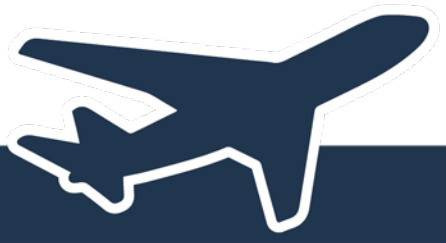
U.S. DEPARTMENT OF TRANSPORTATION

OFFICE OF INSPECTOR GENERAL

FAA Has Made Progress in Implementing Its Metroplex Program, but Benefits for Airspace Users Have Fallen Short of Expectations

FAA



Report No. AV2019062

August 27, 2019

U.S. DEPARTMENT OF TRANSPORTATION
OFFICE OF INSPECTOR GENERAL

Highlights

FAA Has Made Progress in Implementing Its Metroplex Program, but Benefits for Airspace Users Have Fallen Short of Expectations

Requested by Chairmen Bill Shuster and Frank LoBiondo of the House Committee on Transportation and Infrastructure and its Subcommittee on Aviation

Federal Aviation Administration | AV2019062 | August 27, 2019

What We Looked At

Performance-Based Navigation (PBN) is a top investment priority for the Federal Aviation Administration (FAA) and the aviation industry under the Next Generation Air Transportation System (NextGen). 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. To accelerate PBN, FAA began the Metroplex program in 2010 to increase efficiencies in congested, metropolitan areas with multiple airports. Chairmen Bill Shuster and Frank LoBiondo of the House Committee on Transportation and Infrastructure and its Subcommittee on Aviation requested that we examine the Metroplex program, including whether FAA has delivered new routes and procedures that yield measurable benefits to airspace users and resolved obstacles to PBN. Accordingly, our objectives were to (1) assess FAA's progress in implementing its Metroplex program, including its efforts to resolve key barriers to PBN; (2) compare planned to actual benefits for PBN identified by FAA; and (3) assess the soundness of the methods used by FAA to estimate PBN benefits.

What We Found

FAA has made progress in implementing its Metroplex program but has experienced difficulties meeting timelines and has yet to fully resolve key obstacles. While FAA has completed 7 of 12 Metroplex locations, the Agency does not expect to complete all remaining locations until 2021, 4 years later than originally planned. Delays have occurred largely due to increased community concerns about aircraft noise. In addition, other previously identified PBN obstacles remain, including a lack of automated decision support tools for controllers, unclear terminology used by pilots and controllers for referring to flight paths, and the lengthy procedure amendment process. Further, Metroplex benefits to airspace users have fallen well short of predictions—in post-implementation reports, FAA estimated annual benefits of $31.1 million, which is $30.5 million (49.5 percent) less than the minimum amount initially expected when FAA first planned each Metroplex site. Finally, FAA's methods for estimating benefits overly rely on judgment and are not well documented, limiting the ability to readily test the estimates' robustness and replicate results.

Our Recommendations

FAA concurred with all five of our recommendations. However, FAA's response does not meet our intent for the recommendation related to the need for better documentation, so we are asking FAA to reconsider its actions.

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Memorandum

Date: August 27, 2019

Subject: ACTION: FAA Has Made Progress in Implementing Its Metroplex Program, but Benefits for Airspace Users Have Fallen Short of Expectations
Report No. AV2019062

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

To: Federal Aviation Administrator

The Federal Aviation Administration's (FAA) Next Generation Air Transportation System (NextGen) aims to modernize the Nation's air traffic system and provide safer and more efficient air traffic management. A cornerstone of NextGen is advancing Performance-Based Navigation (PBN), a top investment priority identified by the NextGen Advisory Committee (NAC).[1] 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. New PBN flight procedures can provide significant benefits to airspace users, such as more direct flight paths, enhanced airspace capacity, improved on-time airport arrival rates, and reduced aircraft emissions and fuel burn.

Following a recommendation from a Government-industry task force to accelerate the deployment of PBN,[2] FAA began the Metroplex program in 2010 to increase efficiencies in congested, metropolitan areas with multiple airports. FAA and industry have since prioritized 12 locations[3] where improvements are expected to yield near-term benefits.

[1] The NAC is a Federal advisory committee established to develop recommendations for NextGen portfolios with an emphasis on the midterm (through 2020) and includes operators, manufacturers, and air traffic controllers.
[2] In January 2009, FAA requested RTCA, Inc. (a private, not-for-profit corporation that functioned as a Federal advisory committee) to form a task force to reach consensus on recommended NextGen operational improvements for the 2012 to 2018 timeframe. The task force included representatives from airlines, business aviation, general aviation, military, air traffic control, airports, and manufacturers.
[3] The 12 locations are Houston, North Texas, Northern California, Washington, DC, Atlanta, Charlotte, Southern California, Phoenix, Cleveland/Detroit, Denver, South/Central Florida, and Las Vegas.

We have previously reported on the implementation of PBN routes and the obstacles to increasing their use, including the lack of automated tools for controllers and FAA's efforts to streamline the development of new flight procedures.[4] In response to our recommendation, FAA issued an action plan in 2014 with milestones to address 31 obstacles identified by FAA and industry. In its plan, FAA also stated that the Agency would develop a separate action plan for 10 additional obstacles identified by industry.[5]

The Chairmen of the House Committee on Transportation and Infrastructure and its Subcommittee on Aviation[6] requested that we examine FAA's Metroplex program, including whether FAA delivers new routes and procedures that yield tangible, measurable benefits to airspace users on a consistent and repeatable basis. In addition, they requested that we assess FAA and the aviation industry's progress in resolving obstacles to PBN, such as the lack of new automated tools to help controllers maximize the use of new procedures. Accordingly, our objectives were to (1) assess FAA's progress in implementing its Metroplex program, including its efforts to resolve key barriers to PBN; (2) compare planned to actual benefits for PBN identified by FAA; and (3) assess the soundness of the methods used by FAA to estimate PBN benefits.

We conducted this audit 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 FAA representatives during this audit. If you have any questions concerning this report, please call me at (202) 366-0500, or Robin P. Koch, Program Director, at (404) 562-3770.

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

[4] *FAA Has Not Effectively Deployed Controller Automation Tools That Optimize Benefits of Performance-Based Navigation* (OIG Report No. AV2015081), August 20, 2015 and *FAA Faces Significant Obstacles in Advancing the Implementation and Use of Performance-Based Navigation* (OIG Report No. AV2014057), June 17, 2014. OIG reports are available on our website at http://www.oig.dot.gov/.

[5] In 2013, the NAC identified 19 obstacles to PBN. FAA officials determined that 9 of the obstacles were similar to the 31 they had already identified, leaving 10 remaining to address.

[6] Chairman Bill Shuster of the U.S. House of Representatives Committee on Transportation and Infrastructure and Chairman Frank A. LoBiondo of the Subcommittee on Aviation requested this audit on April 3, 2017.

Results in Brief

FAA has made progress in implementing its Metroplex program but has experienced difficulties meeting timelines and has yet to fully resolve key obstacles.

While FAA has completed 7 of the 12 Metroplex locations,[7] the Agency does not expect to complete all remaining locations until 2021, 4 years later than originally planned. Delays occurred early in the program due to several factors, including problems with implementing the Agency's En Route Automation Modernization (ERAM)[8] system.[9] Since 2014, further delays have occurred as FAA has implemented new PBN procedures at more sites, largely due to increased community concerns about aircraft noise. For example, in fiscal year 2018, FAA cancelled the Phoenix Metroplex project due to litigation related to a previous PBN project. In response to these concerns, FAA increased its community outreach efforts, which has contributed to an increase in the planned time needed for completing each site from approximately 3 to over 4 years.[10] In addition to noise concerns, other previously identified PBN obstacles remain, including a lack of automated decision support tools for controllers, unclear terminology used by pilots and controllers for referring to flight paths, and the lengthy procedure amendment process. For example, FAA has not yet deployed an automated decision support tool at facilities that manage air traffic close to airports.[11] Although FAA is addressing these obstacles, the Agency's PBN office does not adequately track mitigation strategies to determine if the obstacles are effectively resolved. As a result of these delays and obstacles, the Metroplex program has not achieved expected program timeframes and outcomes.

Metroplex benefits to airspace users have fallen well short of predictions, and there is no consensus on actual benefits achieved.

FAA expected numerous benefits from Metroplex, such as more direct flight paths and greater aircraft fuel savings. However, in post-implementation reports for the seven completed sites, FAA estimated annual benefits of $31.1 million,

[7] These seven locations are: Houston, North Texas, Northern California, Washington, DC, Atlanta, Charlotte, and Southern California. Projects are considered complete when FAA publishes the results of post-implementation analysis.
[8] ERAM is a multibillion dollar system for processing flight data at facilities that manage high-altitude traffic typically above 10,000 feet where aircraft reach their cruising altitudes.
[9] *Weaknesses in Program and Contract Management Contribute to ERAM Delays and Put Other NextGen Initiatives at Risk* (OIG Report No. AV2012179), September 13, 2012.
[10] FAA added 7 months to its Metroplex timeline to accommodate public outreach activities.
[11] These are Terminal Radar Approach Control (TRACON) facilities where air traffic controllers manage aircraft approaching and departing airports generally within a 30- to 50-mile radius.

which is $30.5 million (49.5 percent) less than the minimum amount initially expected when FAA first planned each Metroplex site.[12] Charlotte, NC, is the only site with estimated annual benefits greater than expected. FAA's post-implementation report stated that Charlotte's benefits were due to decreased fuel consumption for westbound departures, most likely caused by a change in the wind velocity. The other sites did not achieve expected fuel savings benefits for various reasons, including designs that increased time and distance flown for some procedures and factors that were not initially considered, such as changes in wind speeds. However, FAA officials stated that the Agency has achieved other benefits that are difficult to quantify, such as increased safety, reduced controller-pilot task complexity, and de-conflicted air traffic routes. As a result, while airspace users acknowledge they received some benefits, they do not believe that the program has met overall expectations in fuel savings, and a consensus has not been reached on the actual benefits achieved.

FAA's methods for estimating Metroplex benefits are reasonable but rely on judgment, and poor documentation limits reproducibility.

FAA's methods focus on separating out Metroplex impacts from those of other factors, such as changes in traffic levels. Specifically, the methods focus on comparing groups of flights determined to have similar characteristics operating in similar environments from a before-and-after perspective. FAA has honed its methods for estimating Metroplex benefits working with industry stakeholders on the Joint Analysis Team (JAT)[13] and by consulting with subject matter experts. Based on our analysis, we consider these methods to be reasonable. However, FAA's methods substantially depend on judgment—i.e., the informed opinions of subject-matter experts, as opposed to a primarily data-driven approach—to define the comparison groups. This hampers the Agency's ability to conduct sensitivity testing of its benefits estimates and to update them as Metroplex procedures continue to evolve.[14] According to FAA experts, they chose their approach in part to keep methodological discussions accessible to JAT members so they would have a common understanding of the results. Furthermore, FAA did not adequately document its methods for estimating benefits; as a result, we had to rely heavily on interviews to understand the Agency's approach. The lack of documentation limits transparency and may hinder the Agency from reproducing its process for estimating benefits in the future.

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[12] FAA estimated benefits for each site in ranges of low and high expected fuel savings.

[13] The Joint Analysis Team (JAT), which includes operational and analytical experts from FAA and industry, was formed to reach a common statement of fact regarding performance impacts and benefits that can be attributed to the implementation of NextGen capabilities.

[14] Sensitivity testing assesses the extent to which results change with changes in assumptions.

We are making recommendations to improve FAA's monitoring and resolution of PBN obstacles, reporting of Metroplex benefits, and documentation of benefits estimation methods.

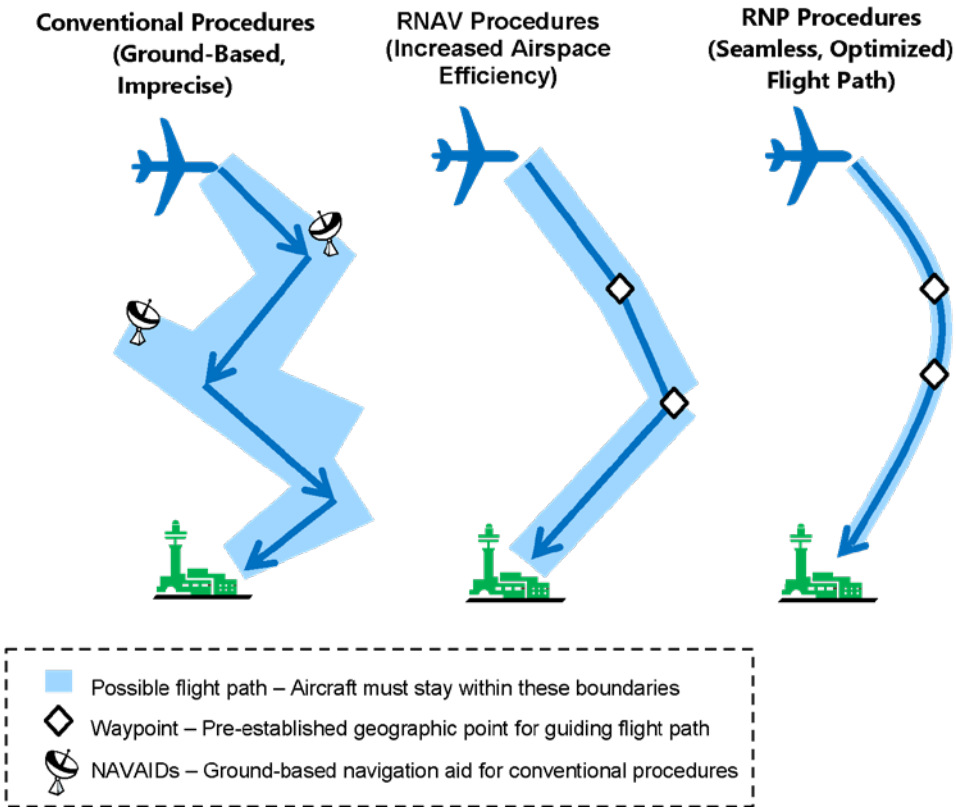
Background

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 consists of two types of procedures:

- **Area Navigation or RNAV** allows pilots to use a combination of satellite signals and other systems on-board aircraft to fly any desired flight path by reducing the limitations imposed by ground-based navigation systems.
- **Required Navigation Performance or RNP** is a more advanced form of RNAV as it adds monitoring capabilities to the cockpit to alert the pilot when the aircraft cannot meet specified navigation performance requirements. Key features of RNP are the ability to fly precise, curved approaches; provide predictable flight paths; and provide improved airport access.

Traditionally, aircraft have been required to fly routes between ground-based navigational aids to maintain required navigation accuracy of on-board systems. RNAV and RNP can increase airspace efficiency by providing more direct paths, thus reducing aircraft fuel burn (see figure 1).

Figure 1. Conventional, RNAV, and RNP Navigational Methods



Source: OIG analysis of FAA data

Since the program's creation in 2010, FAA has spent approximately $200 million on implementing its Metroplex program. During the 2012–2014 timeframe, FAA and industry prioritized implementing PBN at 12 locations, down from the original 21 locations, where improvements were determined to most likely realize the greatest near-term benefits due to factors such as operational needs and site readiness for PBN.

Beginning in 2013, the NAC recommended PBN as one of the top four NextGen priorities. In 2016, FAA further outlined its PBN goals in its PBN NAS Navigation Strategy, which includes the Agency's priorities and milestones over 15 years to fully transition to a PBN-centric NAS—that is, where PBN is used as the basis for daily operations.

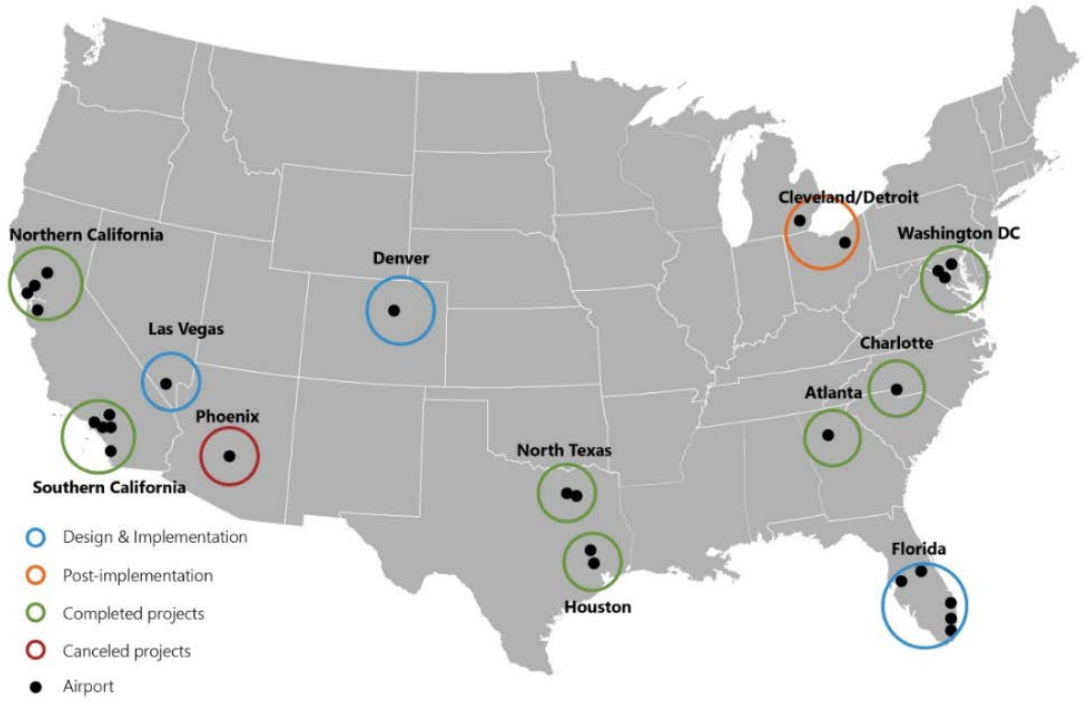
FAA Has Made Progress Implementing Its Metroplex Program but Has Experienced Delays, and Key PBN Obstacles Remain

While FAA has completed 7 of the 12 Metroplex locations, the Agency does not expect to complete all the remaining locations until 2021, 4 years later than originally planned. These delays are due to a number of factors, including community concerns about aircraft noise. In addition, while FAA developed an action plan to address obstacles to PBN identified in 2012, key obstacles remain, such as lack of automated decision support tools for controllers and the lengthy process to amend procedures. Further, the Agency has not adequately tracked mitigation strategies to determine if obstacles were effectively resolved.

FAA Implemented PBN Procedures at Metroplex Sites, but Community Noise Concerns Are Causing Delays

Since FAA began the Metroplex program in 2010, the Agency has completed activities at 7 of the 12 Metroplex sites—Houston, North Texas, Washington, DC, Northern California, Southern California, Charlotte, and Atlanta. There are four remaining Metroplex projects that are ongoing, and one has been canceled—Phoenix—due to lawsuits. These projects are either in the design, evaluation, or post-implementation phases. Figure 2 shows the implementation status of each of the 12 sites.

Figure 2. Metroplex Implementation Sites and Their Status, as of September 2018



Source: OIG analysis of FAA data

For the 7 completed sites, FAA has implemented a total of 503 new procedures and routes—446 PBN and 57 non-PBN procedures—as shown in table 1. These include procedures with optimized descents intended to provide smoother flight paths from high altitude all the way down to the runway that are designed to use less fuel than conventional approaches. In addition, according to FAA, these procedures can increase safety due to more predictable flight paths.

Table 1. Number and Types of PBN Routes Implemented

Metroplex Location	Date Completed	PBN Procedures	Non PBN Procedures
Houston	May 2014	20 RNAV arrivals 20 RNAV departures 6 RNP	14 non-PBN procedures
North Texas	September 2014	32 RNAV arrivals 29 RNAV departures 6 RNP	13 non-PBN procedures
Northern California	April 2015	17 RNAV arrivals 19 RNAV departures, 8 Q-Routes*	1 non-PBN procedure
Washington DC	June 2015	24 RNAV arrivals 25 RNAV departures 3 Q-Routes* 4 T-Routes*	5 non-PBN procedures
Atlanta	November 2016	14 RNAV arrivals 18 RNAV departures 13 T-Routes* 23 Q-Routes*	
Charlotte	January 2017	18 RNAV arrivals 15 RNAV departures	3 non-PBN procedures
Southern California	June 2017	42 RNAV arrivals 52 RNAV departures 21 RNAV RNPs 16 RNAV GPS 1 T-Route	21 non-PBN procedures
Total		**446 PBN procedures**	**57 non-PBN procedures**

*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 lower than 18,000 feet, sometimes down to 1,200 feet above ground level

Source: OIG analysis of FAA reports

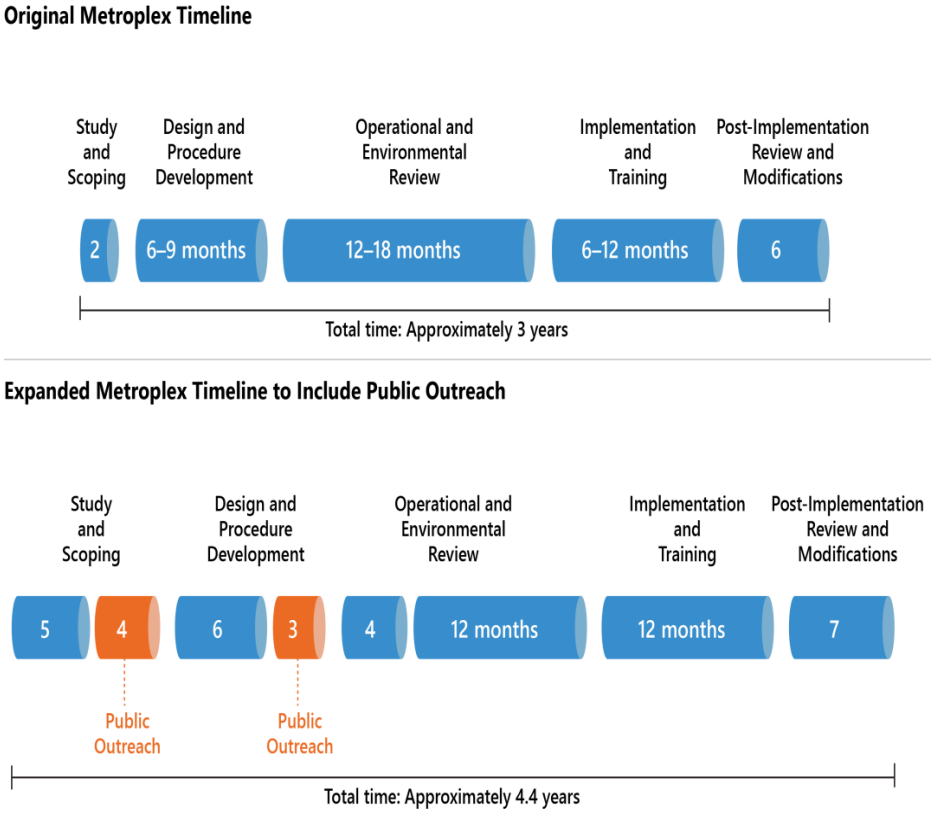
However, the program has experienced delays. FAA originally anticipated that the Agency would complete implementation at all Metroplex sites by 2017. This schedule has since slipped to 2021. Delays at Metroplex sites range from 2 months to over 2 years.

As we reported in 2012 and 2014,[15] several factors caused FAA's early Metroplex delays including work stoppages due to mandated budget cuts, problems with implementing the Agency's ERAM system, and challenges in working with air carriers.

Since 2014, further delays have occurred due to increased community concerns about aircraft noise as FAA has implemented new PBN procedures at more sites. For example, in response to noise concerns, FAA changed its process in 2016 for the last five locations to incorporate community outreach activities throughout a Metroplex project's lifecycle. Additionally, these adjustments contributed to an increase in the planned time needed from the original period of approximately 3 years to over 4 years, as shown in figure 3.[16] This increase is concentrated in the earlier stages of the process to understand and address community concerns and allow public input during the design process.

[15] *Challenges With Implementing Near-Term NextGen Capabilities at Congested Airports Could Delay Benefits* (OIG Report No. AV2012167), August 1, 2012, and *FAA Faces Significant Obstacles in Advancing the Implementation and Use of Performance-Based Navigation* (OIG Report No. AV2014057), June 17, 2014.
[16] FAA added 7 months to its Metroplex timeline to accommodate public outreach activities.

Figure 3. FAA's Original and Expanded Timelines to Complete Each Metroplex Site Implementation



Source: OIG analysis of FAA data

This new process requires FAA to engage with communities to identify and address noise concerns. For example, FAA guidance recommends identifying concerns as early as practicable and considering them in the planning process as well as the need for clarity in how the Agency will use community input.

In some cases, community concerns have escalated into lawsuits, causing even further delays. In fiscal year 2018, FAA cancelled the Phoenix Metroplex project due to litigation related to an earlier Phoenix PBN project where concerns from communities were not resolved. FAA is also facing litigation challenges in Northern California, Washington, DC, and Southern California. In 2015, FAA also established the Noise Steering Committee to address environmental and noise-related issues associated with PBN.

While FAA states that the Agency plans to complete the 11 sites, each of the remaining 4 sites is behind schedule. For example:

- FAA missed its summer 2018 scheduled design phase completion for Las Vegas and set a new milestone date of May 31, 2019. FAA delayed some

of its work in the evaluation phase for Denver until November 2018. According to FAA, both of these delays were due to budgetary and personnel constraints that occurred in the second quarter of fiscal year 2018. FAA also cited the recent Federal Government shutdown as a factor in the Las Vegas delay.

- FAA has experienced multiple work shut downs in the South/Central Florida Metroplex project, which began in 2012 due to budgetary and resource constraints, according to Agency officials. To avoid further delays, FAA re-scoped its efforts for this site. While FAA is still planning to make changes to low altitude routes at five major airports (Miami, Fort Lauderdale, Tampa, Orlando, and Palm Beach), the effort is now more focused on high-altitude route changes. In November 2018, FAA implemented 67 high-altitude routes as an interim step. While FAA has not completed the revised benefits' analyses, this shift to high-altitude routes could impact total possible benefits if there are no changes to the procedures from high altitude down to the runway where planes are landing.

FAA Has Taken Action To Address Some PBN Obstacles, but Other Key Obstacles Remain

While noise concerns have become a major obstacle to successful implementation, other PBN obstacles identified by FAA in 2012 also remain. In addition, FAA has not adequately tracked mitigation strategies to determine if obstacles were effectively resolved.

FAA Has Made Progress in Mitigating Obstacles but Has Yet To Fully Resolve Them

Although FAA reported in 2016 that it had closed and addressed all obstacles identified in 2012, the Agency's current action plan shows that FAA has not completed all outlined mitigation actions. Moreover, our analysis of the Agency's actions for 10 obstacles[17] identified by FAA in 2012 as well as our work at the 5 Metroplex locations we visited[18] shows that key barriers remain, 7 years after they were identified by FAA. In addition, several barriers were identified by FAA as closed, yet we found that some of the obstacles identified in 2012 still have not

[17] FAA identified 31 obstacles to PBN implementation, and we reviewed 10 of them. We randomly sampled five obstacles and pre-selected the other five based on known issues we identified in our audit work.
[18] North Texas, South/Central Florida, Northern California, Charlotte, and Las Vegas.

been fully addressed and remain open. See exhibit D for a list of all 31 obstacles FAA identified and the 10 that we reviewed.

Remaining obstacles include a lack of automated decision support tools for controllers, insufficient training for controllers, unclear phraseology between pilots and controllers, and procedure amendment and design issues. Specifically:

- **Controller Automation Tools.** A key barrier to increasing PBN use is FAA's lack of automated tools that would aid air traffic controllers in merging and sequencing arriving aircraft with differing equipment and capabilities. For operations at high altitude, FAA deployed an automation tool called Time-Based Flow Management (TBFM), but as we have previously reported,[19] FAA did not effectively implement the tool, resulting in inconsistent use. Since our report, FAA has updated its TBFM guidance[20] and has implemented additional capabilities for the tool.[21] However, according to staff at the nine air traffic facilities we visited, TBFM is still used inconsistently due in part to adjacent facilities not using it, mixed equipage,[22] certain procedures not working well with the system, or facilities preferring to use the traditional method of separating aircraft based on distance (referred to as "miles-in-trail") over TBFM. FAA data also indicates that use of the system has increased only moderately or not at all in some locations and decreased in others since our 2015 report.

  According to FAA officials, the Agency is continuing to encourage the use of TBFM throughout the NAS and is scheduled to deploy similar spacing and sequencing capabilities for facilities that manage traffic in the vicinity of airports, Terminal Area Sequencing and Spacing, or TSAS. However, FAA plans to implement the new tool at only nine locations from 2019 through 2022. Moreover, according to FAA officials, the start date may slip to 2020 because industry has asked FAA to prioritize Northeast Corridor activities over other NextGen initiatives if resources are limited. Ultimately, however, implementing and integrating the TBFM and TSAS tools will be key to increasing PBN use, particularly for more advanced PBN procedures that can potentially deliver greater benefits. Of the seven completed Metroplex sites, six have implemented advanced RNP

[19] *FAA Has Not Effectively Deployed Controller Automation Tools That Optimize Benefits of Performance-Based Navigation* (AV2015081), August 20, 2015.
[20] FAA Order JO 7210.3AA, Facility Operation and Administration, provides direction and guidance for the day-to-day operation of facilities and offices under the administrative jurisdiction of the FAA's Air Traffic Organization (ATO) (effective September 13, 2018).
[21] These include: Integrated Departure/Arrival Capability and Ground-based Interval Management – Spacing.
[22] The term mixed equipage refers to aircraft with differing equipment and capabilities. New aircraft usually have the latest avionics, while older aircraft have a mix of avionics of various ages and capabilities. Because of mixed equipage, not all aircraft can fly the most demanding types of PBN procedures.

procedures; however, only 8.2 percent of eligible flights (34,918 of 427,763) use them.[23]

- **Training.** Although FAA considers the training obstacle closed, it has not established a mechanism to determine if the training is adequate. Unlike courses that have an instructor, FAA does not require end-of-course evaluations for local facility-level training, mandatory briefings, and online courses, which is the training method most commonly used for PBN. In response to a prior OIG recommendation,[24] FAA provided online PBN training. However, we have since received differing views from controllers and management on its effectiveness. While the majority of those we interviewed stated that PBN training has been adequate, over a third stated that the training was not sufficient. During our interviews with controllers, we received feedback that PBN training was received in various forms. For example, while some stated that they had received a combination of briefings, computer-based instructions, and simulation, others expressed concerns of only receiving briefings on new procedures and the need for refresher training.

- **Controller-Pilot Phraseology.** As part of its action plan, FAA formed a group of controllers and pilots to develop clear and concise national phraseology—i.e., an agreed-upon list of precise words and phrases—for communicating flight paths. Although the air traffic controller handbook includes guidance regarding phraseology, and FAA has provided some PBN training,[25] 34 of the 35 controllers we interviewed[26] at 4 Metroplex locations offered mixed reviews on their usefulness. While over half stated that phraseology was consistent and clear, 29 percent thought otherwise. Controllers expressed ongoing issues with phraseology, including (1) inadequate or unclear language in the air traffic controller handbook, such as abbreviating PBN speed and altitude restrictions; (2) insufficient training for controllers and/or pilots, which has created confusion; (3) discomfort due to infrequency of use; and (4) increased complexity for controllers due to the need for additional communication with aircraft crew.

- **Amending Procedures.** PBN procedures may need to be amended after their development to account for changes in congestion, delays, or safety

[23] This is based on FAA data from the PBN Dashboard.
[24] *Challenges With Implementing Near-Term NextGen Capabilities at Congested Airports Could Delay Benefits* (OIG Report No. AV2012167), August 1, 2012.
[25] Order JO 7110.65X- Air Traffic Control Handbook.
[26] We selected controllers to interview at four of the five sites visited that were available and knowledgeable about Metroplex according to FAA management. At one of the five sites visited we interviewed personnel without the use of standardized questions. Although we spoke to a total of 35 controllers, only 34 out of 35 were able to respond to the phraseology guidance question due to an employee returning back on shift.

considerations. However, FAA officials at some facilities stated that it could take up to 2 years to get a procedure amended. To address this concern, FAA officials stated that the Agency changed policy to allow an expedited process, approved a software development tool used to design PBN arrival procedures, and established an abbreviated amendment process.[27] However, FAA has not evaluated whether these changes fully resolved issues with amending procedures. We did not specifically test how FAA implemented these changes, but we determined that this obstacle was still a major concern among personnel we spoke with at FAA offices and the air traffic control facilities we visited, with the exception of the Las Vegas Metroplex, which had not recently implemented PBN procedures.

- **Designing Procedures To Account for Variations in Aircraft Performance and Navigation Capability.** FAA has continued to update design guidance based on changes in the system and new types of operations. However, designing procedures to account for a mix of aircraft capabilities continues to be a challenge. In today's NAS, nearly all of mainline and regional aircraft are equipped to fly RNAV procedures and over 90 percent of mainline carriers are equipped to fly more advanced RNP procedures. However, only 30 percent of regional airlines are equipped to fly more advanced procedures. While over half of the controllers we interviewed did not say this was a problem, 32 percent did. According to FAA, the Agency's strategy is to focus on balancing the needs of all stakeholders and providing the right procedures to meet operational needs, while setting a vision for more advanced procedures in the future. Currently, there is an FAA priority to deal operationally with the problem in the Northeast Corridor where a large number of aircraft are not equipped to support advanced PBN procedures. FAA expects that lessons learned from this effort will help with addressing this continuing problem with mixed equipage at high density locations.

We did not identify significant issues for the remaining five obstacles. These obstacles included lack of a single accountable PBN office, need for staffing of the PBN office, delays filling Metroplex team lead positions, issues with establishing special RNAV visual procedures, and retirement of legacy procedures. To address these obstacles, FAA merged two offices to create a single accountable office to provide oversight and management of PBN activities, assigned team leads to all Metroplex projects, increased the use of special RNAV

[27] In response to a September 2009 Federal Government-industry task force report, FAA conducted a study of its processes for developing and implementing flight procedures—the NAV Lean Project. The resulting report contained 21 recommendations for streamlining FAA's processes.

visual procedures, and retired about 500 eligible procedures between 2014 and 2016 out of 2,378 that were identified as eligible.

FAA Has Not Adequately Tracked Mitigation Strategies To Determine Whether Obstacles Were Effectively Resolved

In response to a prior OIG recommendation,[28] FAA completed an action plan in December 2014 with milestones for addressing 31 obstacles identified by the Agency that were impacting the implementation of PBN procedures.[29] In this action plan, FAA committed to reporting the status of open obstacles on a recurring basis.

While FAA worked to address those obstacles in 2015 and 2016 and reported on their status, the Agency did not continue to track them to determine whether its actions had effectively resolved the obstacles. In a July 2016 internal briefing to the Director of Airspace Services, FAA reported that all actions for the 31 obstacles had been completed, and therefore all obstacles were closed and addressed in July 2016, despite not providing documented actions and justifications for all of them.

However, according to FAA, the Agency's efforts to address obstacles that impact the design, development, and implementation of PBN procedures did not end with those actions and mitigations in the July 2016 report, even though the Agency reported the obstacles as closed. FAA provided us with an updated action plan specifically developed for our current audit showing ongoing work associated with 22 of the 31 obstacles. For example, FAA's action plan states that it is still undergoing work on the design of PBN procedures to account for variations in aircraft performance and navigation. Although FAA established a 15-year plan for transitioning to PBN in 2016, including resolving obstacles, the Agency lacks a process to track its planned actions to address the remaining obstacles until they are fully mitigated. As a result, FAA may be missing an opportunity to effectively evaluate whether the Agency's actions to address these obstacles are actually helping to mitigate or resolve them.

Further, in its 2014 action plan, FAA also committed to developing a follow-up action plan to resolve 10 additional obstacles identified by the NAC in 2013.[30] For example, the NAC identified obstacles such as FAA's procedure design criteria not keeping up with technology and reluctance by pilots and controllers to use PBN

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[28] *FAA Faces Significant Obstacles in Advancing the Implementation and Use of Performance-Based Navigation* (OIG Report No. AV2014057), June 17, 2014.

[29] We determined that FAA's actions to develop an action plan were responsive to our prior recommendation.

[30] In addition to its 2012 report on obstacles identified by the Agency, FAA tasked the NAC to develop obstacles from a user perspective. In June 2013, the NAC provided FAA with recommendations to resolve a number of obstacles. (NAC, *Recommendation for Increased Utilization of Performance-Based Navigation Procedures in the National Airspace System*, June 2013.) FAA deemed 10 of these obstacles to be in addition to its own identified obstacles.

procedures due to their complexity. According to FAA, while the Agency initially tracked actions on the additional obstacles, it did not follow through with resolving them. In 2016, FAA closed the 10 remaining obstacles with no documented actions or justification for closing 7 of them. Current PBN officials stated that they do not have to fully address them because they are recommendations from industry representatives. While we agree that FAA is not required to implement the recommended actions, the Agency has not provided industry representatives with an evaluation as to whether they are feasible to implement or a justification for closing these recommended actions identified by the NAC.

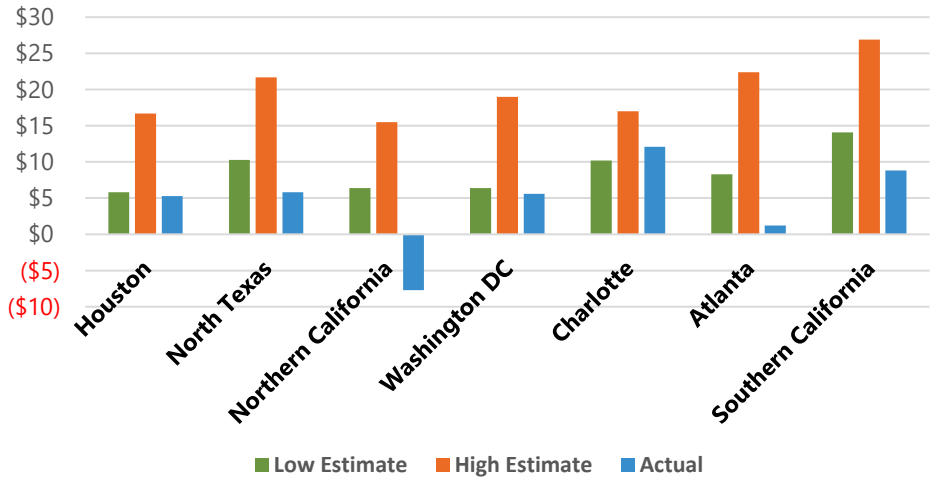
Metroplex Benefits to Airspace Users Have Fallen Well Short of Predictions, and There Is No Consensus on Actual Benefits Achieved

FAA expected numerous benefits from Metroplex, such as more direct flight paths and greater aircraft fuel savings. However, annual benefits for completed Metroplex sites have not met expectations, and FAA has not reached a consensus with industry on the actual benefits achieved.

Completed Metroplex Sites Have Achieved Significantly Lower Benefits Than Expected

FAA's post-implementation reports for the seven completed Metroplex sites show estimated annual benefits of $31.1 million—$30.5 million lower than the minimum amount of annual benefits initially expected when FAA first planned each Metroplex site. As shown in figure 4, the actual benefits achieved for seven completed Metroplex sites are significantly lower than the minimum amount initially predicted—only Charlotte exceeded initial estimations.

Figure 4. Metroplex Implementation Sites Pre- and Post-Implementation Estimated Annual Benefits (in Millions)



Source: OIG analysis of FAA data from post-implementation analysis reports

As shown in figure 4, the Houston Metroplex is expected to save $5.3 million annually in reduced fuel costs for airlines, as opposed to the revised expected savings range of $5.8 to $16.7 million. In another example, Southern California is expected to save $8.8 million, which is $5.3 million less than the lower-end estimate and $18.1 million less than the higher-end estimate.

According to FAA's post-implementation analysis, the less-than-expected benefits in fuel savings was due to several factors, some of which related to the Metroplex implementation and others to factors not initially considered. For example:

- **Houston Metroplex.** Automated traffic merging tools for controllers were insufficient due in part to limited airspace in the Houston area in conjunction with the lack of metering[31] in adjacent airspaces that would allow for better sequencing of aircraft to specific runways.
- **North Texas.** The design and implementation team provided procedure designs that actually increased flying miles for some procedures because of safety concerns with existing procedures. This occurred because agreement could not be reached on study team recommendations that

[31] Time-based metering is intended to deliver aircraft to a specific place at a specific time, which allows air traffic controllers to manage aircraft in congested airspace more efficiently by delivering a more consistent flow of traffic down to the runway.

allowed arrivals into Dallas Love Field Airport to cross over-the-top of aircraft arriving at Dallas-Fort Worth Airport.

- **Northern California.** The post-implementation analysis concluded that the primary drivers of the increased fuel burn were aircraft operator practices and other factors, such as changes in climb rates, cruise altitudes, winds, and fuel prices. However, some benefits were not fully realized because planned airspace changes were not implemented. Due to differences in analysis data samples, no positive or negative benefits related to fuel consumption could be confidently attributed to the Northern California Metroplex implementation.
- **Charlotte.** Benefits exceeded the prediction, most likely due to a change in the wind profile for departures, according to the post-implementation analysis.

FAA and Industry Have Not Reached Consensus on Metroplex Benefits Achieved

Industry representatives have not reached a consensus regarding the benefits achieved. For example, Airlines for America representatives we interviewed stated that the airlines' views differ regarding benefits achieved from the Metroplex program. For one Metroplex location, airline representatives we interviewed stated that Metroplex benefits were minimal or that no benefits were achieved. For example, some of the new routes in the North Texas Metroplex added more track miles and extra fuel burn. In contrast, airline representatives we interviewed stated that they are achieving good benefits from RNAV arrival and departure procedures at the Atlanta Metroplex.

To reach a common understanding regarding performance impacts and benefits that can be attributed to the implementation of NextGen capabilities, FAA formed a team of operational and analytical experts, known as the Joint Analysis Team (JAT). This team performed another analysis of the North Texas Metroplex and found that many factors not initially considered impacted the estimated benefits, such as changes in airline operations and wind speeds, elimination of a regularly used route, and the end of a Federal regulation that impacted airlines' operations at one of the major airports. For this location, the JAT developed estimated benefit ranges for the post-implementation period consisting of $4.5 million to $6.5 million, as compared to the $5.8 million figure found in FAA's post-implementation analysis report. The JAT's methodology is now being used at other sites, beginning with Southern California in 2018.

Although fuel savings benefits are not meeting expectations, FAA states that other operational benefits have been achieved. Specifically, controllers and facility managers have indicated that Metroplex implementation has increased safety due to the de-confliction of routes, smoother transitions in the airspace, and a decrease in pilot controller communication resulting in reduced controller workload. However, FAA has not established a process to measure or track these additional operational benefits because it states these benefits are difficult to quantify.

Furthermore, FAA is publishing conflicting information about PBN benefits. Although FAA PBN officials told us that the official estimates of benefits are detailed in its post-implementation analysis reports, the Agency has published different amounts on its public website for two of the seven completed sites. For example, FAA has posted the benefits estimate of $2.0 million from the design team for Northern California rather than the negative $7.7 million benefits, even though this is a completed site. Although FAA told us that this was because the negative amount was due to factors outside of the Metroplex implementation, this discrepancy was not explained on FAA's website. Similarly, the North Texas data posted are also based on the design team estimates, which overstates the results. In its *Standards for Internal Control in the Federal Government,*[32] the Government Accountability Office calls for Agency management to accurately report information to support decision making and evaluation of the entity's performance. Unclearly or inaccurately reporting Metroplex benefits limits Congress and the Department's ability to assess the progress of the program for purposes of providing and allocating funds, and industry stakeholders may not be able to rely on FAA reported benefits to effectively plan for the investments required to equip aircraft operating in the NAS.

FAA's Methods for Estimating Metroplex Benefits Are Reasonable but Rely on Judgment and Have Not Been Well Documented

FAA's methods for estimating benefits are reasonable. However, the methods depend heavily on judgment, which makes it difficult to assess and evaluate estimates' sensitivity to different assumptions or to update them as Metroplex procedures continue to change. In addition, FAA has not sufficiently documented its methods, further limiting reproducibility and evaluation.

[32] GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G, September 2014.

FAA's Methods for Estimating Metroplex Benefits Are Reasonable, Although They Rely on Judgment

We found FAA's methods for estimating benefits to be reasonable in that it focused on isolating the impacts of Metroplex procedures from the effects of other factors, such as traffic levels, that may have changed during Metroplex implementation. Specifically, the methods focus on comparing the performance of groups of flights determined to have similar characteristics and to occur in similar environments from a before and after perspective. For example, the fuel burn of a group of flights using a particular aircraft type operating in specific weather conditions before Metroplex implementation would be compared with the fuel burn of a group of flights using the same aircraft type and operating in similar weather conditions after Metroplex implementation. The pre-implementation group in the comparison effectively functions as a "control" group—i.e., one that has not received the "treatment" of the Metroplex procedures but is otherwise similar.

Starting in 2015, FAA refined its methods by working with industry stakeholders in the context of the NAC's JAT. The North Texas Metroplex analysis was the first to incorporate JAT input. It differed from previous analyses in that it used the following additional factors to define comparison groups: instrument versus visual meteorological conditions, the distribution of traffic demand during the day, and changes in wind direction and speed. Previously, FAA had based comparisons on a smaller set of factors that included aircraft type, runway configuration, airspace direction, airport approach, traffic level, and weather.

While we found FAA's methods for estimating benefits to be reasonable, the Agency's methods rely heavily on the judgment of subject matter experts. Specifically, FAA relied on the judgment of its own and MITRE subject matter experts to determine the factors used to sort flights into comparison groups and to decide how to use the factors—e.g. how to weigh them against each other and what cut-off values to apply—in defining the comparison groups. Relying on judgment limits FAA's ability to test and update benefits, compared with commonly used analytical methods such as regression, as detailed below.

Dependence on Judgment Limits FAA's Ability To Test the Robustness and Update Benefits Estimates

Because FAA's benefits estimates depend on judgment, it is difficult to test the estimates' robustness—i.e., their sensitivity to different assumptions, such as alternative methods to identify significant factors, number of flight groups to consider, or how flights are grouped. For example, the North Texas Metroplex analysis involved sorting flights using roughly 15 factors and produced approximately 180 comparison groups—all of which were selected based on judgment. To conduct sensitivity testing, FAA would have needed to develop a large number of new comparison groups, each selected one-by-one using judgement for each airport to be analyzed under a different set of assumptions or conditions.

Specifically, FAA's benefits estimates depend on the key assumption that the particular comparison groups the Agency judgmentally selected were appropriate. However, the extent to which the estimates are sensitive to this assumption is unknown because FAA has not conducted sensitivity testing.[33] When FAA conducted analyses using different groupings for the North Texas Metroplex, the different groupings generated substantially different benefits estimates. According to FAA, the alternative groupings chosen were shaped by the desire to identify opportunities for developing further benefits nationally rather than what would necessarily be suitable for sensitivity testing.

FAA's reliance on judgment similarly makes updating its benefits estimates a very involved process. However, Metroplex procedures have continued to change at airports for which FAA has completed its benefits analysis. In addition, FAA's benefits estimation methods also continue to evolve. Yet, FAA has chosen not to update its benefits estimates at airports it has previously analyzed. This reduces the relevance of the benefits estimates available for those airports.

In contrast, there are other commonly used analytical options that rely far less on judgment and readily enable sensitivity testing and updating. For example, regression analysis[34] would allow the data to determine the significant factors to account for to isolate Metroplex effects and would sidestep the need to construct comparison groups. To illustrate, FAA could have analyzed a regression of fuel burn on which flights occurred before and after Metroplex implementation, and measures of other factors potentially affecting fuel burn, such as weather and

[33] Sensitivity testing assesses the extent to which results change with changes in assumptions.
[34] Multiple regression analysis is a general statistical technique used to analyze the relationship between a single dependent variable and several independent variables.

airport congestion. The regression results would indicate which factors significantly affect fuel burn and then would separate out Metroplex impacts from the effects of those factors. For another alternative, cluster analysis[35] allows the data to determine appropriate comparison groups or clusters. However, when asked why FAA chose its judgmental method, FAA experts commented that the workings of these alternative methods were more difficult to communicate. FAA stated that it was important that the methodology discussions be accessible to all JAT members so they could have a common understanding of the results.

Poor Documentation Limits Transparency and Assessment of Metroplex Benefits Estimation

FAA did not sufficiently document its methods for estimating Metroplex benefits. Specifically, FAA's documentation of its Metroplex benefits estimation consisted largely of presentation slides with little text and brief summary reports.

As a result, to understand and evaluate FAA's methodology for this review, we had to rely heavily on multiple interviews with the individuals responsible for developing the benefits estimates. While we were ultimately able to understand FAA's methodology through these interviews, future evaluations could be hindered, especially should the individuals who developed the estimates no longer be available to interview. FAA subsequently provided us with a list of assumptions and choices used in its Metroplex Post-Implementation benefits analyses as of December 14, 2018. However, at three pages in length, it was still summary in nature. This lack of documentation could also impair FAA's ability to reproduce or create similar estimations to compare benefits in the future.

Conclusion

PBN procedures are key to successfully implementing NextGen and realizing its expected benefits to enhance safety, reduce delays, save fuel, and minimize aviation's environmental impact, while increasing NAS capacity. FAA has worked collaboratively with industry to prioritize PBN sites in large metropolitan areas where PBN will have the most impact and has developed a strategy for implementing new procedures throughout the NAS. However, obstacles continue to exist, such as lack of decision support automation tools for controllers, unclear

[35] Cluster analysis is a group of multivariate techniques whose primary purpose is to group objects based on the characteristics they possess.

phraseology between pilots and controllers, and community concerns regarding aircraft noise. These issues have impacted the timeliness and implementation of these new procedures and the corresponding expected benefits. Because FAA has not completed actions to address these obstacles nor determined the effectiveness of its actions, the Agency's ability to fully achieve the expected benefits of its Metroplex program remains limited.

Recommendations

To improve FAA's efforts to resolve obstacles, we recommend that the FAA Administrator:

1. Implement a procedure for assessing online and facility-level Performance-Based Navigation (PBN) training provided to controllers for effectiveness. This procedure should include reporting the results of the assessments on a continuous basis to FAA management in the PBN policy office, and take corrective actions as needed.

2. Implement a process in the PBN policy office to track and evaluate whether actions taken to address identified obstacles have been effective in mitigating them, including the areas of phraseology, training, designing and amending procedures, and automation tools.

3. Identify the corrective actions needed to mitigate the 10 obstacles from the NextGen Advisory Committee that FAA did not include in its action plan, and if feasible, establish milestones for implementing them.

4. Display the same benefits numbers on FAA's NextGen website as those that are reported in post-implementation analysis reports for completed Metroplex sites or declare any differences in the data being reported.

5. Document the methodology used to estimate PBN benefits for each Metroplex site.

Agency Comments and OIG Response

We provided FAA with our draft report on June 27, 2019, and received its response on July 30, 2019, which is included as an appendix to this report. FAA concurred with all recommendations as written and provided appropriate actions and completion dates for recommendations 1 through 4. We are requesting FAA to reconsider its actions for recommendation 5, as detailed below.

For recommendation 5, FAA concurred and requested that we close the recommendation, providing post-implementation reports as evidence that its methodology is fully documented. FAA also stated that it disagreed with some of our conclusions related to this recommendation. However, we note that only the most recent post-implementation reports contain a methodology section, and it is limited to describing data and factors considered for grouping flights. As such, these reports do not meet the intent of our recommendation to fully document the Agency's methodology for estimating benefits. For example, the methodology section does not document key steps, such as methods of determining which factors to consider, how the factors were used, and the number of groups. Moreover, the role of professional judgment in making these determinations is not documented and differences in grouping factors across reports are not explained. This makes it difficult to assess and evaluate the estimates' sensitivity to different assumptions and to update estimates. As we noted in our report, it is critical for FAA to sufficiently document its methodology to allow for transparency and reproducibility as Metroplex procedures continue to change. Therefore, we are requesting that FAA provide additional planned actions to meet the intent of this recommendation.

Actions Required

We consider recommendations 1 through 4 resolved but open pending completion of FAA's planned actions. We consider recommendation 5 open and unresolved and request that FAA provide additional planned actions within 30 days of this report, in accordance with DOT Order 8000.1C.

Exhibit A. Scope and Methodology

We conducted this performance audit between February 2018 and June 2019 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. Our objectives were to (1) assess FAA's progress in implementing its Metroplex program including its efforts to resolve key barriers to PBN, (2) compare planned to actual benefits for PBN identified by FAA, and (3) assess the soundness of the methods used by FAA to estimate PBN benefits.

To assess FAA's progress in implementing its Metroplex program including its efforts to resolve key barriers to PBN, we reviewed prior OIG audit reports and analyzed various FAA Metroplex program documents.[36] We also met several times with FAA's PBN Programs and Policy Group, the primary office responsible for oversight and management of Metroplex and PBN initiatives. Additionally, we conducted interviews with other FAA Headquarters personnel knowledgeable about instrument flight procedures, environmental reviews, community involvement, and Metroplex-related legal actions.

We also conducted field visits at 5 of the 12 Metroplex locations—North Texas, South Central Florida, Northern California, Charlotte, and Las Vegas. We performed work to identify operational impacts from new Metroplex procedures, any ongoing challenges, and whether past barriers had been resolved. We selected these sites based on a number of factors, including input from FAA to obtain a mix of older and more recently completed projects, ongoing projects, and those with positive and negative benefits. Specifically: (1) North Texas was one of the first two sites implemented in 2014, and a team of FAA and aviation industry personnel performed extensive post-implementation analysis; (2) Charlotte was a NextGen Advisory Committee (NAC) priority location that has resulted in greater than expected benefits; (3) Northern California resulted in negative benefits that were significantly lower than expected; (4) South Florida experienced a major re-scoping effort due to environmental issues and community involvement; and (5) Las Vegas was a more recent project beginning design phase activities. During these visits, we interviewed air traffic controllers,

[36] These documents included the Metroplex Handbook, Metroplex Operations Plan, FAA's 2016 PBN Strategy Report, NextGen program management reviews, NextGen Priorities Joint Implementation rolling plans, and the Agency's community engagement plans.

Air Traffic Control managers, Service Area Regional staff, and Airport Authority representatives.

To determine the barriers to PBN as well as actions taken to resolve them, we reviewed several reports issued by FAA and industry between 2012 and 2018.[37] FAA and industry identified 31 and 19 obstacles, respectively. FAA determined that 9 of the 19 were similar to obstacles they had already identified, so they included them as part of the 31.[38] We selected 10 of the 31 FAA and industry-identified obstacles for detailed review—5 were key obstacles we have identified in our past audit work and 5 were randomly selected. We analyzed documentation and conducted interviews with FAA Headquarters and air traffic field personnel to validate actions FAA has taken to mitigate these obstacles. We developed standardized questions based on FAA's 31 obstacles and then obtained responses to those questions from 35 controllers[39] and 20 management staff in 4 of the 5 Metroplex sites visited. At the first site visited, we asked general questions. Subsequently, we developed standardized questions based in part on the information obtained at this initial site. While we consulted with FAA management to ensure we interviewed controllers with direct knowledge of Metroplex at each site visited, we conducted the interviews in a way that allowed the participants to speak freely.

To evaluate PBN usage, we analyzed data we obtained from FAA's PBN Dashboard from July 2017 to June 2018. To validate FAA's usage data, we reviewed MITRE's information system security control plan to validate compliance with National Institute of Standards and Technology (NIST) requirements,[40] assurance that data exchanged between FAA and MITRE was reliable and well controlled, and that FAA and MITRE concluded that the data were accurate and complete.

To compare planned to actual benefits for PBN identified by FAA, we reviewed FAA's analysis reports prepared before and after Metroplex site implementation. We also compared the post-implementation benefits numbers to FAA's benefits' data reported on its public website to determine if the same benefits numbers were reported. In addition, we interviewed FAA, MITRE, and JAT officials to obtain information on benefits estimates. FAA could not provide us data on qualitative benefits as they contend that assessing any operational benefits or gains such as

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[37] FAA's *Obstacles to PBN Implementation* (March 2012); the NAC's *Recommendations for Increased Utilization of PBN in the NAS* (June 2013); FAA's *Obstacles to PBN Implementation Action Plan* (December 2014); FAA's *Obstacles to PBN Status Report* (July 2016); and FAA's *Obstacles to PBN Implementation Update* (May 2018).

[38] FAA has not yet developed an action plan for the remaining 10 industry-identified obstacles.

[39] While we interviewed 35 controllers, not all questions were answered by the controllers due to time limitations (e.g., controllers needing to return to work).

[40] NIST Special Publication 800-171, *Protecting Controlled Unclassified Information in Non-Federal Systems and Organizations*, details security requirements for protecting Government information outside of a Government agency.

efficiency and safety would be challenging. Furthermore, during our interviews with controllers and facility management at each of the five Metroplex sites visited, we asked for their perspectives on both qualitative and quantitative benefits. This interview subject was separate from our standardized questions.

Further, we met with representatives from major air carriers, Airlines for America, Air Line Pilots Association, and National Air Traffic Controllers Association to obtain perspectives on FAA's progress with providing PBN procedures, the extent to which they are using them, and perspectives on whether quantitative and qualitative benefits have been achieved. We also attended NAC meetings to get updates on progress and industry's perspective on FAA's Metroplex program and benefits achieved.

To assess the soundness of the methods used by FAA/MITRE/JAT to estimate PBN benefits, we reviewed all documentation provided to us on benefit analyses of Metroplex implementation. This included FAA presentation slides along with JAT and MITRE reports on analyses of Metroplex implementation at specific sites. In addition, we interviewed JAT, MITRE, and FAA personnel who worked on Metroplex benefits estimation. We asked them about the data, methodology, criteria, and tools used to estimate Metroplex benefits both before and after the JAT reached agreement on an appropriate methodology.

Exhibit B. Organizations Visited or Contacted

FAA Headquarters, Washington, DC

FAA Air Traffic Organization

- Airspace Services
- Mission Support Services
- PBN Programs and Policy Group
- Technical Training
- FAA Office of NextGen
- Technology Development and Prototyping Division
- NAS Systems Engineering and Integration Office

FAA Field Facilities

Charlotte Air Route Traffic Control Center, Charlotte, NC

Dallas Terminal Radar Approach Control, Dallas, TX

FAA Central Service Area, Fort Worth, TX

FAA Eastern Service Area, Atlanta, GA

Fort Worth Air Route Traffic Control Center, Fort Worth, TX

Jacksonville Air Route Traffic Control Center, Jacksonville, FL

Las Vegas Terminal Radar Approach Control, Las Vegas, NV

Miami Air Route Traffic Control Center, Miami, FL

Miami Terminal Radar Approach Control, Miami, FL

Northern California Terminal Radar Approach Control, Sacramento, CA

Oakland Air Route Traffic Control Center, Oakland, CA

Airlines

American Airlines, Fort Worth, TX

Southwest Airlines, Dallas, TX

Other Organizations

Airlines for America, Washington, DC

Air Line Pilots Association, Washington, DC

Charlotte Douglas International Airport Authority, Charlotte, NC

Clarke County Department of Aviation, Las Vegas, NV

National Air Traffic Controllers Association (NATCA) Headquarters, Washington, DC

MITRE Corporation, McLean, VA

NextGen Advisory Committee

NextGen Integration Working Group

RTCA, Inc., Washington, DC

Exhibit C. List of Acronyms

ATC	Air Traffic Controller
CARTS	Common Automated Radar Terminal System
DOT	Department of Transportation
Data Comm	Data Communications
ERAM	En Route Automation Modernization System
FAA	Federal Aviation Administration
GAO	Government Accountability Office
GPS	Global Positioning System
IFP	Instrument Flight Procedures
JAT	Joint Analysis Team
NAC	NextGen Advisory Committee
NIST	National Institute of Standards and Technology
NextGen	Next Generation Air Transportation System
NIWG	NextGen Integration Working Group
OAPM	Metroplex Program
OIG	Office of Inspector General
PBN	Performance-based Navigation
PIA	Post Implementation Analysis
RNAV	Area Navigation
RNP	Required Navigation Performance
SID	Standard Instrument Departure
STARS	Standard Terminal Arrival Route
TBFM	Time-Based Flow Management
TRACON	Terminal Radar Approach Control

Exhibit D. List of 31 PBN Obstacles Identified by FAA

Obstacle	Obstacle Description	Reviewed by OIG
O-1	The lack of one single accountable and responsible office to manage and handle all encompassing PBN matters.	Yes
O-2	The environmental review process is complicated and can be subjected to a lengthy environmental study (EA or EIS), prolonging PBN implementation.	No
O-3	The process for prioritizing IFPs is not transparent to the facilities.	No
O-4	There is no step within the IFP Implementation process for a facility to review chart(s) prior to finalization and publication.	No
O-5	There exists no QA mechanism for FMS database verification and validation prior to implementation.	No
O-6	Testing new concepts at high-density airports is sometimes limited due to operational impacts, which can devalue the concept of PBN.	No
O-7	The process for amending and updating procedures is too long and cumbersome, and requires streamlining.	Yes
O-8	The DCP process to FAA Orders 7110.65 and 7210.3 cannot keep pace with the changing needs of the NAS and NEXTGEN.	No
O-9	Phraseology guidance is inadequate, inconsistent, and unclear throughout the NAS resulting in pilot/controller confusion and unsafe conditions.	Yes
O-10	The rationale for FAA Public criteria that is based on the lowest common denominator avionics is not fully understood and accepted by industry and ATC.	No
O-11	AT field facilities do not have an adequate opportunity to share operational impact on AFS criteria changes during the development process.	No
O-12	When implementing new PBN concepts and policy changes, a gap exists for full implementation due to charting, DCP, automation and other factors.	No
O-13	ATC workforce is either not involved in or aware of the development of LPV procedures.	No
O-14	Optimization of arrival procedures is limited by Center's ability and/or willingness to provide runway assignment prior to TRACON entry.	No

Obstacle	Obstacle Description	Reviewed by OIG
O-15	Design of PBN procedures to account for variations in aircraft performance and navigation capability results in sub-optimal procedures that are not consistently used by ATC. Controllers rely on vectoring to maintain efficiency.	Yes
O-16	ATC operational workforce has yet to be "effectively" trained on PBN standards and technologies, and familiarized with how PBN can benefit ATC and the customers.	Yes
O-17	Human beings entering data in the process introduces risk.	No
O-18	Procedure design philosophy differs between ATC and Operators.	No
O-19	Data block information and capacity is limited and insufficient for ATC to determine aircraft/crew capabilities.	No
O-20	Radar video maps for both STARS and ARTS platforms are becoming unreadable and limited in their ability to rapidly develop and depict PBN routes and waypoints.	No
O-21	Pilots are inconsistently requesting PBN procedures and controllers are not offering them, leading to apathy and confusion regarding procedure availability and who can/wants to fly them.	No
O-22	If sufficient numbers of Q/T Routes are not available by 2020 when VOR MON is in place, then expenditure of funds to sustain unnecessary legacy VOR facilities will be required.	No
O-23	If a suitable PBN-capable backup to GPS is not provided, then the benefits of PBN operations for air carrier aircraft will be limited and costs to retain conventional infrastructure and procedures will increase.	No
O-24	If JO7110.65 and 7210.3 and the AIM are not updated to account for implementation of new PBN procedures, then the transition to PBN will be delayed, user benefits will not be realized, and pilot/controller apathy will increase.	No
O-25	If sufficient numbers of Federal FTE's are not assigned to PBN/OAPM Program Offices, then goals for new procedure development may not be met.	Yes
O-26	Delays filling OAPM Study, Design, and Implementation Team Lead positions may delay the planned schedule.	Yes
O-27	If adequate traffic sequencing, metering, and/or merging and spacing automation tools are not implemented, then increased controller workload and a significant reduction in the use of PBN procedures may result because controllers revert to radar vectors and conventional procedures.	Yes
O-28	If controllers and operations managers are not informed in a timely manner of a loss of GPS and the impacts to flight operations, then increased workload, safety, capacity, and efficiency may be negatively impacted.	No

Obstacle	Obstacle Description	Reviewed by OIG
O-29	If new PBN procedures are implemented without a corresponding reduction in the conventional and unused RNAV procedures, resources will be wasted and benefits for the new PBN procedures will not be achieved.	Yes
O-30	If the process for establishing special RNAV visual procedures is excessively cumbersome and only benefits a few operators, then acceptance by ATC will be limited and the majority of users will not benefit.	Yes
O-31	If new PBN procedures are added to radar video maps for STARS and CARTS platforms without restraint, then the displays may become unreadable due to clutter, resulting in controller workload, information overload and other HF concerns that may result in a safety problem.	No

Source: OIG analysis of FAA's 2014 Obstacles to PBN Implementation Action Plan.

Exhibit E. Major Contributors to This Report

ROBIN **KOCH**	PROGRAM DIRECTOR
COLETTA **TREAKLE**	PROJECT MANAGER
DOMINIQUE **LIPSCOMB**	SENIOR AUDITOR
MARK **GONZALES**	SENIOR ANALYST
JAMES M**ULLEN**	IT SPECIALIST
JAMUAL **FORREST**	ANALYST
BETTY **KRIER**	CHIEF ECONOMIST
JOAO **MACIEIRA**	ECONOMIST
AUDRE **AZUOLAS**	SENIOR TECHNICAL WRITER
PETRA **SWARTZLANDER**	SENIOR STATISTICIAN
MAKESI **ORMOND**	STATISTICIAN
FRITZ **SWARTZBAUGH**	ASSOCIATE COUNSEL

Federal Aviation Administration

Memorandum

Date: July 30, 2019

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 Has Made Progress in Implementing Its Metroplex Program

The FAA's Next Generation Air Transportation System (NextGen) Metroplex[1] program has evolved by necessity to reflect changes in technology, as well as growing public concern about aircraft noise in areas previously not exposed. This was a result of the implementation of new, more efficient, precision flight paths. The extent of community opposition has been greater than anticipated, and the effort to address community noise concerns has both delayed Metroplex implementation and compromised Metroplex efficiency benefits.

Metroplex is a large-scale airspace redesign program implementing Performance Based Navigation (PBN) procedures in complex, multi-airport terminal areas. PBN is essential to National Airspace (NAS) modernization by transitioning to Trajectory Based Operations (TBO). TBO leverages the improvements already made in navigation accuracy, communications, surveillance, and automation to provide significant improvements in the ability to plan, manage, and optimize aircraft routings. By more efficiently utilizing airspace, the theoretical benefits include reduced operating costs, reduced carbon emissions, increased system capacity, and less congestion with fewer flight delays.

The FAA has reviewed the OIG draft report and has the following comments:

- The report cites several times that FAA and "industry" have not reached a consensus on Metroplex benefits. One reason for this is that industry and community stakeholders have competing priorities. Measurable benefits to aircraft operations, such as improved aircraft fuel consumption due to routing efficiency are not a priority for communities concerned about new areas exposed to aircraft noise even though some areas previously exposed to aircraft noise now have reduced exposure. These competing priorities have forced the Agency to reassess and adjust every Metroplex program. As a result, the improved efficiency benefits originally anticipated have not fully materialized.

[1] Metroplexes are metropolitan areas where a large number of airports are concentrated and air traffic becomes congested.

- The FAA does not concur with the OIG assertion that methods for estimating Metroplex benefits overly rely on "judgment" or that poor documentation limits reproducibility. We maintain extensive documentation on benefits estimates, focusing upon site-specific assumptions and actual results. The draft report incorrectly reports that the FAA's documentation of its Metroplex benefits estimation consisted largely of presentation slides with little text and brief summary reports. Detailed reports, including a methodology section, are completed for each Metroplex post-implementation analysis which we have recently provided to OIG for review.

- The use of qualitative data and professional judgment are both necessary for estimating Metroplex benefits. The Agency disagrees that dependence on judgment limits FAA's ability to test the robustness and update benefits estimates. Professional judgment must be applied throughout the analysis process to ensure that reported benefits are attributable to airspace changes. Professional judgment is equally necessary to determine reasons why anticipated benefits are not realized and to tell the full benefits story, which is different in almost every locality. In order to address extensive community concerns about new noise exposure, procedures are designed and implemented that do not maximize efficiency benefits, but do result in less noise exposure. When the Metroplex program began in 2010, the focus was upon optimizing routes and airspace design. When community concerns were included in the design equation, optimization was no longer the only consideration. It is an extraordinarily complex balancing act to provide both efficiency benefits to industry and to minimize new noise exposure in communities. These are usually competing priorities.

- The intent of the Metroplex program was to make efficient use of all available airspace, which created new noise impacts. In many communities, some neighborhoods experience less noise, and some more. Relieved communities generally have not recognized the beneficial noise reductions, while impacted communities strongly oppose the new or increased exposure.

The FAA concurs with all the recommendations, as written, and will complete recommendations 1 through 3 by March 30, 2020. The FAA will complete recommendations 4 by December 31, 2019. FAA provided the OIG with supporting documentation and requested that the OIG close Recommendation 5 within 30 days after issuing the final report.

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.

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