



U.S. DEPARTMENT OF TRANSPORTATION
OFFICE OF INSPECTOR GENERAL

**FAA Completed STARS at Large
TRACONs, but Challenges in Delivering
NextGen Capabilities Remain**

FAA

Report No. AV2018020

January 31, 2018





FAA Completed STARS at Large TRACONs, but Challenges in Delivering NextGen Capabilities Remain

Requested by the Committee on Appropriations, U.S. House of Representatives

Federal Aviation Administration | AV2018020 | January 31, 2018

What We Looked At

FAA is currently modernizing and standardizing the automated systems that controllers rely on to manage air traffic near airports by installing the Standard Terminal Automation Replacement System (STARS) at 11 large terminal radar approach control (TRACON) air traffic facilities. STARS is critical to achieving the expected benefits of the Next Generation Air Transportation System (NextGen), including enhanced capacity and reduced delays. STARS program risks, if not mitigated, could impact the long-term viability of NextGen. For these reasons, the House Appropriations Committee directed our office to provide an update on FAA's progress in implementing STARS at the 11 large TRACONs and determine how the effort will support NextGen capabilities.

What We Found

FAA has installed STARS at the 11 TRACONs and is capable of providing full and sustained operations. However, FAA has experienced challenges in transitioning from the legacy system to STARS. In addition, despite having a detailed management plan for new STARS requirements, FAA could not sufficiently document how new requirements were validated or prioritized. Our review also identified that FAA's installation of STARS power systems do not comply with the Agency's safety regulations and industry standards.

STARS supports several new NextGen capabilities at some of the 11 TRACONs, such as displaying Automatic Dependent Surveillance-Broadcast (ADS-B) information for controllers. However, it does not yet fully support other capabilities that materially impact air traffic management, such as sequencing and spacing tools for controllers that facilitate the use of new performance-based navigation procedures. FAA is planning to establish a new phase of terminal automation to further address NextGen capabilities.

Our Recommendations

FAA concurred with three of our recommendations to improve implementation of STARS requirements and NextGen capabilities and partially concurred with one. Based on FAA's response, we consider all the recommendations resolved and open pending completion of planned actions.

Contents

Memorandum	1
Results in Brief	3
Background	4
FAA Has Made Significant Progress in Implementing STARS, but More Efforts Are Needed To Implement Requirements in Several Areas	5
STARS Now Supports Some NextGen Capabilities, but Key Capabilities With High Investment Priority Will Require Additional Development and Future Changes to STARS	12
Conclusion	15
Recommendations	15
Agency Comments and Office of Inspector General Response	16
Actions Required	17
Exhibit A. Scope and Methodology	18
Exhibit B. Organizations Visited or Contacted	20
Exhibit C. List of Acronyms	22
Exhibit D. Major Contributors to This Report	23




Memorandum

Date: January 31, 2018

Subject: ACTION: FAA Completed STARS at Large TRACONS, but Challenges in Delivering NextGen Capabilities Remain | Report No. AV2018020

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

To: Federal Aviation Administrator



The Federal Aviation Administration (FAA) operates more than 200 terminal radar approach control (TRACON) air traffic facilities to manage air traffic within a 50-mile radius of airports. Currently, FAA is modernizing and standardizing automated systems that controllers rely on to manage this traffic by installing the Standard Terminal Automation Replacement System (STARS) at 11 large TRACONS. This effort, now estimated at \$529 million, is part of FAA's Terminal Automation Modernization and Replacement (TAMR) Program, which aims to implement a common automation platform for terminal systems throughout the National Airspace System (NAS).

In 2013,¹ we reported that FAA faced significant risks in developing and implementing the technical requirements for its terminal modernization effort. FAA had not identified and finalized all the software and hardware requirements needed to successfully modernize and install STARS at the 11 TRACONS, which include the busiest TRACONS in the NAS. In 2014,² we also reported that STARS software requirements were unstable at the initial key site, Dallas-Fort Worth.

STARS is a foundational program for FAA's Next Generation Air Transportation System (NextGen) and critical to achieving NextGen's expected benefits of enhanced capacity and reduced delays in the terminal environment. As a result, STARS program risks, if not mitigated, could impact the long-term viability of

¹ *FAA's Acquisition Strategy for Terminal Modernization Is at Risk for Cost Increases, Schedule Delays, and Performance Shortfalls* (OIG Report No. AV2013097), May 29, 2013. OIG reports are available on our website at <http://www.oig.dot.gov/>.

² *Management Advisory on Weaknesses With Site-Specific Deployment Requirements and Specialist Training for STARS*, August 14, 2014.

NextGen. For these reasons, the House Appropriations Committee³ directed our office to provide an update on FAA's progress in implementing STARS at the 11 large TRACONs and determine how the effort will support NextGen capabilities, such as new routes based on Performance-Based Navigation (PBN)⁴ and Automatic Dependent Surveillance – Broadcast (ADS-B).⁵

Accordingly, our audit objectives were to (1) assess FAA's progress in ensuring STARS meets FAA requirements at the 11 large TRACONs and (2) determine the extent to which STARS supports NextGen capabilities.

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

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

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

³ Committee on Appropriations, U. S. House of Representatives, Committee Report 113-464, May 27, 2014.

⁴ PBN delivers new routes and flight procedures that primarily use satellite-based navigation aids and on-board aircraft equipment to navigate with greater precision and accuracy.

⁵ ADS-B is a surveillance technology that combines precise aircraft location, direction, and ground speed derived from the Global Positioning System (GPS) with other data, and broadcast this information from an aircraft to air traffic control and other nearby appropriately equipped aircraft.

Results in Brief

FAA has made significant progress in implementing STARS at the 11 large TRACONs but continues to identify new requirements for the system.

STARS is now capable of providing full and sustained air traffic operations at all 11 sites. However, FAA has experienced challenges in transitioning from the legacy system—the Common Automated Radar Terminal System (CARTS)—to STARS. For example, when implementing STARS, FAA discovered it had to incorporate more requirements than it originally planned to ensure STARS met all the capabilities of CARTS, resulting in cost growth of about \$90 million. This is because FAA originally underestimated the complexity of transitioning from CARTS to STARS and the specific complex needs of facilities and related airspace. Although FAA has since made progress in resolving the gaps between the two systems, the Agency continues to identify new requirements for STARS and has established a new and separate cost baseline to address these requirements. Moreover, FAA lacks a process for documenting and determining how the Agency prioritizes and validates new requirements. As a result, FAA is missing an opportunity to more efficiently use its resources by implementing the highest-priority capabilities first. Finally, our review identified that FAA’s installation of STARS power systems do not comply with the Agency’s own safety regulations and current industry standards. Continuing to use STARS equipment with its current electrical configuration increases the risk of system outages and other disruptions to major air traffic systems in TRACONs that control 80 percent of all traffic arriving and departing from the NAS.

While STARS supports some new NextGen capabilities at the 11 TRACONs, such as displaying ADS-B information for controllers, it does not yet fully support other capabilities expected to provide significant benefits.

In particular, STARS does not yet support automated tools that help controllers to merge and sequence aircraft that are key to maximizing new PBN arrivals and departures at some of the Nation’s busiest airports. The maximization of PBN routes is a top NextGen investment priority for FAA and industry. According to FAA, the Agency has not yet integrated STARS with other NextGen capabilities due in part to delays in program development schedules and to the limited maturity of automated tools for PBN. FAA is planning to establish a new phase of terminal automation to further address NextGen capabilities. As a result, FAA may face challenges in ensuring that STARS meets and supports future NextGen capabilities and benefits.

We are making several recommendations to improve FAA's implementation of STARS requirements and NextGen capabilities.

Background

In 1996, FAA began a plan to modernize and standardize terminal automation systems by implementing the STARS program throughout the NAS and replacing the existing 1970s-era equipment in TRACONs and associated air traffic control towers. However, FAA experienced extensive software and hardware development with STARS that caused significant cost growth and schedule delays. As a result, FAA needed an interim solution to satisfy immediate modernization needs. From 1998 to 2003, FAA's solution was to update existing software and hardware for automation systems at sites that had not yet been converted to STARS. These systems were referred to as CARTS.

By 2004, FAA was operating two distinct systems at different TRACONs—either CARTS or STARS. While both systems served the same function—to control air traffic in the vicinity of airports—maintaining and upgrading two systems presented cost challenges in software development, hardware purchases, and training. As a result, FAA decided to revise its terminal automation approach through a three-phased acquisition strategy called TAMR. The program is designed to reduce costs by reevaluating alternatives and incorporating lessons learned from earlier phases. This effort became necessary both to replace aging equipment and achieve FAA's goals to enhance capacity and reduce delays through NextGen.

By April 2010, FAA was planning to start the third phase of TAMR. FAA originally planned to replace all 108 of the remaining legacy systems, but the Agency decided to break up the phase into 2 segments:

- The first segment—and current focus of our audit—centers on replacing CARTS with STARS at 11 large TRACONs and addresses short-term objectives such as supporting critical ADS-B sites, migrating to a single platform to reduce development and support costs, and mitigating risks of obsolescence by replacing CARTS with STARS. The original cost estimate for this segment was \$438 million.
- The second segment centers on installing STARS at 97 small-to-medium TRACONs. The original cost estimate for this segment is \$463 million.

FAA Has Made Significant Progress in Implementing STARS, but More Efforts Are Needed To Implement Requirements in Several Areas

Since our last report, FAA has made progress in implementing STARS, which is now capable of sustaining full air traffic operations at all 11 large TRACONs. However, FAA has not effectively implemented STARS requirements in several areas, such as ensuring that STARS meets CARTS capabilities, validating and prioritizing new requirements, standardizing software across all sites, and ensuring STARS meets electrical regulations and industry standards.

FAA Has Faced Challenges in Ensuring STARS Meets Prior System Capabilities

FAA has made significant progress in implementing STARS at the 11 large TRACONs. STARS has moved beyond managing traffic at TRACONs on a limited basis (also known as Initial Operating Capability (IOC)) and reached an important milestone called Operational Readiness Demonstration (ORD) at the last site (the New York TRACON) in April 2017. ORD is the point at which site officials are satisfied that STARS can meet full and sustained operations and can begin decommissioning and removing CARTS (see table).

Table. FAA Progress in STARS Implementation

TRACON	IOC	ORD
Dallas-Fort Worth	04/03/13	07/15/14
Denver	08/26/14	01/22/15
Northern California	01/27/15	07/15/15
Louisville	02/23/15	04/06/15
Southern California	07/12/15	07/08/16
Minneapolis	09/18/15	04/06/16
Atlanta	10/21/15	03/31/16
St. Louis	02/01/16	06/06/16
Potomac	02/25/16	02/07/17
Chicago	04/06/16	11/29/16
New York	05/11/16	04/07/17

Source: OIG analysis of FAA data.

However, FAA has faced difficulties in transitioning from CARTS to STARS. As we have previously reported, a major factor in the difficulty in modernizing automation systems has been addressing the requirement “gaps” between CARTS and STARS. In August 2015, FAA’s Joint Resource Council approved a formal cost increase of \$91 million for the program baseline for the 11 large TRACONS to address new requirement gaps. The gaps and the cost growth were the direct result of two factors. First, FAA underestimated the complexity of replacing CARTS with STARS at the 11 large TRACONS. This was not considered in the development of the original program baseline. Second, FAA did not properly account for site-specific changes to CARTS at the TRACONS made over a 10-year period. These transition issues occurred even through the Agency was fully aware that the two systems were inherently different designs (or system architectures).

The following provides a chronology of FAA efforts to identify and resolve the gaps between the two systems:

- In September 2010, FAA identified a total of 95 CARTS-to-STARS gap requirements which were used to establish the STARS program baseline for the 11 large TRACONS.
- In August 2014, based on our analysis of FAA's gap requirements for the 11 large TRACONS, we reported a total of 114 CARTS-to-STARS requirements in a 2014 management advisory to the Agency.
- In January 2016, based on our analysis of FAA's latest gap requirement document, we identified a total of 160 CARTS-to-STARS requirements.
- As of April 2017, FAA had implemented 156 of the 160 gap requirements needed for STARS to meet the operating capability of CARTS.

FAA believes it has implemented the most critical gap requirements for STARS, and the remaining four gaps, which were deemed non-critical, are scheduled for an upcoming software release in 2018. Two of the requirements involve format changes for data transmitted between air traffic control facilities (i.e., en route and terminal identifications and the number of aircraft in flight). A third requirement involves upgrading airport location identifiers in flight plans from en route facilities, and the fourth requirement provides STARS with ADS-B simulation capabilities for training purposes.

However, FAA has not made a final determination on whether additional requirements are needed for STARS. In August 2015, FAA established a new and separate cost baseline of \$30 million (\$14 million for the 11 large TRACONS) through fiscal year 2018 for post-implementation enhancements—which FAA defines as urgent site requirements identified during operational testing, but deferred for later implementation. These include enhancements to add more CARTS capability into STARS, such as correcting flight track freezes on controller displays and ensuring information transfers between primary and backup systems. FAA plans to address these enhancements in three future software releases, scheduled to start development in late 2017 and to complete testing by 2021. However, the process of identifying these requirements is still ongoing. If the \$14 million is included in the cost to complete STARS at the 11 large TRACONS, we estimate that the total cost associated with this effort will be in the \$543 million range. Although STARS is now operational at the 11 large TRACONS, FAA has yet to complete the requirement identification and installation process. Until these activities are concluded at the 11 TRACONS, STARS will not be able to provide controllers all the capabilities they need to manage air traffic.

FAA Has Not Documented Its Validation and Prioritization Decisions for New STARS Requirements

FAA continues to identify new STARS requirements that are separate and apart from those needed to mirror CARTS capabilities. These requirements were found during the process of testing and fielding STARS at the 11 large TRACONs and were mostly driven by controllers. These new requirements include those which allow greater controls over aural alarms and customize the display of proximity alerts;⁶ both are aimed at helping controllers maintain a margin of safety.

In response to our recommendation to implement better controls to identify new requirements,⁷ FAA finalized a formal Requirements Management Plan in December 2015 that defines the processes and procedures used to plan, develop, monitor, control, and validate hardware and software requirements in all stages of the TAMR program lifecycle. The Plan identifies the roles and responsibilities of the FAA organizations, working groups, and control boards involved with managing program requirements. According to FAA, this document is expected to form the foundation for the TAMR program's requirement management policies and procedures.

However, we found that FAA is not sufficiently documenting some of the key steps outlined in its requirement management process. For example, while FAA identified validating and prioritizing requirements as part of the initial process steps, FAA did not document how requirements were validated and prioritized and the basis for their decisions. According to the Plan, FAA's Mission Support group⁸ is responsible for requirements validation at two points during the process: after requirements identification and within the working group decision process. FAA officials provided us with several examples of requirements that they stated have been through the working group decision process and show evidence of the Mission Support group's validation activity. However, those examples documented the group's agreement to authorize the contractor to begin work—not its decisions to validate or prioritize requirements.

According to FAA's Acquisition Management System (AMS), validation, along with verification, supports key decisions and ensures that the developed product will fulfill mission needs and specification requirements, improves the overall

⁶ Proximity alerts help controllers maintain safe separation distances between aircraft in the terminal environment.

⁷ *FAA's Acquisition Strategy for Terminal Modernization Is at Risk for Cost Increases, Schedule Delays, and Performance Shortfalls* (OIG Report No. AV2013097), May 29, 2013.

⁸ Specifically, the group responsible is the Operational Concepts, Validation, and Requirements Directorate under FAA's Mission Support Services within FAA's Air Traffic Organization.

efficiency and effectiveness of a program and its management across the AMS lifecycle, and supports decision-making and risk management. FAA recognizes that the Agency did not effectively document how it made decisions about requirement validation and prioritization due to lack of clarity of roles and responsibilities. FAA states that roles and responsibilities vary from program to program and are in need of definition. FAA has committed to developing a process that defines roles and responsibilities for requirements by the end of this fiscal year. Without conducting proper prioritization activities for requirements, FAA risks implementing lower priority requirements ahead of higher priority requirements, leading to resource inefficiencies, increased program costs, and longer timelines.

In addition, FAA did not develop requirements management metrics and produce reports that were identified in the Plan. These metrics and reports include the total number of new requirements incorporated in STARS, the number of requirements for each STARS software release, and the current development status of the requirements. Such metrics would allow for better tracking and documentation of correlations between requirements and design changes and the introduction of new requirements. FAA stated that while current Agency procedures, established in 2014, require the development of metrics for the requirements management process, the procedures only cover newly baselined programs and not this phase of the TAMR program, which was baselined in 2011. However, according to its standard operating procedures for requirement plans,⁹ FAA could have used program management reviews to report on metrics designed to monitor and control new requirements.

FAA Has Not Yet Completed STARS Software Merge Activities To Control Costs and Improve System Maintenance

To achieve FAA's goal of a standard STARS software baseline across all TRACONs, including the 11 large TRACONs, FAA plans to merge its multiple STARS software baselines into one to control costs and reduce software maintenance, duplication, and installation risk. However, FAA has yet to complete its merging activities as planned.

⁹ FAA Program Management Office, Standard Operating Procedure, PMO-SOP-005, May 2014.

The STARS software merge is a two-stage process:

- The first stage involved creating a new software release¹⁰ that consolidated software from three TAMR phases (Phases 1 and the two Phase 3 segments). After the completion of operational and regression¹¹ tests for the releases, site evaluations for the newly merged software were completed at seven TRACONs in September 2016.
- The second stage of the software merge involves merging separate STARS software releases at the 11 TRACONs into one release. The separate software releases contained the added STARS capabilities developed through individual operational and regression tests for each release. Earlier this year, FAA had employed 5 separate STARS software releases at the 11 TRACONs. FAA has since combined these releases and reduced the number of separate releases to three. This release is scheduled for completion around September 2017, pending the results of site evaluations at the TRACONs.

FAA developed multiple releases at the 11 large TRACONs to facilitate initial and continuous operations and allow sites to have a release to adapt software to meet local airspace needs. According to FAA, the different releases will evolve into a single software baseline as part of routine software development. However, until FAA can complete its merge into one software baseline, the risk of additional costs and delays due to emergency or unplanned software releases continues.¹²

Electrical Connections for STARS Do Not Comply With Current FAA Regulations or Industry Standards

The electric connections used to supply power to STARS at the 11 large TRACONs do not currently comply with industry standards, manufacturer instructions, FAA regulations, or program requirements. Specifically, at four of the TRACONs we visited (Dallas-Fort Worth, Northern California, Potomac, and New York), we observed that the electrical connections to the processor and the remote sites rely on multiple relocatable power strips that are interconnected to each other in

¹⁰ According to FAA, a software release is the most recent planned increment of a respective software baseline.

¹¹ Regression tests are conducted to verify the integrity of solutions for issues found during operational tests. Additionally, regression testing is performed to ensure that these solutions have not introduced any new problems and to support validation of the system's readiness for operational use.

¹² Emergency or unplanned releases occur when software used to manage live traffic contains missing functions that adversely impact a site without an acceptance workaround.

a series, referred to as a “daisy chain,” mounted to the walls of the STARS processor equipment cabinets (or rack assemblies). However, the power strips in use have specific manufacturer’s warning labels stating that they should not be connected in this way.

According to the U.S. Army Corps of Engineers (the Corps), an entity we commissioned to conduct an independent review of the STARS electrical configuration, the power strips are not intended for series connection. Moreover, STARS documentation states that the system installation must comply with Underwriters Laboratory (UL), National Electric Code (NEC), and FAA regulations, which require the installation and use of listed or labeled equipment in accordance with the manufacturer’s instructions. In addition, FAA’s program requirements state that the system shall be designed to eliminate hardware single points of failure that would cause loss of service of any safety critical function. According to the Corps, the existing STARS electrical configurations introduce additional failure points, creating potential safety, system reliability, and system availability problems.

FAA Technical Operations staff at the TRACONs we visited had previously raised concerns about the continued use of the STARS electrical configuration. FAA officials stated that when STARS was initially implemented in the late 1990’s, power strips were allowed to be connected in series per industry codes. However, industry codes were modified during the mid-2000’s to specifically prohibit this practice. According to FAA, meeting these modified codes would require a redesign of the system. The Agency attempted to mitigate Technical Operations’ concerns by having the STARS contractor certify the STARS electrical configuration at a nationally recognized testing laboratory, which produced a report on the STARS rack assemblies in October 2015. The laboratory tested and certified the design for all future STARS rack assemblies, but not for the STARS rack assemblies that were already installed and operating in the field.¹³ FAA stated that all future STARS rack assemblies delivered and installed in the TRACONs after August 2016 would be certified by the contractor. However, FAA does not plan to assess and verify whether the STARS rack assemblies delivered to the TRACONs before August 2016 meet requirements, which include the assemblies at the 11 large TRACONs. This means that FAA does not know whether the electrical configurations for the STARS rack assemblies at the 11 large TRACONs are in compliance with the laboratory report.

By entrusting the continued functioning of critical STARS equipment through an electrical configuration that has not been assessed, FAA is increasing the risk of

¹³ The Corps noted that while the contractor’s efforts to certify the STARS electrical configuration at a nationally recognized laboratory may address compliance issues with various industry standards, it was done after the STARS systems were deployed which is not a standard industry practice. In addition, the Corps stated that the contractor’s efforts in this regard did not address their specific concerns about failure points, reliability, or availability.

power failures and computer network outages on major systems in TRACONs used to control 80 percent of all traffic arriving and departing throughout the NAS.

STARS Now Supports Some NextGen Capabilities, but Key Capabilities With High Investment Priority Will Require Additional Development and Future Changes to STARS

While STARS supports some new NextGen capabilities at the 11 TRACONs, it does not fully support NextGen capabilities such as PBN, which is expected to provide significant benefits to airspace users. While FAA planned for the installation of STARS at the 11 TRACONs to enable the adoption of NextGen capabilities, several programs providing these capabilities have experienced delays due to concept maturity and risk reduction issues. FAA is planning a new phase of STARS to further address NextGen capabilities. However, FAA may be at risk in ensuring that STARS meets and supports future NextGen capabilities and benefits.

STARS Supports Some NextGen Capabilities but Does Not Fully Support Key Air Traffic-Related Capabilities

The current version of STARS at the 11 TRACONs is now supporting some new NextGen capabilities. For example, FAA states that STARS can display ADS-B information on air traffic controller screens at all 11 TRACONs. In addition, according to FAA, STARS currently supports improved Multiple Runway Operations through wake turbulence recategorization (Wake Recat)¹⁴ at several airport towers associated with the 11 TRACONs. This is important because Multiple Runway Operations is one of the top NextGen capabilities that FAA and industry are pursuing in the 2017 to 2019 timeframe. FAA also states that the current STARS systems will also support capabilities that were prototyped and

¹⁴ Wake turbulence is the swirling air generated from the wings of a flying aircraft as it passes through the air. The turbulence can be hazardous for aircraft passing through it. Wake turbulence recategorization is the safe decrease in separation standards between aircraft. It allows air traffic controllers to safely reduce the spacing between consecutive departures from or arrivals to an airport.

implemented on CARTS that have potential capacity and safety improvements. For example:

- **Automated Terminal Proximity Alert (ATPA)**—This tool alerts controllers when the required minimum safe distance between aircraft on final approach (called “loss of separation”) is about to occur. ATPA was one of the original CARTS to STARS requirement gaps. It was originally implemented at the Minneapolis TRACON in 2011 and is now available at all 11 TRACONs.
- **Final Monitor Aid (FMA)**—This tool helps controllers better manage closely spaced parallel runway operations by providing visual and auditory alerts. It was tested at the Denver TRACON in 2006. The FMA capability is available at several TRACONs, including the Atlanta and Chicago TRACONs.

STARS is also expected to support the Terminal Flight Data Manager (TFDM) program,¹⁵ which introduces electronic flight strips at FAA towers, among other capabilities. TFDM is anticipated to improve airport surface operations by allowing more efficient use of airport runways, taxiways, and gates—another top NextGen investment priority for FAA and industry. A key risk and watch item is effectively integrating TFDM and STARS in the 2020 timeframe.

While STARS supports some new capabilities, it does not yet fully support other key NextGen capabilities that could materially change how traffic is managed. In particular, FAA has yet to implement new tools and procedures that will allow controllers to maximize the use of new precise satellite information to affect congested airspace in the NAS. This includes PBN, which is considered a top investment priority for industry and a stepping stone to trajectory-based operations.¹⁶ In particular:

- **Terminal Sequencing and Spacing (TSAS)**¹⁷—As we have noted in a previous report,¹⁸ a key to 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 the tools is TSAS, which facilitates the use of advanced PBN procedures and the display of PBN routes on STARS controller displays. Software

¹⁵ In June 2016, FAA signed a \$344 million contract to develop TFDM. TFDM implementation is planned to take place at FAA towers between 2020 and 2028.

¹⁶ Trajectory-based operations focuses on more precisely managing aircraft from departure to arrival with the benefits of reduced fuel consumption, lower operating costs, and reduced emissions.

¹⁷ TSAS, formerly Terminal Sequencing and Spacing (TSS), is a component of FAA’s Time-Based Flow Management Work Package 3 Program.

¹⁸ *FAA Has Not Effectively Deployed Controller Automation Tools That Optimize Benefits of Performance-Based Navigation* (OIG Report No. AV2015081), August 20, 2015.

updates from STARS are required to fully utilize TSAS. FAA plans to fully integrate the TSAS tool with STARS beginning in 2019 at 4 of the 11 large TRACONs and 9 air traffic towers. The cost of TSAS is currently estimated at \$176 million.

- **Interval Management Applications**—FAA states controllers will need new automated tools to maximize the benefits of ADS-B and help flight crews adjust speeds and optimize spacing on final approaches to runways. The first phase, which began prototype testing at the Albuquerque Center in 2014, is enabled by automation and is used by controllers for the en route and arrival phases of flight.¹⁹

FAA states that STARS' current lack of support of certain key NextGen capabilities is due in part to delays in development schedules for the new capabilities. For example, FAA delayed the final investment decision for TSAS from 2014 to 2015 due to changes in scope that required deferring capabilities that were lacking in concept²⁰ and operational maturity, requirement refinements, and risk reduction activities. In another example, early plans had FAA implementing Data Communications (DataComm) (digital communications between controllers and pilots) in the TRACONs on or about the 2017–2019 timeframe. Now, FAA does not plan to begin implementing DataComm in the terminal environment until 2025 or beyond.²¹ FAA stated that implementing data link capabilities in terminal airspace will be a complex effort due to the time critical and tactical nature of controller-pilot communications in the final phases of flight.

Further NextGen Capabilities Will Require a New Phase of Terminal Automation

Because STARS does not yet support the full range of NextGen capabilities, such as PBN, FAA is planning a new effort to upgrade air traffic control system capabilities in the terminal environment. This new effort, which will be funded

¹⁹ FAA is developing tools especially for ADS-B, which includes the display of information in the cockpit (known as ADS-B In). These tools consists of a set of ground and flight deck capabilities and procedures that are used in combination by controllers and pilots to more efficiently and precisely manage spacing between aircraft in terminal airspace. Implementing interval management for facilities will require changes to automation systems like STARS to support operations. FAA does not plan to make an initial investment decision on this tool until 2019 with implementation not likely until the 2021 timeframe.

²⁰ Concept maturity refers to stages in which a concept (a broad area of study and analysis) needs to develop to effectively meet Agency strategic objectives or operational improvements.

²¹ FAA is implementing DataComm in the high altitude environment and airport towers. For additional information, see *Total Costs, Schedules, and Benefits of FAA's NextGen Transformational Programs Remain Uncertain* (OIG Report No. AV2017009), November 10, 2016.

and managed separately from FAA's current TAMR activities, is known as "STARS Enhancement #2."²² According to FAA planning documents, this effort will add capabilities to STARS to address separation management, merging and spacing, and transferring airspace between facilities. FAA has scheduled a final investment decision for the new effort in 2019 with implementation after 2021.

Conclusion

FAA's TAMR program is foundational to NextGen and critical to the Agency's goals to increase efficiency and airport capacity in air traffic operations. After nearly 20 years of STARS implementation, FAA has achieved a significant milestone of modernizing terminal automation systems at 11 large TRACONs. However, additional STARS modifications are still needed, and a number of challenges remain before FAA can successfully introduce NextGen capabilities and deliver expected benefits. These include finalizing STARS requirements, better documentation and prioritizing of new requirements, and reducing hardware installation risks. Until FAA addresses these challenges, the Agency is at risk of unmet expectations for modernizing the NAS, additional cost growth, and not delivering high value benefits to airspace users.

Recommendations

To improve FAA's STARS implementation and facilitate NextGen benefits, we recommend that the FAA Administrator:

1. Finalize a timeline for identifying the remaining STARS requirements, including the additional requirements for the "post-implementation enhancements," and quantify the impact these requirements will have on software implementation milestones.
2. Implement a process in the FAA Requirements Management Plan to track and document when and how new requirements are validated and prioritized.
3. Redesign the power supply configuration of STARS rack assemblies to eliminate series connected power strips in the next STARS technical refresh of the 11 TRACONs.

²² This effort was previously referred to as "Terminal Work Package #1."

4. Resolve the electrical configuration issue of the STARS rack assemblies at each of the 11 TRACONs by either: (a) obtaining approval for the configuration from a nationally recognized testing laboratory or (b) assessing and documenting risks posed by the STARS rack assemblies installed at each of the 11 facilities and FAA's acceptance of that risk on air traffic operations.

Agency Comments and Office of Inspector General Response

We provided FAA with a draft of this report on November 8, 2017, and received the Agency's formal response on December 18, 2017, which is included as an appendix to the report. In its response, FAA concurred with recommendations 1, 3, and 4. FAA partially concurred with recommendation 2, stating that its Requirements Management Plan is not an overall plan for the Agency. Instead, FAA stated that the Air Traffic Organization (ATO) is in the process of implementing the Concepts, Validation, and Requirements Operating Model across the ATO and NextGen organizations, which if effectively implemented, will clarify roles and responsibilities for requirements management and would meet the intent of our recommendation. FAA provided target action dates for all four recommendations. Accordingly, we consider our recommendations resolved and open pending completion of planned actions.

In its formal response, FAA disagreed with a number of statements in this report, which we address as follows:

First, FAA stated that it disagrees with our conclusion that its requirements management process is incomplete and lacks details to validate and prioritize new requirements. However, we did not find or conclude that the process was incomplete or lacked details. Rather, as our report states, we found that FAA did not sufficiently document how decisions about new requirements were validated and prioritized before authorizing the contractor to perform work. FAA's planned actions to address our concerns will meet the intent of our recommendation.

Second, FAA stated that we incorrectly concluded that the requirements to ensure STARS meets the CARTS capabilities are not yet identified. However, our concern focuses primarily on implementation—not identification of capabilities. As noted in our report, addressing the gaps between STARS and the legacy system it replaced has been a longstanding issue, and FAA states it has addressed the most critical gaps between the two systems. Furthermore, we note that FAA has established a new cost baseline for STARS for enhancements and urgent site requirements identified during testing that will run through 2021. This new

baseline includes adding more CARTS capabilities into STARS, capabilities that had previously been deferred to a later date.

Third, FAA stated that it disagreed with our conclusions that the current STARS electrical installation poses a risk to the NAS. Also, FAA claimed that the U.S. Army Corps of Engineers found that the Agency's electrical installation was correct and noted that the STARS contractor had it certified at a nationally recognized testing laboratory. However, as noted in our report, the Corps found that the current STARS electrical installation created additional failure points and potential safety reliability, and system availability issues. Further, the Corps noted that the contractor's efforts to certify the electrical configuration at a national laboratory did not address their concerns about, among other things, failure points and reliability. The risk to the NAS as noted in the report is unknown, and additional action by FAA is needed. FAA's proposed actions in the short- and long-term to address our concerns will meet the intent of our recommendation.

Finally, FAA stated that we incorrectly associated the ability to support future NextGen capabilities with the actual implementation of future capabilities. We disagree. Consistent with our objectives, our report illustrates how and when STARS will support new NextGen capabilities and what will be needed to maximize the benefits associated with key initiatives, such as satellite-based ADS-B and new PBN routes at the Nation's busiest airports. Furthermore, our report acknowledges the challenges FAA has faced in linking the schedules of STARS and new capabilities, such as new controller tools for helping controllers sequence aircraft on PBN routes to final approaches to airport runways.

Actions Required

We consider all four recommendations resolved but open pending completion of planned actions.

We appreciate the courtesies and cooperation of FAA representatives during this audit. If you have any questions concerning this report, please call me at (202) 366-1249 or Nathan Custer, Program Director, at (202) 366-5540.

Exhibit A. Scope and Methodology

We conducted this performance audit from November 2015 to November 2017 in accordance with generally accepted Government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient and 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 House Appropriations Committee directed our office to provide an update on FAA's progress in implementing STARS at the 11 large TRACONs and determine how the effort will support NextGen capabilities, such as new routes based on PBN and ADS-B. Accordingly, our audit objectives were to (1) assess FAA's progress in ensuring STARS meets FAA requirements at the 11 large TRACONs and (2) determine the extent to which STARS supports NextGen capabilities.

To assess FAA's progress in ensuring STARS meets FAA requirements at the 11 large TRACONs, we obtained and analyzed key documents from interviews and data requests from the TAMR Program Office at FAA Headquarters and the Terminal Second Level Engineering Group at the William J. Hughes Technical Center's Terminal Second Level Engineering Group within FAA's Program Management Organization. We also obtained and analyzed information from interviews with the Operational Concepts, Validation, and Requirements Group within FAA's Office of Mission Support Organization. In addition, we obtained program funding data from FAA's Office of Budget and Programs. The specific documents we reviewed included program plans, investment decisions, program status briefings, budget and schedule information, requirements lists, requirements processing documents, requirement configuration changes impacting STARS, and software testing plans and results. We also obtained the assistance of DOT OIG Engineering Services to facilitate the commissioning of the U.S. Army Corps of Engineers, who aided us in analyzing technical documents on the electrical configuration of STARS rack assemblies and reporting on FAA's compliance with various internal and industry codes and regulations.

To determine the extent to which STARS supports NextGen capabilities, we obtained and analyzed documents from interviews and data requests from FAA's NextGen Offices of Portfolio Management and Technology Development and the Chief Scientist, Office of Acquisition and Business Services, and Office of the Chief Counsel. We also requested data on current and future NextGen applications supported by STARS from groups within FAA's Program Management Organization such as the Decision Support Programs, Surveillance Services, and Data Communications.

We also conducted site visits to 5 of the 11 large TRACONs to obtain information on STARS deployment, maintenance and implementation issues at air traffic control facilities. The TRACONs visited were Potomac, Southern California, Northern California, Dallas-Fort Worth, and New York. We selected these TRACONs based on site complexity (larger numbers of workstations and airport traffic control towers to support) and stage of implementation. (At the beginning of our audit, Dallas-Fort Worth and Northern California had reached ORD, Southern California was in the midst of reaching ORD, and Potomac and New York had yet to complete IOC.)

Exhibit B. Organizations Visited or Contacted

Federal Aviation Administration

Headquarters

Terminal Automation Modernization/Replacement Program Office, Program Management Organization

Operational Concepts, Validation, and Requirements Group, Mission Support Organization

Office of Portfolio Management and Technology Development, NextGen

Decision Support Programs, Program Management Organization

Surveillance Services, Program Management Organization

Data Communications, Program Management Organization

Office of Acquisition and Business Services

Office of the Chief Counsel

Office of the Chief Scientist, NextGen

Office of Budget and Programs

Sites

William J. Hughes Technical Center (Atlantic City, NJ)

Potomac TRACON (Warrenton, VA)

Southern California TRACON (San Diego, CA)

Northern California TRACON (Mather, CA)

Dallas-Fort Worth TRACON (Dallas-Fort Worth, TX)

New York TRACON (Westbury, NY)

Other Organizations

Intertek Testing Services NA, Inc. (Arlington Heights, IL)

Raytheon Company (Washington, DC)

U.S. Department of Labor, Occupational Safety and Health Administration
(Oakland, CA)

U.S. Army Corps of Engineers (Huntsville, AL)

Exhibit C. List of Acronyms

ADS-B	Automatic Dependent Surveillance - Broadcast
AMS	Acquisition Management System
ATPA	Automated Terminal Proximity Alert
CARTS	Common Automated Radar Terminal System
DataComm	Data Communications
DOT	Department of Transportation
FAA	Federal Aviation Administration
FMA	Final Monitor Aid
IOC	Initial Operating Capability
NAS	National Airspace System
NextGen	Next Generation Air Transportation System
OIG	Office of Inspector General
ORD	Operational Readiness Demonstration
PBN	Performance-Based Navigation
STARS	Standard Terminal Automation Replacement System
TAMR	Terminal Automation Modernization/Replacement
TFDM	Terminal Flight Data Manager
TRACON	Terminal Radar Approach Control
TSAS	Terminal Sequencing and Spacing

Exhibit D. Major Contributors to This Report

NATHAN CUSTER	PROGRAM DIRECTOR
ARNETT SANDERS	PROJECT MANAGER
WON KIM	SENIOR AUDITOR
KIESHA MCMILLAN	SENIOR AUDITOR
MELISSA PYRON	SENIOR AUDITOR
MARVIN TUXHORN	SENIOR AUDITOR
MI HWA BUTTON	ANALYST
TAMARIA KELLY	ANALYST
AUDRE AZUOLAS	SENIOR TECHNICAL WRITER
ANNE-MARIE JOSEPH	ENGINEERING SERVICES MANAGER
AMY BERKS	SENIOR COUNSEL

Appendix. Agency Comments




Federal Aviation Administration

Memorandum

Date: December 18, 2017

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

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 Completed STARS at Large TRACONs, but Challenges in Meeting Requirements and Delivering NextGen Capabilities Remain

The FAA has successfully deployed the Standard Terminal Automation Replacement System (STARS) without flight delays or outages at the 11 Large Terminal Radar Approach Control (TRACON) facilities, which handle 80 percent of all traffic arriving and departing from U.S. airports. The Terminal Automation Modernization and Replacement (TAMR) program achieved all 13 of its Acquisition Program Baseline (APB) milestones¹ on time or ahead of schedule. The uniform STARS automation platform reduces infrastructure costs associated with maintaining multiple configurations, streamlines training, and is the common platform that is the foundation for delivering future NextGen capabilities.

The FAA believes the OIG has mischaracterized key aspects of the TAMR program and STARS system, resulting in a number of inaccurate findings. Our concerns include the following:

- We disagree with the OIG's conclusion that the Requirements Management Process is incomplete and lacks details to validate and prioritize new requirements. The TAMR Requirements Management Plan, developed in December 2015, requires that validation and prioritization take place and identifies the forums and stakeholders involved in each area. The TAMR requirements management process sets forth clear procedures to assess potential requirement changes with input from all stakeholders. This process includes steps for validating new or changed requirements and determining whether the requirements management organization needs to review and validate the requirement. The FAA provided 18 examples of how this prioritization and validation process was implemented as part of implementing STARS.
- The OIG incorrectly concludes that the requirements to ensure STARS meets the Common Automated Radar Terminal System (CARTS) capabilities are not yet identified. The FAA identified all requirements to ensure the transition from CARTS to STARS and provided the OIG with a list of all gaps. As the FAA has informed the OIG on several occasions, post-implementation enhancements (also known as Post-ORD) are not associated with CARTS to STARS gaps, and

¹ 13 APB Milestones include: Authorization to Proceed, Contract Award, Final Investment Decision, Complete installation and checkout of upgraded hardware for CARTS IIE system at N-90 to support ADS-B, Contract Definitization, First-site hardware delivery, Complete IOC at key site on R1, Complete IOC at key site on R2, Complete ORD at key site on R2, Baseline Change Decision, Complete IOC at 5th site, Complete IOC at last site, and Complete ORD at last site.

instead are items found during test and evaluation, transition, and continued use of the STARS software. Post-ORD requirements are continuously identified through the TAMR Requirements Management Process. There is no impact from either CARTS to STARS gaps or Post-ORD requirements to TAMR software milestones, as these requirements are included in each build based on the existing TAMR software build plan.

- Contrary to the OIG’s assertions, the current STARS electrical hardware installation does not pose a risk to the NAS. The U.S. Army Corps of Engineers (Corps) found that the FAA’s installation is correct, both in writing (September 2016 report) and in discussions at two meetings. The Corps September 2016 report states Intertek, an Occupational Safety and Health Administration approved Nationally Recognized Testing Laboratory (NRTL), found the rack enclosure in compliance with testing standards, thus satisfying FAA specifications. The STARS rack assemblies are compliant with Underwriters Laboratories (UL) 60590 as certified by Intertek. Additionally, the STARS system at the 11 Large TRACONs is a quadruple-redundant architecture, which eliminates any single points of failure in the electrical system and minimizes the risk of system outages to beyond five 9s of reliability and availability. Finally, STARS racks are configuration managed and therefore, the FAA is confident that STARS racks at these facilities are consistent with the configuration analyzed by a NRTL. Despite the current configuration being approved by OSHA and the Corps, the FAA has agreed, as a design simplification and modernization, to remove the series connected power strips in the next funded and approved redesign. There is no risk to the NAS for using the configuration managed STARS racks, which are identical to the NRTL certified design, but the FAA has agreed to conduct a risk assessment to verify this for the OIG.
- The report incorrectly associates STARS ability to fully support future NextGen capabilities with the actual implementation of future capabilities. The majority of the future NextGen capabilities cited have not yet been authorized for implementation. For example, the FAA will fully integrate the STARS platform with the NextGen enhancement of Terminal Sequencing and Spacing when it is deployed in 2019. Other OIG referenced Performance Based Navigation (PBN) and Interval Management (IM) tools have yet to be approved and funded for inclusion in STARS.
- The OIG erroneously asserts that Terminal Work Package 1 (TWP 1) will include modifications to “allow a transition to the use of Internet Protocol addresses.” The current scope of TWP 1 consists of air traffic decision support tools, along with improved methods for controller communications; however, this effort does not include the transition of legacy interfaces to Internet Protocol communications.

The FAA concurs with recommendations 1, 3, and 4, as written. We plan to implement recommendation 1 by December 31, 2018 and recommendation 3 by June 30, 2018. Regarding recommendation 4, we concur with option B with the clarification that the FAA does not agree that there are risks to the NAS for using the configuration managed racks, but the FAA will perform a risk assessment to satisfy the OIG’s recommendation and will document the results of that process by December 31, 2018.

We partially concur with recommendation 2 because there is not an overall FAA Requirements Management Plan; however, the Air Traffic Organization (ATO) is in the process of implementing the Concepts, Validation and Requirements Operating Model across the ATO and NextGen organizations, which will clarify roles and responsibilities for requirements management by December 31, 2018.

We appreciate this opportunity to respond to 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.

U.S. DOT IG Fraud & Safety Hotline

hotline@oig.dot.gov | (800) 424-9071

<https://www.oig.dot.gov/hotline>

Our Mission

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.

OFFICE OF INSPECTOR GENERAL
U.S. Department of Transportation
1200 New Jersey Ave SE
Washington, DC 20590



www.oig.dot.gov