



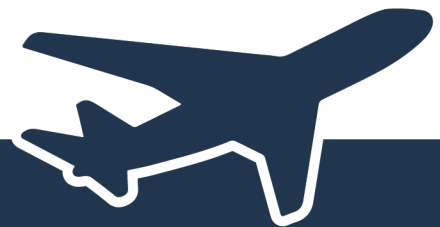
U.S. DEPARTMENT OF TRANSPORTATION  
**OFFICE OF INSPECTOR GENERAL**

**NextGen Benefits Have Not Kept Pace  
With Initial Projections, but Opportunities  
Remain To Improve Future Modernization  
Efforts**

**FAA**

Report No. AV2021023

March 30, 2021





## NextGen Benefits Have Not Kept Pace With Initial Projections, but Opportunities Remain To Improve Future Modernization Efforts

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*Mandated by the FAA Reauthorization Act of 2018*

Federal Aviation Administration | AV2021023 | March 30, 2021

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### What We Looked At

The Federal Aviation Administration's (FAA) Next Generation Air Transportation System (NextGen) is a multibillion dollar infrastructure project aimed at modernizing our Nation's aging air traffic system to provide safer and more efficient air traffic management. Since 2006, our office and others have identified a number of challenges to implementing NextGen programs and capabilities, which have led to program delays and lower usage of new capabilities. Given these concerns, the FAA Reauthorization Act of 2018 mandated that the Office of Inspector General (OIG) study the potential impacts of a significantly delayed, diminished, or completely failed delivery of NextGen. Our audit objectives were to (1) compare the current expected benefits of NextGen with the initial projections and identify the reasons for revising those projections and (2) identify lessons learned from developing and implementing significant air traffic modernization programs.

### What We Found

NextGen's actual and projected benefits have not kept pace with initial projections due to implementation challenges, optimistic assumptions, and other factors. FAA's most recent business case projects total NextGen benefits to be over \$100 billion less than the Joint Planning and Development Office's original estimate, and benefits actually achieved to date have been minimal and difficult to measure. FAA's projections were optimistic about traffic growth and did not account for risk factors. We also found that significant declines in air traffic due to COVID-19 have further extended the timeframe for realizing expected NextGen benefits. In addition, prior OIG NextGen-related work has identified lessons that FAA could use to improve NextGen delivery. For example, while FAA has collaborated with industry to prioritize, implement, and measure benefits of NextGen programs, there are still opportunities for improving transparency, which will be critical to secure industry's long-term investment. Further advancing NextGen will depend on resolving complex implementation challenges, including effectively prioritizing programs, integrating interdependent capabilities, and harnessing controller automation tools to achieve benefits.

### Our Recommendations

FAA concurred with our three recommendations to improve NextGen delivery and other future National Airspace System modernization efforts, and provided appropriate actions and completion dates. Accordingly, we consider all recommendations resolved but open pending completion of the planned actions.

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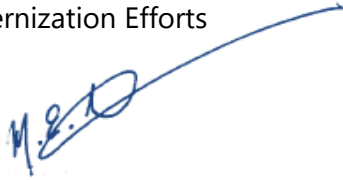


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# Memorandum

Date: March 30, 2021

Subject: ACTION: NextGen Benefits Have Not Kept Pace With Initial Projections, but Opportunities Remain To Improve Future Modernization Efforts  
Report No. AV2021023

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

To: Federal Aviation Administrator

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The Federal Aviation Administration's (FAA) Next Generation Air Transportation System (NextGen)<sup>1</sup> is a multibillion dollar infrastructure project aimed at modernizing our Nation's aging air traffic system to provide safer and more efficient air traffic management. NextGen's goal is to provide new capabilities such as precision satellite navigation, digital data link communications for air traffic controllers and pilots, and an integrated weather system.

Since 2006, our office and others have identified a number of challenges to implementing NextGen programs and capabilities, which have led to program delays and lower usage of new capabilities. As a result, FAA has revised its projected benefits for NextGen multiple times. While NextGen is expected to significantly enhance aircraft operations and foster industry growth, these benefits depend on the successful delivery of the new programs and capabilities.

Given these concerns, the FAA Reauthorization Act of 2018 mandated the Office of Inspector General (OIG) study the potential impacts of a significantly delayed, diminished, or completely failed delivery of NextGen. Accordingly, we initiated an audit to (1) compare the current expected benefits of NextGen with the initial projections and identify the reasons for revising those projections and (2) identify lessons learned from developing and implementing significant air traffic modernization programs.

We conducted this audit in accordance with generally accepted Government auditing standards. Exhibit A details our scope and methodology. Exhibit B lists

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<sup>1</sup> NextGen is a collection of new programs and capabilities, including new air traffic management technologies and procedures; airport infrastructure improvements; and environmental, safety, and security-related enhancements.

the organizations we visited or contacted, and exhibit C lists the acronyms used in this report.

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 Jay Borwankar, Program Director, at (202) 493-0970.

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

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## Results in Brief

### **NextGen benefits are lower than expected due to implementation challenges, optimistic assumptions, and other factors.**

Over the past decade, FAA has updated its projections for NextGen benefits multiple times. In its most recent estimate from 2017, FAA's overall benefits projection is \$113 billion lower than the Joint Planning and Development Office's (JPDO) initial projection.<sup>2</sup> Moreover, benefits actually achieved to date are limited. According to FAA, NextGen generated \$6 billion in total benefits from 2010 to 2018 split between the Agency, airlines, and the traveling public. NextGen's benefits have not kept pace with expectations for a number of reasons, including implementation challenges—such as the 2-year delay in implementing Time-Based Flow Management (TBFM)<sup>3</sup> capabilities for air traffic—that contributed to the Agency reducing its most recent benefit projection by nearly \$66 billion. Furthermore, FAA and aviation stakeholders<sup>4</sup> told us that accrued NextGen benefits are difficult to measure, making it challenging to assess NextGen's impact on the National Airspace System's (NAS) performance. For example, analyses of NextGen benefits related to reduced flight delays must also consider other factors, such as the impact of weather and airline business decisions. Moreover, FAA based its NextGen benefit projections on optimistic assumptions about air traffic growth, and the Agency did not adjust its projections or produce multiple scenarios to account for risk. For example, the initial benefit projections did not factor in the impact of potential economic downturns on the aviation industry or the effect of delays on one program impacting benefits from other programs. Finally, FAA has acknowledged that significant declines in air traffic and passengers due to the unprecedented Coronavirus Disease 2019 (COVID-19) pandemic will further delay the expected timeline for achieving NextGen benefits.

### **Prior OIG work has identified lessons for improving FAA's delivery of NextGen and other future modernization efforts.**

FAA's experience and our prior work has shown that successful NextGen implementation requires support and coordination both between FAA and industry stakeholders and within multiple FAA lines of business. For example, key NextGen technologies depend on airlines' willingness to install costly avionics on their aircraft. Demonstrating NextGen's tangible benefits and prioritizing its most beneficial capabilities is key to securing industry's investment. Beginning in 2013,

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<sup>2</sup> In 2007, JPDO projected that NextGen benefits would total more than \$213 billion. JPDO was established by Congress in 2003 as a multi-agency organization managed by FAA to develop a plan for implementing NextGen.

<sup>3</sup> TBFM is an automation decision support tool to help controllers sequence and space aircraft and enable the use of more efficient approach procedures to airport runways.

<sup>4</sup> Aviation stakeholders include Airlines for America and MITRE Corp.

FAA successfully worked with industry through the NextGen Advisory Committee (NAC)<sup>5</sup> to set top implementation priorities based on benefits and implementation readiness. However, industry representatives have expressed concerns about the continued effectiveness of the NAC following its transition from the Radio Technical Commission for Aeronautics (RTCA) to FAA in 2018.<sup>6</sup> Industry has also requested enhanced transparency about the current state of NextGen benefits; however, FAA last published its NextGen business case in 2016 and does not currently plan to publish additional updates. Along with the need for industry commitment, there are lessons learned related to FAA's ongoing challenges with implementing and integrating NextGen. For example, our work has shown that FAA has struggled to integrate key NextGen technologies and capabilities<sup>7</sup> due to extended program delays that caused ripple effect delays with other programs. In addition, the Agency has not fully made use of its own internal NextGen benefits analyses to help prioritize future implementation decisions. Finally, critical controller automation tools are not yet in use, which hinders FAA's ability to test and evaluate the full impact of new technologies. Leveraging these lessons learned will be critical for deploying NextGen's advanced capabilities, achieving benefits, and modernizing the NAS in a timely manner.

We are making recommendations to improve FAA's analysis and reporting of NextGen benefits, along with the Agency's delivery of NextGen and other future modernization efforts.

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## Background

In 2003, Congress mandated that FAA establish JPDO to develop a plan for implementing NextGen by 2025 and coordinate research efforts with other Federal agencies.<sup>8</sup> NextGen encompasses multiple programs, procedures, and systems at different levels of maturity. Implementing NextGen is a complex undertaking and requires joint investments from FAA (new ground systems for controllers) and airspace users (new avionics and displays for pilots) to realize expected benefits. As part of its efforts, in 2007, JPDO developed a business case for NextGen that presented an overview of the projected benefits and costs of implementing NextGen for FAA and the airlines. JPDO predicted NextGen would

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<sup>5</sup> The NAC was established in 2010 to develop recommendations for NextGen and includes operators, manufacturers, air traffic management, aviation safety, airports, and environmental experts.

<sup>6</sup> The NAC's original charter expired in 2018 and subsequently moved from the RTCA to FAA.

<sup>7</sup> NextGen technologies and capabilities include Data Communications (DataComm), En Route Automation Modernization (ERAM), and TBFM.

<sup>8</sup> FAA's partner agencies for NextGen are the National Aeronautics and Space Administration, Department of Defense, Department of Homeland Security, and the Department of Commerce/National Weather Service.

require significant investments from airlines—an estimated \$14 to \$20 billion by 2025—to equip their fleets with new avionics to enable NextGen capabilities while promising incredible returns on that investment. It also predicted the need for a complete transformation of our Nation’s air transportation system to facilitate the expected doubling or even tripling of demand for air travel by 2025. The legacy air traffic control systems, while safe, were built on technology platforms from the 1940s and 1950s that have largely exceeded their original life expectancy and have since reached the limits of their ability to handle increases in traffic. In 2007, JPDO reported that congestion was costing \$9.4 billion per year in passenger delays and predicted it could grow to \$20 billion per year by 2025 without substantial increases in the NAS’ capacity.

JPDO was disbanded in 2014, but FAA continued to produce business cases for NextGen. To estimate the benefits of planned NextGen improvements, FAA primarily uses its simulation model—the System Wide Analysis Capability (SWAC).<sup>9</sup> JPDO used a similar model and approach in its 2007 business case, but FAA has continued to improve the modeling process and has incorporated updated plans and performance of NextGen and the NAS into its modeling. In addition, for programs that the NAS Systems Engineering and Integration Office<sup>10</sup> does not model, such as airborne rerouting, FAA relies on supplemental benefit estimates from FAA program offices.

FAA’s business case also attempts to quantify benefits of improvements that the Agency has already implemented. FAA does this by updating the benefits data using mostly post implementation operational assessments. FAA works with MITRE<sup>11</sup> and the Joint Analysis Team (JAT)<sup>12</sup> to conduct these analyses. FAA then projects future benefits for these improvements and adds them to the overall benefits projection.

FAA published its most recent and last planned business case in July 2016.<sup>13</sup> However, FAA updated its benefits estimates internally in 2017 in response to our letter reviewing the 2016 business case. Our work identified several issues that led to the estimates being optimistic, including using outdated program

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<sup>9</sup> The SWAC is a fast-time simulation model that estimates expected operational benefits of NextGen improvements for the NAS.

<sup>10</sup> FAA’s NAS Systems Engineering and Integration Office helps to design, analyze, plan, and protect the NAS by managing the NAS Enterprise Architecture, defining NAS requirements, performing enterprise safety analyses, maintaining systems engineering guidance and information, defining security standards, and analyzing NAS performance using computational models and data analytics.

<sup>11</sup> MITRE Corporation functions as FAA’s federally funded research and development center.

<sup>12</sup> JAT is a joint FAA and industry group of experts that work to develop mutually agreed upon measurements of NextGen programs at key sites. JAT is a subgroup under the NAC.

<sup>13</sup> According to FAA officials, FAA does not plan to develop another full business case; instead, the Agency is focused on working with industry on joint program benefit analyses.



schedules, aggressive assumptions about future implementations and traffic growth, and a lack of risk adjustment or alternative scenarios.<sup>14</sup>

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## NextGen Projected and Actual Benefits Are Lower Than Expected Due to Implementation Challenges, Optimistic Assumptions, and Other Factors

NextGen's benefits have not kept pace with initial expectations. FAA's most recent business case projects total NextGen benefits to be over \$100 billion less than JPDO's original estimate, and benefits actually achieved to date have been minimal. Moreover, these benefits are difficult to measure, and FAA has faced key implementation challenges that have limited its success. Additionally, NextGen's benefit projections were optimistic and did not account for risk factors. Finally, significant declines in air traffic and passengers due to COVID-19 have extended the timeframe for realizing expected NextGen benefits.

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### NextGen Benefits Are Significantly Lower Than Initially Projected

In 2007, JPDO's initial business case projected that NextGen would generate \$213 billion<sup>15</sup> in benefits by 2025 from capacity increases. Subsequently, in 2012, FAA published its own benefit projections for NextGen totaling \$118 billion through 2030<sup>16</sup> split between FAA, airlines, and the traveling public. FAA has since updated its benefit projections multiple times, with a high of \$199 billion in 2013, down to \$100 billion in 2017 (see figure 1). FAA's 2017 estimate was \$113 billion less than what JPDO originally projected and extended over a longer time horizon—2030 vs. 2025. Although the more recent estimates for NextGen benefits are much lower than JPDO's initial 2007 estimate, NextGen was projected to generate \$100 billion in benefits, which is still significantly higher

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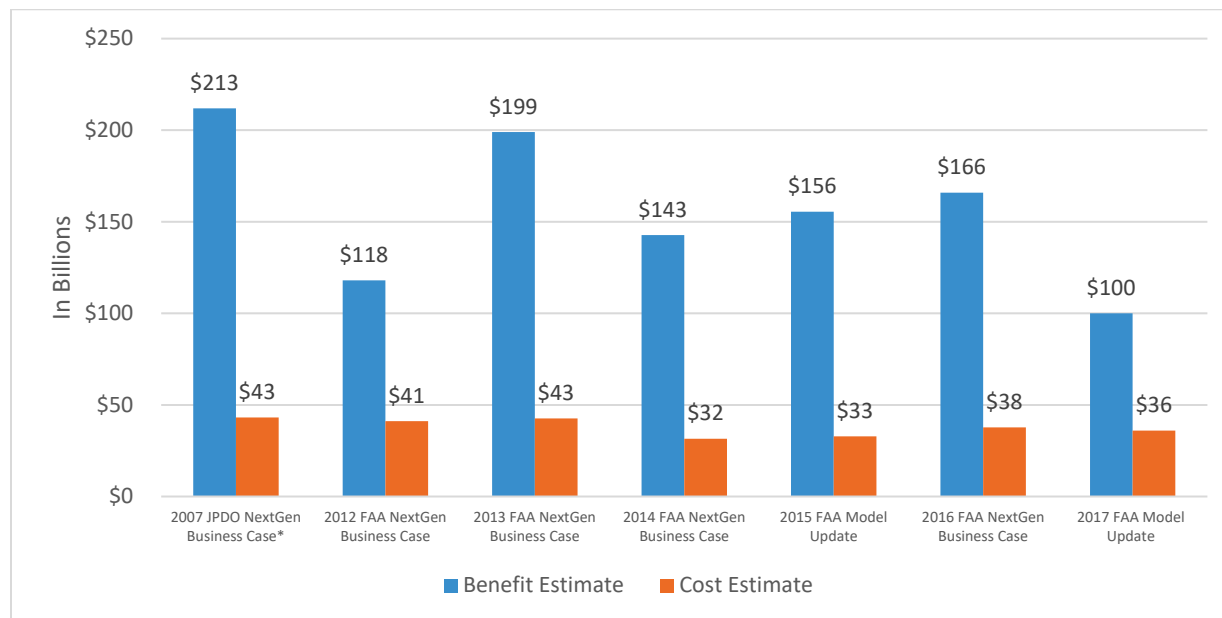
<sup>14</sup> *Letter to Chairman Bill Shuster and Chairman Frank L. LoBiondo Regarding FAA's July 2016 NextGen Business Case*, (OIG Correspondence No. CC2017015), August 15, 2017. OIG products are available on our website at <http://www.oig.dot.gov/>.

<sup>15</sup> The \$213 billion is based on forecasted capacity increases. The analysis of other sources of benefits, including environmental, safety, and weather, were not mature enough to project a total for 2025. All business case benefit and cost estimates are provided in fiscal year 2018 dollars.

<sup>16</sup> FAA's benefit estimates are more mature and include additional sources of benefits, such as safety, and reduced operating costs to FAA. However, reduced delays are the majority source of benefits from each of FAA's business cases.

than its projected total cost of \$36 billion, giving it a positive return on investment.

Figure 1. NextGen’s Projected Benefits and Costs (in Billions)



\*The 2007 JPDO NextGen Business Case includes benefits through 2025. All FAA estimates are through 2030. Additionally, JPDO’s benefit estimate is from capacity improvements only, whereas FAA’s business cases include additional sources of benefits, such as those arising from improvement in safety and reduced operating costs.

Source: OIG analysis of JPDO and FAA data, converted into fiscal year 2018 dollars for comparison.

FAA has objected to using the JPDO benefit estimates as a baseline for comparison because those estimates were not produced solely by FAA, and officials claim they were never supported by the Agency. However, FAA was a partner agency to JPDO, and the Agency had engaged the contractor that developed JPDO’s estimate. Even disregarding the JPDO estimate, FAA’s 2017 update is the lowest estimate the Agency has produced by billions of dollars.

FAA’s Systems Analysis & Modeling Division asserted that NextGen benefits have not been lost, but simply delayed. The 2030 end date for calculating benefits does not provide a full 20-year lifecycle for many individual NextGen programs due to delays in implementation. The Systems Analysis & Modeling Division contended that if the 2017 estimate was extended through 2035, the total benefits would exceed \$160 billion.

Thus far, FAA claims NextGen has generated \$6 billion in total benefits from 2010 to 2018 split between FAA, airlines, and the traveling public. These benefits represent a small percentage of FAA’s overall \$100 billion total projected benefits and are lower than the \$9 billion that FAA has already invested in implementing

NextGen.<sup>17</sup> Airlines have also made investments to upgrade their aircraft avionics for NextGen. However, the \$6 billion in benefits is in keeping with FAA's 2017 model update that predicted benefits would equal costs in 2024.

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## Impacts of NextGen Programs Are Not Easily Measured

NextGen benefits are difficult to measure according to FAA officials, MITRE, and industry experts. MITRE, JAT, and FAA use sophisticated models and carefully designed pre/post implementation analyses to determine the benefits achieved from NextGen capabilities at specific sites. However, factors outside FAA's control—such as weather and airline business decisions, including changes to their schedules and aircraft fleet composition—can offset any improvements in operations. As such, these factors can impact the projected improvements in flight delay numbers and fuel burn efficiency. Furthermore, site- and technology-specific studies are limited in their ability to fully capture NextGen-related benefits due to the cost and difficulty of conducting them. As a result, FAA is forced to extrapolate the results from some sites to others when incorporating these results into the Agency NextGen benefits model, which could lead to unreliable benefit projections.

In a separate effort, FAA is developing a set of NextGen performance metrics that the Agency plans to report on a daily basis using actual operations while accounting for factors outside FAA's control, such as weather. Specifically, these metrics would measure the impact of Initial-Trajectory Based Operations (iTBO).<sup>18</sup> iTBO is a step towards shifting air traffic controllers to separate traffic using time-based metering, which relies on new controller tools and onboard avionics to improve efficiency. iTBO integrates the key NextGen technologies and capabilities that FAA's model predicts will generate future NextGen benefits, including Performance-Based Navigation (PBN),<sup>19</sup> controller metering automation tools, and Data Communications (DataComm).<sup>20</sup> However, FAA could not provide a

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<sup>17</sup> The \$9 billion includes NextGen funding from 2003 to 2018.

<sup>18</sup> iTBO is the first phase in moving towards full Trajectory Based Operations (TBO), an air traffic management method for strategically planning, managing, and optimizing flights by using time-based management (TBM), information exchange between air and ground systems, and the aircraft's ability to fly precise paths. TBO is a shift in the way controllers separate air traffic from using set distance, miles-in-trail, to using time.

<sup>19</sup> PBN delivers new flight routes that primarily use satellite-based navigation aids and on-board aircraft equipment to navigate with greater precision and accuracy. As such, PBN can provide significant benefits, such as more direct flight paths, improved on-time airport arrival rates, greater fuel savings, and reduced emissions and noise.

<sup>20</sup> DataComm enables air to ground digital communications services between FAA facilities, controllers, aircraft, and flight crews that result in reduced delays, increased throughput and efficiency, enhanced safety, and a reduction in environmental impacts.

date for when these metrics would be available and used to assess NextGen's performance.

Due to FAA's lack of system-wide measures for NextGen performance, we analyzed several performance metrics from the Department of Transportation's Bureau of Transportation Statistics (BTS). Specifically, we looked at taxi times and delays from 2008 to 2019 across the NAS for the 24 largest domestic airlines, including American Airlines, Delta Air Lines, and United Airlines. We were not able to identify any clear improvement to NAS operations overall. Instead, overall operations appeared to become less efficient, with average taxi time, departure delays, and arrival delays all increasing over this period. Airlines for America (A4A) also conducted analysis showing increased block times.<sup>21</sup> However, the impact of a variety of airline business decisions, weather, and other non-NextGen related factors can outweigh the impact of NextGen programs. As such, this analysis is not sufficient to evaluate NextGen's impact on operations. Specifically, FAA's analysis shows that the increases in delays can be attributed to increases in traffic at some large airports. The concentration of additional traffic at these airports has led to significant increases in delays throughout the system.

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## Implementation Challenges Have Delayed and Diminished Programs, Lowering Expected Benefits

Our office, the Government Accountability Office, and others<sup>22</sup> have identified challenges to implementing NextGen programs and capabilities dating back to 2006. These challenges include delays and reduction of the number of planned sites for new controller tools to manage air traffic and new advanced flight procedures that are key drivers for NextGen benefits.

While FAA has deployed much of the infrastructure for NextGen, new capabilities that are expected to generate benefits are not widely used or have yet to be implemented, including advanced PBN procedures and reduced separation standards from Automatic Dependent Surveillance-Broadcast (ADS-B).<sup>23</sup> Additionally, key controller tools such as Terminal Sequencing and Spacing (TSAS),<sup>24</sup> which should facilitate increased use of PBN procedures when demand

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<sup>21</sup> Block time is time from departure gate to arrival gate.

<sup>22</sup> As part of our audit, we reviewed documents from the National Research Council, NAC, and Airlines for America.

<sup>23</sup> ADS-B uses the satellite-based Global Positioning System and is intended to allow FAA to transition from ground-based radar to a satellite-based system for improving surveillance and management of air traffic.

<sup>24</sup> TSAS is a new tool to help air traffic controllers merge and sequence aircraft using time-based metering in the airspace closest to airports.

is high at airports, and Terminal Flight Data Manager (TFDM),<sup>25</sup> which aims to improve efficiency of surface operations, have not yet been deployed.

Some programs—even after they have been deemed fully operational—are not producing their expected benefits, and their new capabilities are not being deployed as widely as originally planned. For example, the first seven completed Metroplex<sup>26</sup> sites—a program that primarily implements new PBN procedures at the largest airports—are producing about half of the benefits originally expected. Additionally, in August 2017 we highlighted several concerns about FAA’s 2016 NextGen Business Case model, including the concern that the Agency was using out-of-date program schedules to calculate projected NextGen benefits that did not reflect delays to key programs. For example, each Metroplex site has taken longer to implement than originally expected—4 to 5 years instead of 2 to 3 years—due to a range of factors including technical issues with the En Route Automation Modernization (ERAM)<sup>27</sup> system’s installation, increased community outreach due to environmental concerns, and issues with procedure design. In addition to the delays, FAA’s 2016 model assumed that a full Metroplex implementation would occur at 31 major airports by 2022, rather than FAA’s subsequently scaled-down plan to implement these improvements at only 19 airports.

In response to our 2017 letter, FAA’s Systems Analysis & Modeling Division staff addressed many of our concerns while updating the NextGen benefits model. Their update resulted in reducing the benefit projection by 40 percent—from \$166 billion to \$100 billion. FAA estimates that approximately \$18 billion (27 percent) of the \$66 billion decrease is attributable to delays and reductions in deployment sites of key NextGen programs and capabilities. Specifically, FAA updated its benefits model to reflect 2-year delays to new TBFM capabilities and the TSAS tool for terminal controllers; a delay and reduction in the number of Metroplex sites; and an up to 8-year delay in relative spacing using Interval Management, another key component of time-based metering.

Of the \$100 billion in benefits projected in 2017, only 18 percent is projected to be generated by programs that have been implemented, with the rest coming from future planned programs and capabilities, such as new controller automation tools and reduced separation standards. However, based on FAA’s

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<sup>25</sup> TFDM is a new decision support tool for airport surface management, including creating virtual departure queues, data sharing with flight operators, and electronic flight strips to help enable time-based metering.

<sup>26</sup> Metroplex is an initiative intended to improve the efficiency of airspace that affects multiple airports near large metropolitan areas by implementing high value PBN procedures and airspace changes.

<sup>27</sup> 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.

past performance, as documented in our prior audit work, these programs could experience delays or may not fully deliver their expected benefits.

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## NextGen Benefit Projections Were Based on Optimistic Air Traffic Growth and Lacked Risk Adjustments

The original JPDO model as well as FAA's later models for NextGen benefits were based on optimistic assumptions about projected air traffic levels. The models relied on the Terminal Area Forecast (TAF),<sup>28</sup> which has consistently predicted significant traffic growth. However, traffic has remained largely flat since NextGen began, and recently traffic has decreased significantly due to the COVID-19 pandemic.

The majority of FAA's projected NextGen benefits are from the flying public experiencing less delay per flight than they would have experienced without NextGen. These benefits, known as Passenger Value of Time (PVT), make up 64 percent of the total benefits in FAA's 2017 projection. The heavy reliance on PVT makes NextGen benefits very sensitive to changes in air traffic and number of passengers. In 2013, FAA updated the dollar value for PVT in its business case model in accordance with DOT guidance<sup>29</sup> from \$28.60 per hour to \$43.50 per hour (a 52 percent increase), with a 1.6 percent annual increase. This contributed to a dramatic increase in the projected benefits for NextGen overall, from \$118 billion to \$199 billion, with PVT accounting for well over half of the total benefits. However, given that FAA's models have consistently overestimated traffic growth, the resulting projected benefits derived from PVT could be greatly inflated.

There is also no consensus on how to calculate PVT. According to DOT guidance, FAA counts every minute equally to add to the total reduction in delays to passengers. As a result, DOT's guidance for calculating PVT leads FAA to higher benefit calculations as compared to some other countries we reviewed. For example, Canada does not include increments of less than 5 minutes, and Germany discounts smaller increments of time compared to larger ones when calculating PVT. Meanwhile, the European Union recommends counting all time

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<sup>28</sup> The TAF is an annual report that projects air traffic at all U.S. airports. FAA has recognized actual traffic has consistently been lower than the last several TAF projections and the shortfall is apparent even in the first projected year, but FAA continues to use it in NextGen benefits forecasts.

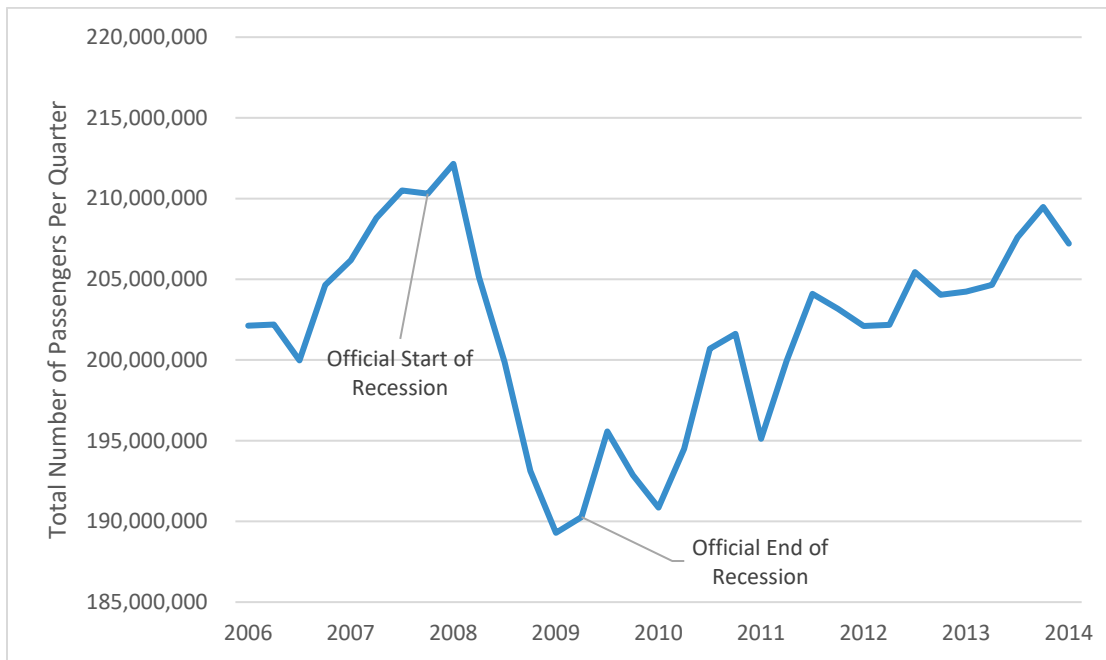
<sup>29</sup> *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis* (9/28/2011), <https://www.transportation.gov/resources/2011-revised-value-of-travel-time-guidance>.

equally but reporting small increments separately, providing greater transparency.

Furthermore, traffic has not grown as expected since NextGen began. In 2007, JPDO predicted NextGen would need to triple capacity to accommodate traffic growth. This contributed significantly to JPDO's initial benefit estimate being much higher than later FAA projections. When traffic levels return and potentially grow as FAA's models predict, delays are expected to continue to increase even with NextGen programs and capabilities fully deployed. For example, FAA's 2016 NextGen business case predicted that without NextGen, flights would be delayed on average by over 20 minutes. However, with NextGen improvements, delays are still expected to increase by almost 15 minutes per flight.

Finally, FAA's NextGen benefit projections did not factor in risks—such as the risk that air traffic growth would not increase as expected. While FAA does provide a risk adjustment when estimating the benefits of individual programs as part of the Acquisition Management System process, it did not perform a risk adjustment in its business cases when projecting the overall benefits of NextGen. Staff from FAA's Systems Analysis & Modeling Division explained that until recently, they have lacked official ranges for the TAF to incorporate in their model to generate different forecasts or risk adjustments. However, there are additional factors that may impact the overall risk of implementing NextGen, such as program interdependencies that are not fully captured by assessing risks for the individual programs. Furthermore, the projections did not factor in other significant events, such as economic fluctuations that occur cyclically, which can also have a measurable impact on traffic levels. For example, the economic recession of 2007–2009 reduced air traffic significantly (see figure 2).

Figure 2. Passenger Throughput Before and After 2007–2009 Economic Recession



Source: OIG analysis of BTS passenger throughput data. Data have been adjusted for seasonal variation.

Factoring in the risk of such cyclical events could improve the accuracy of FAA’s benefit estimates. This is especially the case given that FAA’s benefits model is sensitive to the growth of air traffic, and FAA uses air traffic projections that have historically overestimated growth. Additionally, Office of Management and Budget (OMB) guidance recommends that multiple scenarios and probability distributions be provided when possible in benefit-cost estimates, especially when past experience shows initial estimates were optimistic.<sup>30</sup> FAA’s lack of risk adjustments and its decision to provide only a single scenario for NextGen benefits led to overly optimistic expectations about NextGen’s benefits. As a result, FAA provides no level of assurance to decision makers or stakeholders on whether potential billion-dollar NextGen investments are low, medium, or high risk.

<sup>30</sup> Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs (OMB Circular A-94).



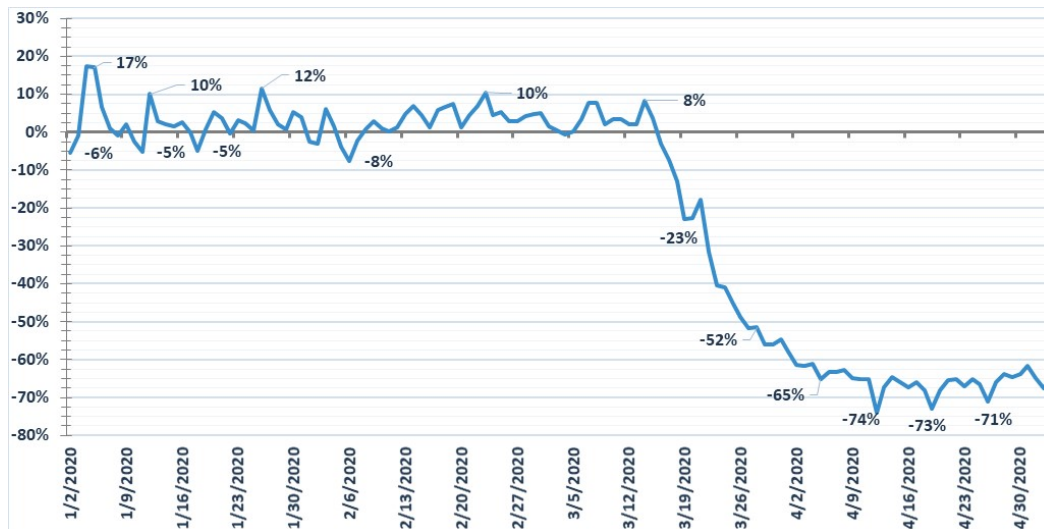
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## COVID-19 Will Further Extend the Timeframe for Capturing NextGen Benefits

FAA acknowledges that NextGen’s benefits will be further delayed by the unprecedented COVID-19 pandemic. Specifically, the COVID-19 pandemic has resulted in a tremendous drop in air traffic and passengers, both of which are major drivers for NextGen benefits. Since early 2020, when the pandemic began in the United States, there have been days in which air traffic decreased over 70 percent and passengers over 90 percent (see figures 3 and 4). Additionally, FAA stated that COVID-19 has led to delays in key NextGen programs, including TFDM and DataComm, which will further affect NextGen’s benefit recovery timeframe.

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Figure 3. Percentage Change in Daily Flights<sup>31</sup> Compared to Prior 3-Year Average

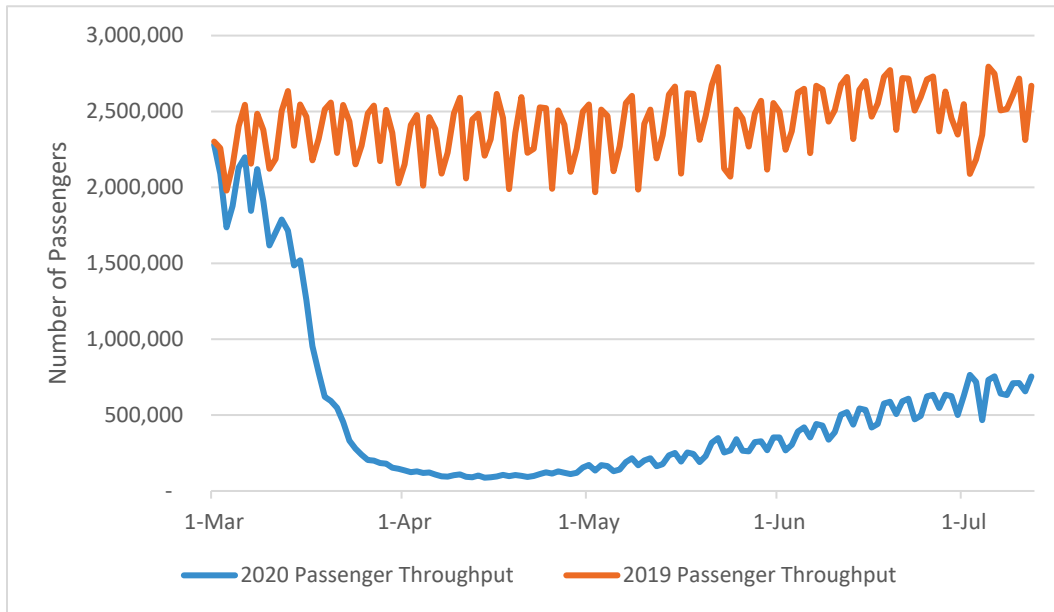


Source: FAA data.

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<sup>31</sup> Chart depicts daily number of Instrument Flight Rules (IFR) flights, which is a set of rules governing flights relying on the aircraft’s instruments and navigation aids. IFR permit aircraft to fly in certain limited visibility and cloud conditions. Virtually any commercial operation—including airlines and business jets—are IFR flights.

Figure 4. Passenger Throughput Data, 2019 and 2020



Source: OIG analysis of Transportation Security Administration data.

It is unknown how long the impacts of the pandemic will last and the extent of the decrease in air traffic. However, according to FAA officials, there will be very little benefit from NextGen during this time, and many systems, such as TBFM and TSAS, could go completely unused until traffic levels return. In addition, capabilities such as PBN will provide much lower benefit because of the reduced traffic.

There will still be some benefits from NextGen, such as consolidating systems and modernizing infrastructure, but these cost savings only made up 2 percent of the 2017 benefit estimate. Furthermore, as previously mentioned, the majority of the already accumulated \$6 billion in benefits are derived from reduced expected delay to passengers (\$3.4 billion), or PVT. Given the impact of COVID-19 on passenger travel, PVT is unlikely to continue to be a source of significant benefits in the near-term.

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# Prior OIG Work Has Identified Lessons for Potentially Improving FAA's Delivery of NextGen and Other Future Modernization Efforts

Our longstanding body of work related to NextGen has identified lessons that FAA could use to improve NextGen delivery. For example, while FAA has collaborated with industry to prioritize, implement, and measure benefits of NextGen programs, there are still opportunities for improving transparency, which will be critical to secure industry's long-term investment. In addition, further advancing NextGen will depend on resolving complex implementation challenges, including effectively prioritizing programs, integrating interdependent capabilities, and harnessing controller automation tools to achieve benefits.

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## FAA Has Collaborated With Industry To Advance NextGen but Can Improve Transparency and Internal Coordination

While FAA and industry have partnered to prioritize and plan programs, securing industry investment remains key to NextGen's long-term success. Central to this effort is FAA being transparent with stakeholders about NextGen benefits. Overall, successful NextGen implementation also requires support and coordination both between FAA and industry stakeholders and within multiple FAA lines of business.

### **FAA Has Partnered With Industry To Prioritize and Plan Programs but Will Require Additional Industry Investment**

NextGen is a large joint investment between FAA (\$21 billion) and industry (\$15 billion). As such, both FAA and industry play a role in advancing and measuring NextGen's success. For example, airline business decisions can have a significant impact on the operational efficiency of the NAS, such as scheduling of flights and fleet types.

Additionally, in order for airlines to fully benefit from NextGen, they need to equip their aircraft with new avionics and other technologies. While airlines have made significant investments in new equipment, they were reluctant to make such investments until they were convinced that NextGen's benefits would outweigh their initial investment and that they could trust FAA would implement them as planned. In the past, FAA worked successfully with industry to implement the first segments of DataComm, a program requiring new onboard avionics

investments by airlines and ground infrastructure by FAA. The collaboration was successful because airlines saw clear and immediate benefits to the investment.

FAA and industry have also already successfully worked together to establish NextGen's top priorities. Under the RTCA—a chartered Federal Advisory Committee—FAA and industry formed the NAC, which provided a forum and structure to work together. In 2013, FAA asked the NAC to prioritize the NextGen programs based on benefits, technological maturity, and implementation readiness. As FAA has implemented these programs, the Agency has used JAT analysis to influence the scope and identify additional sites for several of these NextGen initiatives. For example, JAT found benefits from both Wake Recategorization (Wake Recat)<sup>32</sup> and DataComm Tower Services, which brought greater industry support and helped increase the number of sites for implementation. Alternatively, the JAT analysis of the North Texas Metroplex found that while there were benefits, they were lower than originally expected. This helped limit the implementation of Metroplex elsewhere.

While the NAC was able to prioritize NextGen programs and develop an implementation plan, its charter expired on May 29, 2018, and transitioned from the RTCA to FAA. Industry officials we spoke with are concerned about the continued effectiveness of the NAC, which could influence their continued willingness to invest in NextGen related technologies. Given that a significant amount of industry investment will still be required to advance NextGen, gaining industry partnership and support to continually identify priorities and assess benefits will remain critical.

### **Stakeholders Would Like More Transparency on NextGen Benefits**

A key aspect of securing industry investment in NextGen is communicating NextGen's benefits. Airline officials stated that they would like more transparency from FAA on actual benefits of NextGen programs. For example, JAT's group of experts work to analyze and develop mutually agreed upon results of NextGen programs, such as the impact of Metroplex on fuel burn, at key sites. While airlines support this effort, its scope is limited by the difficulty and cost of conducting such analyses.

According to the airline representatives we spoke with, industry would like to see regular reporting on the benefits of NextGen with clear explanations of where the data are coming from. However, FAA has not published a new business case for NextGen since 2016, and the Agency has no plans to publish an updated business case. According to FAA officials, the Agency does not plan to develop another full business case; instead, it is focused on working with industry on joint program benefit analyses. Yet, given the recent changes to the airline industry in

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<sup>32</sup> Wake Recat safely reduces the separation between aircraft on arrivals and departures.

the wake of COVID-19, further transparency is critical to report on the effective status and benefits of NextGen and inform airlines' planning and investments in new avionics.

### **Prior and Current OIG Work Has Raised Issues About Effective Coordination Across FAA Lines of Business**

NextGen programs require FAA to work effectively across diverse agency lines of business. However, OIG has found that FAA has had issues coordinating NextGen programs across offices and air traffic facilities. For example, implementing Metroplex requires multiple offices to work together to make policy changes, develop new flight procedures, ensure adequate training for controllers on new procedures, and develop new automation tools to allow controllers to manage traffic effectively. Additionally, FAA, industry, and our own work found that TBFM requires air traffic control facilities to work together to facilitate time-based metering. However, lack of a national vision, standardized operating policies and procedures, and intra-facility agreements led to fragmented usage of the tool. While FAA has worked to address these issues, NextGen will continue to present challenges in coordinating across multiple lines of business and air traffic facilities.

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## **Other Lessons Provide Additional Insights Into Complex Implementation Challenges That May Impact NextGen Delivery**

Significant work and challenges remain to implement and integrate NextGen's advanced capabilities. While FAA has formulated its own analysis of NextGen benefits and impact, the Agency does not make use of these analyses to help prioritize future implementation decisions. In addition, critical automation tools are not yet in use, which hinders FAA's ability to evaluate and test new technologies and advance NextGen benefits.

### **FAA Does Not Fully Leverage Its Own Analysis of NextGen Benefits To Help Prioritize Implementation**

Until recently, FAA did not leverage the benefits work of its own Systems Analysis & Modeling Division to help prioritize NextGen funding or deployments. FAA approves and plans implementations of new technologies and capabilities based on cost-benefit analyses performed as part of its Acquisition Management System, which relies on engineering estimates and results of demonstration projects. However, FAA usually does not use the updated projections and post-implementation analysis it already conducts to help reprioritize NextGen

programs and deployment locations to maximize benefits to users and the traveling public. Instead, according to FAA officials, the Agency prioritizes programs based on the Enterprise Architecture and funding. FAA was able to provide one example of leveraging such analyses to help prioritize site selections for iTBO; however, other NextGen programs have not leveraged the Systems Analysis & Modeling Division's work.

FAA has relied on similar work from JAT to reduce the number of Metroplex locations where benefits were lower than expected and to expand the number of locations using Wake Recat due to the program's high benefits. However, other than the recent iTBO work, FAA could not provide examples where the Agency had leveraged its own work to make more efficient implementation decisions. According to the FAA officials we spoke with, the Agency considers a large number of logistical and planning considerations to make deployment decisions, making it difficult to adjust based on actual benefits data. However, some officials we spoke with also agreed that using benefits data would help the Agency make better decisions regarding how and where to invest in future NextGen capabilities.

### **Integrating NextGen Technologies To Enable Advanced Capabilities Remains a Challenge**

NextGen requires FAA to implement multiple new and highly interdependent technologies. Our recent and longstanding body of work has shown that new systems, such as DataComm, ERAM, and TBFM, faced delays and budget overruns. Due to the interdependencies between these systems, delays in one system caused a ripple effect and therefore delayed other systems. While FAA has largely deployed the new infrastructure as described above, FAA continues to face challenges in implementing additional segments of these systems or capabilities. FAA also has yet to implement other key systems that drive NextGen benefits, including TSAS and TFDM.

The Agency has struggled with the shift from planning to actually using the new capabilities to generate benefits for all stakeholders. For example, new PBN procedures have not been as widely implemented as planned due to mixed levels of avionics on aircraft operating in the NAS, lack of controller tools, delays to ERAM, and community legal challenges due to noise concerns. FAA's continued focus on addressing these barriers is needed to achieve the benefits from NextGen.

### **Controllers Are Not Yet Consistently Using Critical Automation Tools, Limiting Potential Benefits**

FAA's experience with NextGen so far has shown that controller automation tools, such as TSAS and TBFM, are critical to increasing the efficiency of operations in the NAS. These new tools can reduce separation of aircraft and facilitate the use

of more advanced flight procedures with shorter and more fuel efficient flight paths. However, in previous audits we found that FAA lacked a national program vision, clear guidance, standard operating procedures, training, and metrics to measure success for TBFM. This resulted in fragmented and inconsistent use by controllers, limiting benefits. MITRE is currently working with FAA to help implement these new technologies, flight procedures, and operating paradigms at several airports. While these changes will provide little to no benefit while air traffic remains low due to the COVID-19 pandemic, according to MITRE, they will provide an environment to more easily test TBO and transition controllers and pilots to using the new systems and capabilities.

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## Conclusion

Over the last decade, FAA and industry have invested significantly in NextGen and achieved a relatively small percentage of the expected benefits from new capabilities. Overall NextGen benefits will fall short of the predictions from JPDO and FAA due to delays to key programs, optimistic assumptions about traffic and passenger growth, and factors outside of FAA's control, including business decisions by airlines and declines in air traffic caused by the COVID-19 pandemic. There are a number of key lessons learned from over a decade of NextGen planning, development, and implementation that FAA can leverage further to benefit future modernization efforts. Leveraging these lessons can help FAA set stakeholder expectations, secure additional industry investment, and continue to make progress in improving the efficiency of the NAS.

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## Recommendations

To improve the delivery of NextGen and other future NAS modernization efforts, we recommend that the Federal Aviation Administrator:

1. Publish metrics that measure performance of NextGen improvements across the NAS.
2. Develop and implement a process that incorporates interim adjusted benefit projections and interim implementation analyses to support prioritization of NextGen programs and deployment locations.
3. Update and provide stakeholders a risk adjusted NextGen benefit projection.

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## Agency Comments and OIG Response

We provided FAA with our draft report on February 5, 2021, and received its response on March 9, 2021, which is included as an appendix to this report. FAA concurred with all three of our recommendations and proposed appropriate actions and completion dates. Accordingly, we consider all recommendations as resolved but open pending completion of the planned actions.

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## Actions Required

We consider all three recommendations to be resolved but open pending completion of FAA's planned actions.



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## Exhibit A. Scope and Methodology

We conducted this audit between October 2019 and February 2021 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 audit objectives were to (1) compare the current expected benefits of NextGen with the original projections and identify the reasons for revising those projections, and (2) identify lessons learned from developing and implementing significant air traffic modernization programs.

To determine and compare the current expected benefits of NextGen with the original benefit projections, we compiled prior NextGen business cases and documents produced by FAA and JPDO. In order to compare early benefits from 2007 to the most recent benefit estimates of 2017, we consulted with an OIG economist and converted the benefit estimates into fiscal year 2018 dollars using the fiscal year average consumer price index. We also compared the original and current estimated costs using the same process.

To identify the causes for revising projections, we compiled and examined program documents produced by FAA, JPDO, and prior OIG reports. We compared business cases produced by FAA and JPDO to identify changes in capabilities and how benefits were modeled. We reviewed prior OIG work to identify previous findings that contributed to revising projections. We also interviewed program officials and other stakeholders, including FAA's Systems Analysis & Modeling Division and other NextGen officials, MITRE, Airlines for America, former JPDO members, and National Aeronautics and Space Administration officials.

We worked with OIG statisticians to obtain and analyze performance metrics data. The statisticians downloaded, unzipped, and imported 144 Airline Service Quality Performance data files from DOT's BTS TranStats website for the years 2008 to 2019. Some of the data elements included are departure, arrival, and elapsed flight times as shown by the Official Airline Guide. The statistician standardized the variables length in those 144 files and then merged them into one file which had over 76 million flight records reported by 24 U.S. certificated air carriers for 8,925 city pairs. Carriers within 1 percent or more of the total domestic scheduled service passenger revenues are required to report data for flights involving any airport in the 48 contiguous states accounting for 1 percent or more of the domestic scheduled service passenger enplanements. The regulation also provides for the voluntary reporting of a carrier's entire domestic

system and voluntary reporting by other carriers. In addition, the statistician summarized some of these data by year and month and computed metrics that focused on data pertaining to this audit such as arrival delays, departures delays, and taxi times.

The statisticians also downloaded from the TranStats website and imported files titled "T-100 Domestic Market Data – U.S. Carriers Traffic and Capacity" for the years 2008 to November 2019. The data fields contain information on passengers and seats. The variable lengths were standardized and merged into one T-100D file that had over 4 million flight records for over 108 million flights, reported by 191 air carriers for 76,288 city pairs. These flights had over 8 billion passengers or 80 percent of the over 10 billion available seats. The statisticians summarized these data by year and month and computed metrics that focused on capacity growth.

We also downloaded passenger throughput data from the BTS and Transportation Security Administration website and imported data into Excel files for the following years: 2000–2003, 2006–2013, and 2019–2020. The data fields contain information on the total amount of travelers that passed through our air traffic system. To adjust for seasonal trends within passenger travel, we consulted with an OIG economist to eliminate the seasonal component. The data were adjusted using the Pindyck and Rubinfeld seasonal adjustment method, which utilizes a 12-month centered moving average. These data were used to determine the impact of external events on the air traffic system.

To identify lessons learned from developing and implementing significant air traffic modernization programs, we reviewed prior OIG reports to determine key challenges and lessons learned during the development and implementation of NextGen. We interviewed program officials as well as external stakeholders such as FAA's Office of the Chief Scientist, NAC, JAT, and MITRE to gain their perspective and discuss the lessons learned they identified during the development and implementation of NextGen.

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## Exhibit B. Organizations Visited or Contacted

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### FAA Offices

Air Traffic Organization

Office of Performance Analysis

Systems Operations Services

Office of NextGen

NAS Systems Engineering and Integration Office

Office of the Chief Scientist

Portfolio Management & Technology Development

Systems Analysis & Modeling

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### Other Organizations

Airlines For America

DOT Bureau of Transportation Statistics

Joint Analysis Team

The MITRE Corporation

NextGen Advisory Committee

National Aeronautics and Space Administration

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## Exhibit C. List of Acronyms

ADS-B	Automatic Dependent Surveillance-Broadcast
BTS	Bureau of Transportation Statistics
DataComm	Data Communications
DOT	Department of Transportation
ERAM	En Route Automation Modernization
FAA	Federal Aviation Administration
iTBO	Initial-Trajectory Based Operations
JAT	Joint Analysis Team
JPDO	Joint Planning and Advisory Committee
NAC	NextGen Advisory Committee
NAS	National Airspace System
OIG	Office of Inspector General
OMB	Office of Management and Budget
PBN	Performance-Based Navigation
PVT	Passenger Value of Time
RTCA	Radio Technical Commission Aeronautics
SWAC	System Wide Analysis Capability
TAF	Terminal Area Forecast
TBFM	Time-Based Flow Management
TBM	Time-based management
TFDM	Terminal Flight Data Manager
TSAS	Terminal Sequencing and Spacing

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## Exhibit D. Major Contributors to This Report

NATHAN CUSTER	PROGRAM DIRECTOR
JAYDEEP BORWANKAR	PROGRAM DIRECTOR
JAMES OVELMEN	PROJECT MANAGER
MELISSA PYRON	SENIOR AUDITOR
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MAKESI ORMOND	STATISTICIAN
JERROD SHARPE	SENIOR ECONOMIST
EVAN ROGERS	ECONOMIST

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## Appendix. Agency Comments

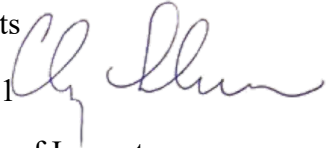


# Federal Aviation Administration

## Memorandum

Date: March 9, 2021

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

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

Subject: Response of the Federal Aviation Administration (FAA) to the Office of Inspector General (OIG) Draft Report: NextGen Benefits Have Not Kept Pace With Initial Projections, but Opportunities Remain to Improve Future Modernization Efforts

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The FAA-led modernization of our nation's air transportation system is one of the most ambitious infrastructure projects in U.S. history. Working with industry and various aviation stakeholders, we have developed long-term National Airspace System (NAS) plans and continue to develop and assess potential new entrants to the NAS.

FAA has reviewed the OIG draft report and has the following comments regarding our approach to benefits. The \$100 billion benefit estimate for NextGen through 2030 represented a detailed modeling analysis conducted in 2017. The result bounds the overall timeframe for realizing the \$100 billion between 2030 and 2035 (pre-COVID-19 pandemic). The FAA estimates of NextGen benefits are segmented into the following three parts:

- **Realized Benefits from Implemented NextGen Capabilities**

Since December 2015, FAA and industry have collaborated, through the Joint Analysis Team (JAT), to achieve consensus on benefits estimates for key NextGen programs<sup>1</sup>. Leveraging JAT methodologies, FAA has completed post-operational analyses of more than 20 capabilities at nearly 200 sites. FAA estimates that NextGen implementations from 2010 through 2019 have accrued \$7.3 billion in benefits to industry and society as follows<sup>2</sup>:

- \$1.3 billion in fuel savings
- \$1.5 billion in other aircraft operating cost savings

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<sup>1</sup> Key NextGen programs include Optimized Profile Descents (OPDs), Wake Re-categorization, Metroplex, Established on RNP (EOR), and Tower Controller Pilot Data Link Communications (CPDLC).

<sup>2</sup> Parts may not sum to total due to rounding.

- \$4.2 billion in passenger travel time savings<sup>3</sup>
- \$0.4 billion in safety.

- **Future Benefits from Implemented NextGen Capabilities**

Implemented NextGen capabilities will continue to contribute to NextGen benefits in future years. To estimate these future benefits in 2017, we extrapolated the detailed post-implementation analyses using standard economic and traffic growth factors. This resulted in a (pre-COVID-19 pandemic) \$21 billion of total benefits from implemented capabilities expected by 2030.

- **Future NextGen Benefits from New Sites and Capabilities**

FAA conducted its first enterprise-level cost-benefit assessment of NextGen in 2012 to confirm that the program provided value to taxpayers and operators and to justify the investment to stakeholders. The analysis, which aimed to capture all expected NextGen costs and benefits, was updated in 2013, 2014, 2016, and finally 2017. By analyzing all NextGen capabilities simultaneously, it ensured proper accounting for program synergies and overlaps<sup>4</sup>.

In early 2020, FAA updated the Future NextGen Benefits estimates by applying a risk factor for slower traffic growth and implementations delays resulting in realization of an expected \$100 billion in the early 2030s. FAA continues to work with industry to build consensus on data, methodologies, and the value of NextGen improvements. The achieved benefits estimated thus far represent a small portion of expected future benefits. As programs continue to capitalize on the deployed NextGen infrastructure, benefits are expected to grow.

Upon review of OIG's draft report, FAA concurs with the recommendations to improve the delivery of NextGen and other future NAS modernization efforts, as written. For recommendations 1 and 3, we plan to complete actions by April 30, 2021. We will implement recommendation 2 by October 31, 2021.

We appreciate this opportunity to offer additional perspective on the OIG draft report. Please contact H. Clayton Foushee at [Clay.Foushee@faa.gov](mailto:Clay.Foushee@faa.gov) if you have any questions or require additional information about these comments.

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<sup>3</sup> Per Department of Transportation (DOT) guidance, FAA values passenger travel time savings when conducting cost-benefit analyses for investment, regulatory, and grant-making purposes.

<sup>4</sup> The latest NextGen business case includes improvements described in The Future of the NAS and in the 2017 NAS Segment Implementation Plan. No new implementations were considered after 2026.

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