



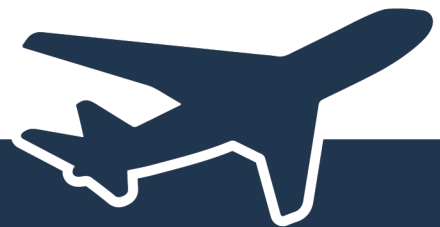
U.S. DEPARTMENT OF TRANSPORTATION
OFFICE OF INSPECTOR GENERAL

**FAA Has Begun To Update ERAM but
Faces Challenges Realizing Full Benefits
for Airspace Users**

FAA

Report No. AV2020040

July 29, 2020





FAA Has Begun To Update ERAM but Faces Challenges Realizing Full Benefits for Airspace Users

Requested by the Senate Committee on Commerce, Science, and Transportation and House Committee on Transportation and Infrastructure and its Subcommittee on Aviation

Federal Aviation Administration | AV2020040 | July 29, 2020

What We Looked At

The National Airspace System (NAS) serves over 44,000 flights a day with over 5,000 aircraft in the sky at peak times. Critical to the NAS's operations are the Federal Aviation Administration's (FAA) 20 Air Route Traffic Control Centers (Centers) that manage high-altitude air traffic. These Centers are equipped with the En Route Automation Modernization (ERAM) system to manage and control high-altitude operations and provide infrastructure for new systems such as high-altitude data link communications for FAA's Next Generation Air Transportation System (NextGen). In response to requests from the Senate Committee on Commerce, Science, and Transportation and the House Committee on Transportation and Infrastructure and its Aviation Subcommittee, we conducted this audit. Our objectives were to (1) evaluate FAA's planned upgrades to ERAM and (2) assess ERAM's ability to support key NextGen capabilities.

What We Found

FAA is making a significant investment to sustain and enhance ERAM's hardware and software at the Centers. Over 6 years, the Agency will replace ERAM's original computer hardware and modernize ERAM's software to allow system improvements and new capabilities. Once these upgrades are complete, ERAM will essentially be a new system with enhanced capabilities. FAA plans to continue to add capabilities and keep the system up to date. FAA has re-categorized ERAM from a moderate to a high-impact system but has not yet determined what security controls the system will require as a high-impact system.

FAA has integrated NextGen capabilities into ERAM but faces challenges realizing full benefits for airspace users. FAA considers ERAM foundational to many NextGen systems, including the Automatic Dependent Surveillance—Broadcast (ADS-B) system, performance based navigation (PBN), and data communications (DataComm). The Agency has integrated ADS-B and PBN with ERAM but has encountered delays implementing DataComm's high-altitude services due to the impact of the Federal Government shutdown in late 2018 and early 2019, air-to-ground network problems, and other issues. Because FAA will develop new procedures and training for controllers and pilots for these capabilities, it is uncertain when these enhancements and NextGen capabilities will provide full benefits for airspace users.

Our Recommendations

We made one recommendation to help FAA improve its efforts to upgrade ERAM to support NextGen capabilities. FAA concurred with our recommendation.

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Memorandum

Date: July 29, 2020

Subject: ACTION: FAA Has Begun To Update ERAM but Faces Challenges Realizing Full Benefits for Airspace Users | Report No. AV2020040

From: Matthew E. Hampton
Assistant Inspector General for Aviation Audits

To: Federal Aviation Administrator

The National Airspace System (NAS) serves over 2.7 million passengers and 44,000 flights per day with over 5,000 aircraft in the sky at peak times. Critical to the NAS's day-to-day operations are the Federal Aviation Administration's (FAA) 20 geographically dispersed Air Route Traffic Control Centers (ARTCC or Center) that manage high-altitude air traffic across the country. These Centers are equipped with the En Route Automation Modernization (ERAM) air traffic control system, which enables air traffic controllers to manage and control approximately 43 million en route operations a year. The ERAM system—a \$3.5 billion program—also provides infrastructure for new systems, including satellite-based navigation and surveillance systems and high-altitude data link communications, for FAA's Next Generation Air Transportation System (NextGen). NextGen is a multibillion dollar effort to modernize the NAS and provide safer and more efficient air traffic management. FAA's long-term goals for NextGen—which are dependent on ERAM—are to increase airspace capacity and reduce flight delays.

Because of the importance of ERAM to air traffic management and NextGen's development, our office has reviewed FAA's progress implementing ERAM and the Agency's challenges for over a decade. In 2018, in response to requests from then Chairman Thune of the Senate Committee on Commerce, Science, and Transportation and then Chairmen Shuster and LoBiondo of the House Committee on Transportation and Infrastructure and its Aviation Subcommittee, we issued a report¹ on outages in ERAM and FAA's actions to address them. This current report also responds to the request. Our audit objectives were to

¹ *FAA Has Taken Steps To Address ERAM Outages, But Some Vulnerabilities Remain* (OIG Report Number AV2019004), November 7, 2018. OIG reports are available on our website at <http://www.oig.dot.gov/>.

(1) evaluate FAA's planned upgrades to ERAM and (2) assess ERAM's ability to support key NextGen capabilities.

We conducted our work in accordance with generally accepted Government auditing standards. Exhibit A presents details on our scope and methodology, and exhibit B presents a list of the organizations we visited or contacted.

We appreciate the courtesies and cooperation of Department of Transportation representatives during this audit. If you have any questions concerning this report, please call me at (202) 366-0500, or Nate Custer, Program Director, at (202) 366-5540.

cc: The Secretary
 DOT Audit Liaison, M-1
 FAA Audit Liaison, AAE-100

Results in Brief

FAA has begun its sustainment and enhancements efforts to update ERAM.

FAA is making a significant investment to sustain and enhance ERAM's hardware, which was installed at the 20 facilities between 2007 and 2008. Over the next 6 years, the Agency will replace ERAM's original computer hardware that is reaching its end-of-life. FAA is also modernizing ERAM's software to allow system improvements and new capabilities for the controller workforce and airspace users through 2025 and beyond. Since the current ERAM sustainment and enhancement efforts began in fiscal year 2017, FAA has been spending approximately \$21 million dollars per month on the efforts. Agency officials expect this level of funding to continue through 2025. Once these upgrades are complete, all the original ERAM hardware will have been replaced, and ERAM will essentially be a new system with enhanced capabilities. FAA plans to continue to add capabilities and keep the system up to date. In 2018, in recognition of the increasing importance of ERAM to the NAS, FAA re-categorized ERAM from a moderate to a high-impact system. The Agency has not yet determined what additional security controls ERAM will require as a high-impact system.

FAA has integrated NextGen capabilities into ERAM but faces challenges realizing full benefits for airspace users.

FAA considers ERAM a foundational system for many NextGen initiatives, including the Automatic Dependent Surveillance—Broadcast (ADS-B) system, performance-based navigation (PBN), and data communications (DataComm),² which is one of the highest-priority NextGen investments for FAA and industry. FAA faces challenges with the planned deployment of the high-altitude phase of DataComm at its 20 en route air traffic control Centers, which overlaps with other enhancements of ERAM and integration of NextGen systems. In addition, FAA has encountered some delays with DataComm's high-altitude services due to the impact of the Federal Government shutdown in December 2018 and January 2019,³ avionics issues, and air-to-ground network problems. Other capabilities, such as ADS-B and PBN, have been integrated with ERAM; however, we found that ADS-B is not being widely used to reduce separation standards between aircraft and that PBN is not being used consistently by the controller workforce to manage high-altitude routes. Because FAA will develop new procedures and training for controllers and pilots for these new capabilities, it is uncertain when

² DataComm provides two-way digital communications between controllers and flight crews to reduce radio voice communication, improve accuracy and safety, and reduce required time for communication.

³ A shutdown of the Federal Government that lasted for 35 days between midnight December 22, 2018, and January 25, 2019.

these enhancements and NextGen capabilities will provide full benefits for airspace users.

We made one recommendation to help FAA improve its efforts on upgrading ERAM to support NextGen capabilities.

Background

FAA designed ERAM to replace its 40 year-old Host Computer System prior to the initiation of NextGen efforts in late 2006. The Agency planned to make ERAM operational at its 20 Centers in December 2010, but due to a series of software-related problems, ERAM's implementation was delayed. FAA declared ERAM fully operational in March 2015.

Figure 1. Air Traffic Controller Using ERAM



Source: FAA

Even though ERAM predates NextGen, FAA expects ERAM to support a wide range of industry and FAA priority NextGen capabilities, including:

- ADS-B, an FAA-mandated priority that uses global positioning system (GPS) satellite-based surveillance technology. ERAM supports ADS-B to enable more accurate tracking of aircraft positions;

- DataComm, a priority of the NextGen Advisory Committee (NAC),⁴ which will allow controllers to send digital messages to pilots; and
- PBN, another NAC priority, which delivers new routes and flight procedures using satellite-based navigation aids and onboard aircraft equipment to enable more precise and accurate navigation. PBN flight procedures provide significant benefits to airspace users, including more direct flight paths, increased airspace capacity, improved on-time airport arrival rates, and reduced aircraft emissions and fuel burn.

ERAM's cumulative estimated cost since 2001, including planned updates and enhancements that will extend beyond 2025, will be over \$3.5 billion.

FAA Has Begun Its Sustainment and Enhancement Efforts To Update ERAM

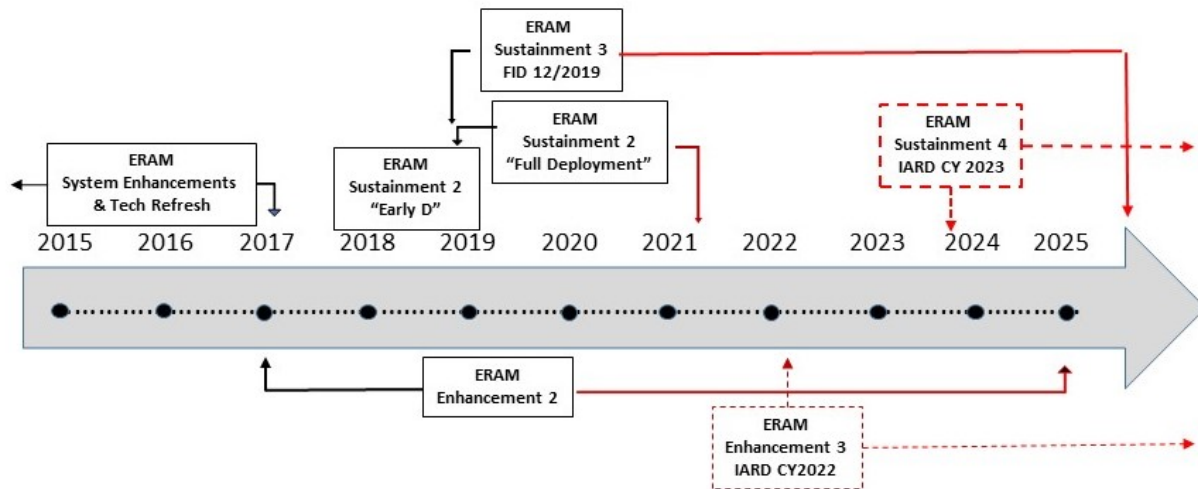
FAA has begun overlapping sustainment and enhancement projects to modernize ERAM by replacing the system's hardware and adding new capabilities. In 2018, in recognition of the increasing importance of ERAM to the NAS, FAA re-categorized ERAM from a moderate impact to a high-impact system.

FAA Has Begun Overlapping Projects To Sustain and Enhance ERAM

FAA has begun the sustainment efforts that will replace ERAM's original hardware, which was installed at the Centers in 2007 and 2008. Since 2017, the Agency has been spending an average of \$21 million per month on these efforts to maintain and enhance the system. FAA expects these overlapping projects to allow ERAM to support current and future air traffic operations and has planned these efforts through 2025 and beyond at a current estimated cost of over \$950 million. See figure 2 for FAA's ERAM timeline.

⁴ The NAC—made up of high-level representatives from throughout the aviation community—is FAA's principal source of stakeholder advice on NextGen issues and provides recommendations that help the Agency fine-tune its NextGen plans.

Figure 2. Timeline for ERAM Sustainment and Enhancement Projects



Source: OIG analysis

FAA Has Begun Its Sustainment Efforts To Replace and Update ERAM's Hardware

FAA began its first ERAM enhancement effort in 2013 with a "System Enhancements and Technical Refresh" project that focused on updates to several operating system software programs and replacement of hardware, such as routers at all 20 Centers. In 2017, FAA began Sustainment 2 to replace ERAM's original hardware, which is reaching its end-of-life and is no longer commercially available or repairable. FAA estimates a cost of \$279.2 million for Sustainment 2.

FAA will implement Sustainment 2 in two phases—Early D and Full Deployment—that will update ERAM's original controller radar display stations. The efforts will include the installation of new system processors and an upgrade of analog display screens to digital standards including high-definition 43-inch flat panel displays for controllers. Also during Sustainment 2, FAA will transition ERAM from an Advance Interactive eXecutive (AIX)-based⁵ operating system to a Linux⁶ system and will make additional improvements to the Centers' testing and training labs.

In December 2019, the Agency's Joint Resource Council⁷ baselined Sustainment 3, which will finish hardware replacement at a cost of \$332.8 million, with completion planned in September 2026. FAA plans to continue sustainment

⁵ AIX is a proprietary UNIX operating system developed and sold by IBM for its computer systems.

⁶ Linux is a family of open source Unix-like operating systems commonly used for computer hardware and software.

⁷ The Joint Resource Council is FAA's senior investment review board.

efforts, including a planned Sustainment 4, through and beyond 2025, but costs and milestones are only in the initial planning and analysis phase.

FAA Has Also Begun Efforts To Enhance ERAM's Capabilities

In 2016, FAA began ERAM Enhancement 2 (EE2). EE2 includes updates to ERAM's software to improve the system for both controllers and technicians who maintain the system. In 2017, FAA began to improve how ERAM processes aircraft flight paths to make it capable of automatically and seamlessly transferring control of aircraft to the Canadian air traffic control system. EE2 was originally baselined at \$251 million and scheduled for completion in 2023. In 2018, FAA rebaselined the project to \$193 million, making a number of technical scope changes and extending the completion date by 2 years to 2025.

FAA plans to continue introducing ERAM enhancements through ERAM Enhancement 3. See table 1 for the status of FAA's progress on EE2 enhancements.

Table 1. Timeline for FAA's Planned Enhancements to ERAM

Enhancement	Description	Projected Cost	Estimated Software Lines of Code ^a	Original Estimated Completion Date	Current Estimated Completion Date ^b
Deployment of trajectory (i.e., flight path) modeling enhancements	Currently, ERAM can use flight-trajectory modeling to better plot aircraft trajectories. The enhancement will improve the accuracy of aircraft trajectories.	\$29.0 M	6,803	December 2022	September 2024
Deployment of initial enhancements to support operation of unmanned aircraft systems in the NAS	Intended to add UAS aircraft performance characteristics and flight plan extension.	TBD	TBD	December 2020	Deferred Indefinitely
Deployment of automated handoffs to Canada ^c	ERAM currently cannot automatically hand off air traffic to Canada. The enhancement will enable automated coordination with Canada and handoff of flight data and aircraft control with Canada.	\$91.3 M	24,519	December 2021	December 2022

Enhancement	Description	Projected Cost	Estimated Software Lines of Code ^a	Original Estimated Completion Date	Current Estimated Completion Date ^b
Improved International Civil Aviation Organization (ICAO) ^d flight plan processing	Will improve controller access to modern aircraft flight data and equipage information available in the ICAO flight plan. ICAO flight plans provide significantly more information to controllers.	\$32.9 M	7,765	December 2022	December 2024
Enhancements to Conflict Probe	ERAM includes a conflict detection capability known as Conflict Probe. These enhancements will improve its ability to reduce aircraft separation from 5 nautical miles to 3 nautical miles and improve capacity.	\$22.8 M	4,767	December 2023	December 2023

^a Software or source lines of code is a metric used to measure the size of a computer program by counting the number of lines in the text of the program's source code. ERAM currently contains over approximately 2 million lines of code.

^b FAA's Acquisition Management System calls for milestones that typically include an Investment Analysis Readiness Decision, an Initial Investment Decision, and a Final Investment Decision.

^c Currently, ERAM automatically hands off air traffic between other FAA facilities in the United States.

^d An international organization that sets standards and regulations for aviation safety, security, and efficiency.

Source: OIG analysis of FAA data

FAA Has Re-Categorized ERAM as a High-Impact System

In April 2018, FAA officials re-categorized ERAM from a moderate to a high-impact system. According to the National Institute of Standards and Technology's (NIST)⁸ categorizations for information systems, a high-impact system is one whose loss of confidentiality, integrity, or availability of information is expected to have a severe or catastrophic adverse effect on organizational operations, organizational assets, or individuals. NIST identifies over 70 security controls that may be required to transition a moderate to high-impact system. These controls

⁸ NIST supports and develops measurement standards and is responsible for developing information security standards and guidelines, including minimum requirements for Federal information systems.

cover factors in high-impact systems such as system backup, contingency requirements, system access monitoring, and alternate processing sites.

According to FAA officials, the Agency is working to identify security controls for ERAM based on its high-impact categorization and had planned to implement the controls by June 2020.

FAA conducted a 2-year evaluation of the safety impact of removing ERAM's backup system as part of the transition from the Host Computer System to ERAM. FAA had retained the Host's backup system, known as Enhanced Backup Surveillance (EBUS) system, until ERAM was more mature. However, ERAM was designed to rely on two identical redundant channels as backup, and FAA, as a result of the safety evaluation, decided to remove EBUS and not replace it with a separate backup system. Yet, in its 2019 decision making process FAA did not consider NIST's requirements for high-impact systems in its decision-making process regarding a replacement for EBUS. In addition to operational concerns about having a backup, NIST's security controls indicate that backup systems and contingency plans are part of the security control requirements for high-impact systems.

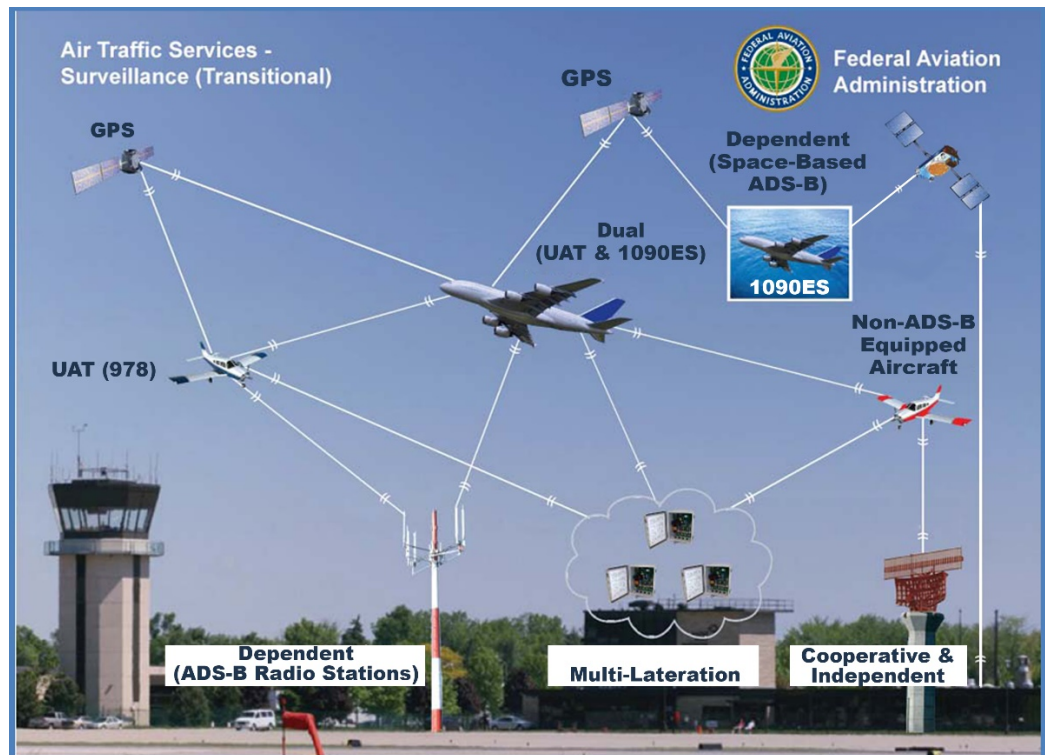
FAA Has Integrated NextGen Capabilities Into ERAM but Faces Challenges Realizing Full Benefits for Airspace Users

Since ERAM became operational at all 20 Centers in March 2015, FAA has successfully integrated ADS-B with ERAM, and the automation system supports PBN routes. However, these new capabilities require training for pilots and controllers and new procedures to achieve expected user benefits. FAA has delayed the implementation of DataComm at high altitudes due to several issues, including the Government shutdown during December 2018 and January 2019. The Agency continues to face challenges modernizing ERAM while integrating new NextGen capabilities and realizing expected benefits.

FAA Has Integrated ADS-B Into ERAM and the NAS

ADS-B is a satellite based surveillance system that uses GPS to track aircraft positions and transmit them to the ground system and then to air traffic control systems (see figure 3).

Figure 3. ADS-B Overview



Source: FAA

FAA has integrated ADS-B capability, at a cost of approximately \$83 million, into ERAM and now uses ADS-B along with long and short range radars at all 20 ERAM Centers. The system allows faster updates and improved accuracy and also provides controllers with more detailed flight information, including aircraft identification, position, altitude, direction, and speed. ADS-B *In*,⁹ which provides information displays in the cockpit, will provide most benefits through technology; its procedures are still evolving.

FAA plans to rely on ADS-B as the primary surveillance source in the NAS, but currently ERAM uses ADS-B as an additional surveillance source on controller displays with information from long- and short-range radars to more accurately track aircraft. FAA is working to implement ADS-B services into ERAM,¹⁰ which will allow aircraft to fly closer together at high altitude (from 5 to 3 nautical miles) and eventually allow the Agency to decommission some radars. However, ADS-B

⁹ ADS-B *In* displays flight information in the cockpit, such as the location of other aircraft. The ability of allowing pilots to see nearby aircraft and obtain other critical information is expected to improve air traffic efficiency and further enhance safety.

¹⁰ FAA has begun enabling track-based display mode capability into ERAM to allow more accurate aircraft tracking using both ADS-B and radar.

is still not the primary surveillance source¹¹ in the NAS.¹² FAA expects that as ADS-B equipage increases, this capability will contribute to increased capacity at airports and enhanced safety in the air and on the ground.¹³

FAA's High-Altitude PBN Procedures Using ERAM Are in Place

Central to FAA's NextGen efforts is the establishment of PBN procedures and routes that primarily use satellite-based navigation and on-board aircraft equipment to navigate with greater precision and accuracy. PBN is also a top priority for industry. PBN includes two types of procedures:

- Area Navigation (RNAV), which allows pilots to use a combination of satellite signals and other on-board systems to fly any flight path by reducing the limitations imposed by ground-based navigation systems, and
- Required Navigation Performance (RNP), a more advanced form of RNAV that adds monitoring capabilities to the cockpit to alert the pilot when the aircraft cannot meet specified navigation performance requirements. RNP enables precise, curved approaches; provides predictable flight paths; and provides improved airport access.

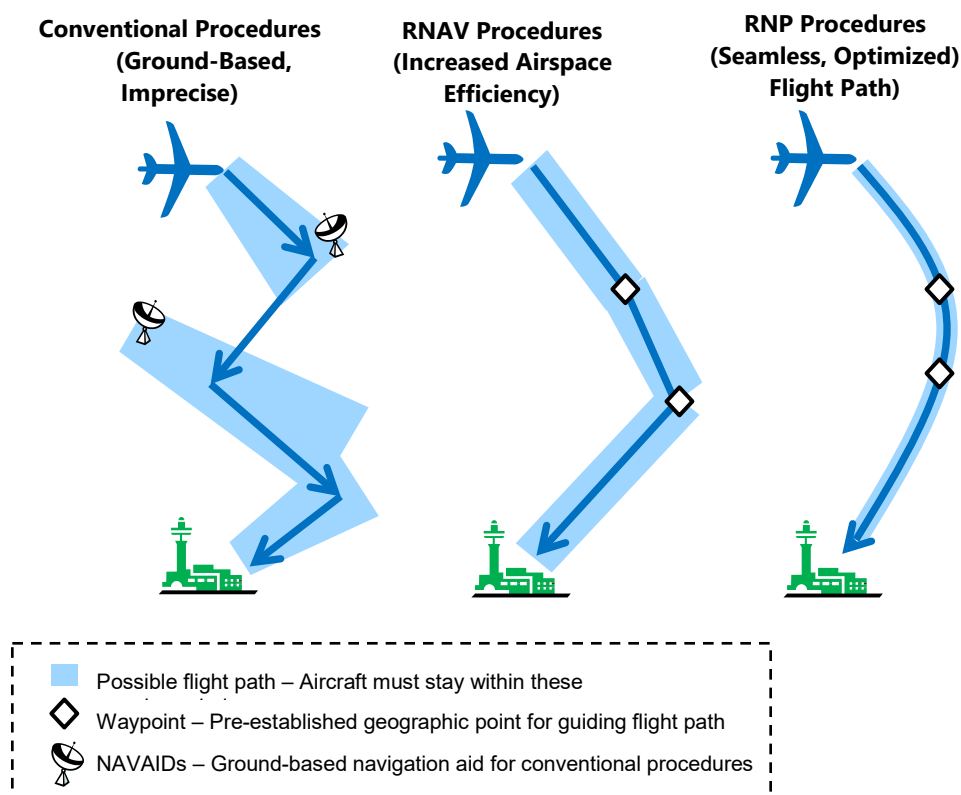
Traditionally, aircraft have been required to fly routes between ground-based navigational aids to maintain the required navigation accuracy of on-board systems. RNAV and RNP can increase airspace efficiency by providing more direct paths, thus reducing aircraft fuel use (see figure 4).

¹¹ FAA considers ADS-B as its preferred surveillance source but still relies on both ADS-B and radar to track aircraft.

¹² Except in non-radar airspace such as the Gulf of Mexico.

¹³ OIG Congressional Briefing, *NextGen Equipage: Status of ADS-B Out Equipage on Commercial and General Aviation Aircraft* (CC2019003), July 24, 2019.

Figure 4. PBN Overview



Source: OIG

With PBN, FAA and airspace users are improving sequencing for aircraft based on time rather than the traditional miles-in-trail method,¹⁴ thus increasing NAS capacity and efficiency. Currently, controllers use ERAM to optimize PBN at high altitudes for aircraft flying on specific routes¹⁵ with Time Based Flow Management (TBFM), an automated tool that helps controllers merge and sequence aircraft. In a previous audit,¹⁶ we found that controllers use TBFM inconsistently due to the lack of training on its use. As a result, FAA has developed new training for controllers on use of TBFM to improve metering operations.

At some Centers that control large areas of airspace, FAA has integrated a tool known as the Ground-Based Interval Management—Spacing (GIM-S) system.

¹⁴ Miles-in-trail describes the number of miles required between aircraft and is used to apportion traffic into a manageable flow, as well as to provide space for additional traffic (merging or departing) to enter the flow of traffic.

¹⁵ These routes, known as Q and T routes, apply RNAV to en route airspace. Q routes are available for RNAV-equipped aircraft operating between 18,000 and 45,000 feet. T-routes are at altitudes below 18,000 feet, sometimes down to 1,200 feet above ground level.

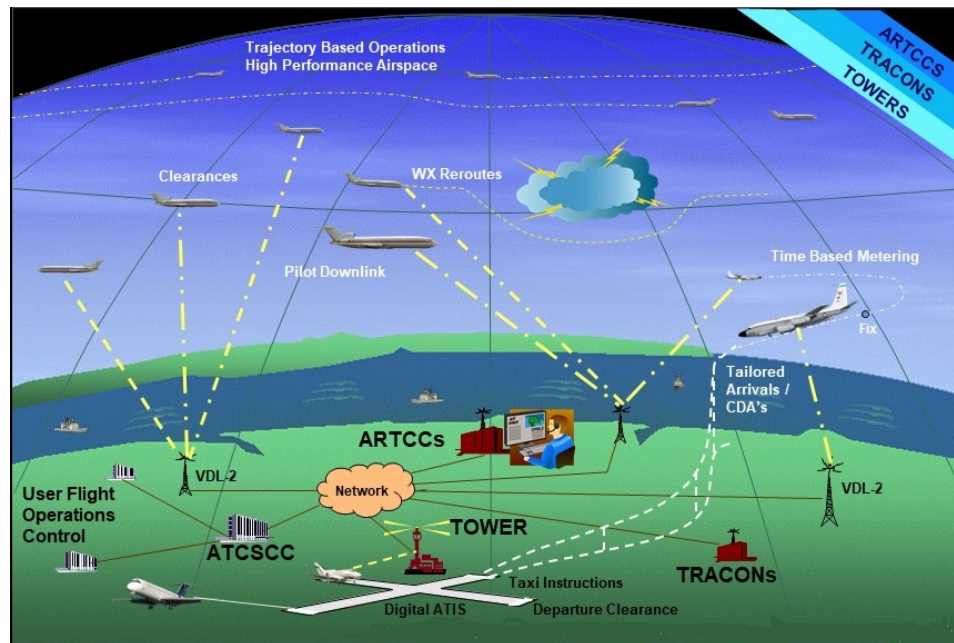
¹⁶ *FAA Has Made Progress in Implementing Its Metroplex Program, but Benefits for Airspace Users Have Fallen Short of Expectations* (OIG Report No. AV2019062), August 27, 2019.

GIM-S enhances PBN by allowing controllers to sequence and space high-altitude aircraft at longer distances than previously possible from their destination airports, thus improving efficiency and airport arrival rates. However, according to FAA officials, the Agency is still developing and refining GIM-S, which will require new training for controllers before the tool is more widely used.

FAA Has Completed DataComm Deployment at Selected Towers but Has Delayed Deployment for High-Altitude Air Traffic

DataComm's digital capabilities (see figure 5) are among NAC's top five priorities. Once deployed, the capabilities will improve the accuracy and efficiency of the communications between pilots and controllers. DataComm—which has required the addition of over 339,000 software lines of code to ERAM's 2 million to support tower and high-altitude services—relies on ERAM to enable new digital high-altitude communication capabilities.

Figure 5. DataComm System Overview



Source: FAA

DataComm tower services provide digital communications to equipped aircraft in place of voice communications, and tower services have proven successful. FAA

completed the deployment of DataComm's tower services capability at 62 airports ahead of schedule. Airspace users have begun seeing benefits from DataComm for pre-departure clearances between airport towers and aircraft. According to FAA officials, the Agency and airspace users expect more significant benefits from the high-altitude portion of the program, such as re-routing traffic around thunderstorms. In November 2019, high-altitude DataComm became operational at the Kansas City and Indianapolis Centers, which are now providing FAA's first en route DataComm services to airspace users.

However, the impact of the Government shutdown in December 2018 and January 2019, air-to-ground network interoperability problems, and aircraft avionics issues resulted in some delays by at least 4 months, primarily for the first and last site operational dates. These delays have required FAA to re-plan the deployment schedule at the remaining Centers, which in turn added costs and delayed benefits to FAA and users. FAA had expected the remaining 18 high-altitude DataComm sites to be fully implemented into the NAS with the planned initial service capabilities by the summer of 2021, and FAA was planning the implementation of the next series of full en route DataComm capabilities to begin in 2024. However, further delays for the completion of the initial services will likely extend this date.

Conclusion

FAA continues to invest in modernizing ERAM and is expected to continue these efforts well into the future. FAA considers ERAM to be vital to its modernization of the NAS and planned NextGen capabilities and has recognized this by upgrading the security categorization for ERAM to a high-impact system. However, the Agency faces challenges managing and executing simultaneous efforts to modernize ERAM while integrating NextGen capabilities with ERAM. The benefits these new systems can provide will not be fully realized until new procedures are developed and implemented and pilots and air traffic controllers are properly trained to use them, which will likely take years to complete.

Recommendations

To improve efforts for upgrading ERAM to support key NextGen capabilities, we recommend that the Federal Aviation Administrator:

1. Develop an action plan with schedule milestones for completing the assessment, test, and mitigation of the new security requirements for ERAM to successfully meet a high-impact system categorization.

Agency Comments and OIG Response

We provided FAA with our draft report on May 7, 2020, and received the Agency's response on June 12, 2020, which is included as an appendix to this report. FAA also provided us with technical comments that we have addressed where appropriate. In its management response, FAA concurred with our recommendation and agreed to implement the action by December 31, 2020.

In its management response, FAA stated that it believes that we mischaracterized aspects of ERAM relating to NIST high-impact system requirements. However, we disagree, since as we noted in our report, NIST's security controls indicate that backup systems and contingency plans are part of the security control requirements for high-impact systems. In addition, as we have also stated in our report, FAA did not consider the NIST requirements for high-impact systems in its 2019 decision-making process on EBUS's replacement. While we recognize that ERAM's reliability has improved and outages are rare, history has shown that when ERAM outages do occur, they can have a significant impact on NAS operations with cascading effects. Therefore, we recommended, and FAA concurred, that FAA develop an action plan with schedule milestones for completing the assessment, test, and mitigation of the new security requirements for ERAM to successfully meet the NIST high-impact system categorization.

Actions Required

We consider our recommendation resolved but open pending FAA's completion of its planned action.

Exhibit A. Scope and Methodology

We conducted this performance audit between February 2019 and May 2020, in accordance with generally accepted Government auditing standards as prescribed by the Comptroller General of the United States. 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.

The Chairman of the Senate Committee on Commerce, Science, and Transportation and the Chairmen of the House Committee on Transportation and Infrastructure and its Aviation Subcommittee requested that we assess FAA's ability to update ERAM to support NextGen capabilities.¹⁷

To assess the FAA's ability to update ERAM to support NextGen capabilities, we obtained and analyzed documents from interviews and data requests from the ERAM Program Office at FAA Headquarters. We obtained and analyzed documents from the En Route Second Level Engineering Group within FAA's Program Management Organization at the William J. Hughes Technical Center. Also, we obtained and analyzed documents from the FAA Program Offices—NextGen, ADS-B, PBN, DataComm, and TBFM/GIM-S. These documents included program plans, investment decisions, program status briefings, and schedule information, requirements, requirements documents, architectural designs, and technical refresh and enhancements efforts impacting ERAM.

We interviewed aviation industry officials and Government experts to understand their historical and current perspectives on ERAM oversight, and performed analyses of industry reports from NAC, the Aviation Management Associates, Red Hat Enterprise Linux, and NIST. We interviewed National Air Traffic Control Association officials to obtain air traffic controllers' perspectives on new capabilities integrating with ERAM. We also interviewed Professional Aviation Safety Specialists officials to obtain their perspectives on the risks of removing ERAM's current backup system and FAA's mitigation strategy for that risk. We also met with the EBUS Safety Risk Management panel to discuss risks associated with operating ERAM without a backup system.

We also conducted site visits at two of five GIM-S equipped ARTCCs—Minneapolis and Albuquerque, which had been using extended metering the

¹⁷ Our objectives for this audit were originally part of a congressional request to evaluate outages in ERAM between 2014 and 2016, and FAA's actions to address them. We reported our findings on those outages in November 2018. See *FAA Has Taken Steps To Address ERAM Outages, But Some Vulnerabilities Remain* (OIG Report Number AV2019004), November 7, 2018.

longest—to learn the Centers’ perspectives on FAA’s ability to sustain, replace, upgrade, and enhance ERAM’s NextGen capabilities. Furthermore, the officials discussed their concerns over the removal of ERAM’s current backup system and FAA’s mitigation strategy.

Exhibit B. Organizations Visited or Contacted

FAA Facilities

FAA ERAM Program Office

FAA William J. Hughes Technical Center

Albuquerque Air Route Traffic Control Center

Minneapolis Air Route Traffic Control Center

Other Organizations

Red Hat Enterprise Linux

Exhibit C. List of Acronyms

ADS-B	Automatic Dependent Surveillance—Broadcast
AIX	Advanced Interactive eXecutive
ARTCC	Air Route Traffic Control Center
DataComm	Data Communications
DOT	Department of Transportation
EE2	ERAM Enhancement 2
ERAM	En Route Automation Modernization
GIM-S	Ground-Based Interval Management—Spacing
GPS	Global Positioning System
NAS	National Airspace System
NAC	NextGen Advisory Committee
NextGen	Next Generation Air Transportation System
NIST	National Institute of Standards and Technology
OIG	Office of Inspector General
PBN	Performance-Based Navigation
RNAV	Area Navigation
RNP	Required Navigation Performance
TBFM	Time Based Flow Management

Exhibit D. Major Contributors to This Report

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Appendix. Agency Comments




Federal Aviation Administration

Memorandum

Date: June 12, 2020

To: Matthew E. Hampton, Assistant Inspector General for Aviation

From: H. Clayton Foushee, Director, Office of Audit and Evaluation, AAE-1 

Subject: Federal Aviation Administration's (FAA) Response to Office of Inspector General (OIG)
Draft Report: FAA Has Begun To Update ERAM but Faces Challenges Realizing Full
Benefits for Airspace Users

The FAA has successfully installed the En Route Automation Modernization (ERAM) system, which is the foundation for NextGen. ERAM deployment in the National Airspace System (NAS) was completed in March 2015, and the transition from the legacy "Host Computer System" to ERAM was one of the most complex efforts undertaken by the Agency in its 60-year history.

Since ERAM has been operational, the system has demonstrated that it is highly reliable and has exceeded system requirements for availability.

The FAA believes that the OIG has mischaracterized some key aspects of the current ERAM system status, most notably:

- We do not agree with the OIG's characterization that consideration of the National Institute of Standards and Technology (NIST) requirements for high-impact systems should have been included in the Safety Risk Management process assessment of the need for a backup capability for ERAM in addition to the system's dual channel architecture for the following reasons:
 - NIST high-impact system requirements do not "call for backup systems capable of taking over operations during contingencies." ERAM's architecture was designed with two functionally-identical channels with dual redundancy, which provides an inherent backup capability. This was implemented to meet

safety availability requirements, not security requirements.

- NIST requires alternate storage sites and alternate processing sites. For NAS systems, our alternate operational facilities are alternate storage and alternate processing sites and are consistent with NIST requirements. Additionally, FAA has met the NIST requirement through the implementation of contingency plans that include formal procedures to ensure the transfer of published air traffic services impacted by the loss of systems/services at a single facility to other facilities that provide redundant processing capabilities.

Upon review of the draft report, the FAA concurs with the recommendation and will develop an action plan with schedule milestones by December 31, 2020.

We appreciate this opportunity to offer additional perspective on the OIG draft report. Please contact H. Clayton Foushee at (202) 267-9000 if you have any questions or require additional information about these comments.

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OIG conducts audits and investigations on behalf of the American public to improve the performance and integrity of DOT's programs to ensure a safe, efficient, and effective national transportation system.

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