircraft operators, passengers, and air traffic controllers benefit from the enhanced safety, efficiency, and capacity of modernization.

Responding to Section 503 of H.R. 302, the FAA Reauthorization Act of 2018, the FAA in 2020 prepared a return on investment report for Congress that summarized the cost-benefit analysis for NextGen programs and priorities. The report was included as an appendix to the NextGen Annual Report for fiscal year 2020 and is planned to be updated annually. However, restrictions from the pandemic initially impeded access to facilities and delayed the installation of investment programs. Moreover, benefit projections require an understanding of future demands. The return on investment analysis will resume when assessments of program schedules are complete.

Collaboration

From planning to implementation to operationalizing NextGen, success is based on the support and coordination across the FAA, other government agencies, and the aviation community.

FAA Workforce

Change is expected, inevitable, and ongoing to advance NAS modernization. To prepare employees for change, the FAA collaborates with its labor unions at local, regional, and national levels. The unions coordinate with their members to find subject matter experts to participate in and co-lead design teams, assessments, and program development and implementation. These working groups provide input and recommendations on the operational suitability of new technologies.

Federal Agency Partners

We engage with other government agencies through the NextGen Executive Board, the NextGen Executive Weather Panel, and other collaborative bodies to leverage stakeholder expertise while gathering resources to advance NAS modernization. The FAA works primarily with the departments of Commerce, Defense, Homeland Security, and Interior; NASA; the National Geospatial-Intelligence Agency; the National Transportation Safety Board; the Environmental Protection Agency; and the Advisory Council on Historic Preservation.

Federal Advisory Committees

Research, Engineering, and Development Advisory Committee

The FAA's Research, Engineering, and Development Advisory Committee (REDAC) provides advice and recommendations to the FAA administrator on the needs, objectives, plans, approaches, content, and accomplishments of the aviation research portfolio. The REDAC considers aviation research needs in five areas: NAS operations, human factors, airport technology, aviation safety, and environment and energy. The REDAC also assists in ensuring the coordination of corollary research conducted outside of the FAA.

Established in 1989, the REDAC strives for a balanced point of view with representation from aviation, aerospace, and related emerging technology-focused corporations, along with government agencies, universities, associations, and consumers.

NextGen Advisory Committee

The NextGen Advisory Committee (NAC) provides independent advice and recommendations to the FAA and responds to specific tasks received from the FAA. The NAC 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.

Established in 2010, the NAC maintains a balanced membership from the aviation community. It consists of senior executives representing airports, aircraft operator associations and airlines, aircraft and avionics manufacturers, air traffic control automation and infrastructure companies, labor unions, international stakeholders, environmental interests, the Department of Defense, and NASA.

Advanced Aviation Advisory Committee

The Advanced Aviation Advisory Committee (AAAC) provides independent advice and recommendations to the Department of Transportation and the FAA, and responds to specific tasks received from the FAA. The AAAC's advice, recommendations, and tasks intend to:

- Improve the safety and efficiency of integrating advanced aviation • Improve the safety and efficiency of integrating advanced aviation technologies, including UAS and advanced air mobility (AAM), into the NAS
- Equip and enable communities to inform how UAS, AAM, and other technologies may operate in ways that are compatible with those communities

Established in 2018 as the Drone Advisory Committee, the AAAC seeks a broad cross-section of the industry for its members. Members represent a variety of stakeholders, such as airports, UAS hardware and software manufacturers, governments, labor unions, academia, industry associations, traditional pilots, UAS operators, and community advocates.

Aviation Industry

Besides interacting with the aviation industry through federal advisory committees, the FAA engages trade associations through collaborative workgroups, industry days, and conferences.

For example, the FAA brought together government and industry stakeholders from space and aviation to form the Space Collaborative Decision-Making Space Operations Committee. The committee implements a recommendation of the Airspace Access Prioritization Aviation Rulemaking Committee. At its inaugural meeting in June 2022, the new committee discussed how to efficiently integrate space operations into the NAS and above while preserving FAA safety standards.

International

The United States is the global leader in aerospace and collaborates, cooperates, and maintains international agreements with countries around the world. Our leadership within, and collaboration with, the international aviation community, achieves results in greater interoperability of avionics, communications, and operational methods.

The FAA and its international partners work through the International Civil Aviation Organization (ICAO) to develop a globally connected and harmonized air traffic management system. ICAO serves as the aviation technical body of the United Nations, providing a forum for its 193 member states to develop, adopt, and implement international aviation standards. The FAA helped lead 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. With representatives from the FAA on all expert panels considered necessary for international harmonization, we help direct global air traffic modernization and mitigate operational risks.

The FAA, key international partners, and regional groups collaborate on various relevant topics associated with air traffic management modernization, such as maintaining international agreements with the European Union, Japan, and Singapore for joint research and development of future air traffic systems. We also work with partners who leverage air traffic management technologies regionally, such as Thailand and the United Arab Emirates.

Working with the Single European Sky Air Traffic Management Research (SESAR) Joint Undertaking and Japan's Collaborative Actions for Renovation of Air Traffic Systems (CARATS) program, we actively work toward global interoperability across the Atlantic and Pacific oceans. We also continue to develop bilateral relationships to harmonize further air traffic modernization programs with NextGen, such as OneSKY Australia, Brazil's SIRIUS program, and New Zealand's New Southern Sky plan.

Local Communities

The FAA's strategy for local communities involves engagement with airports and community leadership. Committees, task forces, standards bodies, and public meetings help the FAA understand challenges and identify solutions to address concerns. Stemming from restrictions on travel and in-person gatherings imposed by the pandemic, the FAA adapted how it interacted with local communities by providing remote access to some meetings. The FAA found that public participation increased when we used remote meeting technology.

Continuous Modernization

NextGen continues to transform the NAS into a modern, efficient, and-flexible aerospace system that fully responds to the changing needs of businesses and customers in the 21st century. The future vision for the NAS builds on the completion of today's NextGen modernization work, incorporating information-centric concepts and technological advances to accommodate new and non-traditional aircraft and operations.

OPERATIONALIZING NEXTGEN

The Next Generation Air Transportation System (NextGen) incorporates transformative technologies and capabilities to increase air travel safety while improving efficiency. It is delivering benefits as it is becoming operational across the National Airspace System (NAS), leading to a new way of managing air traffic known as Trajectory Based Operations. A fully operational system will implement NextGen capabilities at the right places in the NAS, with operators using aircraft equipped to the minimum capabilities list, and raise usage of the deployed capabilities by controllers and pilots to achieve maximum benefits. These changes will propel the NAS into the 2030s and beyond.

Trajectory Based Operations

Trajectory Based Operations (TBO) is a major goal of NextGen. TBO is an air traffic management concept that provides a common understanding of planned aircraft flight paths for all systems and stakeholders. It will enhance the strategic planning of aircraft flows to better manage capacity-to-demand imbalances in the NAS, and provides tools to air traffic managers and controllers to help expedite aircraft movement between origin and destination airports.

A four-dimensional (4-D) flight trajectory is the core tenant of TBO. Defined in latitude, longitude, altitude, and time, the trajectory represents a common reference for where an aircraft is expected to be and when at key points between the origin and destination. An initial trajectory is determined before departure. It is updated based on the aircraft's actual trajectory and in response to emerging conditions

and operator inputs. Trajectory information is shared between stakeholders and automation systems to manage the traffic flow nationally and regionally.

The key elements of TBO are strategic planning, time-based management, Performance Based Navigation (PBN), and enabling technologies, all discussed later in this report, that expand and automate the sharing of common information affecting the trajectory. Through improved strategic planning and time-based management of traffic flows, TBO helps to reduce reactive decision-making and the use of static miles-in-trail restrictions. Expected benefits include improved flight efficiency, increased airspace and airport throughput, and improved operational predictability and flexibility.

The Federal Aviation Administration (FAA) has demonstrated global leadership through the international harmonization of NextGen technologies, leading the world toward TBO. A global air traffic management operations concept, which details the envisioned TBO offered by global air navigation service providers, has been developed by the International Civil Aviation Organization. The FAA's efforts to transition the NAS to TBO are in concert with the TBO concept contained in the updated global concept.

Evolution

TBO implementation is defined by four evolutionary phases—infrastructure, initial, full, and dynamic—but continues to further evolve and mature.

In the infrastructure phase, the FAA deployed foundational communications, navigation, surveillance, automation, information and data exchange, weather, and other capabilities and products to prepare the NAS for TBO.

During the initial TBO phase, the FAA is deploying capabilities for use domain-by-domain with the integrated use of the capabilities left to the human operator.

Under the full and dynamic TBO phases, new capabilities will be available in many operating areas. These capabilities will enable us to automate the integration of time-based management data and tools to greatly improve strategic planning and execution. Furthermore, advanced aircraft and ground automation will be used to enable flight-specific and time-based solutions for reroutes, and advanced flight-specific trajectories and information-sharing to further optimize operations.

Initial TBO

TBO implementation is in the initial phase. Initial TBO, or iTBO, is the collective use of existing and new technologies and capabilities to achieve a fundamental change in integrated departure and arrival operations. Deployment is managed by considering trade-offs between potential benefits, integration risk, and opportunity cost for each operating area, and by considering other FAA priorities, such as safety and sustainment initiatives, and workforce training. Initial TBO implementation is underway at four NAS operating areas. Beyond these four operating areas, the FAA is evaluating and prioritizing opportunities for expanded implementation of initial TBO capabilities.

Northeast Corridor

The Northeast Corridor (NEC), the nation's busiest airspace, spans from Boston to Washington, DC. Congestion and delays there affect the entire country, and the attention is focused on New York and Philadelphia. The NEC received the integrated departure management, tower Data

Communications (Data Comm), and a modernized PBN route structure along the Atlantic coast. Planned capabilities include en route Data Comm, route management, and further use of the Time Based Flow Management (TBFM) decision support system, such as extended time-based management for arrivals. The Terminal Flight Data Manager (TFDM) decision support system is also planned for implementation at many NEC airports.

Mid-Atlantic

The Mid-Atlantic region is centered on the Atlanta and Charlotte airports. These airports regularly use the adjacent center metering for arrivals TBFM tool as well as PBN arrival and departure procedures. Planned capabilities include en route Data Comm, TBFM's integrated departure management, and automated surface management provided by the TFDM system implementation at Atlanta and Charlotte.

Northwest Mountain

The Northwest Mountain region is focused on Denver International Airport. Tower Data Comm, new PBN procedures, and TBFM's extended metering tool were implemented at Denver. Enhanced TBFM system capabilities improved departure management from other airports in the region. Planned capabilities include en route Data Comm and TFDM.

Southwest

The Southwest region is centered on Los Angeles and Las Vegas airports. These airports regularly use TBFM for arrivals. Integrated departure management and tower Data Comm are in place at most major towers in the area. Planned capabilities at the two airports are en route Data Comm, updated TBFM arrival metering, and TFDM.

Multi Regional TBO

Beyond the first phase of TBO, in 2020, the FAA's 4-D Trajectory (4-DT) Live Flight Demonstration project team showcased the FAA's progress toward "connected aircraft," where aircraft can communicate with other aircraft and air traffic control facilities in real time through broadband communications services.

This capability means the agency is on the way to enabling pilots and controllers to negotiate timely and complete reroutes required for TBO, which is a tenet of the full and dynamic phases of TBO. Through the enhanced data sharing and integration of TBO across different regions, the FAA will better know where and when an aircraft will be to help achieve TBO benefits.As a global concept, the FAA carried the momentum of the

The Flight Management System (FMS) screen shows an amended real-time controller pilot data link communications clearance "direct to SOHOW," a fix over Illinois, sent before the aircraft departed from Seattle, Washington, during a live-flight demonstration of Trajectory Based Operations in 2020. The magenta line indicates the active shortened route in the FMS. The original routing is the blue-dashed line.

4-DT demonstration into the Multi Regional TBO demonstration project. The project involves the FAA, Nav Canada, Japan Civil Aviation Bureau, Civil Aviation Authority of Singapore, and Aeronautical Radio of Thailand with support from aviation community partners.

The project is part of the FAA's effort to evolve TBO, reflecting progress as we move from planning to implementation and integration into the NAS.

Because regions around the world do not operate the same way or have the same capabilities, this project enables each air navigation service provider partner to demonstrate regional TBO priorities while staying aligned with the global TBO concept and operational values.

Five scenarios were executed in a laboratory at the Florida NextGen Test Bed in 2022 to highlight the operational value and identify the technical capabilities of TBO. One scenario featured TBO-related interactions from multiple flights as they crossed several flight information regional boundaries operated by different air navigation service providers. A second scenario focused on two flights leaving the Pacific Northwest that interacted with each other during tactical and strategic route changes before landing in Toronto.

The project will culminate in a live-flight demonstration of TBO technical capabilities integrated with a connected aircraft scheduled for 2023.

Change Management

The FAA is implementing a vigorous change management strategy to help prepare the workforce for the operational differences of TBO. This strategy includes leadership mobilization, consistent communication and coordination, integrated evolution planning, training, and alignment of processes.

Operational changes introduced by TBO require new air traffic planning and management techniques—for example, time-based management—for air traffic controllers, air traffic managers, pilots, and flight dispatchers. Successful implementation of TBO requires more than just the deployment of sound technology and procedures. The FAA and operator workforces also must be engaged so that they understand the purpose and concepts behind the technologies. Shared FAA and operator collaboration, operational decision-making, and ground and aircraft investments are also necessary. All stakeholders must have a clear understanding of TBO and a commitment to its success.

The FAA is pursuing a systematic approach to TBO implementation, which focuses on employing change management to take on the required intersections of technology, procedures, policies, and operator and workforce education and training. The FAA developed a change management plan focused on leadership mobilization, stakeholder engagement, communication, training/education, and organization/workforce alignment. Additionally, the FAA seeks to promote new skill sets for TBO while keeping employees proficient with legacy techniques.

Joint Commitments

To operationalize NextGen and achieve TBO requires the participation and commitment from aviation industry stakeholders. Aircraft operators face business decisions, such as flight scheduling, fleet assignment, or aircraft equipage, that can greatly influence the operational efficiency of the NAS.

The FAA acknowledges that the aviation industry's follow-through on commitments is integral to achieving NextGen's full potential. It is why the FAA and industry, through the NextGen Advisory Committee (NAC), have collaborated in program planning and prioritized industry investment as a vital component of NextGen's long-term success.

The NextGen Priorities Joint Implementation Plan identifies the Northeast Corridor, multiple runway operations, surface and data sharing, PBN, and Data Comm as implementation focus areas. The plan represents a set of commitments that industry stakeholders recommend as the highest priority to the aviation community, and it captures FAA pre-implementation, implementation, and industry milestones. The joint collaboration and risk mitigation process have been key to implementing past commitments, improving operational capabilities, and delivering benefits within the NAS.

With the NAC, stakeholders are engaged in the best steps forward. The committee is an example of where innovation, regulation, and collaboration meet implementation. Information sharing is continually improving transparency and decision-making.

NAS MODERNIZATION

Current National Airspace System (NAS) modernization began with the Federal Aviation Administration (FAA) developing a new infrastructure and computer systems to host NextGen capabilities. As we operationalize NextGen, that foundation is essential to enabling Trajectory Based Operations (TBO) and other innovations that will increase the safety, efficiency, capacity, predictability, and resiliency of the NAS. This section covers many of the improvements in infrastructure and technologies enabling TBO.

Data Communications

Data Communications (Data Comm) provides a secure air-to-ground data link to supplement voice communications with digital messages. Aircraft avionics and air traffic control automation systems are integrated to form a Data Comm application known as Controller Pilot Data Link Communications (CPDLC).

Using CPDLC, air traffic controllers and pilots quickly and accurately send, review, and accept a variety of text-like messages with a push of a button, which reduces read-back errors and communication time. Airline flight operations centers receive the same information as the flight deck simultaneously, providing decision-makers with shared awareness for faster reaction and agreement to flight changes. Safety improves with the reduced likelihood of missing a message or hearing and acting on a message intended for another aircraft.

With Data Comm, NAS efficiency and capacity increase, and the decreased fuel consumption lowers operating costs and engine exhaust emissions. The Data Comm program is a NextGen Advisory Committee (NAC) priority area and will offer the message exchange speed necessary for TBO. Data Comm is expected to save operators more than $10 billion and the FAA about $1 billion in operating costs over the program's 30-year life cycle.

Tower Service

Data Comm started with tower service in 2016 and is available at 65 airports. The latest sites to become operational are Cincinnati/Northern Kentucky International Airport in 2021, and Jacksonville and Palm Beach international airports in 2022.

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

When weather or other factors delay departures, CPDLC revised clearances improve accuracy, timeliness, and air traffic controller and pilot productivity. Controllers can deliver many CPDLC messages in the time required to conduct one clearance via voice, which reduces gate delays and improves taxi-out times and airport traffic flow. During severe weather, some flights have saved more than 90 minutes of delay time. Tower service operations continue to grow, and the number of operators participating has more than doubled since 2016.

En Route Services

Initial en route services began at the Indianapolis and Kansas City en route centers in 2019 and at Washington en route center in 2020. Since then, Oakland and Minneapolis became operational, and Miami began testing in 2022. The technology is scheduled to deploy to the remaining 15 centers by spring 2024.

These services include messages 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.

Initial en route services help reduce flight delays and enable pilots to take efficient flight paths. They further increase operational efficiency and lower costs for airspace users while enhancing safety. Full en route services are more complicated and expand upon messages offered by initial en route services. Data Comm full en route services are scheduled for deployment from March to September 2024.

Deployment of en route Data Comm has been slower than expected. It was delayed by the 2018-2019 federal government shutdown, problems finding proper interoperability of the avionics air-to-ground network, and the pandemic, which stopped all Data Comm facility training and testing.

Data Comm Benefits

Data Comm operates at 65 air traffic control towers and five en route centers as of the end of 2022. In 2022, Jacksonville and Palm Beach international airports became the latest airports to activate tower service. More than 6,000 aircraft flown by 84 domestic and international air carriers, as well as several dozen business jet operators, are equipped for Data Comm.

More than 13.7 million flights serving 1.9 billion passengers have been cleared with CPDLC. Measured benefits of CPDLC tower service through September 2022 include an estimated:

An aircraft flight management system displays an amended real-time controller pilot data link communications clearance during a flight during the 4-D trajectory live-flight demonstration in 2020.

- 3.6 million minutes of communication time saved
- 166,500 read-back errors avoided
- 2.6 million minutes of airspace-user time saved
- 36.5 million kilograms of carbon dioxide emissions prevented

From March 2019 through September 2022, the Data Comm program supported the delivery of more than 17 million en route messages to 23 different aircraft types and 22 operators. Benefits through September 2022 for en route CPDLC include:

- 321,000 read-back errors avoided
- 1.2 million minutes of communication time saved

Performance Based 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 using GPS satellites is primarily used because they create precise 3-D flight paths. Ground-based navigation remains as a backup when GPS satellite service is unavailable.

Since 2015, PBN has been the standard in the NAS during normal conditions and is a NAC focus area. The FAA has published 353 PBN routes for cruising altitudes and 9,401 PBN departure, arrival, and approach procedures, but they may not suit every airport or phase of flight. The FAA works with the aviation community to determine the validity of a PBN procedure based on the airport, airspace, air traffic, reaction from residents, and costs versus benefits.

PBN routes and procedures in a busy or congested area set up consistent flight paths and help maintain an anticipated flow of aircraft to and from an airport. As a main element of TBO, PBN enables air traffic control decision support systems to improve schedule feasibility for constraint points and comply better with the schedule.

PBN departure procedures provide fixed paths for aircraft from takeoff to en route airspace with minimal level-offs. Standard flight paths simplify navigation tasks for controllers and pilots in all weather conditions. They do not have to issue and follow step-by-step climb and turn instructions. Equivalent lateral spacing operations, or ELSO, are possible because of PBN. ELSO increases capacity by enabling more aircraft to take off from the same runway during the same time period.

For en route airspace, low-altitude T-Routes and higher altitude Q-Routes flown by aircraft equipped for RNAV provide a PBN alternative to conventional Jet routes and Victor routes. 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 169 new Q-Routes along the East Coast. These routes operate above 18,000 feet and extend offshore over the Atlantic Ocean and Gulf of Mexico. The more direct flight distances will shave off 40,000 miles and 6,000 minutes of travel time annually and lower fuel consumption. Fewer converging points and more simple flows also enhance safety.

Toward the end of the flight is the arrival procedure. Using an arrival with an optimized profile descent, pilots can program the aircraft's flight management system for ideal speed and altitude requirements for various points along the flight path. Aircraft then glide continuously with engines nearly at idle power from the top of the descent to landing with minimal level-off segments. Aircraft stay at higher, more fuel-efficient altitudes closer to the airport, and pilots avoid using speed brakes and frequent thrust lever adjustments. The procedure also decreases the amount of communication necessary between pilots and air traffic controllers.

Approach procedures are flown for the final distance to the runway. When available and appropriate, pilots can fly a required navigation performance (RNP) approach. RNP has the highest level of precision. An RNP procedure designated as "authorization required," RNP (AR), adds onboard performance monitoring and alerting. Another type of RNP approach procedure, called RNAV (GPS), uses GPS with a Wide Area Augmentation System to enhance the accuracy and integrity of position estimates. RNP is flexible and adapts to unique operational requirements, which can include avoiding terrain or obstacles, de-conflicting airspace, or resolving environmental constraints.

Metroplex

The FAA completed the Metroplex program after closing out the final metroplex project in South-Central Florida in 2022. It joined the other finished metroplexes in Atlanta, Charlotte, Cleveland-Detroit, Denver, Houston, Las Vegas, Northern California, North Texas, Southern California, and Washington, DC.

A metroplex is a metropolitan area with commercial and general aviation airports serving at least one large city. The program began in 2010 and used a systematic, integrated, and expedited approach to implementing PBN routes, procedures, and airspace changes. Metroplex worked to improve predictability and flexibility in transitioning traffic between en route and terminal airspace and between terminal airspace and runways. Departures and arrivals are segregated in the terminal area and en route airspace.

Each location has a unique system of airports, aircraft, geography, and weather patterns. They have complex air traffic flows and are among the busiest areas of airspace in the nation. Every project was a multi-year effort to bring benefits to congested airspace near high-traffic airports.

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

NextGen Distance Measuring Equipment

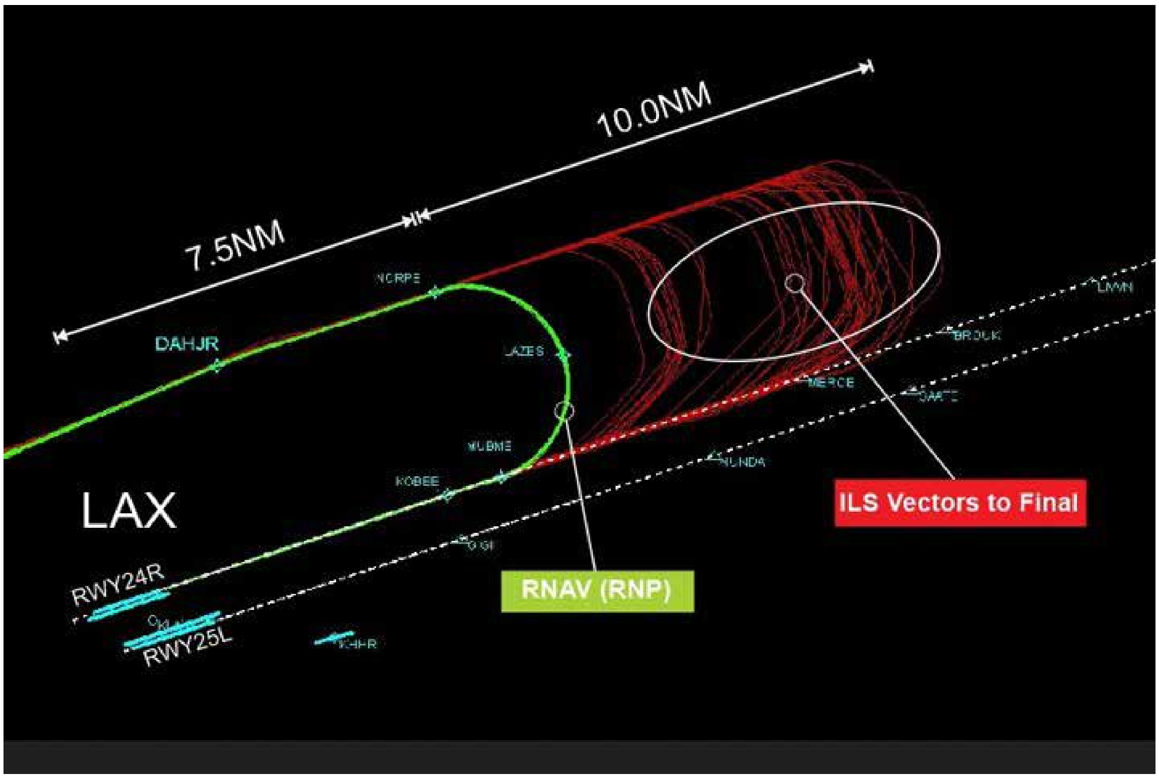
An expansion of distance measuring equipment (DME) is underway to maintain an appropriate level of ground infrastructure for PBN in the event of satellite service disruptions. Aircraft can keep flying PBN where there is coverage without requiring aircraft to have an inertial reference unit, which is a self-contained navigation system.

Redundant coverage will allow aircraft to continue flying PBN routes and procedures in case of single DME failures. This capability will minimize pilot and controller workload during interrupted satellite service while maintaining the capacity and efficiency of PBN.

The FAA is installing more than 120 new DME stations through 2035 to support en route and terminal traffic across the nation. New DME stations are operating at eight locations.

Established on RNP

Future NAS-wide implementation of concepts taking advantage of PBN procedures is managed by the Integrated NAS Design and Procedures Planning program. The program's initial focus is Established on Required Navigation Performance (EoR), a separation standard using a PBN instrument approach procedure to shave miles off of flights near an airport.



Aircraft flying into Los Angeles International Airport (LAX) using Established on Required Navigation Performance (EoR) take a shorter path to the runway. The green RNAV (RNP) lines represent flights over multiple days while the red Instrument Landing System (ILS) tracks show a one-day sample. Independent EoR has proven successful at Denver and Houston, and LAX is the first airport with only dual parallel runways to use it.

EoR is designed for equipped aircraft flying into busy airports with parallel runways when they need to turn 180 degrees to line up with the runway. "Established" is to be stable or fixed on a flight path, in this case, stable on the PBN procedure.

Using an RNP procedure to establish an aircraft, controllers can clear pilots on the approach to turn to the final distance to traffic at parallel runways sooner than if the aircraft had to maintain the standard separation of 3 nautical miles horizontally or 1,000 feet vertically. The pilot can follow the procedure to the runway without instructions from air traffic control while other aircraft are approaching an adjacent parallel runway.

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

Less distance traveled saves fuel and time and decreases engine exhaust emissions. Using PBN procedures more often increases predictability, which supports Trajectory Based Operations. Stabilized PBN procedures reduce the number of go-arounds after aborted approaches. Fewer radio transmissions between controllers and pilots lower the chances of read-back errors and give them more time to concentrate on other tasks.

In 2015, Denver was the first airport to conduct EoR for widely spaced independent parallel runways, while Seattle-Tacoma International Airport began limited dependent parallel operations. (Dependent runways require a diagonal separation.) EoR for widely spaced operations became a national standard in 2016. George Bush Intercontinental Airport in Houston began widely spaced operations in 2017. Houston and Denver International Airport added simultaneous independent approaches for dual and triple runways after the FAA approved it as a national standard in 2018.

Los Angeles International Airport began EoR in September 2021, the first site to run pure independent dual parallel runway operations. Plans are in place to expand operations to the east side of the airport. In 2022, Houston expanded EoR operations, with aircraft now able to turn on all four available downwind directions.

EoR at Denver has been shown to shorten each aircraft's path to the runway by about 6 nautical miles in visual conditions and close to 30 nautical miles in instrument meteorological conditions. The FAA plans to mature EoR research by validating variations of the EoR concept in an operational environment. Concept validation captures operational lessons learned and identifies potential new research areas. An FAA goal is to expand EoR to more airports.

Multiple Airport Route Separation

Multiple Airport Route Separation (MARS) extends the EoR concept to more than one airport. It is a system of authorized instrument flight procedures (IFP), air traffic control procedures, communication requirements, and surveillance that permits aircraft to safely fly with reduced separation criteria once aircraft are established on a PBN segment of a published instrument procedure to adjacent airports. The MARS concept can be applied to various types of IFP pairings, including departures, approaches, and missed approaches to deconflict flows to and from the airports.

MARS will leverage applicable safety analyses for EoR and closely spaced parallel runway operations. If the safety case results are good, MARS will enable expanded use of RNP and new access to airports and runway configurations.

MARS reduces the miles flown, fuel consumption, and engine exhaust emissions depending on the location. Throughput and overall NAS efficiency will increase. MARS is intended to function with existing controller staffing and resources and needs no new software or aircraft equipment.

Potential benefits were analyzed to enable the FAA to continue to investigate the potential of MARS. The FAA completed safety analyses and initial controller training in 2022. The FAA plans to establish a new national standard for MARS or a site-specific waiver to the current national standard in 2023 and begin MARS operations at key sites by 2024.

Surveillance

The FAA is capitalizing on the benefits of new technologies and reshaping our surveillance infrastructure to optimize services for NAS operations. The Automatic Dependent Surveillance–Broadcast (ADS-B) ground infrastructure is fully deployed and integrated into automation platforms. ADS-B uses ground stations, properly equipped aircraft, and GPS to inform air traffic controllers and other aircraft of the location of aircraft on the ground or in the air.

GPS satellites enable more precise surveillance through Automatic Dependent Surveillance-Broadcast and way of flying with Performance Based Navigation.

Automatic Dependent Surveillance–Broadcast

ADS-B enabled the FAA to transition from primarily using radar to mainly using GPS satellites with ground stations to track aircraft. Real-time precision, shared situational awareness, and advanced applications for pilots and controllers are the hallmarks of ADS-B, now the preferred method of surveillance for air traffic control in the NAS.

ADS-B collects data from different sources to fuse into a single track on air traffic displays, increasing the stability and accuracy of the surveillance presentation compared to a radar-only mode. The fusion of data increases resiliency during a surveillance system outage because surveillance no longer depends on one source. ADS-B Out equipment became a requirement to operate in a large portion of the controlled U.S. airspace on January 1, 2020.

An ADS-B Out equipped aircraft sends a signal once per second, providing the aircraft's position and other information to air traffic controllers and surrounding aircraft equipped with 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 separation standard in en route airspace below 23,000 feet. The change increased NAS efficiency for commercial operators.

With optional ADS-B In equipment, pilots can receive real-time traffic, flight, and weather information services at no extra cost to them. ADS-B's efficiency saves time and fuel, reducing delays and aircraft emissions.

ADS-B In Applications

Interval Management

Interval management (IM) is an ADS-B In application that enables more efficient and precise spacing between aircraft in en route or terminal airspace. IM requires FAA investments in air traffic management and decision support automation systems, and operator investments in flight-deck avionics. IM will use new procedures for the initiation, execution, and cancellation of an operation. During an IM operation, the Flight Deck Interval Management (FIM) avionics provides the flight crew a speed to maintain to precisely achieve and maintain an ATC-issued spacing interval, in time or distance, relative to a lead aircraft.

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

The FAA has partnered with American Airlines and Aviation Communication & Surveillance Systems (ACSS), to certify and install ADS-B In avionics on the airline's fleet of Airbus A321 aircraft. In June 2022, the FAA started evaluating initial IM operations in Albuquerque en route center's airspace consisting of two clearance types: cross and maintain. We will gather operational data on the use and benefits of initial IM operations and review lessons associated with procedures and training for one year. Results from the operational assessment will be shared with the operator community after the evaluation is complete.

CDTI-Assisted Visual Separation

Cockpit Display of Traffic Information (CDTI) technology enables another ADS-B In application called CDTI-Assisted Visual Separation (CAVS). Supported by accurate ADS-B location and velocity data, CAVS can be used as a substitute for continuous visual observation of traffic-to-follow under specified conditions. However, it does not relieve the pilot of the responsibility to see and avoid other aircraft. Once the flight crew has visually acquired the traffic-to-follow and accepted a visual approach clearance, the pilot can use the CDTI to maintain separation during a visual approach even when out-the-window visual contact is lost.

CAVS operation is transparent to the controllers and requires no new procedures or phraseology.

It is expected to reduce go-arounds from traffic getting too close on the final approach. In partnership with the FAA and Aviation Communication & Surveillance Systems, also known as ACSS, American Airlines started equipping its Airbus A321 fleet with ADS-B In avionics and training its pilots, and commenced CAVS operations in May 2021. The CAVS benefit report was completed in September 2022.

The FAA is also working on CDTI-Assisted Separation on Approach (CAS-A) with the same avionics functionality used for CAVS. CAS-A will not require out-the-window visual contact and will allow for flights to continue at lower ceiling thresholds, which increases throughput.

Controllers can achieve reduced along-path approach spacing during certain weather conditions by relying on pilot-applied “visual” separation from controller-assigned traffic-to-follow using the CDTI. CAS-A operations require new phraseology but do not change any requirements for instrument or visual approach procedures.

Surveillance Portfolio Analysis

The Surveillance Portfolio Analysis (SPA) program will modernize the surveillance infrastructure, provide resiliency of surveillance services across the NAS, and develop advanced surveillance data processing applications required for the future. In 2022, the FAA developed requirements for surveillance services, architecture alternatives, and future technologies to enhance the existing infrastructure. Future analyses will incorporate weather information provided by surveillance assets and surveillance requirements to accommodate nontraditional operators.

Automation

The FAA acquired automation systems that enable air traffic controllers to better manage air traffic in their assigned airspace. Upgraded air traffic control platforms allow controllers to separate, sequence, and vector aircraft; monitor alerts; and issue weather advisories using modernized displays and interfaces. The Traffic Flow Management System (TFMS), Time Based Flow Management (TBFM), and Terminal Flight Data Manager (TFDM) are automated decision support systems that help controllers and air traffic managers to more effectively respond to changing conditions, accommodate user preferences, and resolve traffic flow constraints. Each system has specific roles and tools, but together they provide integrated, responsive, and collaborative traffic flow management solutions that maximize efficiency and reduce delays through each phase of flight. These decision support systems are at the heart of the FAA's vision for TBO.

ERAM and STARS Platforms

The En Route Automation Modernization (ERAM) system replaced the 40-year-old En Route Host computer and backup systems used at 20 FAA en route centers and it is on the way to facilities in Alaska and Hawaii. ERAM is vital for modern air traffic control and navigation. It is the foundation for the FAA to build NextGen capabilities.

ERAM increases capacity and improves efficiency. En route controllers can track as many as 1,900 aircraft at a time, which is 800 more than possible with the Host system. ERAM can process data from 64 radars versus the 24 the legacy system handled, extending coverage beyond facility boundaries.

Most of the original ERAM equipment has been in service for more than 10 years. A refreshment program will replace the balance of the original ERAM system that has not yet been refreshed and complete the operating system transition from IBM AIX to Linux. The program is completing system engineering, software development, survey coordination for operational sites, and site installation activities. The refresh will enable ERAM equipment to comply with the FAA's security requirements and better support the delivery of safe and efficient air traffic services to the flying public. The program is scheduled for completion in 2026.

The Standard Terminal Automation Replacement System (STARS) is a real-time digital processing and display system at terminal radar approach control and air traffic control tower facilities. It replaced the legacy Automated Radar Terminal System at more than 200 FAA and Department of Defense terminal radar facilities and 600 FAA and Department of Defense 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. NextGen's sustainment program for STARS is ongoing.

Traffic Flow Management System

To oversee air traffic NAS-wide, the Air Traffic Control System Command Center uses the efficiency-critical TFMS, which maintains a 99.9 percent uptime. Command Center staff work 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 (TRACON) facilities, in collaboration with other stakeholders, including the airlines, general aviation, and military, to provide a big-picture awareness of the airspace system.

Small disruptions can promptly lead to local flight delays, causing a ripple effect across the country. Failure to coordinate a response can lead to large-scale rerouting, delays, and flight cancellations. Disruptions in airspace capacity caused by weather, excessive traffic, or emergencies require a coordinated effort to ensure safety, efficiency, and equity in delivering air traffic services.

TFMS capabilities are enabled by custom applications running on commercial hardware. These tools are the highlights of TFMS:

- Unified Delay Program (UDP) streamlines the distribution of slots during ground delay programs. It gives the FAA explicit control of the slot allocation policy, creating a more efficient delay mechanism than airborne holding.
- Collaborative Trajectory Options Program (CTOP) enables users to communicate alternative route preferences to traffic managers mitigating constraints. CTOP is designed to improve coordination with users and implement their preferences faster.
- Airspace Flow Programs (AFP) mark a major step in en route traffic management. An AFP develops a real-time list of flights filed into a constraint area and enables the metering of demand into the area based on expected departure times. It is integral to managing traffic flow during severe weather. This capability facilitates TBO.
- Collaborative Airspace Constraint Resolution (CACR) identifies constrained airspace and provides potential solutions for pre-departure and airborne flights. The capability assists traffic planners in determining flight-specific traffic management initiatives while accounting for airspace options and user preferences. The integration of weather forecast products into CACR enhances congestion prediction capabilities and allows users to submit their preferences for constraint resolution.
- Airborne Rerouting Capability (ABRR) enables TFMS-developed airborne reroutes to be sent directly to controllers for ERAM processing. It improves the previous method of amending the route over a telephone. Traffic managers can select flights within their center on their traffic management display and reroute them. This capability is a notable contributor to TBO, automatically connecting TFMS and ERAM to make airborne reroutes feasible and practical.
- Pre-departure Rerouting Capability (PDRR) enables TFMS developed pre-departure reroutes to be sent to and implemented by controllers before takeoff. PDRR can electronically exchange reroutes between traffic managers and controllers before aircraft depart. This capability is a companion to ABRR, making pre-departure reroutes feasible and practical. Electronic delivery reduces errors and enhances safety.

Flow Management and Data Services (FMDS) is the planned replacement for TFMS. This system will use a modern architecture design and provide new functionality deployed faster by separating the data from the services and applications. FMDS increases security and performance, and it allows an application to redeploy faster following an update without having to also redeploy the data.

FMDS functions are anticipated to be deployed as microservices, optimally in a cloud infrastructure. The system will improve data integration, increase data sharing, and manage the larger volume of continually produced NAS data. Initial operating capability is expected in late 2029.

Time Based Flow Management

TBFM manages terminal and en route air traffic using time. Its core function is to schedule aircraft within a stream of traffic when necessary to reach a defined point, such as a meter fix or meter arc, at specified moments, creating a time-ordered sequence of traffic. The TBFM schedule is based on wind forecasts, aircraft flight plans, the desired separation at the defined points, and other parameters.

The scheduled times allow for traffic flow merging while minimizing coordination, reducing the need for vectoring and holding, and using airport and airspace capacity efficiently. The superior capabilities of TBFM are preferred to miles-in-trail procedures when departure or arrival flows are subject to traffic management initiatives or when supporting PBN procedures. TBFM tools increase efficiency by allowing aircraft to fly PBN approach procedures to the runway. TBFM capabilities enable an increase in arrivals and departures in areas where demand for runway capacity is high. The flying public experiences fewer delays and reduced carbon emissions resulting from TBFM efficiencies.

TBFM operates at 20 en route centers and is adapted for most major airports served by those centers. TBFM is a vital part of the NAS and a main component of TBO.

These are some of TBFM's capabilities:

- Single Center Metering (SCM) enables air traffic controllers and managers to view and manage arrival flows to airports in an en route center's airspace.

- Adjacent Center Metering (ACM) is an extension of SCM that can meter to neighboring facilities.
- Constraint Satisfaction Point (CSP) is a tool that identifies an arc, fix, point, or other reference elements for metering.
- Speed Advisories are generated within TBFM to assist controllers in meeting the scheduled times of arrival at the meter fix or arc and terminal meter points.
- Coupled Scheduling (CS) and Extended Metering (XM) add CSPs for an aircraft to meet the scheduled time of arrival along its route, leading to a more optimal distribution of delays over a greater distance from the airport or CSP.
- Ground Interval Management–Spacing (GIM-S) automates speed advisories before descent to enable en route controllers to meet the scheduled time of arrival.
- En Route Departure Capability (EDC) assists air traffic managers with formulating release times to a CSP to manage a miles-in-trail restriction.
- Departure Scheduling leads to determining a runway departure time from TBFM for the release of aircraft. Departure Scheduling can be used to schedule into an arrival flow or into the EDC.
- Integrated Departure/Arrival Capability (IDAC) allows the tower to schedule departures electronically.

Looking ahead, these are some enhanced and new capabilities:

- Terminal Sequencing and Spacing (TSAS) efficiently sequence aircraft and assigns a runway by showing the metering plan to terminal air traffic controllers and extending time-based metering to the runway. Extending the aircraft's trajectory plan to the runway improves predictability and accuracy for advanced PBN procedures. TSAS initial operation has been delayed, and future deployments are unknown.
- Dynamic Routes for Arrival in Weather (DRAW) combine the weather avoidance capability of National Aeronautics and Space Administration (NASA) dynamic weather routes with an arrival scheduler and arrival-specific rerouting algorithms. DRAW can determine more efficient routes and balance arrival demand across meter fixes

in the presence of weather. DRAW algorithms also improve routing and traffic distribution in the absence of weather. The arrival-specific rerouting algorithm continuously searches for opportunities to reroute as track and flight plan data are updated. The system is integrated with arrival scheduling components used by TBFM to allow traffic management coordinators to devise a trial plan to determine the effect of proposed DRAW reroutes on arrival scheduling before actually implementing them. Traffic managers could also use this integrated route and schedule trial planner to build and plan a route of their own manually.

- Machine learning (ML) trajectory prediction comprises a major component of TBFM by projecting aircraft location. These predictions are calculated using aircraft performance models, which contain thrust and drag information for aircraft. Errors in trajectory models translate into tactical, hands-on decision-making, leading to inefficiencies. This project will apply emerging technologies, such as machine learning, artificial intelligence (AI), and data analytics, to obtain more accurate aircraft performance model input. The ML/AI will be used to develop functional forms for parameters, such as thrust and drag, for trajectory predictions, reducing reliance on limited and infrequently updated aircraft-specific model data. Development of the ML concept began in 2021 and will be completed in the first quarter of fiscal year 2023.

Over the next five years, TBFM will be sustained with a complete system engineering analysis to support the Internet Protocol Version 6 upgrade. This upgrade will address security requirements, a system engineering analysis for the Red Hat Linux upgrade for new hardware selection, complete hardware procurement, and the operational integration of hardware at relevant facilities.

Terminal Flight Data Manager

Some of the best opportunities to improve the efficiency of air traffic can be found on the ground and in the terminal airspace. The FAA is developing TFDM to take advantage of those opportunities.

TFDM will modernize control tower equipment and processes, streamline the sequence of aircraft scheduled to depart, reduce delays, improve situational awareness, and improve the air travel experience for the flying public.

TFDM works by integrating digital flight strips with surface surveillance data to create accurate, real-time predictive tools for the terminal environment. TFDM will share data among controllers, aircraft operators, and airports to better stage arrivals and departures, and manage traffic flow within terminal airspace for greater efficiency. The surface departure management capability will improve gate departure efficiency and significantly reduce or eliminate queues of airplanes waiting on taxiways to depart.

A departure scheduler with live data from air traffic systems and flight service providers will enable collaborative decision-making on the surface. The system will offer a departure metering capability, runway balancing, and other surface management tools, improving surface traffic flow management.

Enhanced data integration with TBFM and TFMS will enable airlines, controllers, and airports to share and exchange real-time data, which will result in improved surface traffic management as well as improve the products produced by TFMS and TBFM.

TFDM will replace several systems, leading to greater efficiency and cost avoidance. They include Advanced Electronic Flight Strips (AEFS), Electronic Flight Strip Transfer System (EFSTS), Surface Movement Advisor (SMA), Airport Resource Management Tool (ARMT), and Departure Spacing Program (DSP).

Early deployment achieved several benefits for TFDM development, including early industry engagement and reduction in operational risk. The production TFDM system will replace these initial capabilities.

TFDM will be deployed to 49 airports in two configurations through 2029. Full functionality of Configuration A at 27 airports will include electronic flight data, surface surveillance data integration, traffic flow management data exchange and integration, a surface situational awareness display, and full decision support tools. Configuration B is planned for 22 airports and includes electronic flight data and, at selected sites, a surface situational awareness display.

TFDM will also use a multi-build strategy for its deployment. Build 1 features full hardware development, electronic flight data exchange, runway assignment predictions, basic load balancing, surface situational awareness viewer via TFMS, and maintenance tools. The Build 1 key site is Cleveland, which began operating in 2022. Build 2 features surface scheduling, surface metering, advanced runway load balancing, metrics reporting and analysis, and departure spacing program replacement through integration with TFMS and TBFM. Charlotte is the Build 2 key site, with initial operating capability scheduled for 2024.

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. NextGen capabilities provide the data, information services, standards, and a system-wide information management environment needed to perform aviation mission-critical and support operations from flight planning to post-operational analysis. Information availability, sharing, and distribution are increasing in importance to NAS modernization in the years ahead.

System Wide Information Management

System Wide Information Management (SWIM) enables the exchange of accurate aeronautical, flight and flow, surveillance, and weather information to FAA and external users in near real-time. It is the gateway for information sharing between government, industry, and NAS automation systems.

Because SWIM provides a common platform where data producers publish information and subscribers access it through a single connection, it eliminates the number and types of unique computer interfaces formerly needed to access data from different sources, reducing cost and complexity. SWIM's common data format enables collaboration between the aviation community and governments worldwide.

SWIM establishes the infrastructure, standards, and services needed to optimize the secure exchange of relevant data for the NAS and the aviation community. SWIM's governance of NAS programs ensures services are SWIM-compliant and meet all FAA standards, which reduces the cost and risk for FAA programs to develop and deploy services. To comply with the FAA's policy of protecting sensitive unclassified information, SWIM has security controls to prevent sensitive information from being transmitted to external users.

Partnerships with industry and other government agencies 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. With SWIM, the FAA can transition to net-centric NAS operations and TBO.

Fifteen FAA programs and several external organizations, including airlines, provide data for 80 services sent via the SWIM network, supporting all

phases of flight. More than 800 consumers are registered to access the information; of those, about 400 are regular users. The availability of data has created a new information ecosystem. Companies are using information from SWIM to develop value-added products for the aviation community that lead to a better experience for the flying public.

NAS Enterprise Messaging Service

The NAS Enterprise Messaging Service (NEMS) is a NAS-based implementation of message-oriented middleware responsible for distributing messages among information producers and consumers. It is a main component of the SWIM infrastructure. Producers and consumers connect to the NEMS platform to exchange content in a "publish-subscribe" and "request-response" model. This model is the foundation for stable and timely movement of information to and from a broad community of users.

SWIM messaging using NEMS allows for flexible and efficient system interactions, eliminating the need for specific producer-to-consumer interfaces. NEMS is a scalable system that can adapt to growth in operations and shifts in demand. Other SWIM core services offered include messaging, service management, security, and mediation, which is a SWIM capability that can transform data, such as from a newer to an older message version.

The FAA plans to complete its third technical refresh of the NEMS infrastructure in 2023, with the goal of expanding capacity in support of increased bandwidth requirements for planned NAS programs. This refresh will include updating NEMS nodes, local and global load balancers, NEMS storage devices, and Solace appliances.

SWIM Flight Data Publication Service

The SWIM Flight Data Publication Service (SFDPS) gives en route flight data from the ERAM system to various consumers. They can access data about flights, airspace, operations, and general messages for use in research, analytics, business processes, and other activities. Examples of available data include flight plans, flight tracks, beacon codes, altimeter settings, sector configuration data, and status of handoff, routes, special activity airspace, or ERAM.

Consumers using the data can glean valuable insight. For instance, they can compare predicted versus actual departure times, compare control times versus actual departure times, determine the busiest departure and arrival fixes, and measure the busiest traffic areas. Among its features are fast and accurate flight matching, and easy data integration with software applications such as Google Maps.

New features in 2022 include enhanced location data, more sophisticated tracking data, wider access to aircraft transponder codes, and access to airport ramp data. A new SFDPS flight strip revision number will enable controllers to positively match SFDPS flight plan data with air traffic control flight plan data.

SWIM Terminal Data Distribution System

The SWIM Terminal Data Distribution System (STDDS) converts surface and terminal surveillance data collected from ADS-B, radar, or multilateration at airport towers and TRACONs into easily accessible information.

STDDS publishes data from Airport Surface Detection Equipment Model X, Airport Surface Surveillance Capability, electronic flight strip transfer system, runway visual range system, STARS, and tower data link services.

The system enhances data feeds by eliminating redundant or conflicting information. It provides fast and accurate flight matching capability for complete air traffic management situational awareness from surface to cruising altitude, and enables the Surface Visualization Tool. The tool supports safety by showing the same information that tower controllers see to air traffic managers in the corresponding TRACON and en route center, as well as other NAS and non-NAS consumers.

STDDS also uses NEMS to send surface information from airport towers to the corresponding terminal radar facility so traffic management coordinators can assess how to optimally balance demand with capacity.

The FAA installed STDDS at 38 TRACONs, which draw information from more than 200 airports and more than 400 individual systems. The TRACONs received a STDDS technical refresh, completed in 2022, with enhancements to the services for surface movement events, tower departure events, terminal automation information, and infrastructure, monitoring, and control.

Identity and Access Management

Identity and Access Management (IAM) authenticates and authorizes users through a dedicated FAA public key infrastructure to securely identify NAS users and protect NAS information.

With IAM authorization, SWIM can centrally manage access privileges to NAS data on the NEMS platform. This capability reduces cybersecurity vulnerabilities by enforcing appropriate security policies when creating, managing, and revoking access privileges. IAM authentication certificate services are available through four U.S. locations on the NAS internet protocol operational network and within the four NAS enterprise security gateways.

The IAM strong authentication capability was completed in 2022. This effort included integrating new commercial off-the-shelf applications to mitigate multiple existing security vulnerabilities; conducting development, regression, and functional testing; and bringing more capacity for NAS-to-NAS system authentication.

NAS Common Reference

NAS Common Reference (NCR) is an enterprise-level service that compiles information from multiple information producers to give consumers information about NAS status and constraints. With this single SWIM service, consumers can access real-time, correlated data for decision-making.

NCR provides a common situational awareness of traffic flow management and can process initial individual consumer requests and publish updates as NAS status and constraint data changes. It also can filter capabilities so that consumers receive only the data they want.

The service is available through the Atlanta and Salt Lake City network enterprise management centers. A connection to the Aeronautical Common Services and performance improvements were accomplished in 2022.

Cloud Integration

Cloud computing technologies and information-sharing made possible by SWIM will enable the dynamic configuration of applications and information resources to meet the real-time demands of users and service suppliers. Replacing FAA-owned data centers with off-site locations in the cloud increases efficiency and flexibility, thereby saving time and money.

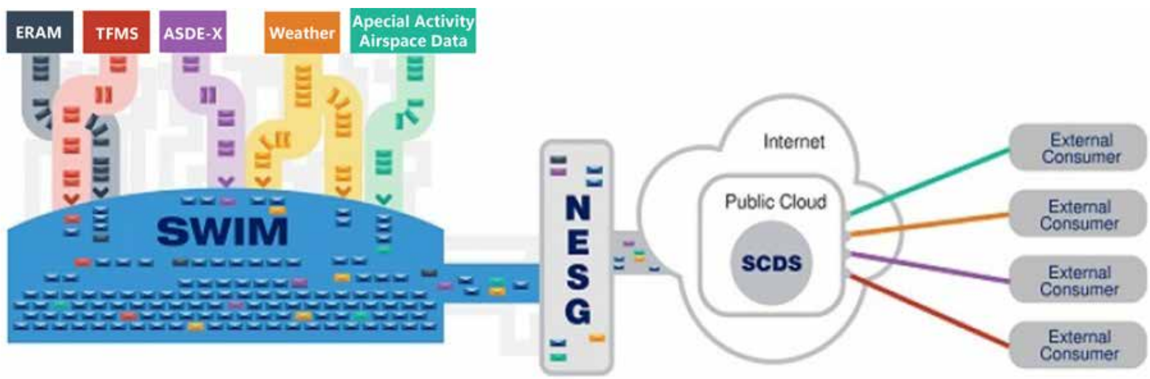
SWIM Cloud Distribution Service

The SWIM Cloud Distribution Service (SCDS) was deployed in 2019. It provides publicly accessed non-sensitive NAS data in near real-time without the inconvenience of connecting to the NAS Enterprise Security Gateway (NESG), which secures information between NAS and non-NAS networks. All SCDS products are approved for public release by the NAS Data Release Board and are not intended for NAS operational use.

Instead of waiting months to access data through the old registration and distribution process, 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 flow to meet the needs of more users.

A scalable and reliable cloud environment supports the future anticipated growth of services and evolving data exchange scenarios. SCDS leverages an externally hosted cloud infrastructure service and has about 230 users actively extracting data from more than 700 subscriptions across the available data services.

Evolving from the SCDS, a portal named SWIFT (SWIM-Industry FAA Team) deployed in 2021 to further improve the collaboration between the FAA



The SWIM Cloud Distribution Service (SCDS) allows external consumers access to non-sensitive NAS data, such as flight and flow information, in near real-time without directly connecting to the NAS Enterprise Security Gateway (NESG), lowering FAA operating costs and enabling more efficient use of bandwidth.

SWIM program and industry. SWIFT provides a single place for the SWIM community to access SWIM. SWIFT offers a collaborative environment for outreach activities related to FAA information services shared via SWIM.

The interactive portal provides customizable, real-time access to 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. SWIFT was refreshed in 2022 and plans to complete its fourth version of the portal in 2023.

Information Management Services

Aeronautical Common Services

Aeronautical Information Management Modernization (AIMM) seeks to improve the safety and efficiency of the NAS by delivering modern, integrated digital aeronautical information. This mission is implemented with the AIMM enhancements, which intend to aggregate the information previously distributed through multiple information services.

Previous work from AIMM Phase 2 was leveraged to modernize aeronautical information to provide a shared platform via the Aeronautical Common Services (ACS), which integrates, standardizes, and improves the distribution of aeronautical information.

The ACS ingests aeronautical data from authoritative sources and transforms, validates (for integrated products), verifies, stores, and distributes the resultant aeronautical information to users and systems through enterprise web services.

Web services give integrated static definitions for aeronautical information, such as airports, navigation aids, airspace, and obstacles. It also dynamically updates the status of schedules, Notices to Air Mission, and similar content. An airspace conflict detection service lets consumers see if a specified airspace and schedule will clash with another. Other ACS services are feature requests and change notifications. ACS has been operational since 2021, and upgrades to the system are scheduled to begin in 2023.

Common Support Services–Flight Data

Common Support Services–Flight Data (CSS-FD) is a program that will modernize flight information management and facilitate transition of new applications to the new NAS information exchange environment.

The CSS-FD program will standardize flight information exchange within the NAS and internationally while complying with ICAO standards. CSS-FD will enhance flight planning and filing, and provide enterprise-level services for quick and agile access to common flight information.

CSS-FD will leverage current and near-term capabilities or enhancements to respond to shortfalls in flight data exchanges, and it is a key step to achieving TBO. The CSS-FD Phase 1 initial investment decision was completed in 2022, and a final investment decision is scheduled for 2025.

SWIM Connected Aircraft

Connecting aircraft using commercial broadband internet communication services instead of aviation-specific infrastructure opens the possibility of exchanging a wider and more abundant set of information with greater speed. This new connectivity will enable the use of SWIM between aircraft and automation systems to improve operational awareness and decision-making needed for TBO.

The connected aircraft project takes on the challenge of creating an environment where air traffic management systems can handle complex operational information exchanges, such as the transmission of controller clearances and safety-critical data, in a new and less restrictive way. The activity will evaluate system architecture alternatives and performance and safety requirements. It will establish an integrated roadmap for developing future air traffic management services and policies that take advantage of the emerging air/ground connectivity.

By ensuring global interoperability, this effort will include coordinating with International Civil Aviation Organization (ICAO) technical panels to develop a globally connected aircraft concept. An integrated framework will be established to further advance air traffic management concepts that leverage the connected aircraft.

The controller decomposition analysis project builds a framework to categorize air traffic control information based on its operational use rather than its source. This work will identify and validate tasks and decisions employed in managing flight operations and categorize them as safety-critical, efficiency-critical, and advisory. This project includes establishing a data distribution platform to organize and distribute connected aircraft software applications.

Post-Departure Coordination and Airborne Negotiation

The Post-departure Coordination and Airborne Negotiation project continues to grow the Flight and Flow Information for a Collaborative Environment (FF-ICE) concept. FF-ICE provides a collaborative decision-making environment that enables the sharing of appropriate data across a wider set of participants. This environment helps to create greater coordination across air traffic management communities, increasing

A flight planning application on an electronic flight bag can be used to coordinate the negotiation between air traffic control constraints and airline operations center preferences for time savings, fuel savings, or speed improvements.

situational awareness and supporting the larger performance target of enabling TBO.

The project will investigate the concept and perform an engineering analysis to mature FF-ICE. It will include collaboration with other air navigation service providers and airspace users, through tabletop exercises and validation activities.

FF-ICE Release 1 involves pre-departure planning before engaging air traffic control. It increases interoperability, efficiency, and capacity. With Release 1 winding down, efforts have begun to explore the next steps in Release 2.

Release 2 supports TBO through ground-to-ground and air-to-ground exchanges using SWIM and air traffic flow management to develop and maintain an agreed 4-D trajectory during flight. It includes strategic negotiations and stakeholder interactions, which occur after air traffic control engagement, predominantly after departure clearance delivery.

The project will build upon the outcomes and lessons learned from previous activities, including Release 1 and 2 demonstrations and the 4-D Trajectory Live Flight Demonstration the FAA conducted in 2020. The FAA will continue to investigate and perform engineering analyses to coordinate clearances and manage agreed-on trajectories to mature the FF-ICE Release 2 concept in 2023.

Flight Deck Collaborative Decision-Making

The Flight Deck Collaborative Decision-Making (FD-CDM) program responds to disparities in implementing advanced flight deck automation to support flight crew decision-making in a collaborative environment. The program will research and develop initial applications, standards, and advanced services to support future NAS operations and enable collaborative decision-making by leveraging emerging connected aircraft capabilities and advancements in internet protocol technologies.

The FAA will develop the concept and standards, and determine initial NAS and SWIM services to be exchanged with the flight deck. The effort will support the flight crew's decision-making by providing electronic flight bag applications that enable future capabilities, for instance, the delivery of digital taxi instructions to the flight crew, which is part of the initial project phase. A speech recognition prototype is being developed to transcribe verbal taxi instructions into digital text format for enhanced digital taxi instructions delivery.

Beyond surface operations, a collaborative decision-making environment can often require the complex exchange of information, which is difficult to do via traditional voice communication. Sharing trajectory intent and negotiating a complicated trajectory to obtain a more efficient flight profile is often challenging because of the enormous effort required to process the information, particularly during high traffic volume.

Direct communication with aircraft through a combination of voice and automation will increase efficiency and situational awareness and offers better business decision alternatives for all stakeholders regardless of the traffic or level of complexity. Digital communication resolves shortfalls in voice radio communication and enables an information-rich environment to promote collaborative decision-making between air traffic controllers and flight crews.

Follow-on efforts are expected to deliver incremental capabilities, such as flight clearances and trajectory negotiation. A prototype application for digital taxi instructions was evaluated in 2022, which included establishing a basic FD-CDM architecture.

Digitization of Airspace Constraints

The digital constraints project will explore the use of advanced methods, such as data analytics and machine learning, to capture and classify the airspace constraints recorded within standard operating procedures and letters of agreement (LOA). An LOA is a formal FAA approval allowing an operator to engage in a specific flight activity requiring authorization.

The project will resolve the problem of incomplete or inconsistent constraint information in databases because of digitally unavailable PDF files. Without the information, there is no machine-to-machine consumption of constraints or the ability to access records of interest. This shortfall hampers the ability of decision support system tools and air traffic control automation platforms to accurately visualize and model constraints in flight planning or collaboration with other facilities.

Existing information exchange standards will be leveraged to create a schema for capturing the airspace constraint data and maintaining it in a common database. Digitizing the constraint data contained in LOAs enables machines to read constraint data. The data will be easier for airspace users to retrieve, manipulate, and exchange in support of future NextGen capabilities. Flight planners can formulate better trajectories that take into account air traffic constraints.

Aeronautical and other NAS status and constraint data, such as those found in LOA and standard operating procedures, will become increasingly important as it is digitized and made available to support the planning and execution of activities in the NAS and around the world.

The introduction of non-traditional aircraft, such as drones, will result in a major rise in airspace constraints. The FAA will allocate airspace and establish corridors for different-performing aircraft. We must make sure airspace users and service providers are aware of the areas of these operations. Digitization supports these operations and an increased need for swift identification and exchange of information.

International Aviation Trust Framework

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

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

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, ICAO, and international partners are developing a Global Resilient Aviation Interoperable Network (GRAIN) for exchanging global information at a compatible protection level based on shared risk.

In 2022, the working group developed GRAIN operational governance and concept of operation documentation. Operational implementation support documentation is scheduled to be available as soon as 2024.

Weather Products

Weather is the biggest factor in flight delays. Timely and accurate weather observations and forecasts are essential to aviation safety and for making the best use of aviation capacity. Weather information will become even more important when direct or user-chosen trajectory routing becomes routine with TBO.

Pilots need to know wind speed and direction at cruising altitudes to take advantage of tailwinds and minimize the effect of headwinds. They also need to know if obstructions to visibility will restrict landings at their destination airport and whether the runway is wet and how that will affect braking.

Traffic flow managers and pilots use weather observations and forecasts to determine when they need to plan alternate routes to avoid severe weather. Pilots must dodge turbulence, icing, and thunderstorms with heavy rain and hail to elude damage to the aircraft and the potential for injuring passengers.

The NextGen Weather program is working to reduce the effect 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.

NextGen Weather Processor

The NextGen Weather Processor (NWP) combines information from environmental satellites, weather radars, lightning detection systems, meteorological observations from surface stations and aircraft, and the NOAA numerical forecast models to generate advanced aviation-specific weather products for FAA users and NAS stakeholders. These products will be available from the Common Support Services–Weather (CSS-Wx) system.

The NWP replaces and enhances the functionality of the Weather and Radar Processor and Corridor Integrated Weather Display with a single common weather processing platform that reduces operating costs and offers new capabilities. En route and terminal users can view weather products on the NWP aviation weather display for consistent and easy-to-read weather information.

The fully automated processor identifies aviation safety hazards and translates weather information needed to predict route blockage and airspace capacity constraints up to eight hours in advance. The NWP produces improved weather mosaics and predictions, and formats them for integration into air traffic control decision support systems.

Improved observations and more accurate predictions enable automated decision support systems to create and use individual trajectory-based profiles, which optimize the use of available airspace. Air traffic controllers and managers can pick the best aircraft routing and precisely space departing and arriving aircraft. The NWP capabilities will decrease avoidable aircraft diversions, delays, and cancellations.

The NWP program completed its software development ahead of schedule and is working toward system testing. Key site installation and testing is planned for 2023, and key site initial operations are scheduled for 2024.

Common Support Services–Weather

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 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.

CSS-Wx will offer NWP mosaics to controllers, enabling more precise and timely information to respond to pilot requests to deviate around hazardous weather. Traffic flow managers and airline operations centers can develop better plans to maximize the use of airport capacity.

The system can filter weather information by location and time to isolate data for a specific geographic area. It provides more precise information on where adverse weather is located and how it is moving, which allows runways to remain in use longer and reopen quicker after adverse weather clears.

CSS-Wx publishes weather datasets in geographically standardized formats that are adopted broadly around the world. The CSS-Wx program is continuing to develop and test software. Like the NWP, key site installation and testing is planned for 2023, and key site initial operations are scheduled for 2024.

Weather Forecast Improvement

One piece of the Weather Forecast Improvement (WFI) program is to support service analysis and evaluate remaining shortfalls for future NWP and CSS-Wx enhancements. They are part of the larger mission of the WFI program to ensure NextGen operational weather capabilities use a broad range of weather improvements and technologies to mitigate the effects of weather on future NAS operations.

WFI seeks solutions to safety issues and delays attributed to weather. Planned efforts include evaluating alternative solutions to the service needs, recommending the most promising approach, and making a business case that adequately funds selected candidates.

WFI program members will collaborate with decision support system developers to plan on integrating weather information into their automated tools. This approach will lead to technologies that refine decision support even during weather events. The program intends to improve the decision-making process and accuracy of aviation weather information to include an automated translation of weather information into constraints placed on the NAS.

WFI incorporates three projects that respond to the need to improve weather prediction and the use of weather information in the future NAS:

Deicing is often required during the winter before takeoff. Poor weather is the leading cause of air traffic delays, which is why the FAA is working to introduce new technology to mitigate or avoid traffic disruptions.

Air Traffic Management Weather Integration

Air Traffic Management Weather Integration (AWI) work includes exploring weather advisories, weather translation techniques to anticipate air traffic operations affected for weather constraints not caused by thunderstorms, and collaborative laboratory experiments designed to investigate AWI concepts and capabilities.

NWP and CSS-Wx upgrades will be evaluated. Exploration of the Cloud Services for Aviation Weather initial concept will create mission-analysis-type products and may lead to potential capabilities for further maturity and technology demonstration.

False, missing, or obsolete depictions, or rapidly changing areas of weather contribute to a wrong picture of the weather in an air traffic controller's sector. Precipitation on the Glass is a project that will study the need for a more accurate portrayal of precipitation that is current and easy to correlate to a controller's primary display for better decision-making.

Weather Community of Interest

The weather community of interest promotes communication, collaboration, and weather information-sharing among FAA organizations, other federal agencies, and industry groups. It will also support the reconciliation of methods used to access weather information and information capabilities and products; ensure appropriate availability, access, and consistency of weather information; and identify and assimilate operational and business needs for weather information in the NAS. These activities will be conducted on behalf of multiple organizations.

International

WFI works to enhance global leadership through direct involvement in the ICAO Meteorology Panel and as the technical representative of the U.S. Meteorological Authority. The program is developing and coordinating harmonized requirements for producing and disseminating meteorological information supporting international air navigation. The requirements will be adopted as standards and recommended practices in Annex 3 of the ICAO Meteorological Service for International Air Navigation, and for inclusion in the ICAO Procedures for Air Navigation Services–Meteorology and other ICAO guidance documents.

Runway Operations

Closely spaced parallel operations (CSPO) refer to the simultaneous approaches 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 NextGen Advisory Committee.

With increasing air traffic, the need is growing 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. Runway capacity increases for departures when visibility is limited through reduced separation standards and increased operations. Enabled by improved flight deck capabilities, CSPO reduces separation for dependent approaches, leading to increased arrival capacity for parallel runway operations in instrument meteorological conditions. CSPO can also decrease operational costs with reduced delays, fuel consumption, and engine exhaust emissions.

The FAA completed the dependent departures site assessment and selection document, and the safety study and NAS sites assessment report for integrated arrivals/departures in 2021. The FAA plans to develop a demonstration schedule for integrated arrivals/departures.

Remote Towers

Remote tower demonstrations have been underway as a trial program. The program is intended to inform the development of a non-federal remote tower equipment system design approval process and associated criteria and standards.

Remote tower technologies seek to enable control tower services at small and rural airports without a traditional brick-and-mortar control tower on site or with an aging tower. Remote towers are not intended to replace the role of the air traffic controller; the FAA is not procuring remote towers.

Safety was, is, and will continue to be the priority. Detailed safety analyses compared air traffic controllers' use of ground-level remote towers to an out-the-window view from a tower cab. The analyses focused on safely and efficiently providing visual flight rules airport tower services.

Initial remote tower programs were conducted at two airports in Class D airspace:

- Leesburg Executive Airport in Virginia has medium traffic density. Operational evaluations, a preliminary remote tower business case, and a surveillance system upgrade were completed in 2022.
- Northern Colorado Regional Airport in Fort Collins has low traffic density. An operational evaluation and remote towers technical requirements document were completed in 2022.

Enhanced capabilities associated with remote towers include panoramic video and color cameras with pan-tilt-zoom and night vision features. Automated identification and relevant aircraft information may be displayed on video monitors. Cost benefit analyses are based on initial tower implementation and lifecycle costs of construction and systems associated with traditional air traffic towers. Air traffic control services are equivalent for remote towers and on-site towers.

The FAA will construct a test bed for remote towers at the William J. Hughes Technical Center and Atlantic City International Airport. Locating remote tower testing in Atlantic City would allow 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 test processes and system design approval activities can become more efficient using this plan.

Safety

As a global leader in aerospace, the FAA fosters innovation and international cooperation in evolving enhanced aviation technologies that improve system safety and mobility. With an eye to the future, NextGen efforts continue to improve flight safety, ensuring the safe introduction of non-traditional operations, such as commercial space and advanced air mobility.

Two NextGen elements work together to pursue safety as we modernize the NAS: NextGen Enterprise Safety and the NextGen Safety Portfolio.

Enterprise Safety

The FAA Safety Management System (SMS) takes an agency-wide approach toward NextGen initiatives. FAA organizations are required to guide their SMS activities and systematically seek acceptable safety risk levels. SMS emphasizes safety management as a fundamental business process to be considered with the same priority as other aspects of business management. The NextGen SMS uniquely applies to NAS modernization activities.

The 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. They manage 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.

The interconnected nature of NextGen when introducing new technologies into the NAS presents complex safety challenges that call for an integrated SRM (ISRM) approach. While traditional safety risk management typically focuses on the individual systems or system modifications to the NAS, the principles of NextGen's ISRM seek a wider perspective of exploring and preventing unacceptable safety risks associated with integration and interactions among various NAS components.

ISRM 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 organizational, system, and program boundaries. It relies strongly on FAA-wide collaboration to capture the most relevant safety information to assist with decision-making.

NextGen Safety Portfolio

The NextGen Safety Portfolio enables and manages the exploration, development, and maturation of NextGen safety concepts, programs, and capabilities.

Aviation Safety Information Analysis and Sharing

The Aviation Safety Information Analysis and Sharing (ASIAS) program is a joint government and industry initiative to proactively analyze extensive data sources and advance aviation safety. ASIAS can discover systemic safety issues that span multiple airlines, fleets, and global air transportation system regions before accidents or other safety incidents occur.

A computer screenshot of the Airport Surface Anomaly Investigation Capability (ASAIC) shows air traffic activity. ASAIC has multiple stakeholders within the FAA who use the tool to monitor sudden stops, irregular turns, missed arrivals and departures, long taxi times, runway reduced separation, and more.

ASIAS has data-sharing agreements with more than 40 commercial carriers, including all major U.S. airlines, and a repository of over 30 million digital flight records. Dozens of organizations participate in ASIAS, including government agencies, commercial airlines, general aviation and on-demand Part 135 air carriers, flight training schools, aircraft manufacturers, labor associations, and trade associations. It is a central conduit for the voluntary exchange of safety information between the FAA and the aviation community, and a national resource for the aggregation, analysis, and dissemination of aviation safety information.

ASIAS collects information from many sources, including airline proprietary flight data, publicly available safety data, FAA safety reports, air traffic control recordings, and weather. This data has been invaluable in monitoring safety risks, evaluating the effectiveness of deployed safety mitigations, and identifying emerging hazards. ASIAS continues to develop advanced analytical capabilities for enhanced insight into domestic and international operating environments.

The FAA developed the Rotorcraft ASIAS Integration Services Environment to support safety analysis for the rotorcraft community. This effort delivered the Operationalizing ASIAS Analytical Capabilities report, which notes improvements to the hazard and vulnerability discovery models used for ASIAS studies. The FAA also merged multiple datasets to develop an aviation safety metric.

Moving forward, we will accelerate the procurement of ASIAS 3.0 and transition data and selected technologies to the new version. The FAA also plans to support a new governance model for ASIAS.

System Safety Management Transformation

System Safety Management Transformation (SSMT) is a stakeholder-driven, cross-functional effort. It incorporates the best available, most timely safety risk data for current and forecasted NAS operations using safety risk assessment models. Anomaly detection and safety risk assessment tools include information from fatal accidents and significant incidents, support the identification of latent and emergent risks, and represent potential system failures.

The primary objective of SSMT is to support the development and implementation of SMS across the air transportation system to ensure safety risk is managed to an acceptable level. Through its tools and analytical capabilities, this program complements the FAA's existing safety risk analysis capabilities.

SSMT delivers information sharing environments, safety management analyses, prototype systems, functioning models, and safety tools for commercial aviation, general aviation, and drone operations. Capabilities will be integrated using multiple data sources and shared across the aviation community through the deployment of local system safety risk baseline tools, risk prediction tools, and integrated forecasts.

Ultimately, NAS stakeholders will use the tools to identify precursors and contributing factors to accidents, allowing interventions to be developed and implemented before system safety issues become incidents.

These are some of the tools in various stages of development:

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

The focus for SSMT over the next few years is to move away from analysis and research to investment and implementation of the developed toolsets.

ACCOMMODATING ALL OPERATIONS

The aerospace industry has continued to tremendously grow and innovate in the past several years, with new types of operations taking flight. Non-traditional aircraft often use cutting-edge technologies for more efficient and sustainable air transportation. They also present new challenges because they need to share the National Airspace System (NAS) alongside traditional aircraft. The Federal Aviation Administration (FAA) must accommodate the new operations without disrupting existing air traffic. We are developing innovative traffic management concepts and evaluating technologies such as a new collision avoidance system to safely incorporate advanced drones, supersonic aircraft, spacecraft, and other future users into the NAS.

Advanced Air Mobility

Advanced air mobility (AAM) is a rapidly emerging sector of the aerospace industry, which aims to safely and efficiently integrate new, highly automated aircraft into the NAS and the aviation ecosystem. The AAM ecosystem also includes a framework for infrastructure development, airspace access, operations, and community engagement.

AAM captures a broad category of revolutionary new aircraft incorporating vertical takeoff and landing, electric propulsion, and autonomous technology. These aircraft will serve roles such as air taxis, air ambulances, and cargo delivery aircraft, and they will operate between places previously underserved by aviation in urban, suburban, rural, and regional environments. Some companies will immediately introduce autonomous operations while others will start by offering flights with a pilot on board and eventually transition to autonomous operations.

The new aircraft are transforming the aviation market as start-up technology companies, along with corporate expansions, will be vying for airspace in record numbers. Additionally, electric aircraft may reduce emissions and fuel consumption.

The FAA works with the National Aeronautics and Space Administration (NASA) and other stakeholders to develop a framework to help emerging aviation markets safely develop an air transportation system that moves people and cargo.

The FAA has a long, successful history of safely bringing new technology into aviation. While the FAA's current regulations were not written with many of the new AAM aircraft in mind, the regulatory structure is flexible enough to certify new technologies, including these aircraft and their operations. We are committed to safely integrating AAM aircraft into the airspace system according to FAA standards.

To ensure the evolution and growth of AAM, industry and the FAA will need to work together within their respective roles, industry as the innovator and the FAA as the regulator, to ensure performance-based rulemaking that will support growth. We continue collaborating with research partners across government, industry, academia, and international organizations to exchange research priorities, progress, and challenges of AAM.

Urban Air Mobility

Urban air mobility (UAM) is a subset of AAM in and around cities. The FAA is exploring how to safely integrate UAM operations into the NAS. In collaboration with NASA and the aviation industry, the FAA is maturing its UAM concept to address air traffic requirements, policies, procedures, and equity. We envision a safe and efficient aviation transportation system that will use highly automated aircraft to transport passengers, cargo, or both.

The UAM concept of operations addresses the feasibility of crewed and uncrewed passenger and cargo aircraft in urban environments at lower altitudes. It considers the evolution of aircraft technology and associated levels of autonomy for air traffic management and flight rules. UAM flights may use a new unmanned aircraft systems traffic management (UTM) or traditional air traffic management.

The UAM engineering project will analyze required capabilities and information exchanges, and define potential requirements and architecture to allow UAM. The FAA completed the initial conceptual systems architecture and the initial UAM operational variation analysis report in 2021. In 2022, the agency released the initial version of the technical evaluation plan. The concept of operations will continue to mature.

Unmanned Aircraft Systems

Unmanned aircraft systems (UAS) are unmanned aircraft, or drones, and the equipment necessary for the safe and efficient operation of these aircraft. UAS technology and operations continue to grow in volume, variety, and complexity. The FAA works with stakeholders to develop policies, procedures, and rulemaking so UAS can safely operate within the NAS. The FAA published the Integration of Civil Unmanned Aircraft Systems in the National Airspace System Roadmap (Version 3, 2020) and had implemented UAS operations over people in 2021. The integration of AAM and UAS into the NAS is moving to beyond visual line of sight (BVLOS) operations, where the pilot of the aircraft can no longer see it. BVLOS paves the way for future remotely piloted AAM operations.

To advance the integration of BVLOS operations, such as urban cargo delivery, into the NAS, the FAA began Phase 2 of the BVLOS NAS evaluation in 2022. Phase 2 continued to evaluate the integration of BVLOS operations for drones heavier than 55 pounds in the airspace above 400 feet.

The project analyzed, tested, and evaluated multiple scenarios with increased operational tempo and a variety of aircraft, thereby raising the operational and environmental complexity. It culminated with two weeks of successful live-flight evaluations in the third quarter using large UAS and a final demonstration. Results of the evaluation will inform project stakeholders on gaps and associated needs of BVLOS operations on communications, navigation, and surveillance services among users.

Industry aspires to operate with remote pilots through greater degrees of autonomy as the industry matures. The FAA will evaluate UAS technologies as they progress. In coming years, the FAA will collect data and coordinate and integrate these more complex operations involving drones, including small UAS package delivery, large carrier cargo delivery, and passenger transportation.

Operating Environments

The extensible traffic management (xTM) framework is a new air traffic management architecture that will use an industry supply of third-party services. These services complement FAA air traffic services to exchange relevant aircraft information among UAS operations and between the UTM and conventional systems for safe flight separation.

UAS Traffic Management

The airspace up to 400 feet above ground level will operate under UTM, where drones meet established performance requirements and cooperatively separate through shared situational awareness. Crop monitoring, pipeline inspection, firefighting support, and short-distance package delivery are some of the operations that might take place in this airspace not served by traditional air traffic services. The FAA's DroneZone, Low Altitude Authorization and Notification Capability (LAANC), and Airborne Collision Avoidance System for Rotorcraft are programs that support operations in this airspace, which could be urban, suburban, or rural locations.

The UTM Integrated Capabilities program establishes the concepts, requirements, and use cases associated with UTM and the flight information management system (FIMS) to safely manage UAS operations primarily through operator-to-operator and operator-to-FAA sharing of flight intent and airspace constraints.

FIMS will support the increasing tempo of UAS access to airspace and will eliminate the need for waivers that are considered case by case. This program will also continue developing ongoing standards to expand collision avoidance research and requirements for a new user-class in UTM to ensure future systems are interoperable within the NAS.

Air Traffic Management

In air traffic management (ATM) airspace up to 60,000 feet, UAS will receive traditional air traffic services where required. Below 18,000 feet, operators will follow a mix of visual and instrument flight rules, and examples of UAS uses in this airspace include emergency monitoring and inspection missions. On-demand mobility, such as UAM or regional cargo delivery, may also operate in this airspace. At and above 18,000 feet, UAS operations like large cargo delivery, border security, and weather monitoring would ioperate only under instrument flight rules.

The FAA in 2021 had completed our analysis on UAS operations in ATM airspace and found the demand for these operations is within the parameters of existing automation systems.

Upper Class E Traffic Management

UAS operating at altitudes above 60,000 feet in the Upper Class E traffic management (ETM) environment will be certified and cooperatively separated through shared situational awareness. Air navigation service provider coordination will be limited for these flights, some of which may be long-endurance operations supporting internet services or research.

Operations at these altitudes have historically been limited because traditional fixed-wing aircraft are not designed to fly in thin air in the upper stratosphere. With the anticipated increase in demand for crewed and uncrewed upper airspace operations, the FAA is updating an ETM concept of operations. The ETM framework will include overall conceptual principles and assumptions, supporting architecture, information flows and exchanges, and FAA and ETM operator roles and responsibilities.

The FAA will use the concept of operations to develop and evaluate the capability to enable safe and efficient operations in Upper Class E airspace. The work will identify potential technical requirements and architecture; ensure harmonization between ETM, ATM, and possibly even the UTM environments; and develop the necessary system prototypes.

Technologies and Capabilities

The FAA is implementing programs in support of drone integration. Here are a few of them covering registration, airspace authorization, detecting and avoiding other aircraft, and security.

DroneZone

The FAA DroneZone is a website for registering all types of UAS. The information technology platform hosts several applications and the supporting infrastructure that improves the user experience. The platform can address future small UAS requirements and improve current business processes.

In addition to incorporating the small UAS registration service, the FAA in 2022 released DroneZone beta web applications to support the collection and processing of airspace authorizations and waivers, operational waivers, and accident reporting.

Looking ahead, the FAA will develop products and continue enhancements. These efforts will improve the user experience and increase the efficiency of internal processes required to operate small UAS in the NAS. The FAA will also develop a single access point for all DroneZone capabilities used by the UAS community.

Low Altitude Authorization and Notification Capability

LAANC automates how the FAA approves small UAS to fly in controlled airspace for recreational pilots. LAANC simplifies and expands access to controlled airspace at or below 400 feet, increases awareness of where drone pilots can fly, and informs air traffic controllers of where and when drones are operating.

The FAA established altitudes at and below which UAS may be granted automatic authorization. Through the UAS data exchange, LAANC allows the FAA and FAA-approved companies to share data about airspace restrictions and pilot requests. These companies, known as UAS service providers, develop desktop and mobile applications to provide LAANC access for drone pilots.

The FAA introduces capabilities over a yearly cycle through prototyping and national rollouts. As requirements and operating rules mature, the FAA will implement updates to realize operational enhancement. In 2022, we deployed a common logging and monitoring service for LAANC.

UAS Ecosystem Capabilities

The FAA has identified these six UTM ecosystem areas of application development: enterprise and core, regulatory aircraft, operator, airspace, operational, and safety and security. The FAA Application Programming Interface (API) Portal project provides a framework for developers to design, publish, and document APIs in a secure environment for internal and external access to UAS data and business functions.

The FAA is migrating the DroneZone and LAANC platforms to the FAA Cloud Services ecosystem through the UAS Ecosystem Capabilities program to maintain continuity of services. The transition will also adjust the current UAS data model to the NAS data model standard.

Airborne Collision Avoidance System

The Airborne Collision Avoidance System X (ACAS X) has the flexibility to provide a collision avoidance capability for new user classes, reduce unnecessary alerts, support the use of alternative surveillance sources, and enable future airspace procedures and operations. The ACAS program is divided into multiple subsets, including ACAS sXu for small UAS and ACAS Xr for rotorcraft. The outcome is interoperable collision avoidance technologies for different types of aircraft.

Small UAS

ACAS for Small UAS (ACAS sXu) is a modular, tunable, and scalable technology to detect and avoid traffic. The core logic is common to all implementations but agnostic to physical architecture, surveillance sources, and communication links, which allows the ACAS sXu concept to accommodate fluid standards and regulatory circumstances in an environment where many stakeholders offer different small UAS capabilities. It complements the ongoing standards being developed under the ACAS X program to develop requirements for UAS.

The FAA will complete the full set of files and accompanying validation and safety reports associated with the final review and comment version of the minimum operational performance standards for RTCA, an industry non-profit organization that develops technical guidance for aviation.

Rotorcraft

ACAS for Rotorcraft (ACAS Xr) extends the collision avoidance system capability with an optimized alerting logic. This version accounts for the unique flight characteristics of rotorcraft to enhance safety because they can hover and fly near other fixed-wing aircraft at slower speeds and lower altitudes.

In 2022, the FAA completed architecture reports for the surveillance tracking and threat resolution modules and released the Run 2 logic package to the RTCA for review. The requirements roadmap for ACAS Xr was also developed by the FAA along with the safety characterization and analysis. The project will develop ACAS Xr minimum operational performance standards for RTCA approval.

Remote Identification

Remote identification of drones is crucial to integrating them into the NAS because it serves as the foundation for the safety and security needed for more complex drone operations. The Remote ID rule requires most drones operating in U.S. airspace to have Remote ID and transmit information, such as the drone's identity, location, and control station or takeoff location, by September 16, 2023. Remote ID helps the FAA, law enforcement, and other federal agencies find the control station and contact the pilot when a drone appears to be flying unsafely 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. DISCVR will provide capabilities to receive, correlate, retrieve, and distribute timely, comprehensive UAS information to authorized FAA staff and federal security partners using Remote ID information. It also includes supporting services that provide common authentication and authorization of users, service logging and monitoring, and geospatial data management. In the fourth quarter of 2022, the FAA completed stakeholder engagement and service enhancements for DISCVR, as well as the common authentication service and common logging and monitoring.

Space Operations

The growth of the commercial space industry during the past decade has been dynamic and is rapidly evolving. New technologies contribute to an increase in operational tempo. Commercial space operations encompass launches, reentries, and increases in other space activities, such as suborbital flights, testing new spacecraft and operations, incorporating new and emerging entrants into the NAS, and reviewing new spaceport configurations. The FAA continues to improve efficiencies in how it manages space operations to meet the current and projected increase in volume, scale, and scope of space operations.

In fiscal year 2022, the FAA safely managed 69 commercially licensed space launches and five reentries. To ensure safety and security during commercial space operations, the FAA blocks airspace for extended periods of time. With 14 FAA-licensed spaceport operators across the country, complex restrictions affect more and more NAS users. The FAA's guiding principle of safety remains paramount even as we focus on maximizing airspace availability to support space operations and minimizing disruption to other NAS stakeholders.

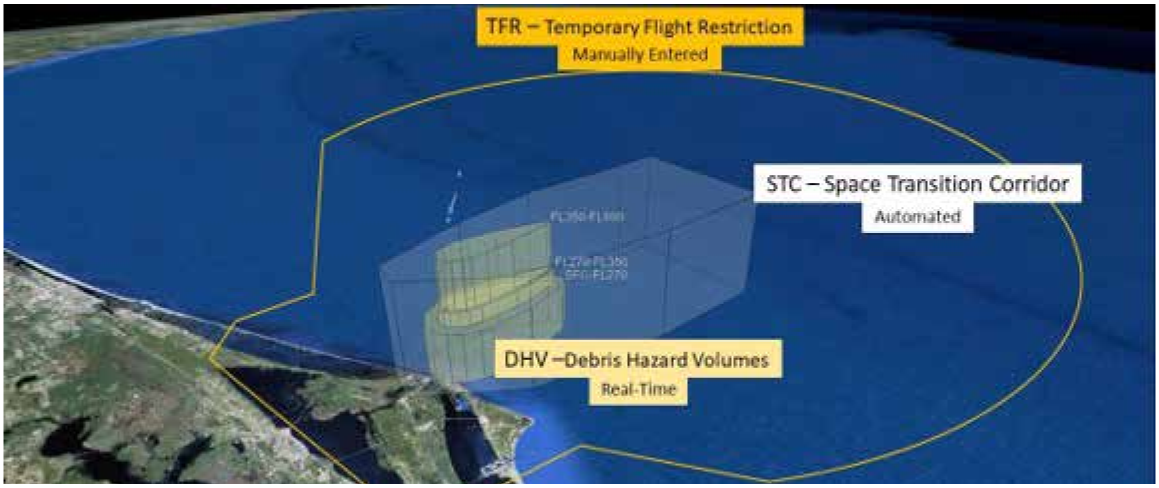
Integration Capabilities

In 2021, the FAA incorporated the first phase of the Space Data Integrator (SDI). At the Air Traffic Control System Command Center, the SDI minimum viable product (MVP) was initially deployed to provide a near real-time capability to monitor location and status of launch and reentry spacecraft and automate data transfer to Traffic Flow Management System. The SDI MVP is expected to increase overall efficiency and awareness, and reduce manual processes.

The FAA is establishing an enterprise-wide view of data and a community of interest because multiple government and industry organizations receive, use, and collect commercial space operations data. Space information management will enable the development of common information standards and space information technology data exchange.

Improving situational awareness of a space operator's spacecraft location, trajectory, potential or live debris, and return to Earth is vital to safely and efficiently managing air traffic during space operations. The use of SDI is expected to expand as partnerships with commercial space operators grow. NAS users affected include the FAA and other government agencies, airlines, related aviation technology companies, airports, and international airspace users.

The space integration engineering and analysis project identifies and analyzes air traffic management and air traffic control (ATC) services necessary to integrate space operations into the NAS. The FAA plans to improve the capability of ATC to prepare for, monitor, and respond to launch and reentry operations. For example, for ATC personnel, space data information would be transformed into existing NAS automation and effectively displayed "on the glass."



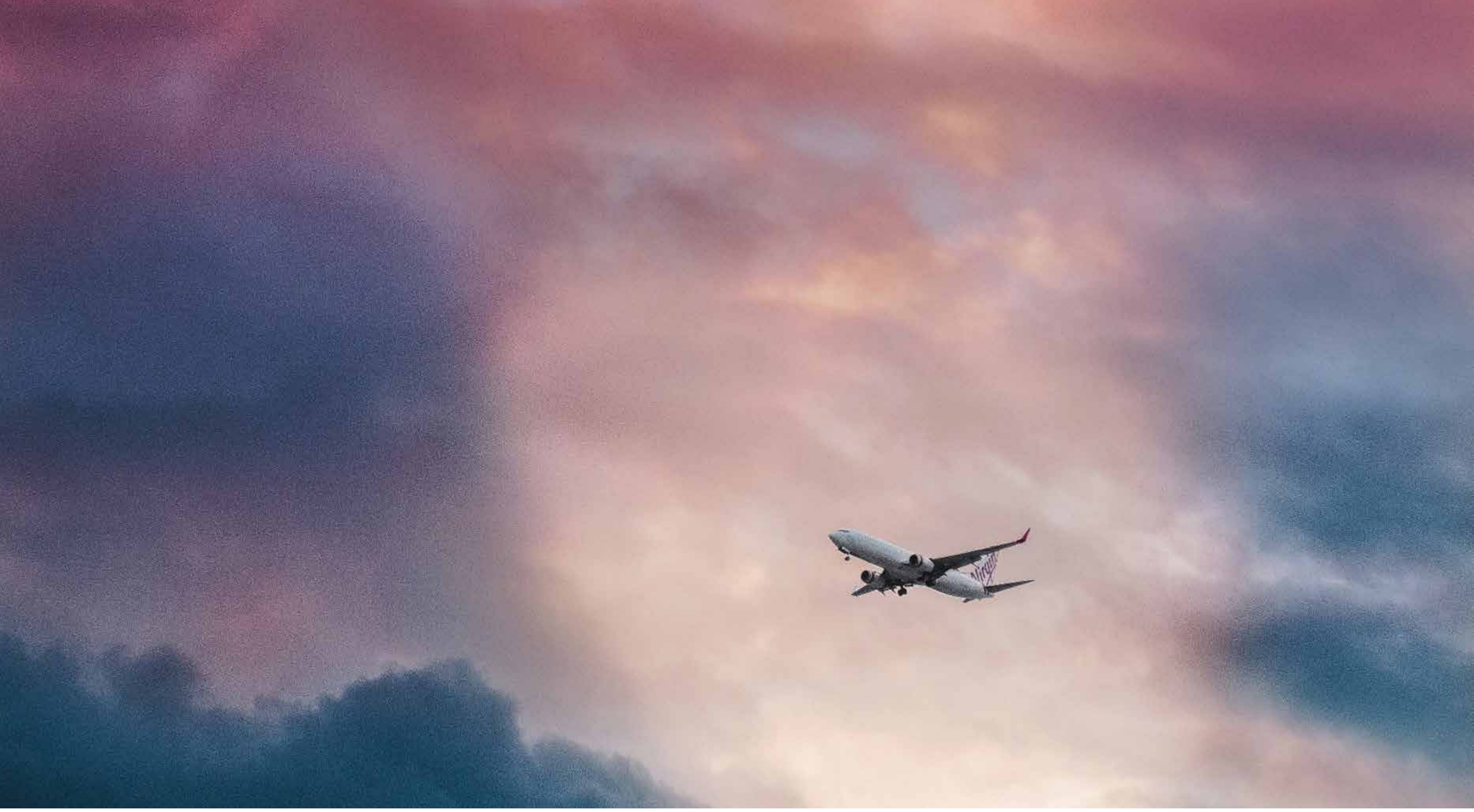
An FAA prototype Hazard Risk and Management software generates debris hazard volumes (boxes) much smaller than if controllers temporarily restrict flights in a portion of airspace (yellow line). Real-time hazard area generation would allow for smaller, shorter, and flight-tailored airspace restrictions to reduce flight delays, reroutes, and additional fuel burn.

Hazard Volume

The Space Integration Capabilities Hazard Volume project will help customize and minimize airspace restrictions during space operations. Reducing airspace closures will reduce flight delays, reroutes, and fuel burn caused by lengthy restrictions. The Department of Transportation awarded the project the Meritorious Achievement Award Silver Medal in recognition of exceptional service for a project DOT deems critical to commercial space operations.

The FAA led a team of agency, industry, and academia members to demonstrate a public-private approach to space integration that leverages dynamically generated hazard areas. SpaceX teamed with the FAA in the interest of public safety and agreed to use the prototype hazard risk and management software. It generated debris hazard volumes using live data during the January 19, 2020, in-flight abort launch mission from the NASA Kennedy Space Center in Florida.

As the mission progresses, the FAA will be able to manage the airspace more dynamically, resulting in less airspace blocked off before and during launch and reentry, and reduce the duration of closed airspace to other NAS users as the mission progresses.



INFORMATION-CENTRIC FUTURE

The future vision for the National Airspace System (NAS) builds on the maturation of the Next Generation Air Transportation System (NextGen) and the increased reliance on digital information. This vision supports the continuing evolution of Trajectory Based Operations (TBO); it also supports the Federal Aviation Administration's (FAA) plans for embracing new users, innovative technologies, and the expanding information environment. The FAA will integrate these non-traditional operators and leverage the new environment to provide more flexible and nimble support to the traditional aviation community.

Info-Centric NAS

As the FAA operationalizes NextGen and expands TBO to more areas of the country, we are also advancing a vision for the Info-Centric NAS (ICN), incorporating innovative technologies into a fully integrated information environment for the U.S. air transportation system. This environment will provide the information that enables interoperability among NAS users and the predictive algorithms that will support operations and safety.

The FAA published "Charting Aviation's Future: Vision for an Info-Centric National Airspace System" in 2022. The ICN vision builds on NextGen 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. It is described through three key areas: operations, infrastructure, and integrated safety management. We are collaborating with other government, industry, and academic partners to align to a common vision to build an information-centric aerospace future.

Operations

Future NAS operations will be characterized by collaboration among diverse traffic management service providers, agile systems and services, and a fully integrated information environment. In this environment, humans will guide the objectives while automated technologies process the information and recommend how to solve problems in ways that best meet the objectives.

New traffic management services, referred to as extensible traffic management (xTM), will handle the operation of new entrants in certain airspaces without the need to engage traditional traffic management services. Highly automated and third-party-managed xTM services will apply commercial practices to safely scale service growth in line with demand.

Collaboration within traffic management services that integrate an increased variety and number of new aircraft, missions, and operations will be essential. Under the fully integrated information environment with unrestricted access to information, decision-making will be distributed optimally. This integration will allow migration toward dynamic information services, providing changes when needed for all operations. NAS participants will benefit from a seamless exchange of information, supporting cooperation and safety.

Infrastructure

Industry is deploying advances in network infrastructure technologies, and commercial providers are using that modernized infrastructure to deliver telecommunications services to a wide range of users. This infrastructure already universally covers the NAS with enhanced availability, reliability, and security, and evolves on pace with technology. The NAS will leverage this commercial infrastructure and applications that meet performance requirements to deliver services securely, everywhere, and always.

Advances in communications technology and the use of internet protocol for supporting services and high-performance wireless services will enable secure and reliable information sharing with aircraft and service suppliers everywhere. In combination with other platforms, satellites in low earth orbit could augment terrestrial wireless coverage in the continental United States while providing service to oceanic and other domains.

Network security will use a zero trust model, a strategic approach to cybersecurity that secures an organization by continuously validating every stage of a digital transaction. It will interoperate with an international trust framework to enable the use of fully defined information assurance controls and credential management for aviation. This will allow secure information transfer across international and domestic security boundaries.

Cloud-related technologies will allow automation services to scale dynamically in response to added workload or component failure. Advances in artificial intelligence will enable continuous monitoring of status and will respond to failures or demand spikes with or without human intervention. Machine-learning approaches will enable effective prediction of potential failures, demand, and preventive maintenance applications.

Technological developments will enable a shift to distributed decision-making, with many decisions being made locally rather than the centrally based practice seen in the system today. Service overlaps will enable resilience, and specific outages will not diminish operational capability because of the available redundancies.

Integrated Safety Management

Integrated safety management means maintaining the NAS as the safest airspace system in the world. One way to do it is through tailored safety processes to ensure safe and efficient use of shared airspace. Another way is through interoperability. That means using diverse technologies to enable various aircraft to talk to each other and perform in harmony. Additionally, the FAA will employ new innovative technologies to continually monitor for real-time changes in risk.

Collaboration and safety services will be essential to adjusting flows in mixed-use airspace. New tailored flight rules (TaFR) will be defined to accommodate new operations and services. TaFR will support cooperative separation, allowing xTM suppliers to provide strategic traffic advisories. Flights can then tactically self-separate as a detect-and-avoid procedure under TaFR.

The NAS will promote in-time safety through continuous monitoring, modeling, and verification to detect anomalies and alert for changes in risk. Models will project potential unsafe conditions and alert the aircraft operator, flight deck, service suppliers, or air traffic management as appropriate.

Data will be available from many sources aboard many aircraft, including surveillance of surrounding aircraft. Monitoring of all means of independent information will be used to confirm data integrity in real time. Continuous monitoring will enable an operational response to the current risk level while post-operation modeling can reconstruct unsafe conditions or anomalies and support causal analysis.

APPENDIX A

NextGen Implementation Work Plan Through 2027

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

NextGen is the FAA's comprehensive overhaul of the NAS, 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 Enterprise Architecture (EA), to describe the evolution of air traffic control through implementation of new services, technologies, and infrastructure. The EA also contains roadmaps to help guide identification, tracking, and maturation of concepts that will further advance the NAS.

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

Overall NextGen Transformation		
Foundational Infrastructure This period can be considered the foundational infrastructure phase of NextGen.	**Expanding Capabilities** This period focuses on expanding NextGen capabilities and improving the infrastructure established in the previous period.	**Realizing and Leveraging NextGen** Realizing and leveraging NextGen allow for capabilities that require additional maturation or concept development. The capabilities are future, and in some cases, near-term, that will benefit the NAS in terms of safety, efficiency, predictability, and flexibility.
Trajectory Based Operations Phases		
Infrastructure Deployment of foundational automation, surveillance, weather, and information and data exchange infrastructure to support TBO enabling capabilities and products.	**Initial** Initial TBO capabilities deployed for use by NAS operating areas with the integration of the capabilities left to the human operator.	**Full and Dynamic** Under Full and Dynamic TBO phases, new capabilities will be available at many operating areas and will allow automated integration of time-based management data and tools to greatly improve strategic planning and execution. Advanced aircraft and ground automation will be used to enable flight-specific time-based solutions for reroutes, and advanced flight-specific trajectories and information-sharing to further optimize operations.

Figure A-1: NextGen Transformation and TBO Phases

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 organizations, use the plan to identify and prioritize capabilities.

NextGen Benefits

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

- **Access and Equity:** Provides an operating environment that ensures that all airspace users have right of access to the air traffic management (ATM) resources needed to meet their specific operational requirements and that the shared use of airspace by different users can be achieved safely. The global ATM system should ensure equity for all users that have access to a given airspace or service. Generally, the first aircraft ready to use the ATM resources will receive priority except where significant overall safety or system operational efficiency would accrue, or national defense considerations or interests dictate that priority be determined on a different basis.
- **Capacity:** Exploits the inherent capacity to meet airspace user demands at peak times and locations while minimizing restrictions on traffic flow. To respond to future growth, capacity must increase, along with corresponding increases in efficiency, flexibility, and predictability, while ensuring that there are no adverse impacts on safety and giving due consideration to the environment. The ATM system must be resilient to service disruption and the resulting temporary loss of capacity.
- **Efficiency:** Addresses the operational and economic cost-effectiveness of gate-to-gate flight operations from a single-flight perspective. In all phases of flight, airspace users want to depart and arrive at the times they select and fly the trajectories they determine to be optimum.
- **Environment:** Contributes to the protection of the environment by considering noise, emissions, and other environmental issues in the implementation and operation of the aviation system.

- **Flexibility:** Ensures the ability of all airspace users to modify flight trajectories dynamically and adjust departure and arrival times, thereby permitting them to exploit operational opportunities as they occur.
- **Predictability:** The ability of airspace users and ATM service providers to provide consistent and dependable levels of performance. Predictability is essential to users as they develop and operate their schedules.
- **Safety:** Uniform safety standards and risk and safety management practices should be applied systematically to the air transportation system. In implementing elements of the system, safety needs to be assessed against appropriate criteria and according to appropriate and globally standardized safety management processes and practices.

NextGen Portfolios

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

Portfolio Descriptions

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

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

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

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

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

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

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

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

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

Environment and Energy: The FAA's strategic environmental goal is to develop and operate a system that reduces aviation's environmental and energy impacts to a level that does not constrain growth and is a model of sustainability. Noise, air quality, climate, energy, and water quality are some of the potential environmental constraints to increasing aviation capacity, efficiency, and flexibility. Collaborating with industry and academia, this portfolio accelerates the maturation of engine and airframe technologies to reduce aviation noise, fuel use, and emissions. It will also provide test data, analyses, and methodologies to overcome barriers to the adoption of alternative jet fuels that are compatible with existing fuel infrastructure and gas turbine engines.

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

Detailed Work Plans

This section describes the detailed work plans for the 11 NextGen portfolios. The portfolios list operational improvements, current operations, and the corresponding capabilities of each; these portfolio components are associated with the years in which activities occur. The dates and timelines included in the tables are for planning purposes only and are based on information from the February 2022 NSIP baseline.

The COVID-19 pandemic that began in early 2020 caused unprecedented effects on aviation and the broader economy. Uncertainty continues today relative to milestones, industry commitments, and projected benefits. As of the publication of the NSIP 2022 baseline, programs conducted assessments. Accordingly, plans to develop or implement NextGen capabilities were adjusted and reflected in the 2022 baseline to the extent possible.

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 that the industry and the FAA have negotiated as key capabilities that will benefit the industry and improve NAS operations over time.

See Figure A-2 for how to read the detailed work plans.

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

How to Read Detailed Work Plans

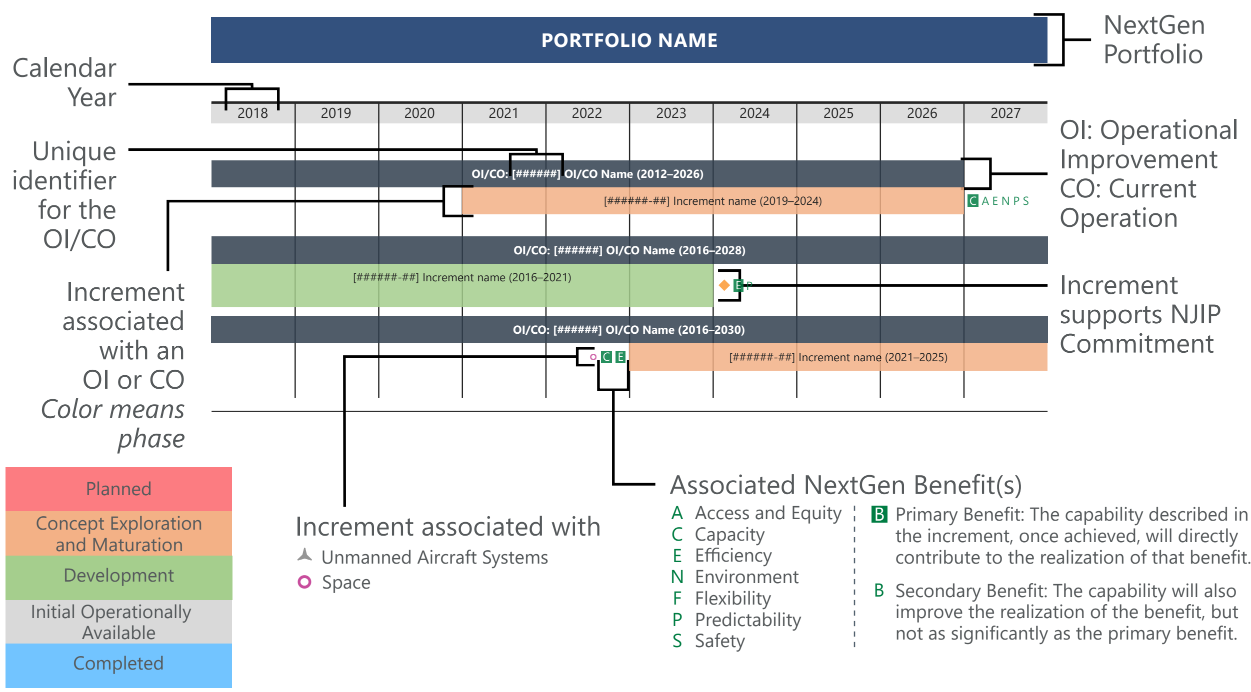


Figure A-2

IMPROVED SURFACE OPERATIONS

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027

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

OI: [104117] Improved Departure Scheduling into Overhead Streams (2015–2030)

E C, P [104117-32] Improved Departure Operations using Mobile Applications (2026–2030)

OI: [104206] Full Surface Traffic Management with Conformance Monitoring (2026–2035)

S E [104206-22] Electronic Exchange of Taxi Information (2026–2029)

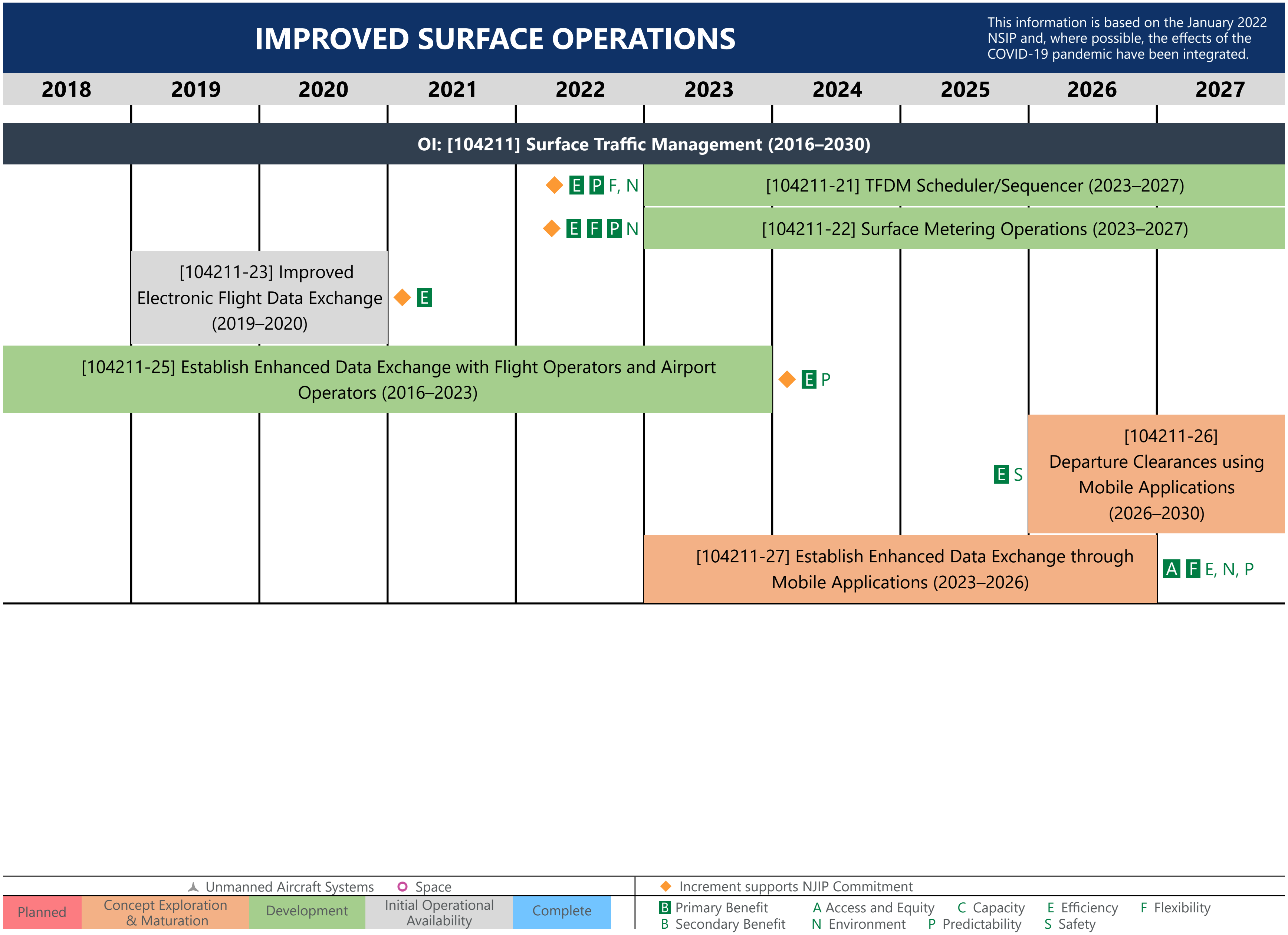
CO: [104208] Enhanced Departure Flow Operations (2016–2019)

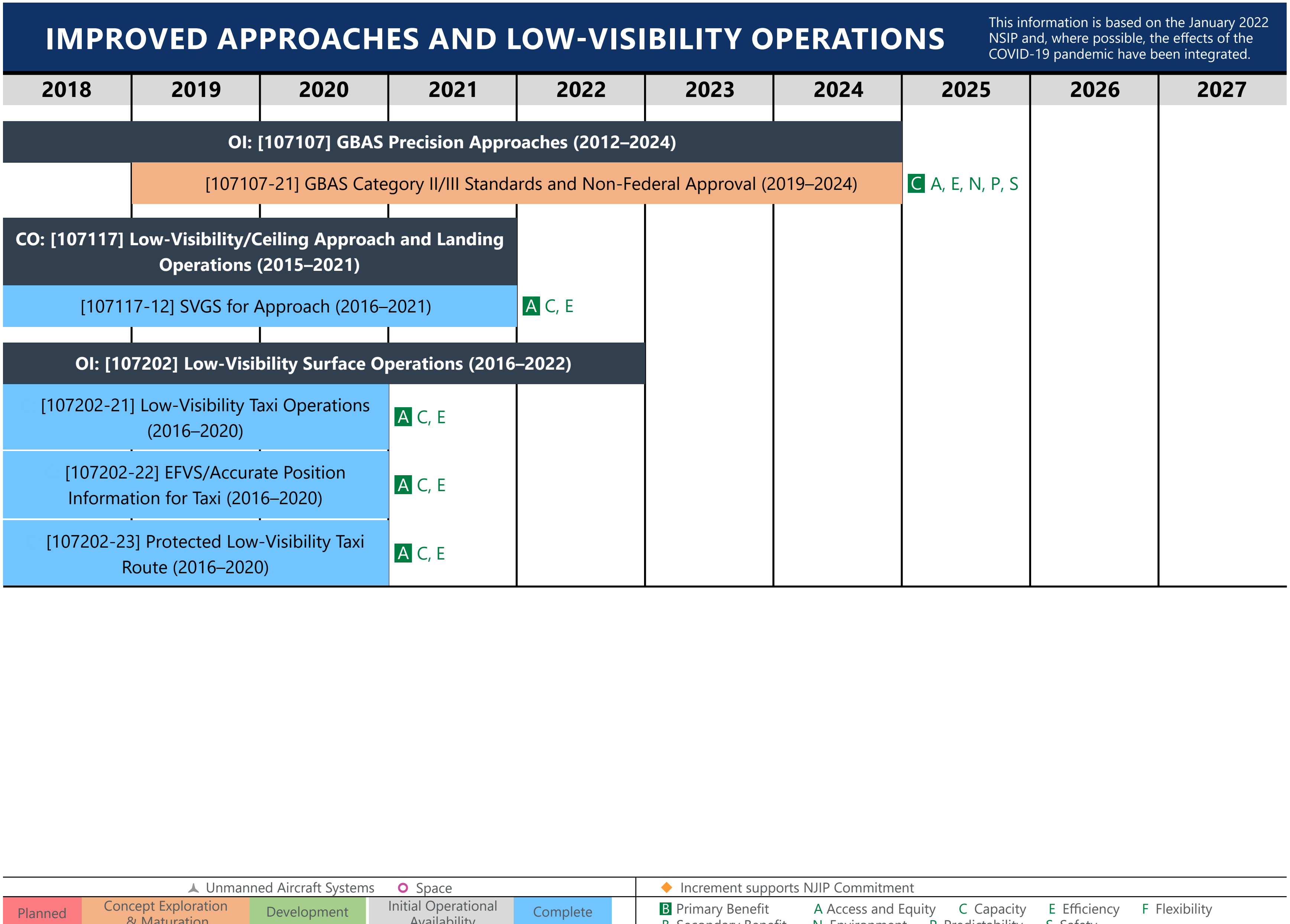
[104208-12] Revised Departure Clearance via Data Comm (2016–2019) F S

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

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

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


IMPROVED SURFACE OPERATIONS
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [104211] Surface Traffic Management (2016–2030)
E P F, N
[104211-21] TFDM Scheduler/Sequencer (2023–2027)
E F P N
[104211-22] Surface Metering Operations (2023–2027)
[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
E S
[104211-26] Departure Clearances using Mobile Applications (2026–2030)
[104211-27] Establish Enhanced Data Exchange through Mobile Applications (2023–2026)
A F E, N, P
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
S Safety
F Flexibility


IMPROVED APPROACHES AND LOW-VISIBILITY OPERATIONS
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [107107] GBAS Precision Approaches (2012–2024)
[107107-21] GBAS Category II/III Standards and Non-Federal Approval (2019–2024)
C A, E, N, P, S
CO: [107117] Low-Visibility/Ceiling Approach and Landing Operations (2015–2021)
[107117-12] SVGS for Approach (2016–2021)
A C, E
OI: [107202] Low-Visibility Surface Operations (2016–2022)
[107202-21] Low-Visibility Taxi Operations (2016–2020)
A C, E
[107202-22] EFVS/Accurate Position Information for Taxi (2016–2020)
A C, E
[107202-23] Protected Low-Visibility Taxi Route (2016–2020)
A C, E
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operational Availability
Complete
B Primary Benefit
B Secondary Benefit
A Access and Equity
N Environment
C Capacity
P Predictability
E Efficiency
S Safety
F Flexibility

IMPROVED MULTIPLE RUNWAY OPERATIONS

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027

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
- [102141-28] Amend Dependent Runway Separation Standards for Runways Spaced Greater Than 4,300 Feet (2016–2018) ◆ C N

OI: [102157] Improved Parallel Runway Operations with Airborne Applications (2020–2035)

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

⅄ Unmanned Aircraft Systems O 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
S Safety
F Flexibility

IMPROVED MULTIPLE RUNWAY OPERATIONS

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

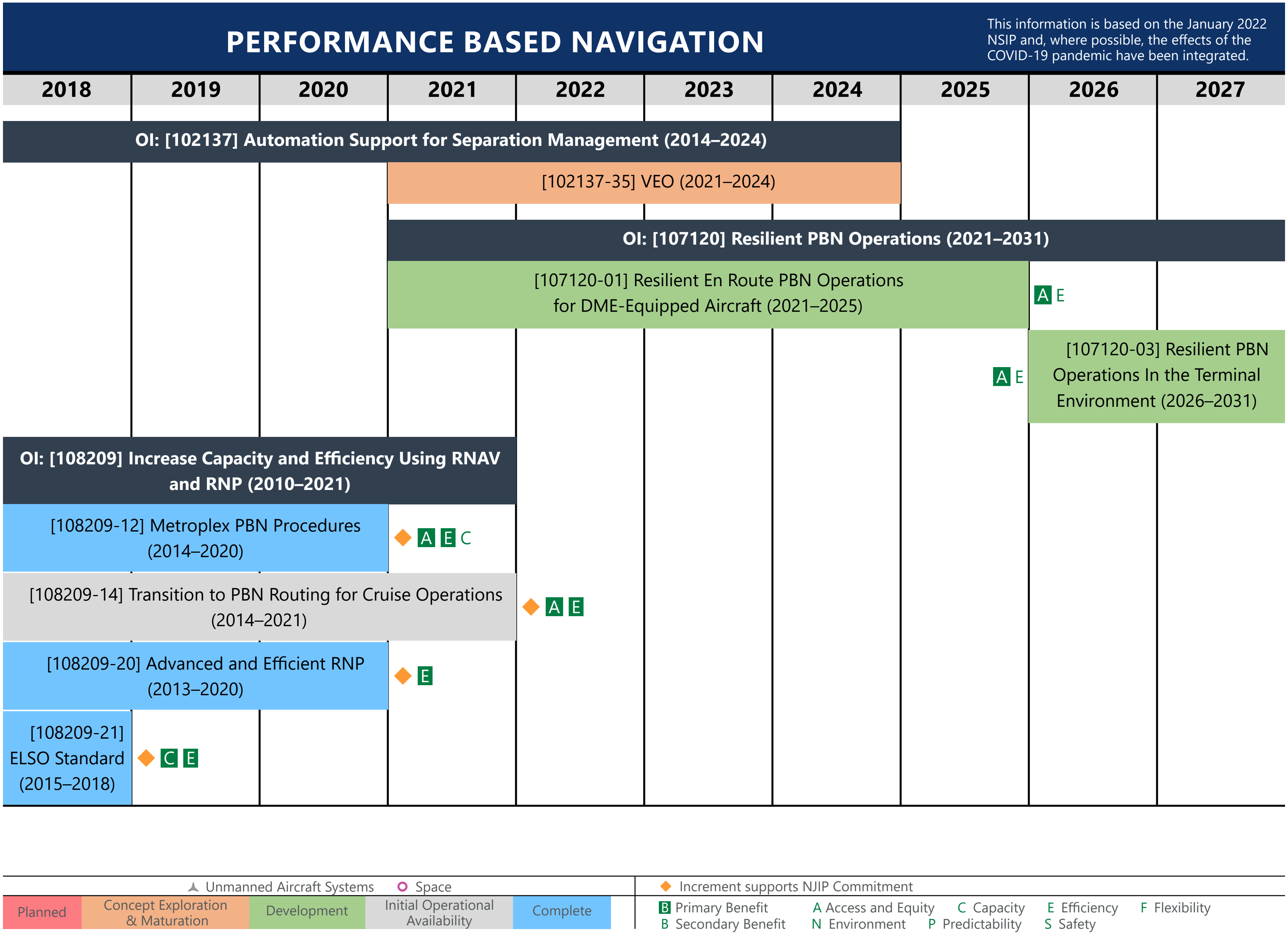
2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	OI: [102161] Improved Parallel Runway Operations for Departures (2019–2023)								
	[102161-01] Dependent Stagger Departures for CSPO (2019–2023)					C E			
	[102161-02] Further Reductions to Departure Divergence Requirements for CSPO (2019–2023)					C E			
	[102161-03] Decreased Separation Requirements for Mixed Operations on CSPR (2019–2023)					C E			

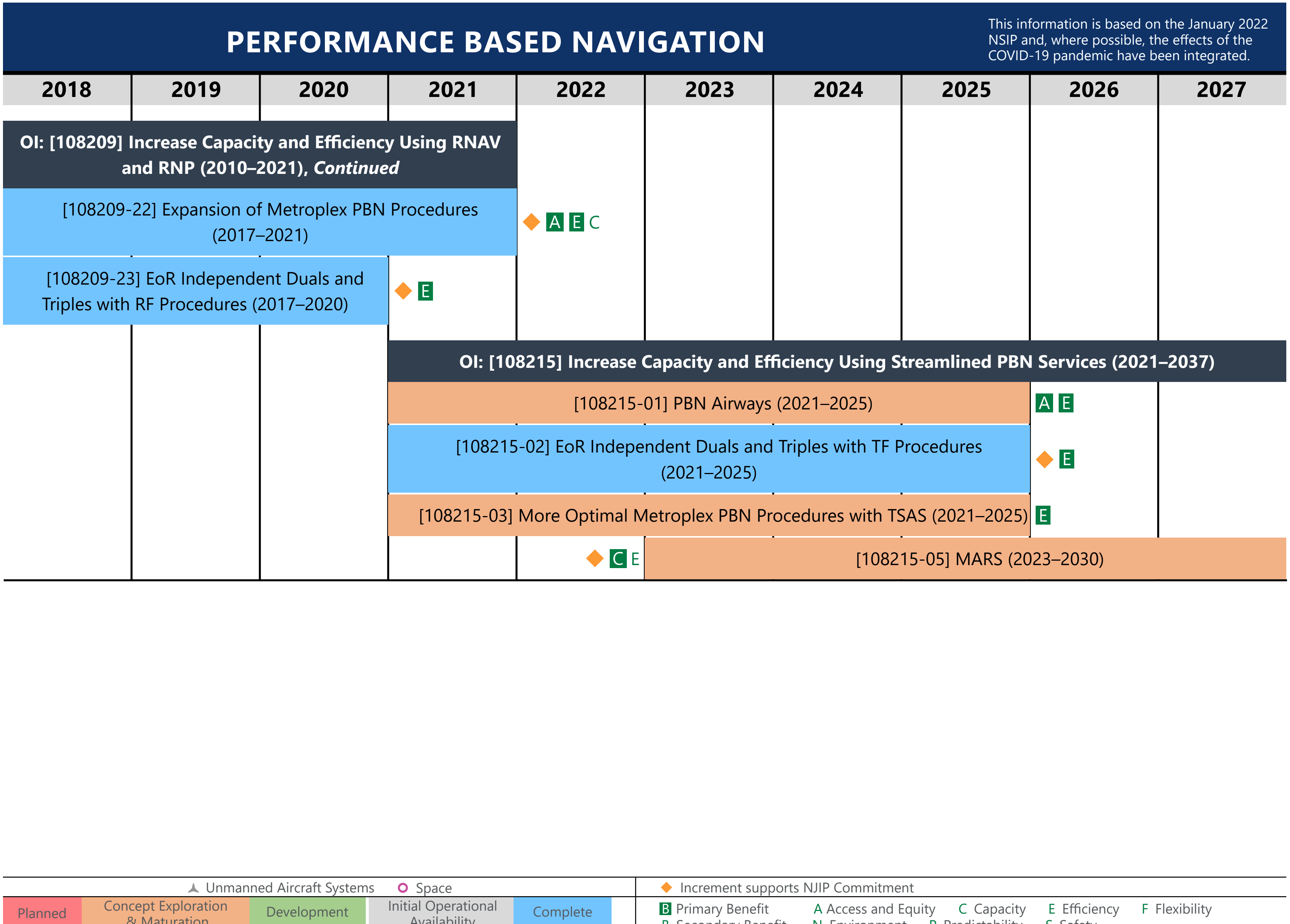
⅄ Unmanned Aircraft Systems ○ Space

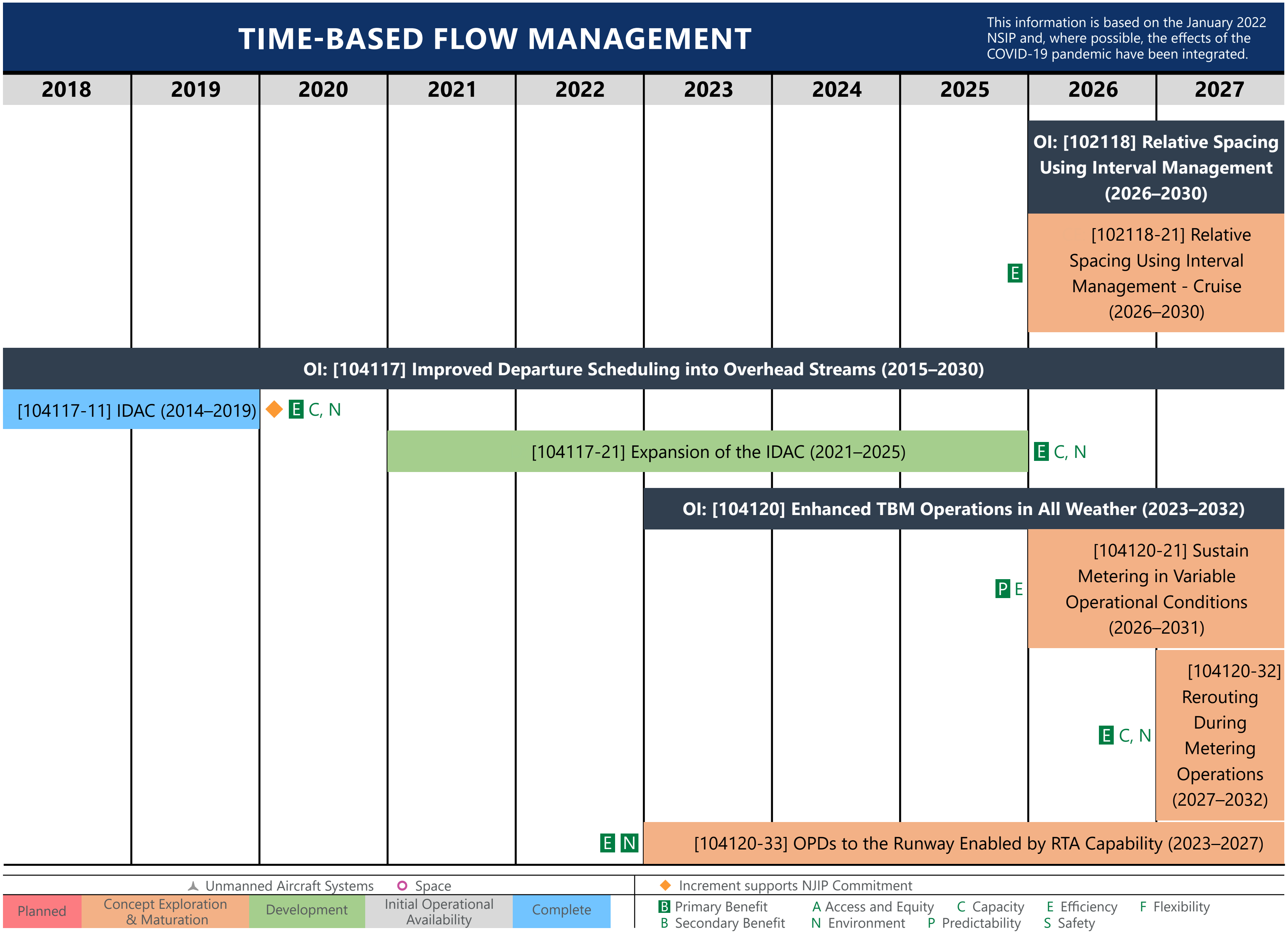
◆ Increment supports NJIP Commitment

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

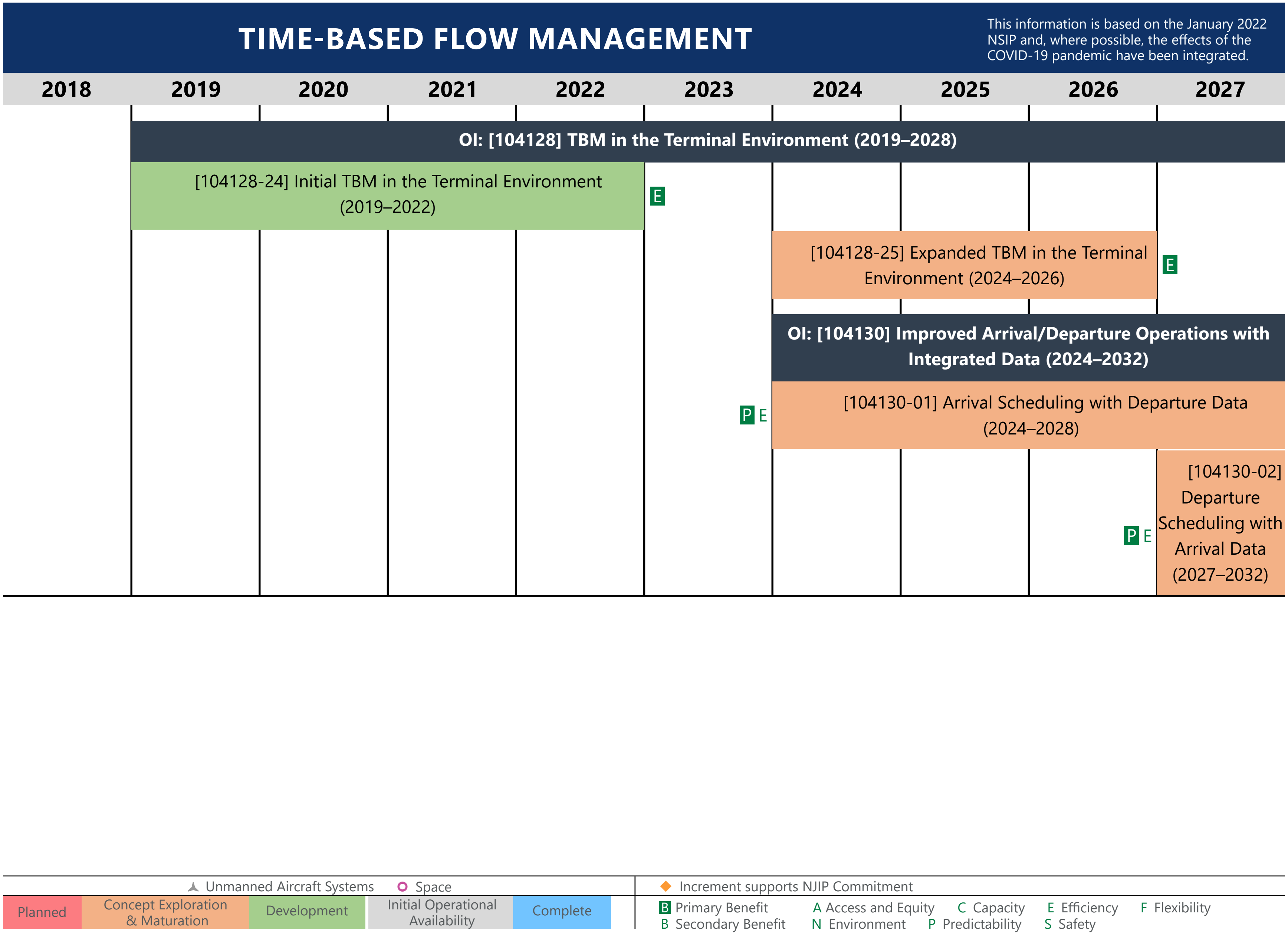
B Primary Benefit · B Secondary Benefit · A Access and Equity · N Environment · C Capacity · P Predictability · E Efficiency · S Safety · F Flexibility


PERFORMANCE BASED NAVIGATION
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [102137] Automation Support for Separation Management (2014–2024)
[102137-35] VEO (2021–2024)
OI: [107120] Resilient PBN Operations (2021–2031)
[107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021–2025)
A E
A E
[107120-03] Resilient PBN Operations In the Terminal Environment (2026–2031)
OI: [108209] Increase Capacity and Efficiency Using RNAV and RNP (2010–2021)
[108209-12] Metroplex PBN Procedures (2014–2020)
A E C
[108209-14] Transition to PBN Routing for Cruise Operations (2014–2021)
A E
[108209-20] Advanced and Efficient RNP (2013–2020)
E
[108209-21] ELSO Standard (2015–2018)
C E
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
S Safety
F Flexibility


PERFORMANCE BASED NAVIGATION
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [108209] Increase Capacity and Efficiency Using RNAV and RNP (2010–2021), Continued
[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
OI: [108215] Increase Capacity and Efficiency Using Streamlined PBN Services (2021–2037)
[108215-01] PBN Airways (2021–2025)
A E
[108215-02] EoR Independent Duals and Triples with TF Procedures (2021–2025)
E
[108215-03] More Optimal Metroplex PBN Procedures with TSAS (2021–2025)
E
C E
[108215-05] MARS (2023–2030)
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operational Availability
Complete
B Primary Benefit
B Secondary Benefit
A Access and Equity
N Environment
C Capacity
P Predictability
E Efficiency
S Safety
F Flexibility



TIME-BASED FLOW MANAGEMENT
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [102118] Relative Spacing Using Interval Management (2026–2030)
[102118-21] Relative Spacing Using Interval Management - Cruise (2026–2030)
E
OI: [104117] Improved Departure Scheduling into Overhead Streams (2015–2030)
[104117-11] IDAC (2014–2019)
E C, N
[104117-21] Expansion of the IDAC (2021–2025)
E C, N
OI: [104120] Enhanced TBM Operations in All Weather (2023–2032)
[104120-21] Sustain Metering in Variable Operational Conditions (2026–2031)
P E
[104120-32] Rerouting During Metering Operations (2027–2032)
E C, N
[104120-33] OPDs to the Runway Enabled by RTA Capability (2023–2027)
E 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
N Environment
C Capacity
P Predictability
E Efficiency
S Safety
F Flexibility


TIME-BASED FLOW MANAGEMENT
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [104128] TBM in the Terminal Environment (2019–2028)
[104128-24] Initial TBM in the Terminal Environment (2019–2022)
E
[104128-25] Expanded TBM in the Terminal Environment (2024–2026)
E
OI: [104130] Improved Arrival/Departure Operations with Integrated Data (2024–2032)
P E
[104130-01] Arrival Scheduling with Departure Data (2024–2028)
P E
[104130-02] Departure Scheduling with Arrival Data (2027–2032)
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
S Safety
F Flexibility

TIME-BASED FLOW MANAGEMENT

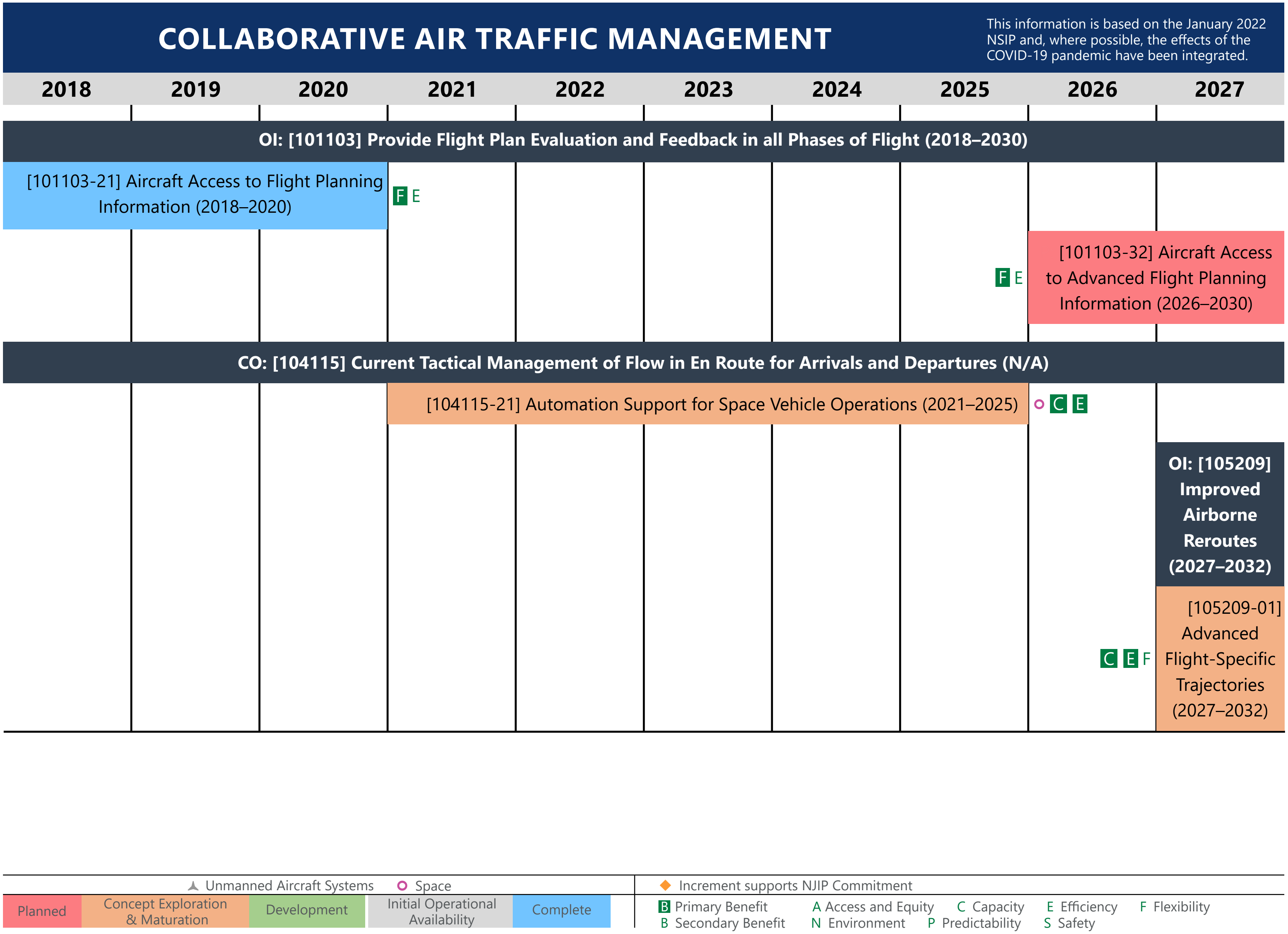
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

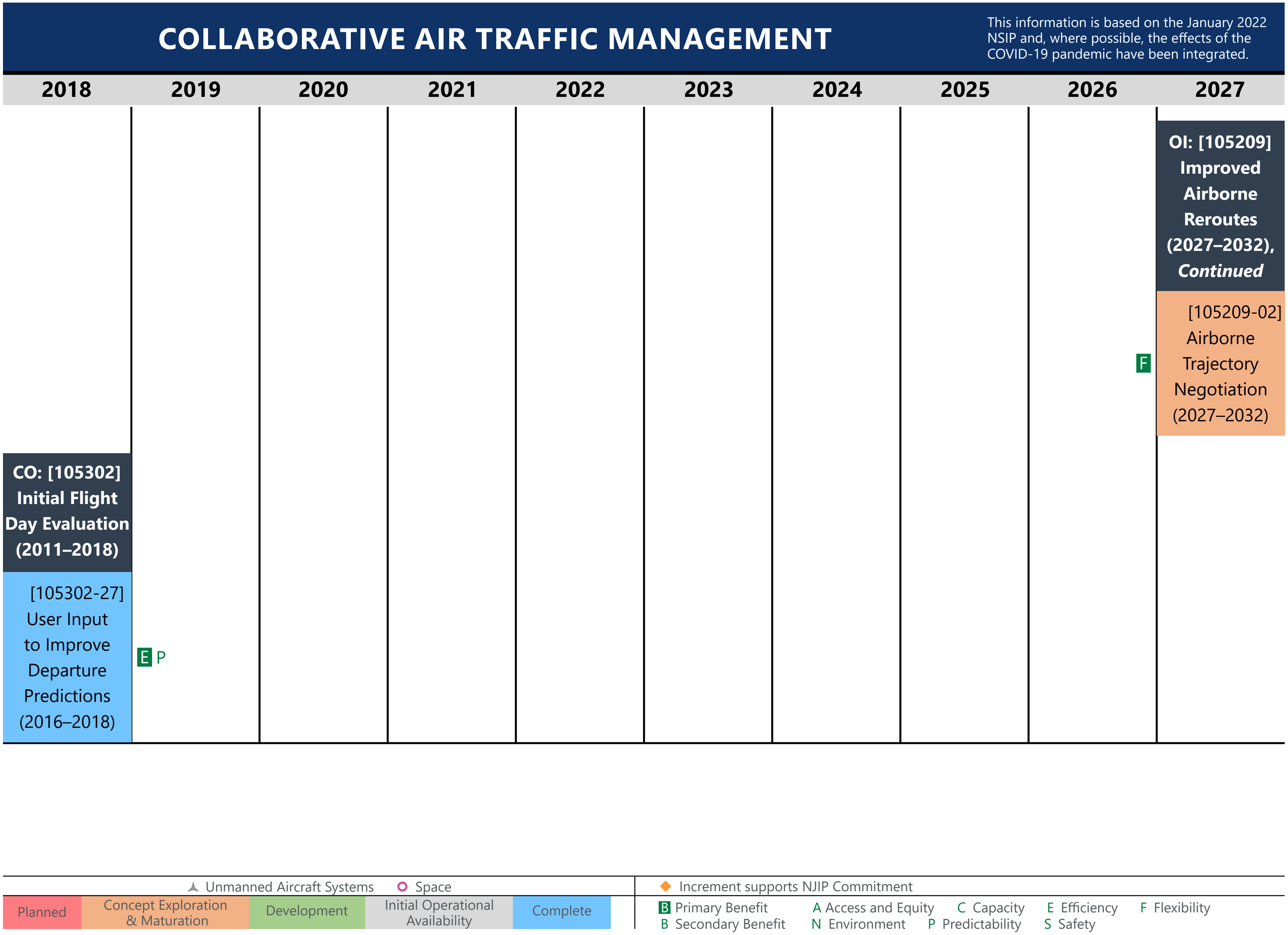
2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
									OI: [104131] Improved Arrival Metering Operations (2027–2035)
									E [104131-02] Meet TBM Constraints Using RTA Capability (2027–2032)

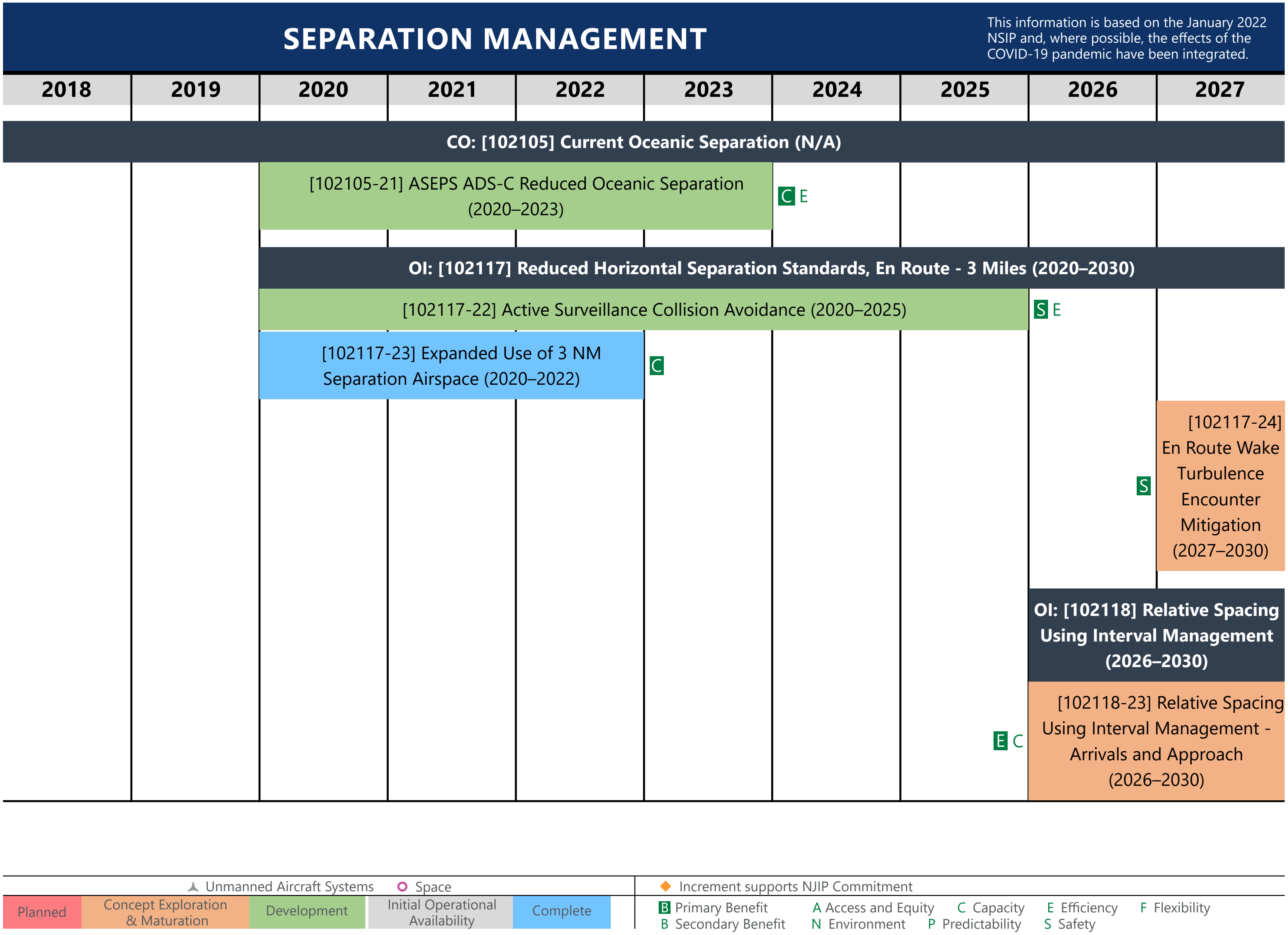
Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

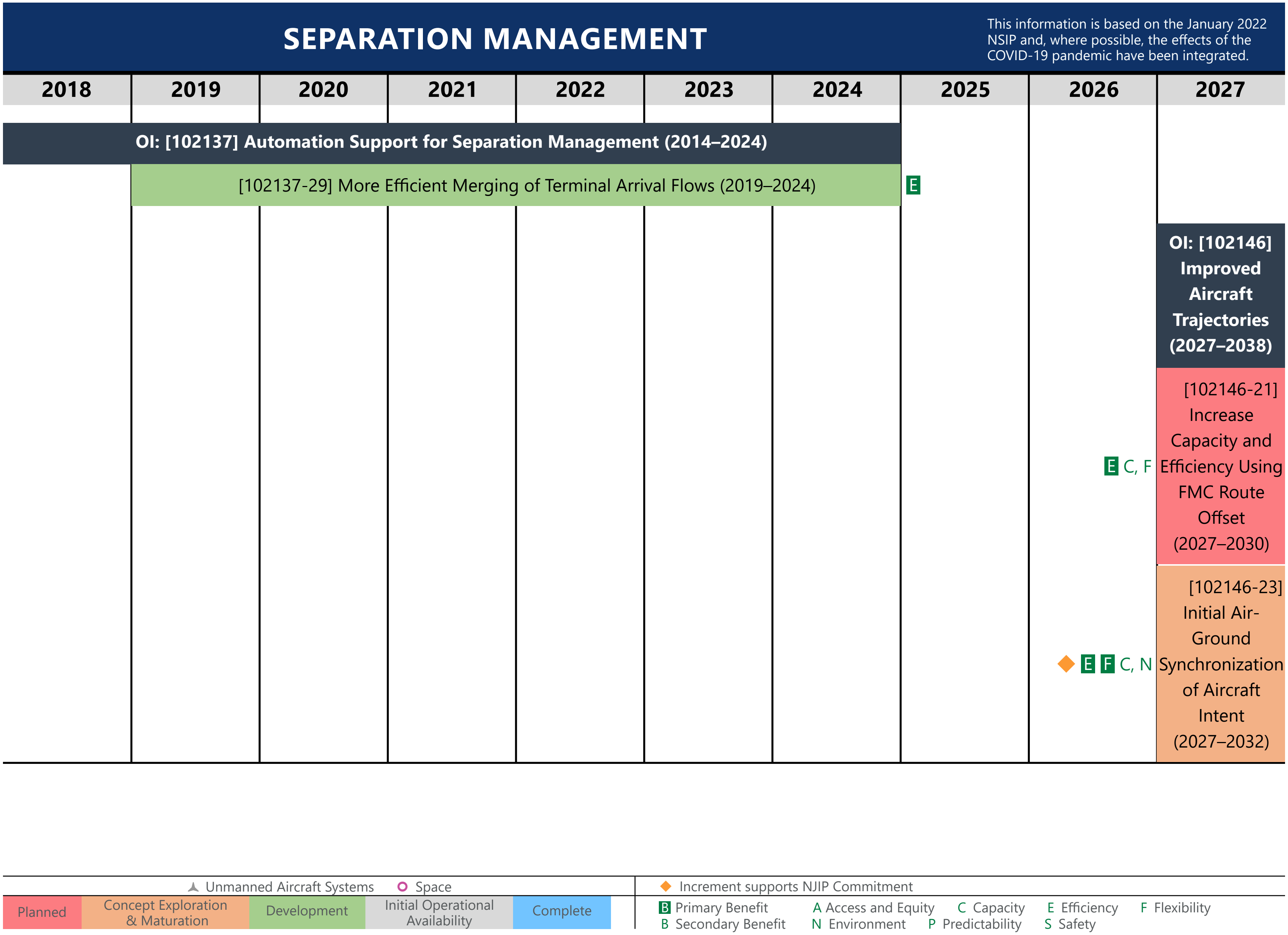
Planned | Concept Exploration & Maturation | Development | Initial Operational Availability | Complete

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


COLLABORATIVE AIR TRAFFIC MANAGEMENT
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [101103] Provide Flight Plan Evaluation and Feedback in all Phases of Flight (2018–2030)
[101103-21] Aircraft Access to Flight Planning Information (2018–2020)
F E
[101103-32] Aircraft Access to Advanced Flight Planning Information (2026–2030)
F E
CO: [104115] Current Tactical Management of Flow in En Route for Arrivals and Departures (N/A)
[104115-21] Automation Support for Space Vehicle Operations (2021–2025)
C E
OI: [105209] Improved Airborne Reroutes (2027–2032)
[105209-01] Advanced Flight-Specific Trajectories (2027–2032)
C E F
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
S Safety
F Flexibility

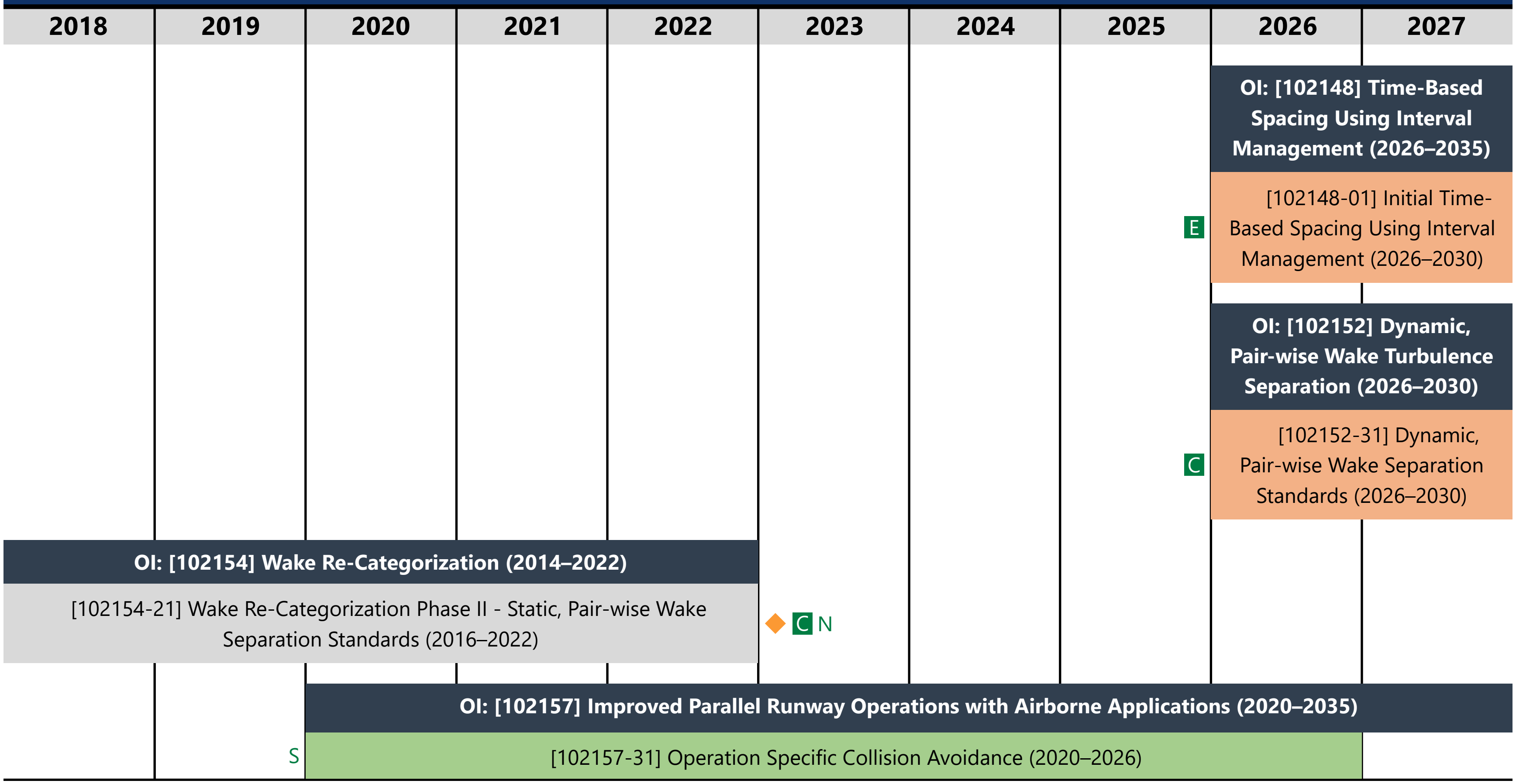

COLLABORATIVE AIR TRAFFIC MANAGEMENT
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [105209] Improved Airborne Reroutes (2027–2032), Continued
[105209-02] Airborne Trajectory Negotiation (2027–2032)
F
CO: [105302] Initial Flight Day Evaluation (2011–2018)
[105302-27] User Input to Improve Departure Predictions (2016–2018)
E P
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
S Safety
F Flexibility


SEPARATION MANAGEMENT
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
CO: [102105] Current Oceanic Separation (N/A)
[102105-21] ASEPS ADS-C Reduced Oceanic Separation (2020–2023)
C E
OI: [102117] Reduced Horizontal Separation Standards, En Route - 3 Miles (2020–2030)
[102117-22] Active Surveillance Collision Avoidance (2020–2025)
S E
[102117-23] Expanded Use of 3 NM Separation Airspace (2020–2022)
C
[102117-24] En Route Wake Turbulence Encounter Mitigation (2027–2030)
S
OI: [102118] Relative Spacing Using Interval Management (2026–2030)
[102118-23] Relative Spacing Using Interval Management - Arrivals and Approach (2026–2030)
E C
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
S Safety
F Flexibility


SEPARATION MANAGEMENT
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [102137] Automation Support for Separation Management (2014–2024)
[102137-29] More Efficient Merging of Terminal Arrival Flows (2019–2024)
E
OI: [102146] Improved Aircraft Trajectories (2027–2038)
E C, F
[102146-21] Increase Capacity and Efficiency Using FMC Route Offset (2027–2030)
E F C, N
[102146-23] Initial Air-Ground Synchronization of Aircraft Intent (2027–2032)
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
S Safety
F Flexibility

SEPARATION MANAGEMENT

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.



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 S Safety F Flexibility

SEPARATION MANAGEMENT

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027

OI: [102158] Automated Support for Initial Trajectory Negotiation (2019–2029)

- ◆ C E, F, S — [102158-03] Enhanced En Route Data Comm Services (2026–2029)

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

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

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 | S Safety | F Flexibility

SEPARATION MANAGEMENT

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
									OI: [102160] Advanced Automation Support for Separation Management (2027–2032)
								S	[102160-01] En Route Separation Tools to Support PBN Routes (2027–2030)
								C S	[102160-02] Controller Tools for Managing Advanced Wake Separation Standards (2027–2032)

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 | C Capacity | E Efficiency | F Flexibility | N Environment | P Predictability | S Safety

SEPARATION MANAGEMENT

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027

OI: [102160] Advanced Automation Support for Separation Management (2027–2032), *Continued*

E C, S — [102160-03] Separation Management Tools to Increase PBN Procedure Utilization (2027–2030)

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

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

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

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

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

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

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

SEPARATION MANAGEMENT

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027

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

- E — [104102-37] Improved Oceanic Weather Routes (2027–2032)

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

- E A — [108212-22] Increased Utilization of SAAs in En Route Airspace (2027–2030)

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

- [108214-01] UAS Airspace Access when Operating within Visual Line of Sight (2017–2018) — Unmanned Aircraft Systems, S
- Unmanned Aircraft Systems, S — [108214-02] UAS Airspace Access when Operating Beyond Visual Line of Sight (2020–2024)

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 | S Safety | F Flexibility

ON-DEMAND NAS INFORMATION

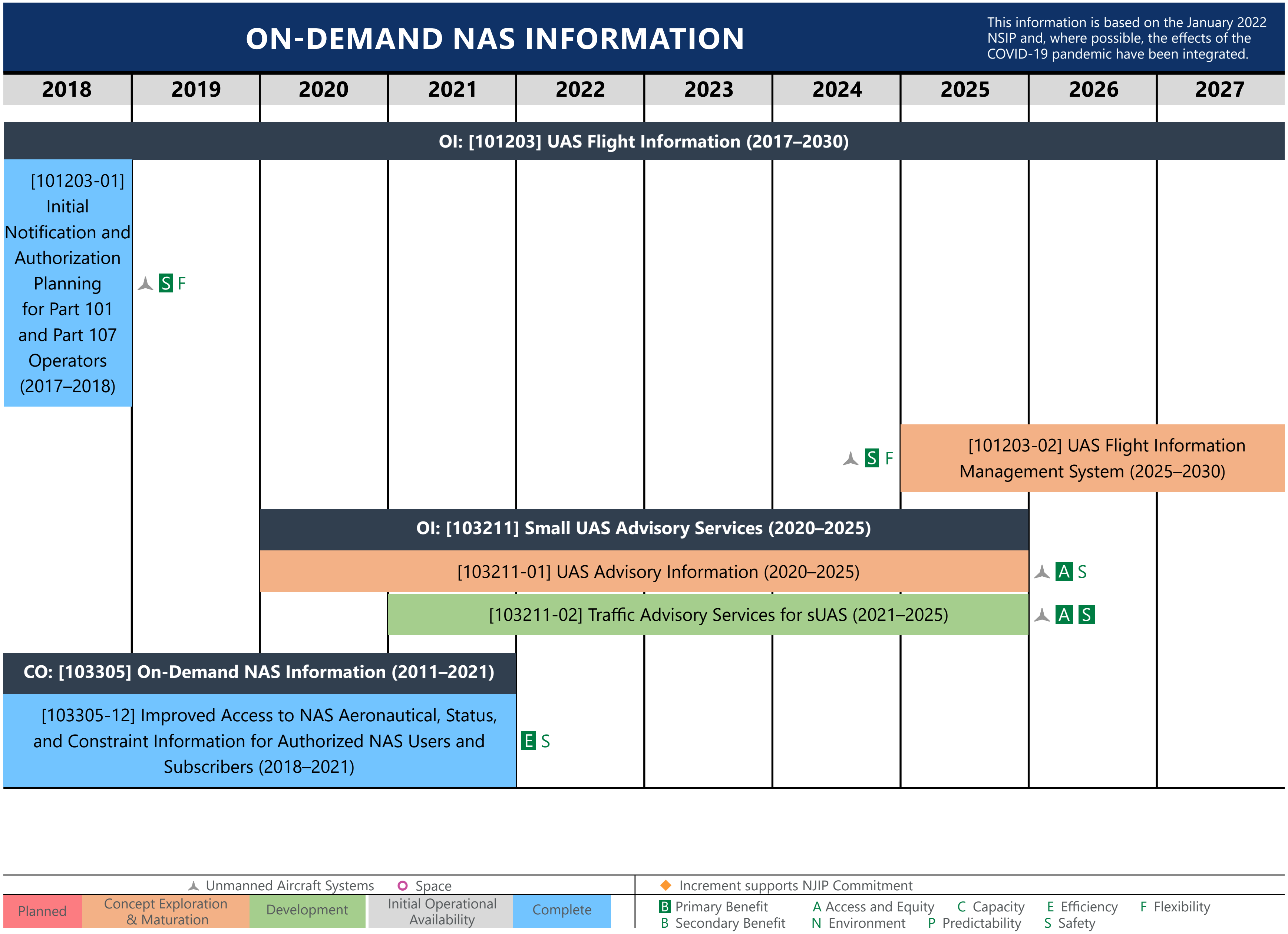
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

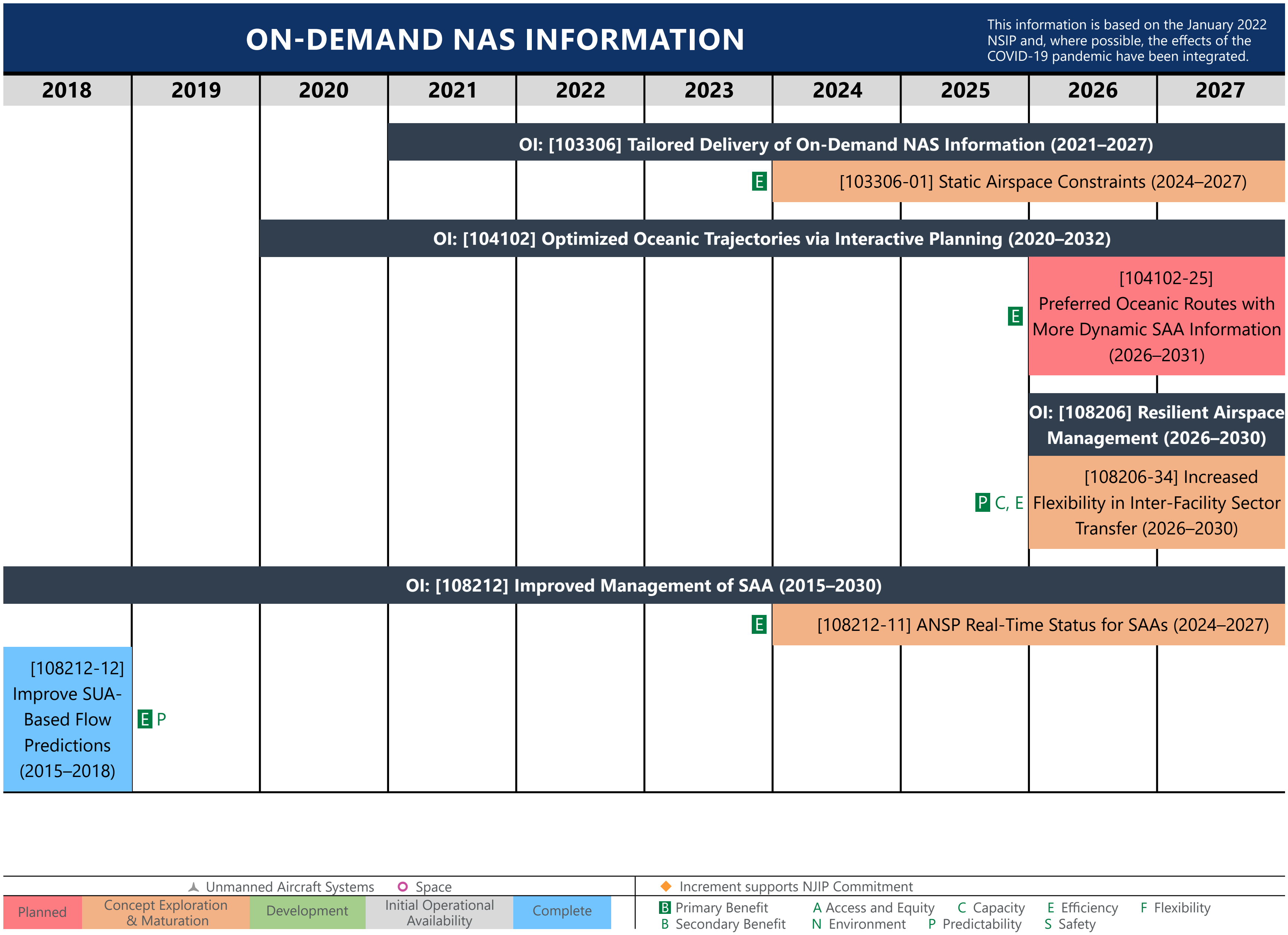
2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
								OI: [101104] Provide Automated Flight Plan Constraint Evaluation with Feedback (2026–2032)	
							E	[101104-21] Constraint Evaluation Feedback (2026–2030)	
									OI: [101202] Flight Management with Trajectory (2027–2035)
								E	[101202-23] Extended Flight Planning Horizon (2027–2032)

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 · S Safety · F Flexibility


ON-DEMAND NAS INFORMATION
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [101203] UAS Flight Information (2017–2030)
[101203-01] Initial Notification and Authorization Planning for Part 101 and Part 107 Operators (2017–2018)
S F
[101203-02] UAS Flight Information Management System (2025–2030)
S F
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
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
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
S Safety
F Flexibility


ON-DEMAND NAS INFORMATION
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [103306] Tailored Delivery of On-Demand NAS Information (2021–2027)
E
[103306-01] Static Airspace Constraints (2024–2027)
OI: [104102] Optimized Oceanic Trajectories via Interactive Planning (2020–2032)
E
[104102-25] Preferred Oceanic Routes with More Dynamic SAA Information (2026–2031)
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 (2024–2027)
[108212-12] Improve SUA-Based Flow Predictions (2015–2018)
E P
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
S Safety
F Flexibility

ON-DEMAND NAS INFORMATION

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
OI: [108212] Improved Management of SAA (2015–2030), *Continued*									
[108212-21] Improved Access to SAA Information (2018–2022)					E P				
					E	[108212-24] Planned Airspace Constraints (2024–2027)			

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

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

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

ENVIRONMENT AND ENERGY

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

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

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

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

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

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

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

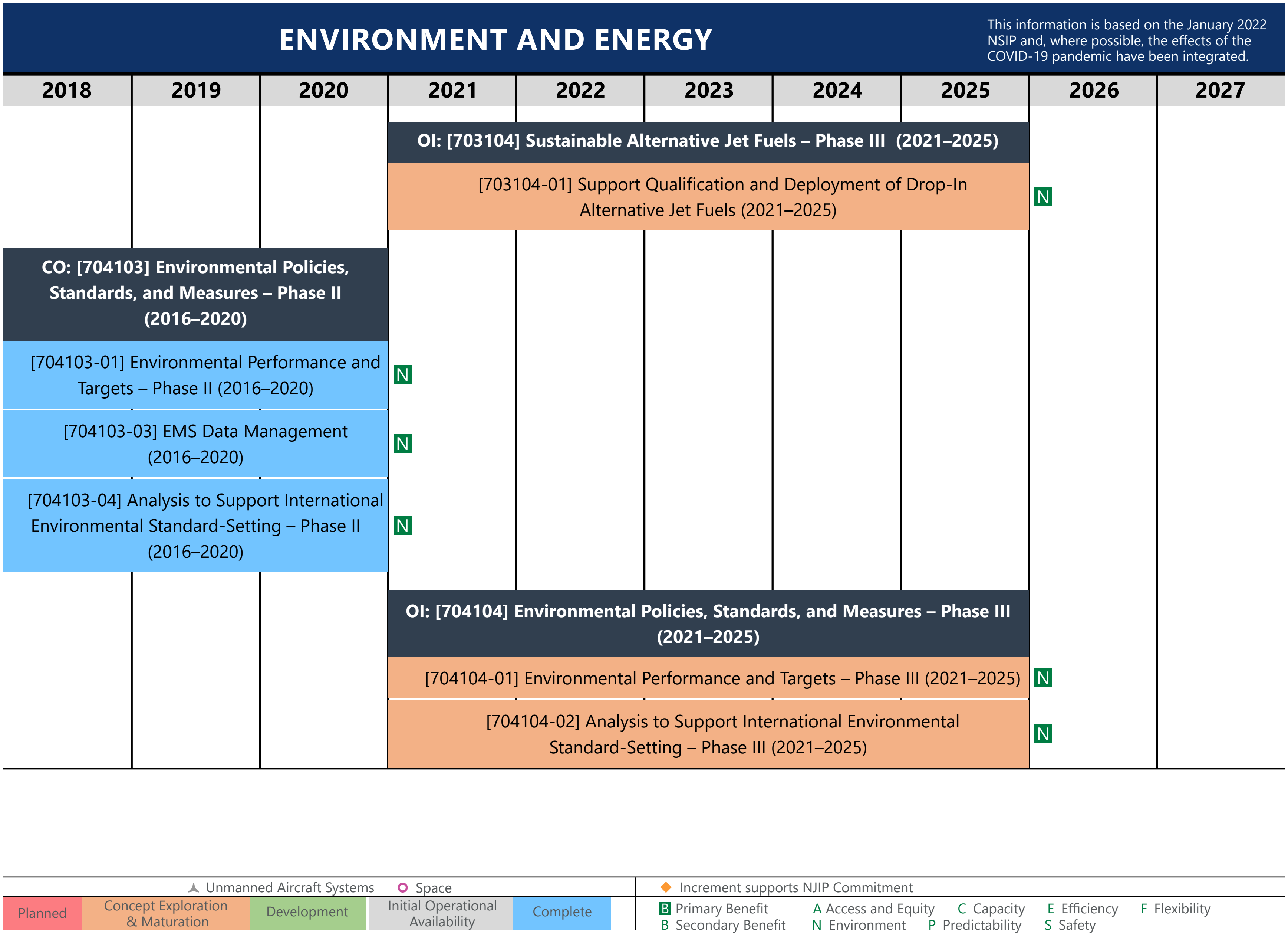
[703103-01] Other Advanced Drop-In Aviation Alternative Jet Fuels – Phase II (2016–2020) N

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

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 | S Safety | F Flexibility


ENVIRONMENT AND ENERGY
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [703104] Sustainable Alternative Jet Fuels – Phase III (2021–2025)
[703104-01] Support Qualification and Deployment of Drop-In Alternative Jet Fuels (2021–2025)
N
CO: [704103] Environmental Policies, Standards, and Measures – Phase II (2016–2020)
[704103-01] Environmental Performance and Targets – Phase II (2016–2020)
N
[704103-03] EMS Data Management (2016–2020)
N
[704103-04] Analysis to Support International Environmental Standard-Setting – Phase II (2016–2020)
N
OI: [704104] Environmental Policies, Standards, and Measures – Phase III (2021–2025)
[704104-01] Environmental Performance and Targets – Phase III (2021–2025)
N
[704104-02] Analysis to Support International Environmental Standard-Setting – Phase III (2021–2025)
N
Unmanned Aircraft Systems
Space
Increment supports NJIP Commitment
Planned
Concept Exploration & Maturation
Development
Initial Operational Availability
Complete
B Primary Benefit
B Secondary Benefit
A Access and Equity
N Environment
C Capacity
P Predictability
E Efficiency
S Safety
F Flexibility

SYSTEM SAFETY MANAGEMENT

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027

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
- [601104-03] Expanded Analytical Capabilities to Include New Entrants (2022–2025) S
- [601104-04] Vulnerability Discovery through Automated Outlier Detection (2022–2025) S

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 | S Safety | F Flexibility

SYSTEM SAFETY MANAGEMENT

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
OI: [601202] Integrated Safety Analysis and Modeling (2014–2025)									
[601202-01] Automated Operational Anomaly Detection, Analysis and Forecasting Models (2014–2018)	S								
[601202-03] Tailored, Domain-Specific Baseline and Predictive Risk Models (NextGen Portfolio Support) (2015–2018)	S								

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

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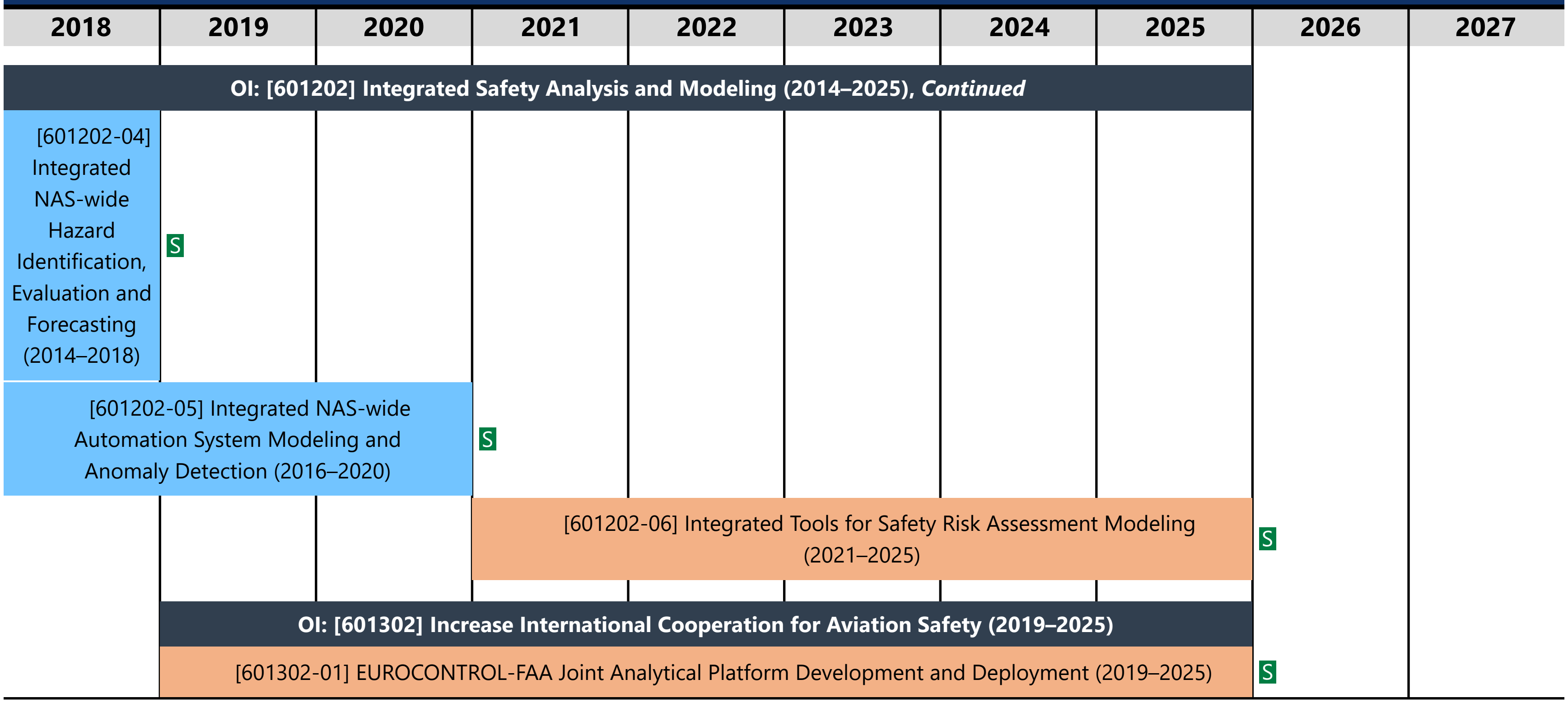
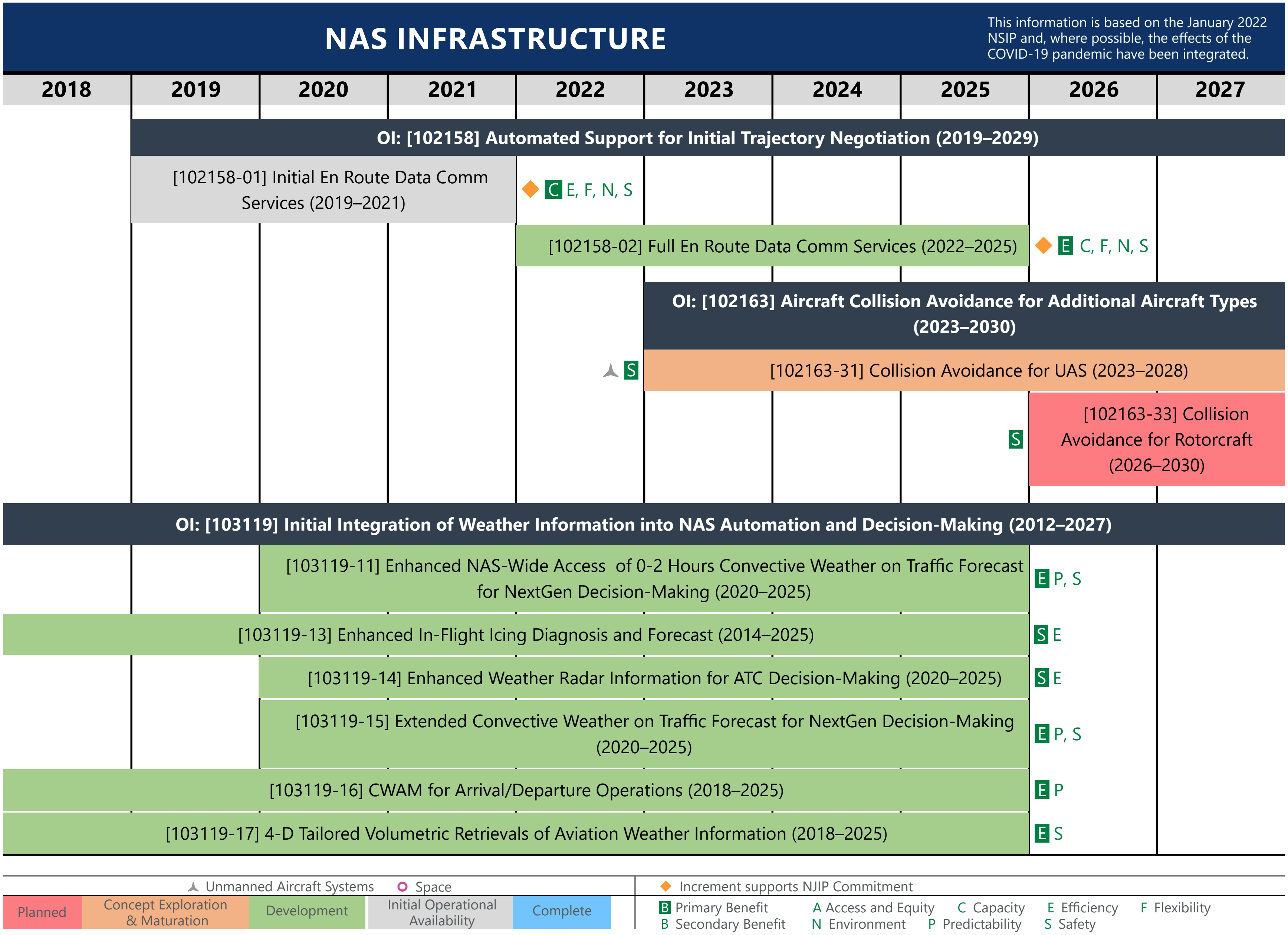


Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

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 | S Safety | F Flexibility


NAS INFRASTRUCTURE
This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
OI: [102158] Automated Support for Initial Trajectory Negotiation (2019–2029)
[102158-01] Initial En Route Data Comm Services (2019–2021)
C E, F, N, S
[102158-02] Full En Route Data Comm Services (2022–2025)
E C, F, N, S
OI: [102163] Aircraft Collision Avoidance for Additional Aircraft Types (2023–2030)
S
[102163-31] Collision Avoidance for UAS (2023–2028)
S
[102163-33] Collision Avoidance for Rotorcraft (2026–2030)
OI: [103119] Initial Integration of Weather Information into NAS Automation and Decision-Making (2012–2027)
[103119-11] Enhanced NAS-Wide Access of 0-2 Hours Convective Weather on Traffic Forecast for NextGen Decision-Making (2020–2025)
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
[103119-17] 4-D Tailored Volumetric Retrievals of Aviation Weather Information (2018–2025)
E S
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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P Predictability
E Efficiency
S Safety
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NAS INFRASTRUCTURE

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

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

- [103119-18] Enhanced Turbulence Forecast and Graphical Guidance (2018–2025) — S E
- [103119-19] Enhanced Ceiling and Visibility Analysis (2012–2025) — E S
- [103119-21] Enhanced Convective Weather Using Satellite-Based Observation in Offshore Oceanic Airspace (2017–2027) — E P, S

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

- E S — [103123-01] Severe Weather to Aircraft Notification (2021–2027)
- E — [103123-02] Net-Enabled Access to NextGen Common Weather Information Source – Enhanced (2025–2030)
- E C, S — [103123-03] Enhanced Icing Information (2021–2026)
- E C, S — [103123-04] Expanded Turbulence Information (2021–2027)
- E — [103123-05] Generation of Enhanced NextGen Weather Information – Extended (2021–2027)
- E S — [103123-06] Expanded Ceiling and Visibility Information (2021–2026)

Unmanned Aircraft Systems | Space | Increment supports NJIP Commitment

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

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NAS INFRASTRUCTURE

This information is based on the January 2022 NSIP and, where possible, the effects of the COVID-19 pandemic have been integrated.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027

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

- E — [103123-07] Enhanced Weather Products from Improved Satellite Observation Data (2023–2027)
- E S — [103123-08] Enhanced Automated Winter Weather Information (2026–2030)
- Space, E S — [103123-09] Space Weather Information (2023–2026)
- [103123-10] Improved Terminal Precipitation on the Glass (2021–2026)

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

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

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Trajectory Based Operations

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

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

NextGen's path to TBO (Figure A-3) integrates the following capabilities that are grouped into five themes:

- Infrastructure: Improvements to communications, navigation, surveillance, automation, and information exchange infrastructure implemented over the past decade. The FAA will continue to introduce new capabilities and enhance existing technologies in these areas to fully implement TBO.

- Integrated Arrivals: Operational changes focused on the arrival phase of the operation, including navigation procedures and time-based management capabilities required for TBO. Future enhancements to time-based metering capabilities are already planned to further improve interaction of time-based metering with other traffic management initiatives, resulting in the smooth flow of traffic and more efficient use of airspace. Currently, standard terminal arrival procedures with an optimized profile descent and the Established on RNP separation standard are already available in the NAS.

- Integrated Departures: Operational changes at the airport and in the departure phase of the flight, including navigation procedures and time-based management capabilities, are necessary for TBO. Departures enabled by PBN and Data Communications (Data Comm) for departure clearances are available at many busy airports, including the Integrated Departure/Arrival capability which automates the process of monitoring departure demand and identification of departure slots. Additionally, clearance improvements for surface metering and electronic flight data are being planned that will further improve collaborative decision-making between the FAA and aircraft operators.

- Advanced Trajectory Management: Operational changes focused on strategic and tactical management of aircraft trajectories. This includes operational changes planned for traffic management synchronization across the NAS. With improved strategic flight planning offered by the Traffic Flow Management System and System Wide Information Management in place, we will improve how we manage flights. The FAA has also improved the access to advanced flight planning information via the initial en route services capability for Data Comm; additional services are currently in development.

- Dynamic: Operational changes envisioned for the final phase of TBO are in the earliest stages of planning and concept development. Concepts being explored include the operational use of dynamic wake separation and interval management, an Automated Dependent Surveillance Broadcast In application.

Path to TBO

TBO implementation will evolve over time in a phased approached that targets geographical areas such as the Northeast, Northwest Mountain, Southwest, and Mid-Atlantic regions. This phased approach ensures that air traffic control facilities receive the right capabilities for their needs in the best sequence and at the correct time.

As the FAA extends TBO to new areas, we will choose from the available capabilities at the time of deployment.

Roadmap to TBO

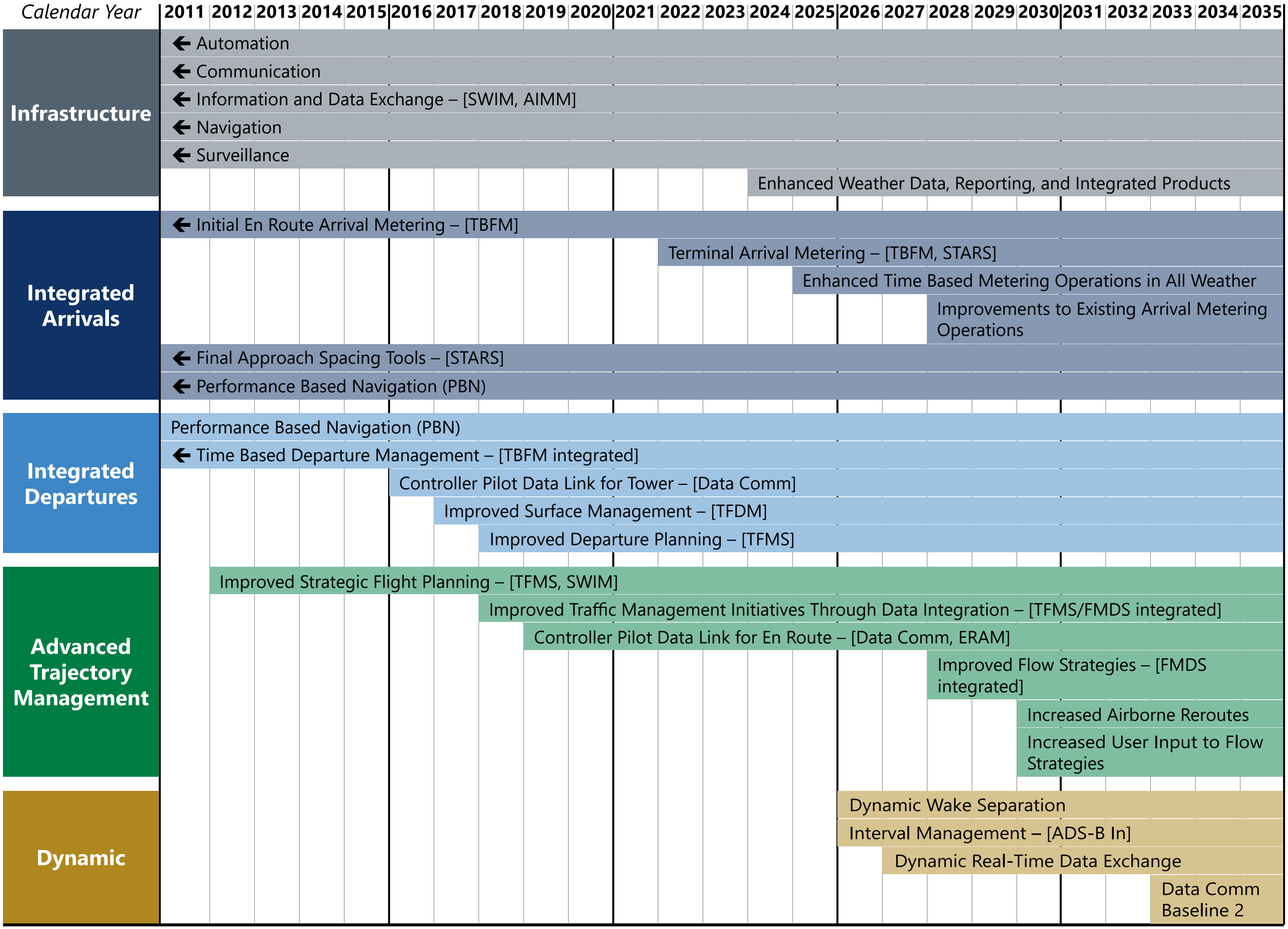

Figure A-4: The integrated TBO capability will deliver the envisioned operational improvement. The capabilities in the shaded boxes represent when additional features will be available. Black left arrows to the left side of the chart indicate the initial capability was deployed before 2011.

2022 and Beyond

NextGen enables a more flexible, robust, and resilient aerospace infrastructure via a series of interlinked programs, portfolios, systems, policies, and procedures that fundamentally change aviation communications, navigation, and surveillance. FAA continues to prepare for a challenging and exciting future by implementing new technologies and air traffic control procedures that transform how we communicate, navigate, and track aircraft in our nation’s skies.

APPENDIX B

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

4-D	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
ACM	Adjacent Center Metering
ACS	Aeronautical Common Services
ACSS	Aviation Communication & Surveillance Systems
ADS-B	Automatic Dependent Surveillance–Broadcast
AEFS	Advanced Electronic Flight Strips
AFP	Airspace Flow Program
AI	Artificial Intelligence
AIMM	Aeronautical Information Management Modernization
API	Application Programming Interface

ARMT	Airport Resource Management Tool
ASAIC	Airport Surface Anomaly Investigation Capability
ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air Traffic Control
ATM	Air Traffic Management
AWI	Air Traffic Management Weather Integration
BVLOS	Beyond Visual Line of Sight
CACR	Collaborative Airspace Constraint Resolution
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
CS	Coupled Scheduling
CSP	Constraint Satisfaction Point

CSPO	Closely Spaced Parallel Operations
CSS-FD	Common Support Services–Flight Data
CSS-Wx	Common Support Services–Weather
CTOP	Collaborative Trajectory Options Program
Data Comm	Data Communications
DISCVR	Drone Information for Safety, Compliance, Verification, and Reporting
DME	Distance Measuring Equipment
DRAW	Dynamic Routes for Arrival in Weather
DSP	Departure Spacing Program
EA	Enterprise Architecture
EDC	En Route Departure Capability
EFSTS	Electronic Flight Strip Transfer System
ELSO	Equivalent Lateral Spacing Operations
EoR	Established on Required Navigation Performance
ERAM	En Route Automation Modernization
ETM	Upper Class E Traffic Management
FAA	Federal Aviation Administration
FD-CDM	Flight Deck Collaborative Decision-Making

FF-ICE	Flight and Flow Information for a Collaborative Environment
FIM	Flight Deck Interval Management
FIMS	Flight Information Management System
FMDS	Flow Management and Data Services
FMS	Flight Management System
GIM-S	Ground Interval Management–Spacing
GRAIN	Global Resilient Aviation Interoperable Network
IAM	Identity and Access Management
ICAO	International Civil Aviation Organization
ICN	Info-Centric NAS
IDAC	Integrated Departure/Arrival Capability
IFP	Instrument Flight Procedure
ILS	Instrument Landing System
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
LOA	Letter of Agreement
MARS	Multiple Airport Route Separation
ML	Machine Learning
MVP	Minimum Viable Product
NAC	NextGen Advisory Committee
NAS	National Airspace System
NCR	NAS Common Reference
NEC	Northeast Corridor
NEMS	NAS Enterprise Messaging Service
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

PDRR	Pre-departure Rerouting Capability
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
SMA	Surface Movement Advisor
SMS	Safety Management System
SPA	Surveillance Portfolio Analysis
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
TaFR	Tailored Flight Rules
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
TSAS	Terminal Sequencing and Spacing
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems
UDP	Unified Delay Program
UTM	UAS Traffic Management
WFI	Weather Forecast Improvement
WVSS	Wake Vortex Safety System
XM	Extended Metering
xTM	Extensible Traffic Management

U.S. Department of Transportation
Federal Aviation Administration

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