



November 2023

AIR TRAFFIC CONTROL MODERNIZATION

Program Management Improvements Could Help FAA Address NextGen Delays and Challenges

GAO Highlights

Highlights of [GAO-24-105254](#), a report to congressional committees

Why GAO Did This Study

NextGen is FAA's multi-decade program to increase the safety and efficiency of air travel by transitioning from a ground-based air-traffic control system that uses radar, to a system based on satellite navigation and digital communications. Through fiscal year 2022, FAA reported spending just over \$14 billion on NextGen. FAA projected that it would cost the federal government and industry at least \$35 billion through 2030.

GAO was asked to examine NextGen progress during the COVID-19 pandemic. Among other objectives, this report 1) describes FAA's progress in meeting NextGen 2018-2022 implementation milestones and how COVID-19 affected that progress and 2) examines the extent to which FAA's efforts to implement NextGen reflect program management leading practices. GAO focused on four critical stakeholder-identified NextGen program areas: navigation, communications, surveillance, and automation. GAO reviewed key NextGen plans, status updates, and performance reports. GAO also interviewed FAA officials and a range of aviation stakeholders to obtain diverse perspectives.

What GAO Recommends

GAO is making four recommendations to improve FAA's management of NextGen. These address five leading practices and include (1) updating NextGen's life-cycle cost estimate and using it to measure performance, and (2) developing a detailed risk mitigation plan to help address challenges to NextGen implementation. FAA concurred with the recommendations.

View [GAO-24-105254](#). For more information, contact Heather Krause at (202) 512-2834 or krauseh@gao.gov.

November 2023

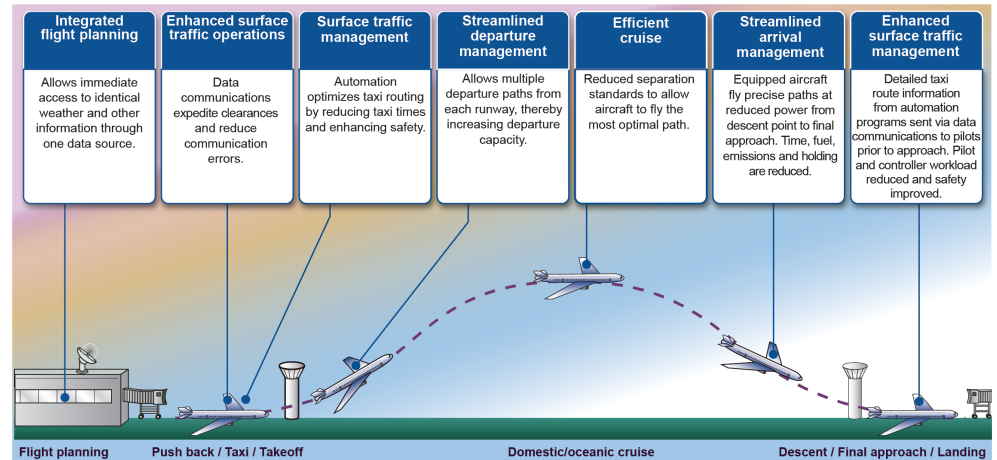
AIR TRAFFIC CONTROL MODERNIZATION

Program Management Improvements Could Help FAA Address NextGen Delays and Challenges

What GAO Found

Since 2018, the Federal Aviation Administration (FAA) made mixed progress meeting milestones in its ongoing effort to modernize air traffic management, known as the Next Generation Air Transportation System (NextGen). This mixed progress, across four critical program areas, has slowed FAA's NextGen efforts to improve the safety and efficiency of air travel and address growing congestion in the national airspace. For example, FAA beat its milestone for deploying more reliable digital communication services at air traffic control towers. However, it did not deploy initial services to all 20 facilities serving en route flights by its September 2021 milestone. As of August 2023, FAA had not completed the deployment of those services at eight en route facilities. FAA also extended milestones for systems to improve flight spacing and sequencing. FAA reported that COVID-19 played a large part in missed milestones, delaying, for example, system testing and training.

Expected Improvements under the Next Generation Air Transportation System



Source: GAO analysis of FAA information. | GAO-24-105254

FAA's efforts to implement NextGen fully or substantially met four leading practices for program management. For example, FAA has a lessons learned database and a program roadmap in line with these practices. However, closer adherence to five other practices could better position the agency to manage the program. For example, the agency has not updated NextGen life-cycle cost estimates since 2017. Doing so could help FAA better assess budget needs and refine annual budget requests, as well as measure its performance against the life-cycle cost estimate. In addition, FAA does not have a NextGen risk mitigation plan that identifies and prioritizes the highest programmatic risks or contains detailed risk alternatives analyses to mitigate identified risks. Such a plan could better equip FAA in its efforts to address the greatest risks and challenges to NextGen.

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Abbreviations

5G	fifth-generation of mobile communication networks
ADS-B	Automatic Dependent Surveillance-Broadcast
ASDE-X	Airport Surface Detection Equipment-Model X
ASSC	Airport Surface Surveillance Capability
ATOP	Advanced Technologies and Oceanic Procedures
Chicago Convention	Article 37 of the Convention on International Civil Aviation
Data Comm	Data Communications
DOT	Department of Transportation
ERAM	En Route Automation Modernization
FAA	Federal Aviation Administration
FMDS	Flow Management Data and Services
FY	fiscal year
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
JRC	Joint Resources Council
NAC	NextGen Advisory Committee
NextGen	Next Generation Air Transportation System
NextGen Implementation Plan	<i>NextGen Implementation Plan 2018-19</i>
OIG	Office of Inspector General
OMB	Office of Management and Budget
PBN	Performance-based Navigation
PIR	post-implementation review

PMI	Project Management Institute
RNAV	Area Navigation
RNP	Required Navigation Performance
Roadmap	National Airspace System Enterprise Architecture Infrastructure Roadmap
SPIRE	Simplified Program Information Reporting and Evaluation
STARS	Standard Terminal Automation Replacement System
SWIM	System Wide Information Management
TAMR	Terminal Automation Modernization and Replacement
TBFM	Time Based Flow Management
TFDM	Terminal Flight Data Manager
TFMS	Traffic Flow Management System
TRACON	Terminal Radar Approach Control
TSAS	Terminal Sequencing and Spacing

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November 9, 2023

The Honorable Sam Graves
Chair
The Honorable Rick Larsen
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Garret Graves
Chair
The Honorable Steve Cohen
Ranking Member
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

The Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration’s (FAA) multi-decade program to increase the safety and efficiency of air travel. It includes the transition from air-traffic control using ground-based radar to a system based on satellite navigation. Full implementation of NextGen requires investment by FAA and the airlines in new technologies and the development of new policies and procedures. To date, NextGen has cost the federal government over \$14 billion, and FAA projected in 2018 that it would cost FAA and industry together at least \$35 billion through 2030.¹

In 2017, we reported that FAA had made progress in implementing some NextGen technologies, such as deploying foundational NextGen systems and other elements of NextGen.² For example, FAA deployed technology in some air-traffic control facilities that allows for more reliable digital communications between air traffic controllers and pilots. FAA also implemented thousands of advanced navigation procedures at some of

¹The \$14 billion reflects FAA’s actual budget for NextGen from fiscal year 2007 through fiscal year 2022, as reported in its Congressional Budget Justification. However, this may not account for all NextGen activities during those years. For example, FAA officials noted that pre-2008, the agency did not identify individual programs and activities as NextGen in its budget documents. FAA estimated in 2018 that NextGen will cost FAA about \$22 billion and will cost industry about \$13 billion by 2030.

²GAO, *Air Traffic Control Modernization: Progress and Challenges in Implementing NextGen*, [GAO-17-450](#) (Washington, D.C.: Aug. 31, 2017).

the nation's busiest airports. However, FAA has stated that additional work is still needed to fully implement these and other elements of NextGen to realize their anticipated safety and efficiency benefits.³

We have also, over the years, reported that FAA's implementation of NextGen has faced a number of challenges, which have contributed to schedule delays.⁴ These challenges include (1) the complexity of software development, (2) additional and unanticipated system requirements, (3) insufficient stakeholder involvement during certain phases of system development, and (4) unanticipated events, such as government shutdowns. The Department of Transportation's (DOT) Office of Inspector General (OIG) has also reported on missed implementation milestones and their effect on achieving NextGen benefits.⁵

Given the challenges that FAA has faced, compounded by the financial toll caused by the COVID-19 pandemic on the U.S. and global aviation industries, you asked us to provide an update on the status of NextGen implementation. This report (1) describes FAA's progress in meeting key NextGen implementation milestones since 2018 and how COVID-19 affected that progress; (2) describes FAA- and stakeholder-identified challenges for FAA's ongoing effort to implement NextGen technologies and systems; and (3) assesses the extent to which FAA's efforts to implement NextGen followed program management leading practices and how these practices could help FAA address identified NextGen challenges.

To describe the status of FAA's NextGen implementation, we used FAA's *NextGen Implementation Plan 2018-19* (NextGen Implementation Plan)—the most recent implementation plan—as the primary baseline to review

³FAA, *NextGen Implementation Plan 2018-19* (Washington, D.C.).

⁴GAO, *Air Traffic Control Modernization: Management Challenges Associated with Program Costs Hinder NextGen Implementation*, [GAO-12-223](#) (Washington, D.C.: Feb. 16, 2012); GAO, *Next Generation Air Transportation System: Progress and Challenges Associated with the Transformation of the National Airspace System*, [GAO-07-25](#) (Washington, D.C.: Nov. 13, 2006).

⁵Department of Transportation, Office of Inspector General, *NextGen Benefits Have Not Kept Pace with Initial Projections, but Opportunities Remain to Improve Future Modernization Efforts*, AV-2021-023 (Washington, D.C.: Mar. 30, 2021).

FAA's progress.⁶ This plan describes FAA's NextGen goals and implementation milestones for four programs and 11 portfolios as of 2018.⁷ From these programs and portfolios, we grouped key systems and capabilities into four program areas (navigation, communications, surveillance, and automation) for our review. We selected these program areas based on past GAO reports and input from selected stakeholders, who identified them as key to achieving the goals of NextGen. We also reviewed FAA budget and planning documents, such as budget estimates and strategic plans, to identify NextGen timelines. We compared individual program status information in these documents with the key milestones in the NextGen Implementation Plan to assess whether FAA met key milestones and how milestones may have changed. We identified implementation milestones as those that included dates that covered the 2018–2022 period; involved the deployment of a system capability, hardware or software upgrade, or navigation procedure; and were identified in our discussions with FAA. For some milestones, we relied on other FAA documents, such as FAA's December 2021 report to Congress and FAA's NextGen status update briefings as well as discussions with FAA officials to further understand how any milestones changed. We also reviewed meeting summaries from FAA's independent advisory body, the NextGen Advisory Committee (NAC).⁸

In addition to reviewing documentation, we interviewed officials from relevant FAA offices, including the NextGen Office and Air Traffic

⁶FAA, *NextGen Implementation Plan 2018-2019* (Washington, D.C.). From 2008 to the onset of the COVID-19 pandemic, FAA generally issued an annual NextGen implementation plan. According to officials, FAA has not issued a new implementation plan, as it continues to assess COVID-19 impacts on planned milestones. The 2018-2019 plan is therefore FAA's most recent NextGen implementation plan.

⁷FAA refers to some parts of the NextGen program as "programs" and to some other parts as "portfolios." These programs and portfolios consist of systems, technologies, policies, and procedures essential for modernizing the national airspace system. We grouped key NextGen systems, technologies, procedures, and other capabilities found in these "programs" and "portfolios" into "program areas" for this report. The program areas include three of the four programs mentioned in the NextGen Implementation Plan. The automation program area includes two NextGen foundational systems as well as major components from three portfolios. The navigation program area is considered a portfolio in the NextGen Implementation Plan. We do not include NextGen's weather and information systems in our scope. We refer to the individual systems, technologies, policies, and procedures within each "program area" as "individual programs" or "projects."

⁸The NAC, established in 2010 under the authority of DOT, provides independent advice and recommendations to FAA regarding NextGen and other efforts FAA is taking to modernize the air-traffic management system. The NAC consists of aviation industry stakeholders. It meets several times a year and reports out on information from FAA on schedule delays and challenges.

Organization, about their work involving the four NextGen program areas. To obtain a range of perspectives on FAA's implementation progress and the potential effects of COVID-19, we also interviewed representatives from nine different industry groups, including MITRE (a non-profit company that manages federally funded research); and aviation industry organizations representing various airlines (both national and regional), general aviation, pilots, aviation technicians, and air traffic controllers that we selected given their role in the development and implementation of NextGen program areas, such as participation in the NAC.⁹

To identify challenges to FAA's NextGen implementation, we reviewed our prior body of NextGen and related aviation work. In addition, we reviewed relevant documents, reports, and meeting summaries from FAA, the DOT OIG, and the NAC as well as interviewed the FAA officials and stakeholders identified above.

To assess FAA's program management practices for NextGen, we reviewed FAA's program management policies and guidelines, including its Acquisition Management System policy and performance reports. We also interviewed agency officials about actions FAA has taken to align with each of the nine leading practices for program management that we identified in prior work. We compared FAA NextGen program management actions to nine leading practices based on the Project Management Institute's (PMI's) standards related to a program's management of scope, cost, schedule performance, and to independent review of performance.¹⁰ The nine leading practices encompass basic principles of program management. With respect to risk management, which is one of the nine leading practices for program management, we also used program management guidance developed by the Office of

⁹General aviation includes most forms of civil aviation that are generally not commercial. The responses from the interviews we conducted were non-generalizable.

¹⁰GAO, *Nuclear Waste Cleanup: DOE Could Improve Program and Project Management by Better Classifying Work and Following Leading Practices*, GAO-19-223 (Washington, D.C.: Feb. 19, 2019). PMI, *The Standard for Program Management*®, Fourth Edition (Newtown Square, PA: 2018). PMI is a not-for-profit organization that has established standards for program and project management that are generally recognized as leading practices for most programs and projects. These standards are used worldwide and provide guidance on how to manage various aspects of projects, programs, and portfolios.

Management and Budget (OMB).¹¹ We used a five-point scoring system to determine the extent to which FAA's program management activities aligned with these nine leading practices in program management.¹² If the score for a leading practice was "fully met" or "substantially met," we concluded that FAA's policy followed that leading practice. If the score was "partially met," "minimally met," or "not met," we concluded that FAA's policy did not fully follow leading practices.

We conducted this performance audit from May 2021 to November 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

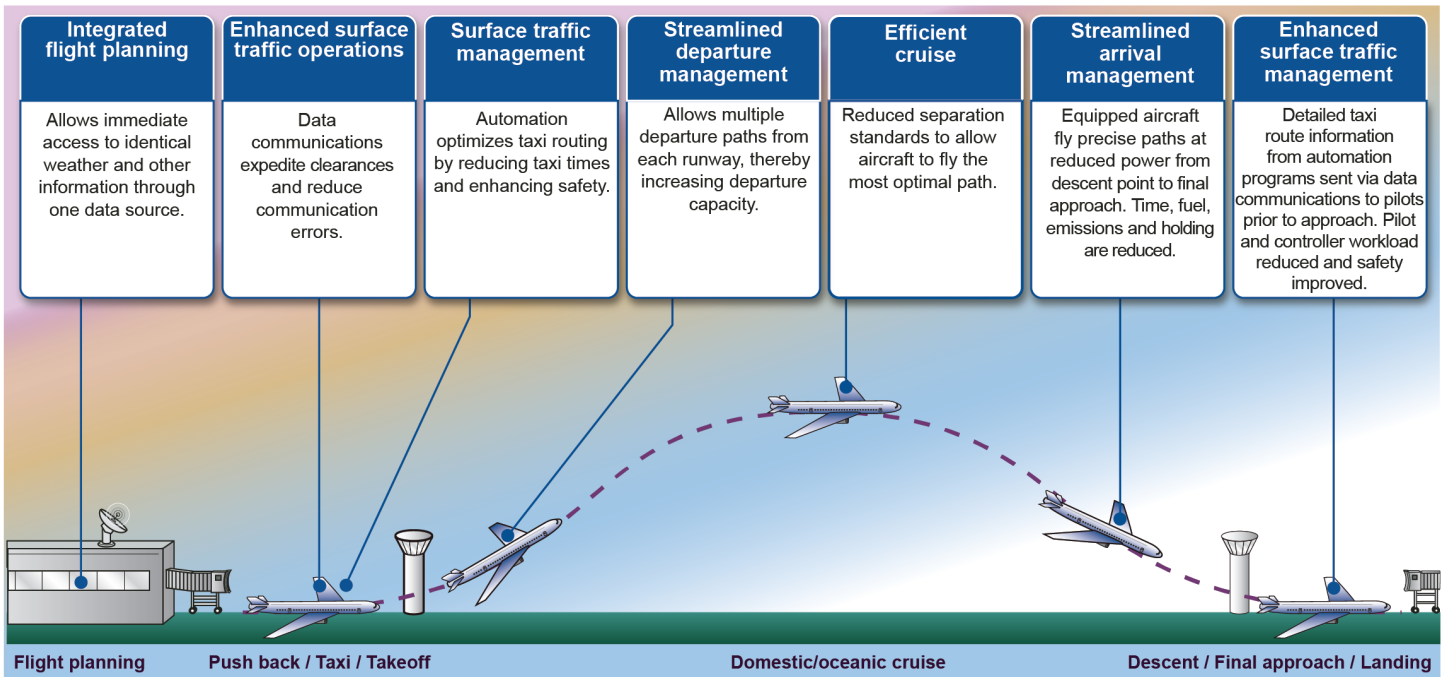
Background

As noted in the NextGen Implementation Plan, FAA's ultimate goal for NextGen is to improve air traffic management and decrease aviation congestion by strategically planning, managing, and optimizing flights from departure gate through arrival gate (what FAA refers to as trajectory-based operations). Trajectory-based operations expand air traffic controllers' ability to manage aircraft based on their altitude, latitude, and longitude by incorporating a fourth element of time. By incorporating time in air traffic management, controllers will be able to know where and at what time an aircraft will be at key points along its route before the aircraft takes off, factoring in conditions and operator inputs. According to FAA, NextGen improvements will help controllers sequence aircraft from departure through arrival; improve efficiency, especially during times when the national airspace is congested; and provide economic savings to aircraft operators (see fig. 1).

¹¹In June 2018, OMB issued implementation guidance and called for agencies to set their own program management standards. OMB stated that agencies may rely on program management leading practices developed by GAO, other agencies, or external voluntary consensus standards bodies. For OMB guidance on risk management and internal controls, see OMB, *OMB Circular No. A-123, Management's Responsibility for Enterprise Risk Management and Internal Control*, M-16-17 (Washington, D.C.: July 15, 2016).

¹²The five-point scoring system was as follows: "fully met" means that FAA's policy completely met the leading practice; "substantially met" means that FAA's policy met a large portion of the leading practice; "partially met" means that FAA's policy met about half of the leading practice; "minimally met" means that FAA's policy met a small portion of the leading practice; and "not met" means that FAA's policy did not meet the leading practice at all.

Figure 1: Improvements to Phases of Flight Expected under the Next Generation Air Transportation System



Source: GAO analysis of FAA information. | GAO-24-105254

NextGen Implementation Plan 2018-19

Congress charged FAA to work with aviation stakeholders in developing the systems and individual programs that make up NextGen to ensure that the new technologies will be used to their fullest potential in both the air-traffic control system and aircraft. The United States is also a member of the International Civil Aviation Organization (ICAO) and FAA helps promote aviation harmonization by ensuring that U.S. systems and procedures are interoperable with those of other ICAO member countries.¹³

Since 2008, FAA generally produced annual implementation plans with proposed multi-year schedules and milestones to help guide the implementation of NextGen program areas. The most recent of these

¹³ICAO is a United Nations Specialized Agency that adopts standards and recommended practices in accordance with Article 37 of the Convention on International Civil Aviation (Chicago Convention) in order for all contracting states (including the U.S.) to have the highest practicable degrees of uniformity in regulations, standards, and procedures in relation to air navigation and transportation. Harmonization is the agreement on and implementation of compatible standards, procedures, and technologies (and associated policy) to ensure interoperability.

multi-year implementation plans is the *NextGen Implementation Plan 2018-2019*. This plan describes the intended operational capabilities and anticipated benefits of, as well as associated implementation milestones for, the planned technologies and systems within each program area.¹⁴

Due to the complexity, cost, and interdependency of some NextGen program areas, FAA has segmented implementation into time frames during which FAA plans to implement certain portions of the programs. By segmenting implementation, FAA divides each individual program into defined parts that require less funding than the entire individual program. For example, for some NextGen technologies, FAA may develop and implement certain operational capabilities at one time and more advanced operational capabilities at a later date. In addition, FAA may prioritize implementation at some locations or facilities. These facilities include three main types of air traffic control facilities: air traffic control towers, terminal radar approach control facilities (TRACON), and en route centers.¹⁵

Key Program Areas and Status as of the *NextGen Implementation Plan 2018-2019*

Four program areas in particular are critical to moving NextGen toward trajectory-based operations. These four areas focus on navigation, communications, surveillance, and automation technologies, all in different phases of implementation as reflected in the *NextGen Implementation Plan 2018-2019*.

Navigation

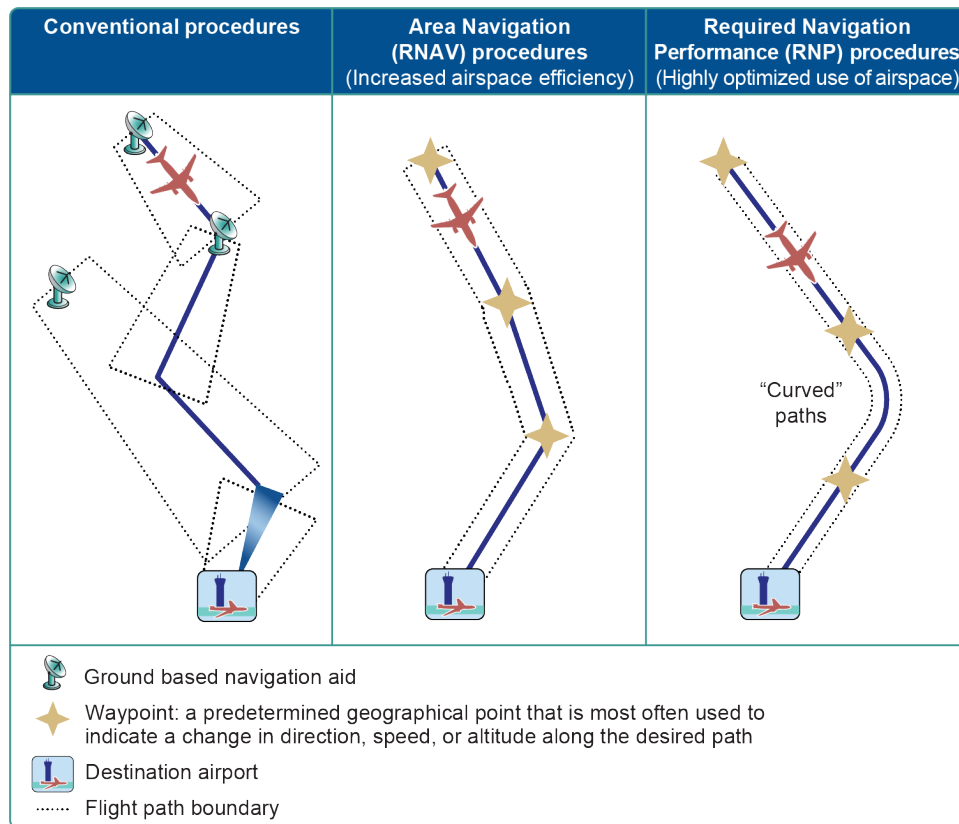
Navigation routes help ensure that aircraft fly safely and remain on course throughout their flight. According to FAA, since 2006, the agency has been transitioning from conventional routes that use ground-based navigational aids to performance-based navigation (PBN) routes and procedures that use satellite-based navigation systems, such as GPS. As shown in figure 2, there are two main categories of navigation routes and procedures within PBN: area navigation (RNAV) and required navigation

¹⁴For what FAA refers to as “programs,” the NextGen Implementation Plan typically lists implementation by month and year through 2023. For what FAA refers to as “portfolios,” the NextGen Implementation Plan divides timelines into 5-year phases that run through 2030, which FAA indicates are for planning purposes.

¹⁵Air traffic control tower controllers generally manage traffic (such as takeoffs, landing, and ground traffic) within 5-nautical miles from the airport. TRACON controllers generally handle aircraft up to about 50-nautical miles from the airport. TRACON controllers are also responsible for monitoring aircraft flying over that airspace and ensuring that there is a safe separation among the flying aircraft surrounding airports. As aircraft fly closer to an airport, TRACON controllers pass control of the aircraft and its information to the tower controller. Controllers at en route centers handle air traffic at higher altitudes traveling between airports.

performance (RNP). RNAV and RNP help aircraft fly more precise routes that increase safety and efficiency as well as reduce fuel burn and emissions. PBN procedures enable aircraft to fly a particular flight path more precisely, so the aircraft will be closer to the “center line” of a flight path than when using conventional navigation procedures.

Figure 2: How Conventional Flight Navigation Procedures Differ from Performance-Based Navigation (PBN) Procedures



Source: GAO analysis of FAA information. | GAO-24-105254

The design and use of PBN procedures and routes are unique to each airport and depend on multiple factors, such as airport size, layout of runways, geographic terrain, weather, complexity of airspace, training of controllers and pilots, and types of equipment of aircraft. Controllers also rely on NextGen communications and surveillance program areas (discussed below) to monitor flight paths in order to determine what types of procedures to assign.

Beginning in 2010, FAA undertook a two-pronged approach for PBN implementation at priority airports. FAA established a multi-year Metroplex program to focus on implementing PBN in the airspace around 11 major metropolitan areas.¹⁶ By the end of 2017, FAA had implemented PBN at seven planned metroplex sites and had already missed the scheduled implementation milestone for the eighth site. The final three metroplex sites were scheduled to be completed at different points in 2018 through 2020. FAA was also implementing PBN at individual airports and as part of its Northeast Corridor project to help address airspace congestion.¹⁷ In 2019, FAA began working on major updates to Atlantic Coast Routes in the Northeast Corridor to reduce delays and improve throughput for high altitude traffic to and from the Florida Metroplex.

Communications

NextGen's Data Communications system (Data Comm) supplements radio-based voice conversations between pilots and air traffic controllers. Data Comm enables controllers to send more reliable, pre-scripted text-based messages with departure clearance instructions and reroutes directly to pilots in the aircraft flight deck. According to FAA, the digital messages reduce the potential for miscommunication, which can occur from widely broadcast voice exchanges. Further, there is no need for the pilot to read back a message for accuracy. Data Comm also facilitates faster communications and can help increase operational efficiency in the national airspace.

For Data Comm to work throughout a flight, FAA must install a data link communications system at two types of air traffic control facilities.¹⁸ In 2015, FAA began its first phase of implementation: deploying Data Comm services to air traffic control towers, with a planned completion date of May 2019. The second implementation phase is at en route centers.

¹⁶A metroplex is a geographic area covering several airports, serving major metropolitan areas and a diversity of aircraft and airport operators, FAA, and others. Each metroplex is a unique system of airports, aircraft, weather patterns, and geography. The 11 locations included under FAA's Metroplex program are Northern California, Southern California, Denver, Houston, North Texas, Cleveland/Detroit, Atlanta, Charlotte, South/Central Florida, Washington, D.C., and Las Vegas.

¹⁷In 2017, the NAC identified the Northeast Corridor as a priority for NextGen implementation, saying that system delays that begin at airports located in the Northeast Corridor have a negative impact on system operations in the rest of the country. The Northeast Corridor includes Boston, the New York City area, Philadelphia, and the Washington, D.C., area.

¹⁸Aircraft operators also must ensure that their aircraft have the correct equipment to use Data Comm to communicate between the flight deck and air traffic control.

Unlike for air traffic control towers, implementation at en route centers was scheduled in two segments. Initial Data Comm services, which handle more routine communications, was scheduled to be completed in September 2021. Implementation of full Data Comm services, which will offer more complex communication capabilities, such as aircraft holding instructions, was to begin 6 months later, in March 2022.

Surveillance

Automatic Dependent Surveillance-Broadcast (ADS-B) is an advanced surveillance technology that enables controllers and aircraft operators to get precise aircraft location data from GPS. According to FAA officials, ADS-B directly supports all NextGen air traffic management services, including air traffic control separation.

FAA's ADS-B system uses ADS-B Out avionics installed in an aircraft to broadcast an aircraft's position, air speed, and altitude typically once a second to FAA-installed ground stations, which then transmit the data to air traffic control facilities. In 2010, FAA mandated that by January 1, 2020, all aircraft operating within certain controlled national air space must be equipped with the ADS-B Out avionics. If aircraft are also equipped with ADS-B In avionics, which FAA did not mandate, pilots can receive, on their flight decks, displays of location position data broadcast by nearby aircraft. ADS-B In avionics also enable pilots to see graphical weather and terrain displays as well as text-based advisories.

After first installing hundreds of ground-based radio stations throughout the U.S. and in the Gulf of Mexico, FAA's implementation effort focused on integrating ADS-B services in air traffic control automation platforms at en route centers and TRACONS.¹⁹ According to the NextGen Implementation Plan, FAA had completed integration at the en route centers and planned to complete the initial service integration at all TRACONS by January 2020.

The NextGen Implementation Plan also included a milestone for completing FAA's integration of ADS-B with surface surveillance systems at 44 airports to help avoid collisions between aircraft and ground

¹⁹According to FAA, the agency had completed the deployment of 634 ground-based radio stations, including deployment on energy platforms in the Gulf of Mexico. According to FAA, removal and replacement of facilities on these platforms, which provide surveillance data to areas that did not have access to traditional radar coverage, are periodically needed because the platforms have a temporary lifespan.

vehicles.²⁰ According to the plan, FAA had completed integration for the 35 airports that had the Airport Surface Detection Equipment-Model X (ASDE-X) and planned to deploy a new and similar surface surveillance system—Airport Surface Surveillance Capability (ASSC)—at nine airports by 2020.²¹

Automation

The NextGen automation program area consists of several automation systems that are intended to help controllers handle growing air traffic and allow aircraft to attain trajectory-based operations. Two of those systems—En Route Automation Modernization (ERAM) and Standard Terminal Automation Replacement System (STARS)—are NextGen foundational systems that facilitate the operation of other NextGen program areas.²² These two systems process aircraft flight and surveillance data to enable use of PBN procedures; enable air traffic controllers and aircraft operators to communicate via Data Comm; and enable the collection of ADS-B and other data to support the management and monitoring of the nation’s air traffic flow. ERAM acts as the platform for flights en route to their destination while STARS generally serves as the platform for the airport terminal environment.

At the time of the issuance of the NextGen Implementation Plan, ERAM was operational at all 20 en route centers, and STARS was deployed at more than 90 percent of TRACON facilities. FAA’s work has largely transitioned to sustaining and enhancing them through technology refreshes and software additions and integrations. The NextGen Implementation Plan identified three ongoing operational upgrades to ERAM and three for STARS. Each upgrade was to be completed in full or

²⁰Many of these airports are among the nation’s busiest. Airport ground vehicles equipped with ADS-B transponders transmit GPS position information to air traffic controllers.

²¹FAA’s NextGen Implementation Plan provided only a 2020 milestone for ADS-B initial operating capabilities for surface surveillance systems. FAA’s December 2021 report to Congress on NextGen identified a September 2020 milestone for completion. ASSC also uses ADS-B and requires the surface movement radar that ASDE-X uses for airport surface movement.

²²FAA’s Terminal Automation Modernization and Replacement (TAMR) program oversees the STARS foundational system. FAA has labeled some STARS projects as TAMR projects and others as STARS projects. For the purposes of this report, we refer to both categories of projects as STARS in this report. FAA has characterized two other systems that are outside the scope of our report as foundational NextGen systems. The System Wide Information Management (SWIM) provides digital data-sharing for NextGen, including weather data. The Advanced Technologies and Oceanic Procedures (ATOP) sustains oceanic automation and improves information exchange between oceanic and other domains.

had multiple segments that were to be completed within the 2018–2022 time period.²³

Other automation systems are also needed to transition NextGen to trajectory-based operations. In particular, there are three automation systems that incorporate time-based metering tools and real-time data exchange. Their intended purpose is to better manage and improve aircraft flow, lessen airspace congestion, and increase airspace capacity.

- Time Based Flow Management (TBFM) is a system for terminal and en route controllers to better manage air traffic by using time-based metering to optimize the flow of aircraft as they approach and depart airspace. TBFM works with PBN procedures to help improve aircraft flow. By the issuance of the *NextGen Implementation Plan 2018–2019*, FAA had deployed TBFM at all en route centers in the contiguous U.S. According to the NextGen Implementation Plan, FAA’s planned enhancements to the system are intended to improve the time-based metering capability, expand TBFM’s capabilities at more locations, and make improvements to enable controllers to more accurately deliver aircraft to TRACONS and optimize aircraft descents.
- Terminal Flight Data Manager (TFDM) is a system to improve the management of an airport’s surface traffic, including aircraft departures. It remained under development when FAA issued the NextGen Implementation Plan.²⁴ It is intended to (1) replace the paper flight strips used in air traffic control towers with an automated electronic flight strip system as well as (2) provide a set of decision-support tools to facilitate management of airport surface resources and improve surface traffic management.²⁵ According to the NextGen Implementation Plan, FAA planned to start implementing TFDM by 2019. FAA anticipated that implementation of the electronic flight strips would be completed at 89 airports in fiscal year (FY) 2028.
- Traffic Flow Management System (TFMS) is a data-exchange system, which focuses on the flow of air traffic in the national airspace.²⁶

²³As implementation of the ERAM upgrades were planned to take several years, FAA broke each upgrade into segments with associated milestones.

²⁴FAA placed TFDM in its Improved Surface Operations portfolio.

²⁵Flight strips contain information for each aircraft’s flight, including aircraft identification, type, departure, and destination.

²⁶The type of data exchanged includes flight plans, departure and arrival times, flow-constraint areas, and re-routes. According to FAA, the latest version of TFMS allows airlines to exchange data via the SWIM system.

According to the NextGen Implementation Plan, TFMS was deployed and FAA was evaluating its automated flight plans and developing enhancements for TFMS to (1) optimize aircraft re-routes around constraints in the national airspace, (2) better inform controllers' decision-making on departure routing operations, and (3) better accommodate aircraft operator preferences related to traffic flow management decisions.

Program Management Practices

The Program Management Improvement Accountability Act of December 2016 required OMB to adopt and oversee implementation of government-wide standards, policies, and guidelines for program and project management in executive branch agencies.²⁷ In June 2018, OMB issued a memorandum on the implementation of this law, which included initial implementation guidance and called for agencies to set their own program management standards. The memorandum stated that the act aims to improve program and project management practices within the federal government. The OMB memorandum also stated that agencies may use program management leading practices developed by us, other agencies, and external voluntary consensus standards bodies. FAA officials told us that FAA does not have its own program management standards, but instead relies on FAA's Acquisition Management System policy to establish the agency's policy and guidance for all aspects of lifecycle acquisition management, including program management.

²⁷For GAO's assessment of OMB's efforts to implement this act, see GAO, *Improving Program Management: Key Actions Taken, but Further Efforts Needed to Strengthen Standards, Expand Reviews, and Address High-Risk Areas*, [GAO-20-44](#) (Washington, D.C.: Dec. 13, 2019).

FAA Has Had Mixed Results Meeting Key Implementation Milestones since 2018, with COVID-19 Playing a Large Part in Missed Milestones

Since 2018, FAA Met or Beat Some Implementation Milestones, but Missed Most Milestones in the Past 2 Years

Our review of FAA and NAC documents as well as interviews with FAA officials showed that FAA has had varying degrees of success meeting implementation milestones found in its NextGen Implementation Plan for the four selected program areas. FAA mostly met its milestones for the surveillance program area. In the communications program area, FAA beat its milestone for implementation at air traffic control towers but not at the en route centers. FAA's navigation program area also experienced several delays both for PBN implementation at metroplexes and in the Northeast Corridor. All five systems in the automation program area experienced delays. In our description of implementation status that follows, we point out some cases where the COVID-19 pandemic affected milestones. Later in this section, we discuss the specific ways COVID-19 and other issues affected FAA's ability to meet program milestones more fully.

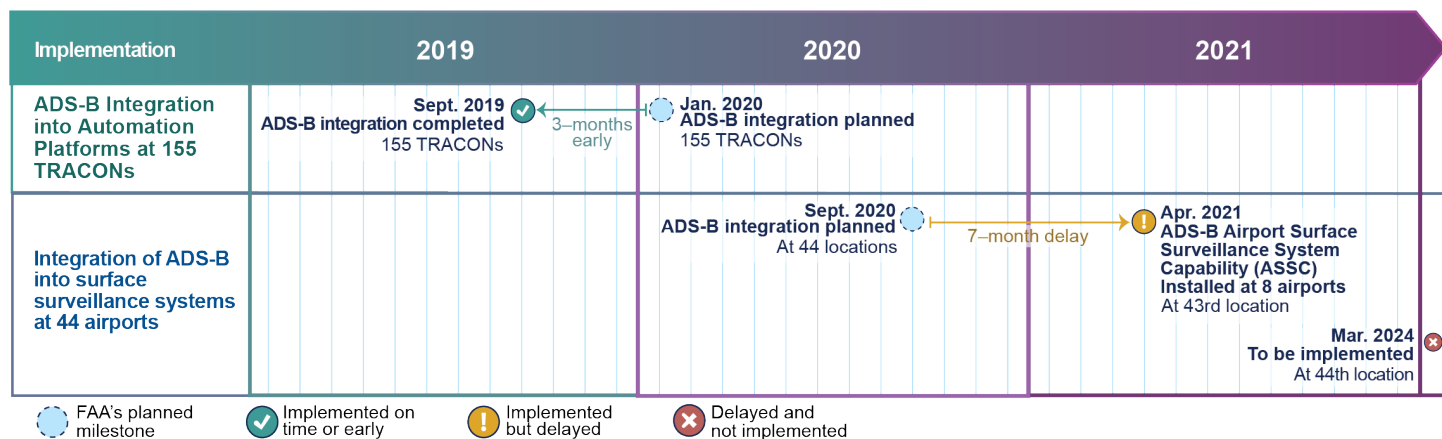
Surveillance

FAA beat the first of its two key NextGen Implementation Plan milestones for completing the integration of ADS-B services at planned sites (see fig. 3). Specifically, FAA deployed ADS-B services at the last two of 155 TRACONs in September 2019, ahead of its target deadline of January 1, 2020. FAA noted that these services allow TRACON controllers to more accurately track aircraft and reduce the risk of runway incursions. In addition, ADS-B provides improved situational awareness to both controllers and pilots. FAA officials also noted that en route air traffic controllers can now use 3-nautical miles to separate aircraft en route instead of 5-nautical miles, thereby increasing airspace efficiency. According to FAA, as of September 2023, 17 of 20 en route centers are using ADS-B for 3-nautical miles operations.

FAA mostly met its second milestone, integrating ADS-B into the surface surveillance systems at 42 of the 44 planned airports by September 2020. FAA completed integration at the 43rd airport (the eighth airport to receive

the new ASSC surface surveillance system) 7 months late in April 2021.²⁸ According to FAA officials, deployment at the final airport (Joint Base Andrews) will occur by March 2024.²⁹ According to FAA officials, surface surveillance systems' ability to use ADS-B helps improve situational awareness and make surface and runway operations safer.³⁰

Figure 3: Federal Aviation Administration's (FAA) Progress toward Meeting Key 2018–2022 Milestones for Automatic-Dependent Surveillance-Broadcast (ADS-B)



Source: GAO analysis of FAA information. | GAO-24-105254

Note: TRACON stands for Terminal Radar Approach Control facility, where air traffic controllers generally handle aircraft from 5- to 50-nautical miles from the airport.

Although not included in the NextGen Implementation Plan, in 2019, FAA initiated a new project to continue maintaining and upgrading ADS-B equipment, including equipment located on energy platforms in the Gulf of Mexico. According to FAA officials, this project is on track to be completed in January 2026. FAA has also long envisioned future ADS-B In applications that will deliver additional operational and safety benefits. However, in August 2022, FAA announced at a NAC meeting that it was delaying the initiation of additional ADS-B In applications to a future, undetermined date. According to FAA officials, this delay is due to a need

²⁸According to FAA officials, this was due to ATC facility access restrictions at the airports due to the COVID-19 pandemic.

²⁹According to FAA, Joint Base Andrews was removed from the ASSC program baseline after the milestone of integrating ADS-B into the surface surveillance systems at 42 of the 44 planned airports by September 2020 was defined. FAA added Joint Base Andrews back as a site based on an FAA Joint Resources Council decision, with a planned deployment date by March 2024.

³⁰This includes the 35 sites where ADS-B is incorporated into ASDE-X.

to balance funds to support existing national airspace system services with program areas that will introduce new functionalities.

Communications

FAA beat its milestone for Data Comm implementation at airport towers but missed two implementation milestones for en route centers (see fig. 4). Specifically, FAA beat its original May 2019 goal of deploying Data Comm to 55 airport towers by almost 3 years. By also coming in under budget, FAA was able to expand deployment to additional towers. By July 2022, FAA had deployed Data Comm to a total of 65 airport towers, including all Core 30 airports.³¹ FAA officials told us that because of the benefits that Data Comm provides—such as reducing communication errors that could compromise safety and create flight delays—more airports requested Data Comm capabilities for their towers. However, FAA stated that at the time of our review, it does not plan to expand Data Comm capabilities to smaller airports.

FAA missed implementation milestones for deploying both Data Comm's initial and full services at en route centers. FAA expected to deploy initial services for the 20 en route centers by September 2021. However, according to FAA data, only two en route centers were completed before the COVID-19 pandemic halted activities. FAA was able to resume deployment in March 2022, and a third en route center became operational in September 2022. In September 2023, FAA officials stated that the agency had deployed initial Data Comm services to 12 en route centers. FAA officials told us that they plan to complete initial Data Comm services deployment to all 20 en route centers by May 2025.

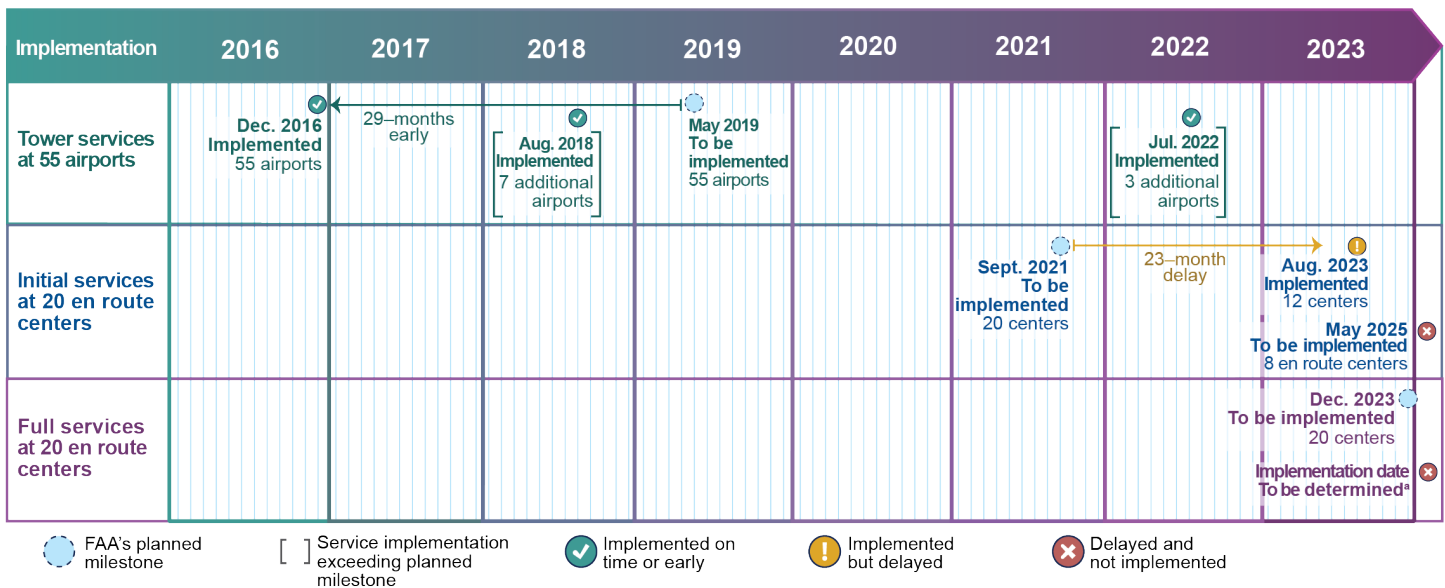
FAA officials told us the delays in deploying Data Comm initial services at en route centers have had a ripple effect on its ability to deploy full services at en route centers. FAA had planned to deploy full services at its first en route center in March 2022 and complete all 20 centers by December 2023. In April 2023, FAA officials told us that they had deployed a subset of full services at the four en route centers where they had deployed initial services so far.³² They added that they are

³¹Core 30 airports are those with significant activity serving major metropolitan areas.

³²FAA's NextGen Implementation Plan also included a November 2019 milestone for completing deployment of initial services at its first en route center. FAA completed that milestone 3.5 months behind schedule.

developing a new schedule for deploying complete full services to the remaining facilities.³³

Figure 4: Federal Aviation Administration’s (FAA) Progress toward Meeting Key Milestones for Data Communications



Source: GAO analysis of FAA information. | GAO-24-105254

^aWhile FAA has not deployed full services, which will offer more complex communication capabilities (e.g., aircraft holding instructions), to any en route center, FAA officials stated that as of August 2023, they had deployed a subset of full services to 12 en route centers that had received initial services.

Navigation

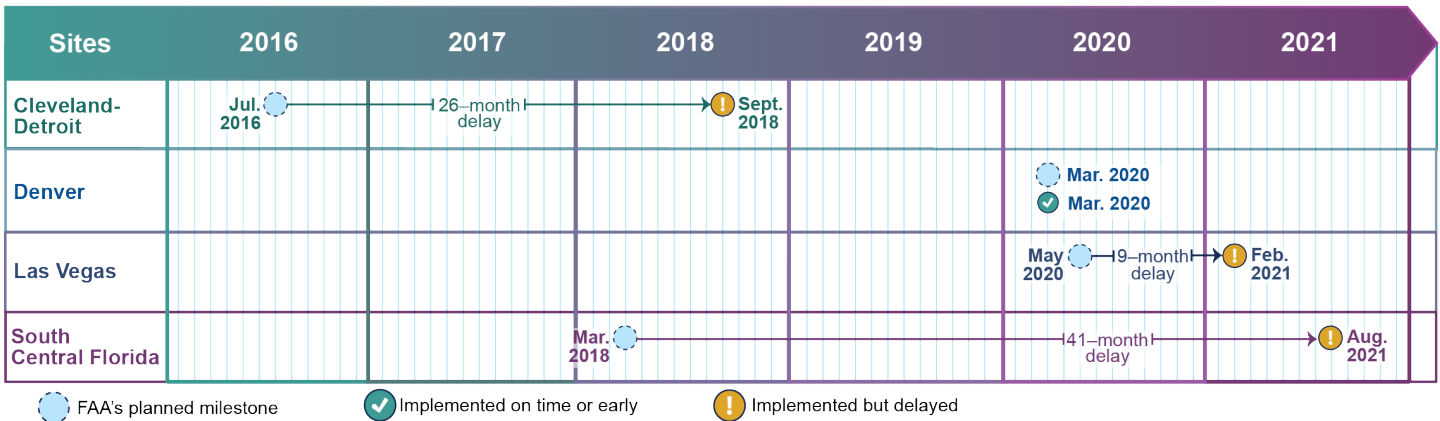
FAA completed PBN implementation at three of the remaining four metroplex sites of its Metroplex Program behind schedule (see fig. 5).³⁴ FAA completed the Cleveland/Detroit site in September 2018, 26 months late. The other remaining metroplex sites all had scheduled implementation deadlines in the 2018–2022 time frame. FAA completed the Denver site on schedule in March 2020, which FAA officials explained was possible because they had completed most of the work before the pandemic. According to agency officials, COVID-19 as well as other factors contributed to FAA completing the other two sites, the Las Vegas

³³In September 2023, FAA officials stated that the agency had enabled the subset of Full Services functionality for dealing with Speeds and Block Altitudes at all 12 currently deployed Initial Services en route centers.

³⁴As of December 2017, FAA had implemented seven of its 11 planned metroplex sites.

and the South-Central Florida metroplexes, 9 and 41 months behind schedule, respectively.³⁵

Figure 5: Federal Aviation Administration’s (FAA) Progress toward Meeting Key Milestones for the Final Four of 11 Performance-Based Navigation (PBN) Metroplexes



Source: GAO analysis of FAA information. | GAO-24-105254

Note: The milestones reflect the date that operational changes to aircraft navigation procedures were planned and implementation completed. According to FAA officials, the agency generally closes out metroplexes about 7 months after the changes are implemented, allowing FAA time to collect data and conduct post-implementation analyses. We excluded from our review seven other metroplexes, where FAA implemented PBN before our 2018–2022 time period.

FAA also fell behind its PBN implementation schedule for the Atlantic Coast routes portion of the Northeast Corridor project, which was supposed to be completed in November 2020.³⁶ In October 2020, FAA officials acknowledged that they had missed nine 2020 implementation milestones, creating a ripple effect on other PBN activities in the Northeast Corridor. FAA anticipated the delayed implementation to be completed by November 2022, but FAA later revised its milestone for completion to spring 2023. On May 1, 2023, FAA issued a statement announcing the implementation of 169 high altitude routes along the U.S. East Coast, including the Atlantic Coast routes. FAA also anticipates that

³⁵According to FAA, the agency reduced the scope of the South-Central Florida metroplex project in 2019 due to the project’s size, complexity, cost, and community noise concerns. Community noise concerns are among the factors that contributed to implementation delays and are discussed further in a section below.

³⁶Started in 2019, the goal of the project updates for the Atlantic Coast Routes is to reduce delays and congestion between the Northeast Corridor and the Florida airports by replacing older, radar-based routes with high altitude PBN routes to segregate flows and better manage traffic to and from major airports on the east coast.

it will conduct post-implementation amendments through November 2023.³⁷

Similar to its approach in implementing PBN in the Northeast Corridor, FAA officials told us that the agency was transitioning to a regional approach toward PBN implementation. In October 2022, FAA published an Airspace Modernization Roadmap Strategy, which sets future PBN strategies across the country.³⁸ According to FAA officials, to carry out the strategy, FAA created three regional Service Area Leadership Teams at the FAA Service Centers to prioritize projects. The strategy has near-, mid-, and long-term goals but does not include timelines or specific projects.

Automation

All five of the automation systems we reviewed experienced some delays over the past 4 years. These delays have had an effect on the implementation schedules of other NextGen systems. For the two foundational systems—ERAM and STARS—FAA completed about half of the milestones planned for upgrading these systems in the 2018–2022 time frame on time (see figure 6).³⁹ For ERAM, FAA met or beat three interim milestones scheduled during this time frame for its three upgrade projects but missed the other interim milestones by several months to almost 2 years.⁴⁰ Even with these interim delays, FAA officials said that

³⁷As result of PBN post-implementation analysis, FAA will amend some of its routes if necessary. FAA officials also told us that, as of December 2022, there were almost 10,000 PBN departure, arrival, and approach procedures in place throughout the nation's airports. As a result, over 80 percent of the nation's commercial airports have at least one RNAV approach. According to the most recent FAA data at the time of our review, from July through September 2022, PBN usage at the Core 30 airports has been around 85 percent for RNAV arrival procedures and 67 percent for RNAV departure procedures.

³⁸FAA, *Airspace Modernization Roadmap Strategy 2022* (Washington, D.C.: 2022). FAA had issued an earlier 2016 PBN navigation strategy with near-, mid-, and long-term goals through 2030 to increase the use of existing PBN procedures and develop new criteria, policies, and standards to allow for more advanced PBN applications.

³⁹The 2018–2022 milestones for both ERAM and STARS generally pertain to projects to upgrade existing system technologies and capabilities through what FAA refers to as sustainments or enhancements.

⁴⁰Of the three ERAM upgrade projects, only one (Sustainment 2) was scheduled to be fully completed within our selected time frame. FAA completed that upgrade in June 2022, almost 2 years late. FAA beat two 2022 segment implementation milestones for an ongoing technology refresh for ERAM equipment (Sustainment 3), which is scheduled to be completed in September 2026. For the other ongoing ERAM upgrade (Enhancement 2), FAA deployed one new system capability in July 2019, 2 months early. However, the deployment of the next capability was delayed until June 2023—5 months past its original target date.

the overall projects are on track to be completed by their final implementation dates.⁴¹ For STARS, FAA completed three upgrade projects, meeting or just missing the three completion date milestones.⁴²

⁴¹FAA officials said they still expect to complete all of its Enhancement 2 and Sustainment 3 projects by December 2024 and September 2026, respectively.

⁴²FAA officials told us that cost and budget priorities caused them in 2019 to halt an additional STARS enhancement that was not reflected in the NextGen Implementation Plan. In mid-2022, FAA added two STARS sustainment projects scheduled for completion in 2027 and 2030.

Figure 6: FAA’s Progress in Meeting 2018–2022 Schedule Milestones for Planned Upgrades to ERAM and STARS Automation Systems, as of September 2023

System upgrade	Project or segment milestones met on time or early	Project or segment milestones completed behind schedule	Project or segment milestones missed, with work ongoing or paused
En Route Automation Modernization (ERAM)			
Enhancement 2 ^a	New system capability deployment (July 2019, 2–months early)	New system capability deployment (June 2023, 5–months late) ^a	—
Sustainment 2	Equipment deployment at first site (Feb. 2018, 1–month early) and final site (July 2018, 5–months early)	Software deployment (July 2019, 7–months late); hardware deployment and final completion (June 2022, 21–months late)	—
Sustainment 3 ^b	Software upgrade (May 2022, 4–months early); hardware upgrade at first site (Nov. 2022, 1–month early)	—	—
Standard Terminal Automation Replacement System (STARS)^c			
Sustainment 1	—	Hardware and software upgrades at 48 sites (Aug. 2020, 1–month late)	—
Sustainment 2	Software upgrade to support new operating system (May 2022, on time)	—	—
Terminal Automation Modernization and Replacement (TAMR) Phase 4	—	Replaced Automated Radar Terminal Systems with STARS at 91 sites (April 2020, 1–month late)	—

■ Projects or segments on time or early
 ■ Projects or segments completed behind schedule
 ■ Projects or segments with schedules missed, with work ongoing or paused
 — Not applicable

Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-24-105254

^aERAM Enhancement 2 includes five implementation segment milestones, each of which reflects the scheduled completion for incorporating a new system capability. Of the two that were scheduled to be completed in the 2018–2022 time frame, one was completed 2 months early and the other was completed 5 months late. According to FAA, the remaining portions of the enhancement remains on schedule for completion by December 2024.

^bERAM Sustainment 3 includes multiple segment milestones, two of which were scheduled to be completed in the 2018–2022 time frame. According to FAA, the entire sustainment, a technology refresh for ERAM equipment that has become either obsolete or unsupported, remains on schedule for completion in September 2026.

^cAccording to FAA, another STARS enhancement was halted in 2019 due to cost and budget priorities.

FAA did not meet its planned milestones for the other three automation systems.

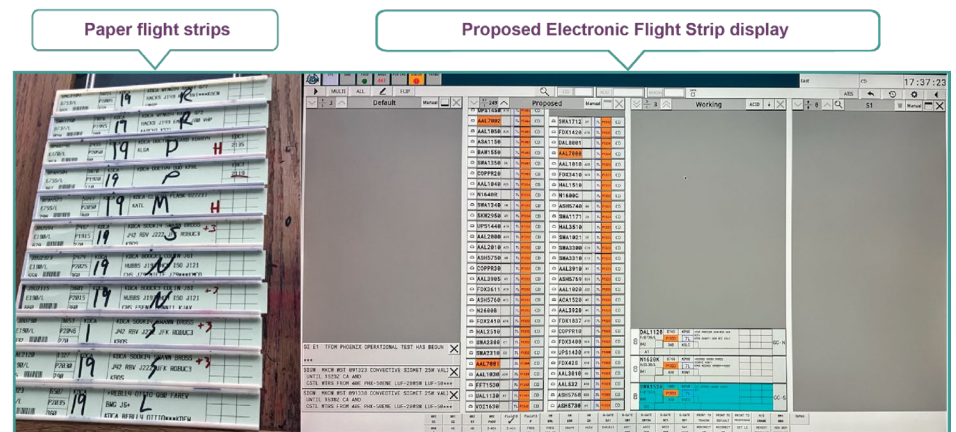
- The first planned enhancement to the Time-Based Flow Management (TBFM) system at the en route centers was delayed 15 months to December 2023. FAA officials attributed delays in part to changes to the Northeast Corridor project as well as the COVID-19 pandemic. As noted in the NextGen Implementation Plan, TBFM is already active in the national airspace. However, according to FAA, technology enhancements are necessary to provide efficient sequencing, extend time-based metering to the runway, and enable expansion of PBN operations. FAA originally planned to enhance TBFM with a Terminal Sequencing and Spacing (TSAS) tool that would enable control towers to use time-based metering in the terminal area to help merge, sequence, and space aircraft. In March 2023, FAA officials told us that FAA deferred TSAS, and a new implementation timeline has yet to be determined. Meanwhile, FAA officials said that the agency will focus on implementing the Integrated Departure/Arrival Capability in the Miami, Florida, market to better deal with the congestion typically found in that airspace.⁴³
- FAA did not meet its implementation timeline for the Terminal Flight Data Manager (TFDM) to replace paper flight strips with electronic flight strips at 89 airports from FY 2020 to FY 2028 (see fig. 7). According to FAA officials, due to pandemic-related travel restrictions, TFDM's first site did not become operational until October 2022, 2 years late, which further delayed deployment to the remaining sites in the TFDM schedule. FAA has revised its TFDM timelines, most recently noting that the final completion date is now February 2030. FAA also decreased the number of airports designated to receive the electronic flight strip system from 89 to 49 airports. Of the 49 airports, 27 towers will receive the electronic flight strip with additional TFDM capabilities to better manage ground traffic flow; 22 airport towers will receive only the electronic flight strips. FAA officials told us in March 2023 that, during the 2023-to-2024-time frame, they are deploying TFDM at 10 of the 49 airports.⁴⁴ According to FAA officials, FAA has

⁴³To make departure flows more efficient, the Integrated Departure/Arrival Capability automates the process of monitoring departure demand and identifying departure slots. It also helps coordinate departure times between airports and provides situational awareness to airport towers so that they can select from available departure times and plan their operations to meet these times.

⁴⁴FAA officials told us that they plan to re-baseline TFDM.

no current plans to deploy TFDM to the 40 other airports that were part of the original schedule.

Figure 7: Paper Flight Strips Compared to Electronic Flight Strips



Source: Federal Aviation Administration. | GAO-24-105254

- FAA continues to support the Traffic Flow Management System (TFMS) but missed planned milestones for several key software and technology refresh projects and deferred others, due to the pandemic restrictions as well as a contract dispute. For example, FAA officials told us that, after modifying its TFMS Release 15 baseline, it was able to complete a testing and evaluation in fall 2022.⁴⁵ The delayed sites for a TFMS Sustainment 2 technology refresh were completed between September 2020 and March 2021. FAA officials also told us that they anticipate completing in November 2023—14-months behind schedule—a technology refresh project to address system outages and latency issues. FAA also shifted the completion of another Tech Refresh Final Investment Decision from September 2022 to April 2023.

According to FAA officials, FAA decided in early 2022 to replace TFMS with a new automation system called Flow Management Data and Services (FMDS). FAA pointed to a number of issues and delays it has experienced with TFMS, including an aging architecture and technology that cannot support future capabilities, inefficiencies in how the system is used, issues with software integration, expensive maintenance, and a

⁴⁵TFMS “releases” typically consists of software upgrades and other steps to address issues that FAA has identified with TFMS.

contract dispute.⁴⁶ According to FAA, FMDS will replace existing TFMS infrastructure with a more efficient system that can better interlink multiple air traffic aeronautical, weather, and flight data information services to improve traffic flow applications. FAA plans to make a final decision on investment for FMDS in early 2025.

FAA's transition to FMDS and delays such as those in implementing TFMS have affected FAA's ability to implement TFDM in the Northeast Corridor airports, which is necessary to meet FAA's goal to implement initial trajectory-based operations in the Northeast Corridor by 2025. Such operations would help to improve spacing and sequencing of flights as well as to improve the overall efficiency of the corridor's congested airspace. According to the NAC, 78 percent of flight delays in the national airspace system begin in the Northeast Corridor, which is one of the most congested areas in the country. Thus, flight delays in the Northeast Corridor have a ripple effect across the country. Since FAA has fallen behind schedule in implementing some key NextGen technologies that are important to trajectory-based operations, it will be a challenge for FAA to meet its planned 2025 milestone.

The Pandemic Slowed FAA's Implementation Efforts and in Some Cases Exacerbated Already Existing Delays

FAA officials and stakeholders we spoke with agreed that the COVID-19 pandemic was a major, though not sole, cause of delays in meeting the milestones included in FAA's NextGen Implementation Plan. After COVID-19 was federally declared as a national emergency in March 2020, FAA took a number of actions that affected NextGen implementation, such as stopping most construction projects at FAA facilities, restricting travel, limiting the number of employees in air traffic control facilities, and extending training requirements. FAA suspended travel for both non-essential personnel and face-to-face engagements at FAA field, technical, and training facilities that were not directly tied to safely operating the nation's airspace. FAA established protocols for entering FAA facilities for mission-critical activities based on the level of COVID-19 infections at facility locations, CDC's travel guidance, as well as state and local protocols.

COVID-19 related travel and facility restrictions contributed to NextGen program implementation delays in three key ways.

- **Testing delays.** FAA officials told us that restricted access to FAA facilities precluded technicians from conducting software and

⁴⁶On October 25, 2021, the FAA Administrator ordered that a special master be appointed to issue findings regarding aspects of the bid protest related to the TFMS contract.

hardware tests at FAA’s Technical Center as well as at locations nationwide.⁴⁷ Among the affected tests were operational demonstrations and final Technical Center testing for various technologies. As a workaround, FAA held some virtual testing and system demonstrations. However, some tests and demonstrations could not be conducted virtually. FAA provided limited access to its Technical Center for certain tests that needed to be done in person. For example, FAA was able to use a combination of remote and limited in-person access to its development contractor lab and the Technical Center, enabling software development and system testing for TFDM to continue. However, as noted by another industry stakeholder, TFDM is a good example of the limitations of virtual testing—at a certain point, testing must be done on the actual equipment. Both FAA officials and stakeholders also noted that delays resulting from facility restrictions in one location, particularly at the Technical Center, often had ripple effects resulting in delays elsewhere.

- **Deployment delays.** FAA officials told us that at the beginning of the pandemic restrictions, FAA turned its focus to “mission-critical” activities and restricted access to FAA facilities for those purposes. At that time, FAA did not consider NextGen implementation activities to be “mission-critical.” As a result, FAA’s ability to deploy new NextGen technology at planned sites—including at air-traffic control towers, en route centers, and TRACONs—was limited. For example, officials attributed the multi-year Data Comm implementation delays at en route centers and the various automation system delays to limited facility access. Similarly, FAA officials told us that the TBFM program office could not travel to deployment sites from March 2020 through February 2022 to evaluate TBFM software and deploy necessary hardware. In addition, officials said that the inability of subject matter experts, such as air traffic controllers, to travel and access airport facilities to assess current navigation approaches and departures delayed some PBN design work.
- **Training delays.** According to FAA officials, the inability to provide regular training during the pandemic had a significant impact on NextGen’s timelines. Controllers require training, for example, on how to operate both new PBN procedures and new or updated NextGen technologies. For example, at the Las Vegas

⁴⁷The William J. Hughes Technical Center, located near Atlantic City, New Jersey, is FAA’s laboratory for research and development of new aviation technologies. It is also FAA’s main test testing facility.

metroplex, the pause in training and the return of limited in-person training with reduced class size resulted in an 8-month delay. Furthermore, FAA officials said that pandemic-related delays exacerbated challenges in coordinating multiple required training classes. Those classes included NextGen-related training, training for legacy systems still in operation, and controller certification training. FAA developed virtual training courses in an effort to help address the mounting training backlog. In February 2022, FAA officials told us that the agency had returned to almost 80 percent of pre-COVID-19 training levels for some program areas, such as PBN, but hundreds of controllers—both current and new—remained behind schedule.⁴⁸ In April 2023, FAA officials told us that controller training has returned to 100 percent at the FAA Academy.⁴⁹ They further told us that Data Comm and TFDM training has returned to normal.⁵⁰

The pandemic not only restricted FAA travel and facility access, but also affected supply chains. For example, FAA officials cited difficulties obtaining necessary components such as computer chips for some NextGen systems. According to FAA officials at the time of our review, while supply chain issues delayed development, including for TBFM, those issues did not bring any system development to a halt.

FAA noted that other factors in addition to the COVID-19 pandemic also contributed to program implementation delays.

⁴⁸According to a January 2023 DOT OIG report, while around 1,000 air traffic control applicants have graduated from the FAA Academy, located in Oklahoma City, Oklahoma, since FY 2018, only 126 (less than 15 percent) had obtained their certification. See DOT, OIG, *FAA Has Taken Steps To Validate Its Air Traffic Skills Assessment Test but Lacks a Plan To Evaluate Its Effectiveness*, AV2023011 (Washington, D.C., Jan. 11, 2023). Further, as noted in its Air Traffic Controller Workforce Plan, 2021–2030, FAA reported that in FY 2020, FAA hired 920 new controllers, all of whom require training. During that same fiscal year, FAA lost slightly over 1,000 controllers due to retirements, resignations, promotions, transfers, and other reasons. See FAA, *The Air Traffic Controller Workforce Plan, 2021-2030* (Washington, D.C.).

⁴⁹We did not assess information systems for tracking and managing NextGen training as part of this review.

⁵⁰According to FAA officials, Data Comm training resumed in 2022. In addition to the controllers trained at three facilities before the pandemic, controllers at an additional nine facilities have also received Data Comm training as of April 2023. TFDM training started in 2022. As of September 2023, FAA completed TFDM training at five facilities; has training in progress at another site; and plans to complete training at four more sites in 2024.

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- **Changes in related projects.** FAA officials pointed to the 15-month delay for TBFM's first enhancement as an example of a delay with several contributing causes. They explained that staffing issues at the Philadelphia airport and issues with the airspace redesign for traffic from Newark to Philadelphia affected TBFM delays.
 - **The 2018-2019 federal government shutdown.** In addition, the 35-day government shutdown that occurred in December 2018 through January 2019 required FAA to stop most non-excepted work. According to officials, re-opening activities after the government shutdown took substantial time, including coordinating new schedules, making travel arrangements, and ensuring that contractors were staffed. The work stoppage and re-opening activities had a ripple effect on program areas that were then in the midst of implementation. According to FAA, the agency had to change some of its NextGen milestones by 4 to 18 months because of the month-long shutdown.
 - **Technical issues.** FAA has also documented technical issues that have contributed to delays. For example, FAA stated that working through technical issues with air traffic controllers' display monitors and trackballs, in combination with the government shutdown and COVID-19, resulted in the 21-month delay to an ERAM sustainment phase.⁵¹ Due to the interoperability of many NextGen systems, ERAM delays also affected Data Comm's implementation milestones.
 - **Community concerns.** As we have previously reported, local communities have raised issues about aircraft noise, which contributed to some schedule delays related to PBN implementation.⁵² FAA officials have acknowledged that they could have been more proactive in their community outreach regarding noise concerns that arose from implementing new PBN procedures.⁵³

⁵¹A trackball is a computer cursor control device.

⁵²GAO, *Aircraft Noise: FAA Could Improve Outreach through Enhanced Noise Metrics, Communication, and Support to Communities*, [GAO-21-103933](#) (Washington, D.C.: Sept. 28, 2021).

⁵³PBN procedures enable aircraft to fly a particular flight path more precisely along a narrower path, rather than being spread across a wider path. As a result, some communities that are directly under the PBN flight paths were concerned about more frequent noise given the increased number of aircraft. In September 2021, we recommended, and FAA concurred, that the FAA Administrator identify supplemental noise metrics to help FAA assess noise impacts related to proposed PBN flight path changes and provide clearer information to airports and communities on what they can expect from FAA in terms of noise issues. FAA is currently conducting a noise policy review before considering which supplemental noise metrics are appropriate to inform research and policy considerations. See [GAO-21-103933](#).

As a result, some timelines were changed to accommodate community noise concerns about PBN procedures. For instance, although FAA had planned to end implementation at the South-Central Florida metroplex by March 2018, the metroplex project was delayed by 3 years. During that time, FAA held 17 in-person workshops in 2019 and 12 virtual workshops in June 2020 during the pandemic, to help address residents' concerns, as well as extended the comment period for its draft environmental assessment.

FAA and Stakeholders Cited Unanticipated Events, Varying Levels of Aircraft Equipage, and the Changing National Airspace as NextGen Challenges

Unanticipated Events Can Amplify NextGen Planning and Implementation Challenges

While FAA has made progress implementing NextGen since 2018, the agency faces ongoing planning and implementation challenges due to COVID-19. The COVID-19 public health emergency ended in May 2023; however, FAA continues to modify plans and schedules resulting from COVID-19 related delays. For instance, while FAA has resumed training controllers for Data Comm, the restricted access to facilities during the pandemic continues to affect its implementation schedule for NextGen. As of April 2023, FAA officials said that these disruptions required, and would continue to require, the prioritization and deconfliction of schedules at each of the facilities.

FAA and stakeholders we interviewed recognized the need for the agency to be agile in responding to unanticipated events, like COVID-19, moving forward. One key stakeholder representing air-traffic controllers stated that FAA has been flexible and agile since resuming Data Comm training in mid-2022. More broadly, FAA and stakeholders view the deployment of initial Data Comm services to a few en route centers as a good example of FAA's agility in modifying its implementation schedule and continuing to move forward based on facility availability and COVID-19 conditions. Rather than resuming implementation with a pre-determined schedule for deploying Data Comm to each en route center, FAA deployed to en route centers as scheduling and COVID-19 risk levels allowed. While this

implementation strategy helped FAA resume deployment, Data Comm remains behind schedule.

Delays due to COVID-19 have also required FAA to re-assess and re-prioritize individual programs across NextGen, according to FAA. To assess the future direction of NextGen given delays caused by COVID-19, FAA sought industry input through the NAC in April 2022. FAA tasked the NAC to prioritize six NextGen systems in the automation, surveillance, and communications program areas.⁵⁴ In response to industry feedback, FAA announced revised implementation schedules for these six NextGen systems in August 2022, consistent with the NAC's input. According to FAA at the time of our review, FAA planned to revise implementation schedules for the systems that have been deferred, which demonstrates the lasting impact of the pandemic.

FAA's experience during and after the pandemic showed, more broadly, that revising NextGen plans and implementation schedules can be particularly challenging due to the interdependencies of many NextGen systems. For instance, maximizing PBN benefits, such as shorter and more fuel-efficient routes, depends on new automated tools that allow controllers to merge and space aircraft on final approach to runways. One of these tools (TSAS) facilitates the use of advanced PBN procedures and the display of PBN routes on STARS controller displays. Due to the interdependencies between these systems, any future delays in one system—whether caused by a health emergency, such as a pandemic, or some other unanticipated event—have the potential to delay other systems.

COVID-19 related delays also resulted in concerns about increasing costs of NextGen's individual programs, according to FAA officials. In March 2023, FAA officials estimated the financial impacts of COVID-19 to the NextGen program were \$225 million. They explained that these impacts were primarily due to schedule delays that, in part, required FAA to redo work that had been completed prior to the COVID-19 pandemic, such as training that had expired and site surveys that were outdated. According to FAA, these additional costs and its flat annual budget for NextGen have, in turn, further affected NextGen implementation, requiring re-

⁵⁴Of those six systems, the status of four—Initial and Full Data Comm services for en route centers, TFDM, and TBFM—are captured in this report. The two specific advanced ADS-B In surveillance capabilities that FAA asked for the NAC's input were not included in our scope. According to FAA and the NAC, those two capabilities, once implemented, would improve runway rates and precisely manage spacing between aircraft.

sequencing of timelines and scope adjustments in the August 2022 revised implementation schedules.

While FAA has noted that a flat NextGen budget has affected implementation, the actual budget reported in FAA's congressional budget justification generally aligned with the amounts FAA requested. For example, as reflected in FAA's congressional budget justifications for FY 2012 through 2023, FAA's budget requests and actual budget for NextGen—including system deployment—have remained relatively constant at about \$1 billion annually.⁵⁵ We did not assess FAA's budget requests in relation to NextGen priorities. Nonetheless, representatives from an association representing air-traffic controllers told us that FAA's budget requests for implementing NextGen have not kept up with the growing costs of materials and labor over time. Later in this report, we discuss the importance of life-cycle cost estimates to program management, which could help better inform and justify budget requests. Related to funding, FAA and stakeholders also told us that funding disruptions—due to sequestration, continuing resolutions, and government shutdowns—have affected NextGen. For instance, FAA reported that the 2018-2019 government shutdown required FAA to adjust and re-plan approximately 81 out of 186 government and industry NextGen milestones.⁵⁶

Equipping Aircraft with NextGen Avionics, which Hinges in Part on Industry Buy-in, Is a Continuing Challenge

Another ongoing challenge to NextGen implementation is achieving the level of equipage needed to ensure that operators can realize NextGen benefits. While the foundational systems—ERAM and STARS—do not require aircraft operators to install avionics, other NextGen systems do. With the exception of ADS-B Out, which was mandated, FAA relies on the operators to voluntarily equip their aircraft with the necessary avionics. According to FAA, aircraft operators have achieved different levels of aircraft equipage for PBN, Data Comm, and ADS-B.

- **PBN.** As of September 2022, 99 percent of air transport aircraft were equipped for RNAV operations and 99 percent were equipped for

⁵⁵We used the actual budget amount FAA reflected in its congressional budget justification for each fiscal year, but for FY 2022 used the continuing resolution budget amount FAA reported because the actual budget was not yet available at the time the congressional budget justification was developed.

⁵⁶The *NextGen Priorities Joint Implementation Plan Calendar Year 2019-2021* is FAA's agreement with the NAC on joint priorities for the next 3 years, including Data Comm and PBN. This plan includes a narrower subset of the various program and portfolio areas than the NextGen Implementation Plan and establishes government and industry milestones.

certain types of RNP procedures. However, equipage rates ranged from 78 to 88 percent for other types of RNP procedures.

- **Data Comm.** As of January 2023, there were 9,184 in-service aircraft equipped with Data Comm avionics, which exceeded FAA's goal of having 3,800 aircraft equipped by the end of 2023. However, there were no regional aircraft equipped with Data Comm at that time.
- **ADS-B.** As of April 2023, out of approximately 220,000 aircraft currently registered in the U.S., 155,596 aircraft (71 percent) had properly functioning ADS-B Out avionics installed, including 100 percent of U.S. Part 121 commercial air carriers.⁵⁷ In addition, 131,444 aircraft (60 percent) had ADS-B In capabilities installed, which were not mandated.

Having aircraft with varying equipage levels and capabilities in the national airspace system is commonly referred to as mixed equipage. These differences can lead to operational inefficiencies, which the NAC has identified as a primary risk to achieving full NextGen benefits. One stakeholder noted that the equipage decisions of some operators can affect the NextGen benefits realized by other operators. Specifically, aircraft not equipped with PBN avionics can cause slowdowns at certain airport hubs, even for aircraft that are equipped, since controllers have to use procedures that align with each aircraft's equipage. As a result, mixed equipage can inhibit operators of better-equipped aircraft from achieving returns on their avionics investments.⁵⁸

According to stakeholders representing pilots, airlines, and aviation researchers, cost continues to be a barrier to airlines choosing to install avionics voluntarily. This barrier has been exacerbated by the pandemic's effect on some aircraft operators' revenues, according to these stakeholders. We reported in October 2021 that U.S. passenger airlines experienced an unprecedented reduction in the demand for air travel in

⁵⁷In general, Part 121 air carriers are regularly scheduled carriers that operate under the requirements of 14 C.F.R. Part 121. These carriers generally include large, U.S.-based airlines, regional air carriers, and all cargo operators. While FAA mandated that aircraft must be equipped with ADS-B out to fly in certain controlled airspace, aircraft not flying in those controlled airspaces are not required to equip.

⁵⁸To help address the challenge of mixed equipage levels and the resulting different levels of aircraft capability, FAA and industry collaborated to develop the Minimum Capabilities List in May 2020. The list presents the recommended minimum aircraft capabilities, and associated equipage, needed to derive the maximum benefit from NextGen investments. However, the list does not address mixed equipage within the existing fleet; rather, the purpose of the list is to guide aircraft equipage for future aircraft.

2020 as a result of the COVID-19 pandemic, which affected airline revenue.⁵⁹ For instance, the top three major U.S. airlines experienced a 94 percent decline in passenger revenues in the second quarter of 2020 compared to the second quarter of 2019. While travel demand rapidly recovered beginning in the spring of 2021, stakeholders told us that the pandemic introduced uncertainty among airlines regarding their finances going forward. One stakeholder added that, in some cases, it could be more cost effective for airlines to wait until they acquire new aircraft rather than retrofitting existing aircraft with NextGen systems.

In addition, industry stakeholders at a 2021 NAC meeting noted that regional fleet equipage is particularly complicated since a regional airline can operate for more than one carrier. They explained that determining who should pay for the aircraft equipage and associated pilot training in such cases is challenging. As a result, some airlines—particularly regional airlines—have been hesitant to equip with NextGen avionics. For instance, in January 2023, FAA told us that no regional aircraft were equipped with Data Comm. To address this issue, the NAC had previously recommended that FAA consider incentives for regional jet equipage.⁶⁰ FAA provided an incentive from 2014 through 2019 for operators to equip with Data Comm, which resulted in more than 2,465 aircraft being equipped by 2019, exceeding FAA’s goal of 1,900 equipped aircraft. As of April 2023, FAA did not have a planned budget for additional incentives to provide for regional aircraft to equip with Data Comm, according to FAA officials.

Both industry stakeholders representing pilots and a recent NAC report indicated that individual program delays and re-scoping capabilities in NextGen program areas could erode industry’s confidence and may lead to future investment reluctance.⁶¹ FAA officials recognized that pandemic-related implementation delays have made the realization of benefits a moving target, which might affect equipage decisions.⁶² Moving timelines affect when industry will see the returns on their investments, and such returns are critical in encouraging participation in future equipage efforts,

⁵⁹GAO, *COVID-19 Pandemic: Observations on the Ongoing Recovery of the Aviation Industry*, [GAO-22-104429](#) (Washington, D.C.: Oct. 21, 2021).

⁶⁰NAC, *NextGen Integration Working Group Rolling Plan 2019-2021 Final Report* (2018).

⁶¹NAC, *Prioritize NextGen Programs for Implementation*, NAC Task 22-1 (Apr. 29, 2022).

⁶²Furthermore, because many NextGen systems are interdependent, delays in one system may delay the realization of benefits from some other systems, potentially affecting equipage decisions.

according to the NAC. Furthermore, while individual programs within NextGen deliver benefits once operational, the DOT OIG found in March 2021 that NextGen's benefits have not kept pace with initial expectations. The DOT OIG found that at the time of its report, FAA's most recent business case projects total NextGen benefits to be over \$100 billion less than the original estimate.⁶³

Consequently, the NAC informed FAA that it will need to effectively communicate its plans for future investments in the ground-based automation systems (e.g., TBFM) before operators decide to equip or make strategic investment decisions on how to best equip with interdependent communications, surveillance, and navigation avionics. Several industry stakeholders representing airlines, pilots, and controllers also stated that they would like to see more transparency with regard to FAA's planning. According to the NAC and a stakeholder we spoke with, aircraft operators rely on FAA planning documents, including deployment plans and implementation schedules, to help them determine if and when to make aircraft technology investments. FAA has taken several steps to more closely collaborate with industry on NAC priorities. For example, in the August 2022 NAC meeting, the Northeast Corridor workgroup, which includes members from industry and FAA, planned to meet more frequently to strengthen communication and collaboration.

The Changing National Airspace System Poses Additional NextGen Implementation Challenges

FAA faces several additional challenges to NextGen implementation as the NAS continues to evolve, according to FAA and stakeholders. These challenges include cybersecurity risks posed by a more connected NAS, integration of new entrants into the NAS (such as unmanned aircraft systems (drones) and commercial spacecraft), and potential spectrum interference.⁶⁴ We discuss FAA's risk management practices later in the report, which could help address emerging challenges.

- **Cybersecurity.** FAA and stakeholders representing controllers and pilots identified cybersecurity as an ongoing challenge to NextGen implementation. Through NextGen, FAA is shifting the air-traffic control system from a point-to-point communications system to an internet-based, interconnected system. The increasing connections

⁶³DOT, OIG, *NextGen Benefits Have Not Kept Pace with Initial Projections, but Opportunities Remain to Improve Future Modernization Efforts*, AV-2021-023 (Washington, D.C.: Mar. 30, 2021).

⁶⁴We have previously reported on several of these issues. For example, we reported on the challenge of cybersecurity and integrating new entrants to the NAS in 2017. See [GAO-17-450](#).

between aircraft and other systems, combined with the evolving cyber threat landscape, could lead to increasing risks for future flight safety. To help address cybersecurity risks related to the integration of new NextGen technologies into the NAS, FAA reported that the agency uses specific risk-management programs (e.g., risk modeling) and collaborates with interagency, international, and aviation community partners.⁶⁵ In addition, FAA established an integrated cybersecurity test facility to, in part, assess the security of individual systems.⁶⁶ We recently reported on aviation cybersecurity in 2020, and as of 2023, cybersecurity challenges across the federal government remain on GAO's High-Risk List.⁶⁷ Specifically, we reported in 2020 that interdependencies across the aviation ecosystem underscore the importance of identifying, mitigating, and coordinating cybersecurity risks to ensure critical infrastructure protection.⁶⁸ While FAA and stakeholders cited cybersecurity as a challenge for NextGen implementation, we did not assess FAA's actions related to cybersecurity as part of this review.

- **New entrants.** Several industry stakeholders noted concerns about the integration of drones and commercial spacecraft into the NAS. According to a 2021 FAA report, these airspace users were not envisioned when NextGen began and have implications for budgets, planning, and how the airspace is structured.⁶⁹ FAA's 2021 report

⁶⁵FAA, *NextGen Implementation Plan 2018-19*.

⁶⁶According to FAA, FAA developed and integrated a non-classified cyber testbed in December 2015 and established a classified cyber testbed in April 2021.

⁶⁷In October 2020, we made six recommendations to FAA to strengthen its avionics cybersecurity oversight program. In addressing one recommendation, FAA conducted a risk assessment of the cybersecurity of avionics systems, identified cybersecurity-related risks for its oversight plan, and developed a plan that includes how it will address those risks. FAA has not yet implemented the remaining five recommendations, which were to be implemented based on the cybersecurity risk assessment that FAA conducted. GAO, *Aviation Cybersecurity: FAA Should Fully Implement Key Practices to Strengthen Its Oversight of Avionics Risks*, [GAO-21-86](#) (Washington, D.C.: Oct. 9, 2020). In April 2023, our biennial update to our High-Risk List continued to include cybersecurity as a government-wide high-risk area. GAO, *High-Risk Series: Efforts Made to Achieve Progress Need to Be Maintained and Expanded to Fully Address All Areas*, [GAO-23-106203](#) (Washington, D.C.: Apr. 20, 2023).

⁶⁸The aviation ecosystem refers to the global network of airframe manufacturers, suppliers, carriers, airports, and other entities. Critical infrastructure provides essential functions—such as supplying water, generating energy, and transporting people and commerce—that underpin American society.

⁶⁹FAA, *Modernization of the Air Transportation System (a multi-year effort) Report*, (Washington, D.C.: Dec. 2021).

stated that accommodating these new users in a safe and efficient manner involves careful planning and stakeholder engagement in determining the required NextGen procedures, automation support, and communication, navigation, and surveillance capabilities necessary to account for those users' unique performance characteristics and different types of aircraft. FAA has been working to integrate new entrants into the NAS and with NextGen. For example, we reported that FAA made progress in its development of procedures, technologies, and industry coordination that are designed to reduce some of the inefficiencies integrating commercial space users into the NAS.⁷⁰ However, in June 2023, the DOT OIG reported that some of these efforts have had limited effectiveness.⁷¹ For instance, a new tool developed to provide launch and reentry data to stakeholders is accessible at one location, which prevents all affected stakeholders from receiving near real-time information regarding the status of a commercial space operation. While FAA intends to expand access to the tool, FAA has delayed making an investment decision until 2027.

- **Spectrum interference.** Stakeholders representing pilots, business aviation, and general aviation identified wider use of the fifth generation of mobile communication networks (5G) as a potential challenge to NextGen implementation. We previously reported that managing the diverse uses of spectrum (e.g., for mobile voice telecommunications and aviation applications) is a complex, challenging task and involves accommodating growing demand while protecting existing uses.⁷² 5G is the latest generation of mobile communications and is expected to provide faster connections. However, the radio frequencies used in 5G can be close to those used by an important piece of safety equipment in aircraft, potentially leading to hazardous interference with navigation systems that, according to one stakeholder, could impact PBN. For instance, 5G interference can affect equipment that PBN operations require, resulting in an error message to the pilot. In May 2023, FAA finalized

⁷⁰GAO, *Commercial Space Transportation: FAA Continues to Update Regulations and Faces Challenges to Overseeing an Evolving Industry*, [GAO-21-105268](#) (Washington, D.C.: June 16, 2021).

⁷¹DOT, OIG, *FAA Has Deployed a Prototype System for Monitoring Commercial Space Operations but Faces Integration Challenges*, AV-2023-036 (Washington, D.C.: June 21, 2023).

⁷²GAO, *Spectrum Management: Agencies Should Strengthen Collaborative Mechanisms and Processes to Address Potential Interference*, [GAO-21-474](#) (Washington, D.C.: June 29, 2021).

stricter requirements for radio altimeters in airplanes to address the potential for hazardous interference. However, FAA continues to assess the potential impacts of 5G on aircraft equipment by, for example, requesting that operators and pilots who experience equipment anomalies notify FAA. We have ongoing work to examine spectrum receiver interference as the demand for spectrum continues to increase.

FAA and others have indicated that an internal reorganization may be necessary to manage the NextGen program going forward. In its FY 2023 budget submission to Congress, FAA proposed an organizational realignment of the NextGen program office, in part, to reflect the evolution of the NextGen program.⁷³ However, Congress did not approve the realignment. In January 2023, legislation was introduced that directs the Secretary of Transportation to re-designate FAA's Office of NextGen as the Office of Advanced Aviation and to appoint an Associate Administrator to head the office and coordinate rulemaking and approval processes related to integrating new technologies into the NAS, among other things.⁷⁴ In addition, legislation was introduced in June 2023 that would, among other things, terminate FAA's NextGen office and transfer its responsibilities to others within FAA.⁷⁵ In the event that FAA reorganizes its NextGen office, our prior work has shown that there are key reform practices, such as establishing goals and outcomes and involving employees and key stakeholders, that can help facilitate such transitions.⁷⁶

⁷³These proposed changes were also, in part, to fulfill the requirements in the FAA Reauthorization Act of 2018. Under Section 545, FAA was required to establish a Chief Technology Officer reporting directly to the Chief Operating Officer. Under Section 711, FAA was required to appoint an Assistant Administrator for Research and Development responsible for management and oversight of all FAA's research and development programs and activities. Pub. L. No. 115-254, tit. V and VII, §§ 545, 711, 132 Stat. 3186, 3374 and 3410 (2018).

⁷⁴Advanced Aviation Act, H.R. 220, 118th Cong. (2023).

⁷⁵Securing Growth and Robust Leadership in American Aviation Act, H.R. 3935, 118th Cong. (2023).

⁷⁶Key reform practices include establishing goals and outcomes; involving employees and key stakeholders; using data and evidence; addressing fragmentation, overlap, and duplication; addressing high-risk areas and long-standing management challenges; and leadership focus and attention, among others. GAO, *Government Reorganization: Key Questions to Assess Agency Reform Efforts*, [GAO-18-427](#) (Washington, D.C.: June 13, 2018).

FAA's Efforts to Implement NextGen Followed Several Leading Practices in Program Management but Fell Short in Fully Meeting Others

FAA Followed Four Leading Practices in Program Management

Following leading practices in program management is important to the success and effectiveness of major efforts such as the NextGen program. Of the nine leading practices in program management that we used to assess FAA's overall management of NextGen, FAA fully or substantially met, and therefore we concluded it followed, four leading practices.⁷⁷ FAA partially met, and therefore we concluded it did not fully follow, five leading practices. There were no cases where we concluded that FAA minimally met or did not meet a practice.

Table 1 describes the four leading practices in program management that FAA followed and provides the results of our analysis, including the identification of various program management tools—such as roadmaps, plans, and reporting mechanisms—that FAA used that demonstrate adherence to the leading practices.

⁷⁷ GAO, Nuclear Waste Cleanup: DOE Could Improve Program and Project Management by Better Classifying Work and Following Leading Practices, GAO 19 223 (Washington, D.C.: Feb. 19, 2019). PMI, The Standard for Program Management®, Fourth Edition (Newtown Square, PA: 2018).

Table 1: Leading Program Management Practices Followed by FAA in Managing the NextGen Program

Leading practices in program management	Federal Aviation Administration’s (FAA) Next Generation Air Transportation System (NextGen) actions	GAO assessment
The program should have a process and database for collecting and sharing lessons learned.	<ul style="list-style-type: none"> • FAA conducts post-implementation reviews (PIR) after an individual program is complete to gather information and report on lessons learned to improve implementation. These reviews determine whether performance, cost, schedule, and benefit goals are being attained. • FAA provides PIR reports to its Joint Resources Council (JRC)—a review board of senior FAA personnel tasked with the approval and oversight of billions of dollars of agency investment decisions. FAA also tracks lessons learned at NextGen meetings on a more ad hoc basis. FAA posts PIRs in its document repository, its Knowledge Services Network site. Any FAA staff can access this site. 	Fully met
The program should have an independent oversight body that conducts periodic reviews of the progress of the program.	<ul style="list-style-type: none"> • FAA has two bodies that provide oversight functions: the NextGen Advisory Committee (NAC) and the JRC. • The NAC consists of a range of over 20 industry members and non-voting FAA representatives. The NAC is expressly tasked with providing independent advice and recommendations to FAA. • The JRC is an executive governance board consisting of senior level FAA representatives and is responsible for the approval and oversight of the annual investment of billions of dollars in major systems acquisitions, including NextGen acquisitions. • These bodies along with oversight the NextGen program receives from Congress, GAO, and the Department of Transportation Office of Inspector General provide a valuable check on the program and meet the intent of this practice. 	Fully met
The program should have a program management plan and a roadmap that are updated regularly.	<ul style="list-style-type: none"> • Through 2018, FAA produced an annual NextGen implementation plan, which it considered its program management plan. While it has not updated its implementation plan for over 4 years, FAA officials said FAA has effectively kept NextGen planning updated through its NextGen Annual Report and the National Airspace System Enterprise Infrastructure Roadmap (roadmap) last updated in February 2023. These documents include most key elements covered in the previous implementation plan. The NextGen Annual Report includes key program management plan elements, including NextGen’s concept, vision, benefits, and goals, as well as a work plan for program components. The roadmap shows more detailed plans and schedules for implementing all National Airspace System (NAS) acquisitions, including NextGen. While FAA has updated the roadmap annually, it did not update the annual report for 2022. In August 2023, FAA officials stated that FAA expects to issue the 2022 report in 2024. 	Substantially met

Leading practices in program management	Federal Aviation Administration’s (FAA) Next Generation Air Transportation System (NextGen) actions	GAO assessment
The program should have a reliable, integrated master schedule that is updated on a regular basis. ^a	<ul style="list-style-type: none"> • FAA has had an integrated master schedule since 2015. According to FAA officials, the roadmap serves as the integrated master schedule, which defines the individual NAS component schedules, including NextGen, and dependencies between these various components. • FAA updated the NextGen master schedule monthly for internal use prior to the COVID-19 pandemic but did not do so during the pandemic. FAA officials said it was not cost effective to continue monthly updates, as schedules would need to be redone. Recently, FAA has updated the schedules for some NextGen program areas, including Terminal Flight Data Manager. In addition, FAA officials told us they are updating the Data Communication schedule for full services at en route centers. 	Substantially met

Source: GAO analysis of FAA documentation and interviews. | GAO-24-105254

Note: We scored FAA’s management actions for each leading practice on a five-point scale, from “fully met” to “not met.” “Fully met” means that actions have been taken that completely meet the selected practice. “Substantially met” means most but not all actions to meet the selected practice have been taken. “Partially met” means that some, but not all, actions necessary to address the practice have been taken. “Minimally met” means that few actions toward addressing the practice have been taken. “Not met” means no actions toward addressing the practice have been taken.

^aWe did not assess the reliability of FAA’s integrated master schedule.

FAA officials told us that these tools, which we found to be consistent with key program management practices, helped NextGen’s complex, interconnected program areas progress. FAA officials told us that the agency was generally in position, with its program management plan and roadmap in place, to explain and demonstrate which individual program schedules were affected by the pandemic and how other individual program schedules might be affected in the future. Further, FAA officials explained that because FAA has an established framework for collecting and sharing lessons learned from the COVID-19 pandemic, the agency may be better positioned to address challenges that result from similar unanticipated events in the future.

FAA Did not Fully Follow Five Leading Practices in Program Management	Table 2 describes the remaining five leading practices in program management that FAA did not fully follow and provides a summary of our assessment.
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Table 2: Leading Program Management Practices Not Fully Followed by FAA in Managing the NextGen Program

Leading practices in program management	Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGen) actions	GAO assessment
The program should have a reliable, integrated, comprehensive life-cycle cost estimate that is updated on a regular basis. ^a	<ul style="list-style-type: none"> While FAA tracks the acquisition costs of its individual programs within NextGen, according to FAA, it has not tracked life-cycle costs since a 2017 NextGen cost-benefit analysis. While FAA officials said that the COVID-19 pandemic prevented them from updating NextGen life-cycle costs, the last update preceded the pandemic by several years. In addition, FAA told us that it currently tracks life-cycle costs at the program level, which can be difficult to estimate for some individual programs. However, these data are not always updated. 	Partially met
The program's performance should be measured against baselines established in an integrated master schedule and against the program's life-cycle cost.	<ul style="list-style-type: none"> FAA officials said they track baselines of major system investments within NextGen, including master schedule baselines, through FAA's Simplified Program Information, Reporting, and Evaluation (SPIRE) tool. This tool includes 17 reportable program performance metrics to serve as early warning indicators of major system investment issues and to check cost, schedule, and performance monthly. In addition, the Joint Resources Council (JRC) reviews NextGen program performance on a quarterly basis. FAA said that reporting generally occurs monthly in a non-COVID environment, but given the operational effects of the COVID-19 pandemic, reporting was not as regular as officials would have liked. In addition, according to FAA officials, FAA does not track NextGen program life-cycle costs but does track individual program acquisition costs that are a subset of life-cycle costs. 	Partially met
Program risk management should be conducted throughout the life of the program and include risk mitigation plans prioritizing risks and analyzing alternatives.	<ul style="list-style-type: none"> FAA has developed a NextGen risk management framework and conducts many risk analysis activities, including identifying, tracking, categorizing, and analyzing risks through its risk register, required under its Acquisition Management System policy and risk management framework.^b FAA uses its Active Risk Manager tool to identify, track, and categorize risks (high, medium, and low) at both the NextGen and individual program levels. According to FAA, officials also discuss risks at both those levels at formal meetings, including at quarterly JRC meetings, and develop actions to mitigate individual risks. However, FAA does not have a NextGen risk mitigation plan that prioritizes the highest NextGen programmatic risks and includes a range of mitigation alternatives for the highest programmatic risks identified.^c 	Partially met
The program should include monitoring and controls, including conducting root cause analyses and developing corrective action plans.	<ul style="list-style-type: none"> To monitor and control NextGen, FAA relies on its performance reporting system, risk management system, and, according to FAA officials, regular meetings at the NextGen and individual program level to discuss cost, schedule, performance, and risk and to monitor corrective action. In addition, FAA officials explained that the analyses they conduct after making changes to individual program baselines and conducting post-implementation reviews (PIR) constitute root cause analyses. However, FAA's Acquisition Management Policy does require root cause analyses prior to rebaselining, that is, when programs first exceed cost and schedule baselines by more than 10 percent. PIRs conducted after an individual program is implemented also are the basis for corrective action plans. FAA told us that once a corrective action is identified, it is managed and reported during risk board meetings at the NextGen and individual program level until closure. 	Partially met

Leading practices in program management	Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGen) actions	GAO assessment
Performance reporting and analysis is done in a way that provides stakeholders a clear picture of program performance.	<ul style="list-style-type: none"> • FAA tracks cost, schedule, and performance metrics for its individual programs through its SPIRE metric tool and documents NextGen performance reporting in FAA’s annual Performance and Accountability Report and budget documents to Congress. • However, its reporting can provide an overly positive picture of performance because those reports do not include individual programs within NextGen that exceeded their respective budgets by over 10 percent in the prior year. FAA removes them from the report and does not include those individual programs in its Performance and Accountability Report until they are rebaselined. However, FAA on occasion has not rebaselined individual programs, so these programs do not appear again in the reports. 	Partially met

Source: GAO analysis of FAA documentation and interviews. | GAO-24-105254

Note: We scored FAA’s management actions for each leading practice on a five-point scale, from “fully met” to “not met. The 5-point scoring system was as follows: “fully met” means that FAA’s policy completely met the leading practice; “substantially met” means that FAA’s policy met a large portion of the leading practice; “partially met” means that FAA’s policy met about half of the leading practice; “minimally met” means that FAA’s policy met a small portion of the leading practice; and “not met” means that FAA’s policy did not meet the leading practice at all.”

^aWe did not assess the reliability, integration, or comprehensiveness of FAA’s life-cycle cost estimate.

^bFAA’s Acquisition Management System policy establishes policy and guidance for all aspects of life-cycle acquisition management, including NextGen systems, for the agency.

^cFor the risk management leading practice, FAA does not include risk mitigation plans that prioritize risks and analyze alternatives, as called for by the Office of Management and Budget’s program management practices for risk management.

Regular Updates of NextGen Life-Cycle Cost Estimates and Measuring Performance against Those Estimates

FAA has not updated its full NextGen life-cycle cost estimate since 2017. Regularly updating life-cycle cost estimates and measuring performance against these estimates are two program-management leading practices. FAA explained that the COVID-19 pandemic has prevented it from making recent updates to NextGen life-cycle costs and that it is difficult to estimate costs for some individual programs within NextGen. For example, many FAA personnel worked on metroplexes and procedures, but those costs are not all associated with the NextGen PBN budget. Updating its life-cycle cost estimate for NextGen overall as well as measuring performance against these estimates could help FAA assess its budget needs and refine its annual budget requests. Doing so could be particularly useful given that FAA and stakeholders told us that funding uncertainty and budget concerns have been an ongoing challenge that has affected NextGen implementation and planning. In addition, regular life-cycle cost updates could help FAA ensure that Congress has a more accurate picture of FAA’s long-term funding needs and effectively allocates resources.

Risk Mitigation Plan with Risk Alternatives Analysis

FAA conducts a number of risk management activities, including use of a risk register to categorize risks as high, medium, or low. However, FAA

does not have a NextGen risk mitigation plan that identifies and further prioritizes the highest programmatic risks and contains detailed risk alternatives analyses to choose the best way to mitigate these high-level programmatic risks. FAA officials told us that NextGen program managers are responsible for developing alternative actions to address risks and that they believe current risk management actions are sufficient to manage the NextGen program.

According to OMB guidance, after identifying and prioritizing risks, an effective risk management process requires the development of clear plans to mitigate risks and an analysis of alternative approaches. Developing and documenting such a plan and considering risk mitigation alternatives enable an agency to systematically identify and assess a range of risk response options guided by the level of risk an agency is willing to accept. This may help FAA identify and select the best options to address identified challenges, including unanticipated events such as COVID-19, challenges related to new entrants, and cybersecurity risks. These analyses could put FAA in a better position to explain the highest programmatic risks it is facing while implementing NextGen and why the risk mitigation approach it selected was the best among other alternatives.⁷⁸

Root Cause Analysis for Projects That Require Rebaselining or Exceed Cost or Schedule Estimates by a Specified Threshold

FAA relies on its performance reporting system (the Simplified Program Information, Reporting, and Evaluation (SPIRE) tool), risk management system, and monthly meetings at the NextGen and individual program level to monitor NextGen. However, FAA's Acquisition Management System policy does not include requirements for a formal root cause analysis to be conducted when there is evidence that an individual program's cost, schedule, or performance baseline will not be met. According to OMB Memo M-16-17, agencies should perform a root-cause analysis of internal control deficiencies to ensure that subsequent strategies and plans address the root of the problem and not just the symptoms.

FAA officials told us that they attempt to identify causes contributing to a program's cost or schedule overruns or failure to meet performance goals in several ways. First, officials said FAA reports cost or schedule estimates exceeding 10 percent of their baseline at the quarterly Joint Resources Council (JRC) meetings and discusses causes. While useful,

⁷⁸The DOT OIG made a similar finding in the area of risk management. See DOT, OIG, *FAA Has Made Progress Implementing NextGen Priorities, but Additional Actions Are Needed to Improve Risk Management*, AV2018001 (Washington, D.C.: Oct. 18, 2017).

such informal discussions fall short of the formal analysis needed to ensure that FAA has identified the root cause—among multiple potential causes—of cost and schedule overruns. Second, FAA officials explained that they conduct baseline-change decision analyses.⁷⁹ However, a baseline-change decision analysis occurs only after FAA decides to rebaseline an individual program’s cost, schedule, or performance parameters and focuses on factors affecting project performance rather than root causes. In addition, such an analysis does not occur, according to officials we interviewed, if FAA chooses to move forward with an individual program or project that has breached its cost or schedule by at least 10 percent without rebaselining.⁸⁰ Finally, FAA officials said they use post-implementation reviews (PIR) as a form of root cause analysis. Those reviews, however, occur only after implementation has been completed at a particular site and may not necessarily reflect broader or deeper cost, schedule, or performance issues that may have arisen in the individual program.⁸¹

In the absence of a policy requirement calling for a formal root cause analysis when estimated costs or schedules exceed a certain threshold, FAA lacks reasonable assurance that it is positioned to prevent additional cost and schedule overruns that could jeopardize achievement of NextGen programmatic goals. In FAA’s case, ensuring that its Acquisition Management Policy triggers a root cause analysis could help FAA identify and address the root causes of cost or schedule overruns. Such a trigger could be when costs or schedules exceed 10 percent of an individual program’s cost or schedule baseline (FAA’s threshold for considering rebaselining). This analysis would support corrective actions being taken in a timely manner and more realistic and achievable milestones being set. As mentioned above, FAA faces a number of emerging challenges as

⁷⁹Baseline change decision analysis within FAA occurs when a NextGen program has exceeded cost, schedule, or performance baselines by more than 10 percent and FAA has decided to continue with the program area but rebaseline its cost, schedule, and performance parameters. The analysis identifies the factors that led to the cost and schedule overruns.

⁸⁰FAA must consider terminating programs that exceed 10 percent of cost or schedule baselines or fail to achieve 90 percent of performance goals. When a cost or schedule breach is 50 percent or more, FAA must terminate the program or make a written determination to continue the program and send the determination to Congress.

⁸¹PIRs identify lessons learned that form the basis for corrective action plans, according to FAA officials. This practice is similar to OMB Circular No. A-123’s call for the results of root cause analyses to feed into corrective action plans for internal control deficiencies. FAA officials also told us that once a corrective action is identified, it is managed and reported during risk meetings at the NextGen and individual program level until closure.

More Transparent NextGen
System Performance
Reporting

it continues to implement NextGen. More regular and systematic root cause analyses along with the development of corrective actions may, in turn, help prevent other individual NextGen programs from experiencing similar cost or schedule overruns.

FAA's performance reporting related to NextGen's individual programs—specifically, the annual Performance and Accountability report—did not always provide a complete picture of performance. This is because the report does not include the major system investments within NextGen that have exceeded their performance targets and are to be re-baselined. Such projects are removed from reporting.⁸² For example, FAA's 2020 Performance and Accountability report, which included 20 major system investments critical to the implementation of NextGen, noted that seven performance targets were missed that year, meaning that 65 percent (13 of 20) of its major system investments met its goals. The 2021 report included performance reporting for 11 major system investments critical to the implementation of NextGen that had not missed milestones or had already received new performance goals.⁸³ FAA officials told us that the other nine NextGen major system investments were not included in this report because FAA had yet to set new performance goals for them.

According to FAA, since major system investments generally do not recover from significant delays in either cost or schedule, the agency does not continue to include major system investments with missed performance goals in subsequent performance and accountability reports. FAA further stated that new cost and schedule goals are often necessary in order to meaningfully measure major system investment progress. FAA noted that it internally tracks all individual program cost and schedule baselines through its performance reporting tool SPIRE. FAA also provides information on individual programs that have missed cost and schedule baselines in an appendix in its budget submission to Congress. According to our leading program management practices, providing

⁸²Since 2012, FAA's target for each year is to keep 90 percent of its major system investments within 10 percent of its cost, schedule, and performance goals. Up until 2019, FAA had met this annual goal.

FAA defines major system investments as FAA programs that have lifecycle costs greater than \$100 million, or are key enablers of NextGen, or are classified as being the most complex, highest risk, and will most extensively change airspace operations.

⁸³The DOT IG raised similar transparency issues in the area of performance reporting in a recent report. See DOT, OIG, *FAA Needs Additional Accountability and Transparency in Reporting Performance Measures and Targets for Major System Investments and Environmental Reviews*, AV2022023 (Washington, D.C.: Mar. 14, 2022).

stakeholders with a clear picture of program performance is important. Had FAA noted in its 2021 Performance and Accountability report that nine major system investments would be receiving new cost and schedule performance goals and still included these major system investments as part of its performance calculation, FAA could have provided a clearer picture of overall program performance and progress. Being transparent in future performance and accountability reports about which major system investments were rebaselined or received new performance goals could provide Congress and stakeholders a more accurate view of NextGen progress and enhance FAA accountability.

Conclusions

Completing the modernization of the nation's air traffic system largely rests on FAA's successful implementation of NextGen and its many program areas designed to provide for safer and more efficient air travel. FAA has reported spending at least \$14 billion on NextGen from FY 2007 through 2022 and expects to spend billions more through 2030, based on the agency's most recent estimates. FAA has used several leading practices in program management to help it continue to implement this far-reaching and complex program. Closer adherence to other such practices, specifically those related to life-cycle cost estimates, risk mitigation, and root cause analyses, may help FAA better manage implementation and the NextGen budget going forward. Particularly in light of the many COVID-19 related implementation delays and increased program costs that FAA experienced in recent years, these practices could help the agency manage its efforts to rescope and rebaseline some individual programs and help it achieve its stated NextGen goals and projected program benefits.

In addition, given NextGen's complexities, its long timeline, and the challenges stakeholders and FAA identified, implementation may at times warrant risk mitigation or course change. While FAA engages in a number of risk management activities, unless it develops a comprehensive risk management plan that is focused on NextGen and identifies alternatives to address high-level risks, FAA will be less equipped to quickly and effectively pivot to adapt to change and mitigate risks. And until FAA ensures that its Acquisition Management System policy requires root cause analyses of cost overruns and missed milestones when cost or schedule assessments exceed an FAA-determined threshold or have to be rebaselined, FAA has less assurance that it has taken steps to avoid major course corrections in the future.

Finally, unless FAA provides greater transparency in its public performance reporting, as called for by leading practices in program

management, Congress and stakeholders will have an incomplete view of overall NextGen program performance. Providing greater transparency into individual programs' cost, schedule, and performance goal revisions and rebaselining can also enhance accountability.

Recommendations for Executive Action

We are making the following four recommendations to FAA:

The FAA Administrator should develop an updated life-cycle cost estimate for NextGen, measure FAA's performance against it, and create a schedule for updating the life-cycle cost estimate regularly. (Recommendation 1)

The FAA Administrator should develop and document a detailed risk mitigation plan focused on NextGen, which outlines how FAA identifies and prioritizes high-level risks to the NextGen program, provides alternatives for mitigation, and provides a rationale for the selected mitigation approaches. (Recommendation 2)

The FAA Administrator should ensure that its Acquisition Management System policy includes a requirement to conduct root cause analyses on individual NextGen programs that exceed a specific threshold of cost, schedule, or performance variance and when the program is rebaselined. (Recommendation 3)

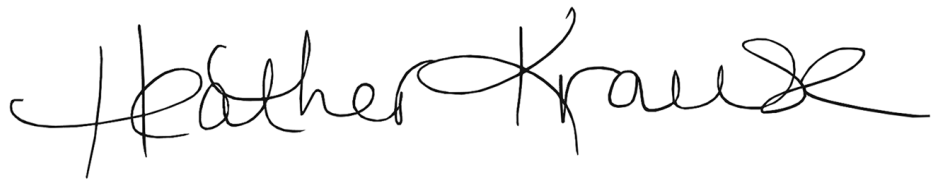
The FAA Administrator should include information in future NextGen Performance and Accountability reports to make clear which individual programs within NextGen are awaiting or have received revised cost, schedule, and performance goals, as well as those that FAA does not intend to rebaseline. (Recommendation 4)

Agency Comments

We provided a draft of this report to the Department of Transportation (DOT) for review and comment. In its comments, reproduced in appendix I, DOT concurred with our recommendations and stated that it will provide a detailed response to each recommendation within 180 days of the report's issuance. DOT also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or krauseh@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.

A handwritten signature in black ink that reads "Heather Krause". The signature is written in a cursive style with a large, stylized 'H' and 'K'.

Heather Krause
Director, Physical Infrastructure

Appendix I: Comments from the Department of Transportation



**U.S. Department of
Transportation**
Office of the Secretary
of Transportation

Assistant Secretary
for Administration

1200 New Jersey Avenue, SE
Washington, DC 20590

September 28, 2023

Heather Krause
Director, Physical Infrastructure
U.S. Government Accountability Office
441 G Street NW
Washington, DC 20548

Ms. Krause:

The Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration (FAA) modernization initiative to transform the U.S. National Airspace System (NAS). We work diligently to modernize air traffic management, thus improving the safety and efficiency of air travel and addressing growing congestion in the national airspace system. Most of the modernized infrastructure is in place, and NextGen has delivered more than \$9.5 billion worth of total benefits between 2010 and 2022, with future benefits expected to grow substantially. The airspace has gone from a ground-based to a satellite-based system to track aircraft. Many aircraft now receive flight plans and other information via data messages when at the airport. When airlines equip more of their aircraft with the avionics needed to leverage NextGen technologies, we will realize the full potential of airspace modernization.

The FAA must balance sustaining current NAS operations with investments in NextGen priorities. The FAA continues to assess the consequences of delays and funding shortfalls caused by the pandemic on programs, particularly enroute Data Communications (Data Comm), Time Based Flow Management (TBFM), Terminal Flight Data Manager (TFDM), and System Wide Information Management (SWIM), even as we mark significant milestones for these initiatives.

Based on our review of the draft report, the Department concurs with GAO's four recommendations to improve the FAA's management of NextGen and will provide a detailed response to each recommendation within 180 days of the final report issuance.

We appreciate the opportunity to respond to the GAO draft report. Feel free to contact Gary Middleton, Director, Audit Relations and Program Improvement, at (202) 366-6512 with any questions or if GAO would like to obtain additional details about these comments.

Sincerely,

A handwritten signature in black ink, appearing to read "Philip A. McNamara".

Philip A. McNamara
Assistant Secretary for Administration

Appendix II: GAO Contact and Staff Acknowledgments

Contact

Heather Krause at (202) 512-2834 or krauseh@gao.gov

Staff

Acknowledgments

In addition to the contact named above, David Sausville (Assistant Director); Kieran McCarthy (Analyst-In-Charge); Martha Chow; Melanie Diemel; Jennifer Echard; Cristian Ion; Delwen Jones; Jennifer Leotta; Natasha Oliver; Aaron Olszewski; Alicia Wilson; and Elizabeth Wood made key contributions to this report.

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Stephen J. Sanford, Managing Director, spel@gao.gov, (202) 512-4707
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Washington, DC 20548

