August 10, 2020

The Honorable Roger Wicker  
Chairman, Committee on Commerce,  
Science, and Transportation  
United States Senate  
Washington, DC  20510

Dear Chairman Wicker:

As directed in H.R. 302 (P.L. 115-254), the FAA Reauthorization Act of 2018, Section 503, I am pleased to provide you with the Federal Aviation Administration’s Return on Investment for NextGen Program Report for Fiscal Year 2019.

We have sent identical letters to Senator Cantwell, Chairman DeFazio, and Congressman Graves.

If I can be of further assistance, please contact me or the Office of Government and Industry Affairs at (202) 267-3277.

Sincerely,

Steve Dickson  
Administrator

Enclosure
August 10, 2020

The Honorable Maria Cantwell
Ranking Member, Committee on Commerce,
   Science, and Transportation
United States Senate
Washington, DC 20510

Dear Senator Cantwell:

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Administrator

Enclosure
August 10, 2020

The Honorable Peter DeFazio
Chairman, Committee on Transportation
and Infrastructure
House of Representatives
Washington, DC  20515

Dear Chairman DeFazio:

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Enclosure
August 10, 2020

The Honorable Sam Graves
Ranking Member, Committee on Transportation
and Infrastructure
House of Representatives
Washington, DC  20515

Dear Congressman Graves:

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Steve Dickson
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Enclosure
Return on Investment Report

Prepared in response to Section 503 of H.R. 302, the FAA Reauthorization Act of 2018

July 2020
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Executive Summary

The Federal Aviation Administration’s (FAA) Next Generation Air Transportation System, or NextGen, is the comprehensive overhaul of the nation’s airspace system to make flying even safer, more efficient, and more predictable with new technology, innovative procedures, and instantly connected information from departure to arrival.

NextGen is not a single, monolithic program; it is a series of concerted investments in technologies, changes in procedures, and modernized policies. Accordingly, to track the progress of NextGen, Section 503 of H.R. 302, the FAA Reauthorization Act of 2018, requires the preparation of a report on the return on investment (ROI) of each NextGen program. This report presents a summary of the cost-benefit analysis for each NextGen program and a summary of the most recent NextGen priority list that reflects the need for a balance between long-term and near-term user benefits.

Summary of Return on Investment of Major NextGen Programs

This report focuses on the following major acquisition programs within the NextGen Facilities and Equipment budget and primarily draws from the official business case analysis reports produced by each program:

- ADS-B (Automatic Dependent Surveillance – Broadcast), including Surveillance and Broadcast Services (SBS) Future Segments
- AIMM (Aeronautical Information Management Modernization) Segment 2 (S2)
- CSS-Wx (Common Support Services – Weather)
- Data Comm (Data Communications) Segment 1 Phase 1 (S1P1) and Segment 1 Phase 2 (S1P2)
- ERAM (En Route Automation Modernization) System Enhancements and Tech Refresh, Enhancements 2 (EE2), and Sustainment 2
- NWP (NextGen Weather Processor)
- SWIM (System Wide Information Management) Segments 1, 2A, and 2B
- TBFM (Time Based Flow Management) Work Package 2 (WP2) and Enhancement 1
- TFDM (Terminal Flight Data Manager)

These comprise the capital programs that have been funded through the NextGen budget that have achieved successful Final Investment Decisions (and thus have established acquisition baselines) at the time of writing.
Table ES-1 summarizes the return on investment data of each program. This information is extracted from the official business case analysis reports (BCAR) produced by each program as part of their progression through the FAA Acquisition Management System (AMS). No attempt has been made to update these individual studies, which date from as early as 2007, to reflect changes to their underlying assumptions.

### Table ES-1. Summary of ROI Data for Each NextGen Program.

<table>
<thead>
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<th>Program</th>
<th>Calculation Year</th>
<th>Net Present Value ($M)</th>
<th>Benefit/Cost Ratio</th>
<th>Payback Year</th>
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### Summary of NextGen Priority List

The NextGen priority list is drawn from the latest FAA Joint Implementation Plan, which is informed by independent advice and recommendations from the NextGen Advisory Committee (NAC). The current priorities consist of five focus areas:

- Multiple Runway Operations
- Performance Based Navigation
- Surface and Data Sharing
• Data Communications
• Northeast Corridor.

The FAA and industry have identified commitments within each of the focus areas to increase safety; reduce aviation's impact on the environment; enhance controller productivity; and increase predictability, airspace capacity, and efficiency.
1. **Introduction**

The Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration (FAA)-led modernization of our nation's air transportation system. Its goal is to increase the safety, efficiency, capacity, predictability, and resiliency of American aviation. This overhaul brings together innovative technologies, capabilities, and procedures that improve how we fly from departure to arrival.

Airlines, pilots, and air traffic controllers gain better information and tools to help passengers and cargo arrive at their destinations more quickly, while aircraft consume less fuel and produce fewer emissions. This transformation is being achieved through an ongoing rollout of improvements which began in 2007. NextGen remains on target to have all major components in place by 2025.

This report responds to the requirements in Section 503 of H.R. 302, the FAA Reauthorization Act of 2018. Section 503 requires the FAA Administrator submit to Congress a NextGen “Return on Investment Report.” The legislation defines return on investment as, “the cost associated with technologies that are required by law or policy as compared to the financial benefits derived from such technologies by a government or a user of airspace.” The report is to include, for each NextGen program:

- An estimate of the date the program will have a positive return on investment
- An explanation for any delay in the delivery of expected benefits from previously reported estimates on delivery of such benefits, in implementing or utilizing the program
- An estimate of the completion date
- An assessment of the long-term and near-term user benefits of the program for
  - (A) the Federal Government
  - (B) the users of the national airspace system, and
- A description of how the program directly contributes to a safer and more efficient air traffic control system.

Section 503 also stipulates that the Administrator shall develop, in coordination with the NextGen Advisory Committee (NAC), a prioritization of the NextGen programs.

a. **Scope**

NextGen is a wide-ranging endeavor, encompassing new technologies, procedures, and policies, for the FAA and aircraft operators. The FAA’s NextGen budget includes Facilities and Equipment (i.e., capital investment); Operations; and Research, Engineering, and Development components. This report focuses on the following major acquisition programs within the NextGen Facilities and Equipment (F&E) budget:
- ADS-B (Automatic Dependent Surveillance – Broadcast), including Surveillance and Broadcast Services (SBS) Future Segments
- AIMM (Aeronautical Information Management Modernization) Segment 2 (S2)
- CSS-Wx (Common Support Services – Weather)
- Data Comm (Data Communications) Segment 1 Phase 1 (S1P1) and Segment 1 Phase 2 (S1P2)
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- NWP (NextGen Weather Processor)
- SWIM (System Wide Information Management) Segments 1, 2A, and 2B
- TBFM (Time Based Flow Management) Work Package 2 (WP2) and Enhancement 1
- TFDM (Terminal Flight Data Manager)

These comprise the capital programs that have been funded through the NextGen budget that have achieved successful Final Investment Decisions (and thus have established acquisition baselines) at the time of writing.

b. Methodology

The most authoritative source of information regarding the return on investment of NextGen programs are the official business case analysis reports (BCAR) produced by each program as part of their progression through the FAA Acquisition Management System (AMS). Accordingly, this report primarily draws from the BCARs. Each BCAR is rigorously reviewed by the FAA’s Office of Investment Planning and Analysis (IP&A). The data within the BCAR is considered authoritative and forms the basis for acquisition decision milestones such as the Initial Investment Decision (IID) and Final Investment Decision (FID). Where available, for each program we present the investment’s Net Present Value (NPV), Benefit/Cost (B/C) ratio, and the break-even year.

Per the FAA’s Office of Aviation Policy and Plans “Economic Analysis of Investment and Regulatory Decisions—Revised Guide”,¹ NPV is defined as the discounted net present value of a series of outputs and resource inputs using the equation:

\[
NPV = \sum_{t=0}^{k} \frac{(B-C)_t}{(1+r)^t} = \sum_{t=0}^{k} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{k} \frac{C_t}{(1+r)^t}
\]

¹ [https://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/ECONOMIC.pdf](https://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/ECONOMIC.pdf)
where

\[ B_t \text{ and } C_t \text{ are benefits and costs in year } t, \]
\[ r = \text{ the discount rate, and} \]
\[ k = \text{ the total number of periods in the evaluation period of the project.} \]

Using the same terms, the B/C ratio is defined as the present value of benefits divided by costs using the equation:

\[
\frac{\sum_{t=0}^{k} B_t}{\sum_{t=0}^{k} C_t} \frac{1}{(1 + r)^t}
\]

For the NextGen priority list, this report draws from the latest FAA Joint Implementation Plan which is informed by advice from the NextGen Advisory Committee (NAC). The objective of the NAC, a chartered Federal Advisory Committee, is to provide independent advice and recommendations to the FAA and to respond to specific tasks received directly from the FAA. The NAC’s advice, recommendations, and responses to FAA-assigned tasks relate to concepts, requirements, operational capabilities, the associated use of technology, and related considerations to operations that affect the future of the Air Traffic Management System. In addition, the NAC recommends consensus-driven standards for FAA consideration relating to Air Traffic Management System modernization, which the FAA may adopt. The joint plan focuses on delivering tangible implementation benefits across all NextGen focus areas and aligns the agency’s and aviation community’s priorities.

c. Organization

This report is organized into two major sections: the first documents the return on investment information for each major NextGen program, while the second covers the current NextGen priority list.

For each of the major NextGen programs, this report summarizes:

- the technological and procedural innovations that help the program contribute to a safer and more efficient air traffic control system
- how the program provides benefits to the Federal Government and to the users of the National Airspace System (NAS)
- the types of costs associated with implementing the program, and
- the economic analysis of the program, including an estimate of the date the program will achieve a positive return on investment.
The section on the NextGen priority list includes background on how the FAA collaborates with the aviation community through the NAC, the current NextGen priority list including the major focus areas, and how the priority list has been refined and evolved over time.

d. Assumptions and Limitations

This report draws heavily on information and data produced by various FAA entities, such as the individual program offices, dating back to 2007. While each program follows standard FAA guidelines, there may be slight inconsistencies in data sources and assumptions, which arise because the analyses that form the basis of these have been performed by different people at different points in time. No attempt has been made to update the studies cited here.

The references that form the basis for this report were all completed well before the onset of the global pandemic associated with the novel coronavirus. The impact of this pandemic on the aviation industry has been dramatic. For example, domestic commercial passenger operations have declined by almost 65 percent year-over-year, while international operations have declined even more. Such a dramatic decrease in air traffic operations will profoundly affect the cost-benefit calculus of NextGen programs. In particular, projected operator cost savings and safety benefits will be greatly reduced until traffic returns to pre-pandemic levels. FAA implementation costs for these programs may also increase slightly, as program schedules become stretched out.
2. Major NextGen Programs

ADS-B

a. Program Description

Automatic Dependent Surveillance – Broadcast (ADS-B)\(^2\) is an advanced surveillance technology that enables equipped aircraft, or surface vehicles, to broadcast their identification, position, altitude, velocity, and other information. This concept utilizes a position source on the aircraft, which is more accurate than existing radar-based surveillance sources, for broadcasting positional information approximately once per second. This feature provides improved accuracy and more timely information updates than conventional surveillance. The superior positional accuracy, and the ability to provide additional aircraft-derived flight parameters, will result in increased safety and efficiency in the national airspace system (NAS). ADS-B is automatic because no external stimulus is required; it is dependent because it relies on on-board navigation sources and on-board broadcast transmission systems to provide surveillance information to other users. The aircraft or vehicle originating the broadcast may or may not have knowledge of which users (which could be aircraft or ground-based) are receiving its broadcast.

ADS-B technology additionally facilitates the implementation of Traffic Information Service-Broadcast (TIS-B), ADS-B Rebroadcast (ADS-R), and Flight Information Service-Broadcast (FIS-B) to support enhanced situational awareness and other applications. TIS-B service provides traffic information to equipped aircraft and surface vehicles based on the conventional radar returns received for transponder-equipped aircraft. ADS-R provides traffic information to equipped aircraft based on ADS-B transmissions from aircraft on independent datalinks. FIS-B provides weather and NAS Status information to equipped aircraft.

The introduction of Surveillance and Broadcast Services (SBS) into the NAS will improve the safety and efficiency of some well-established operations that are currently supported by radar and other existing surveillance sources and facilitate the introduction of new applications that promise to improve safety and increase capacity. The FAA will use the new surveillance capability to provide Air Traffic Control (ATC) services and more accurate data for Traffic Flow Management (TFM)

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\(^2\) This summary is primarily based on “Business Case Analysis Report for Surveillance and Broadcast Services Program – May 2012” and “Business Case Analysis Report for Surveillance and Broadcast Systems – August 2007”.
services. Users will use the surveillance and broadcast services capability to support flight operations.

**ADS-B Segments 1&2**

The SBS program integrated the existing Capstone system into its baseline and has managed the nationwide expansion of surveillance and broadcast services.

On August 27, 2007 the SBS program, which is responsible for the implementation of ADS-B, TIS-B, and FIS-B, received its final Joint Resources Council (JRC) baseline decision for Segments 1 and 2.

In Segment 1, SBS was baselined to:

- Achieve Initial Operational Capability (IOC) at five key service delivery points
- Integrate ADS-B into four ATC automation systems
- Collect data for the certification of separation standards
- Achieve official operational status in 2010
- Publish a proposed ADS-B final rule that would mandate ADS-B equipage
- Develop an integrated Concept of Operations (CONOPS)
- Award the SBS Service Provider Contract
- Finalize a backup strategy
- Publish the ADS-B “Out” Notice of Proposed Rulemaking
- Maintain and expand the Alaska infrastructure
- Conduct modeling for separation standards development
- Conduct Joint Acceptance Inspection in the Gulf of Mexico
- Perform standards development for ADS-B applications
- Complete separation standards reports for key service delivery points
- Publish the Final ADS-B Rule in the Federal Register.

Segment 2 included:

- Proliferation of aircraft equipage
- Aircraft-to-aircraft application development
- NAS-wide deployment of SBS
- Integration of nine surface surveillance systems with SBS.

**SBS Future Segments FY14-FY20**

The continued investment in SBS future segments from FY14 to FY20 is to accomplish the following:

- Continue provision of baseline services and applications. The SBS program acquired the majority of the services described above through the award of a service provider contract. The on-going subscription fees associated with continuing the capability require sustained F&E funding.
- Expand coverage in the Gulf of Mexico. The SBS baseline surveillance service includes ADS-B coverage for the US portion of the Gulf of Mexico. Adding additional ADS-B radio stations in Mexico will provide coverage over all of
the Gulf of Mexico air traffic routes extending from US airspace into Mexico, thereby allowing reduced separation on both sides of the border and enabling more efficient handoffs between US and Mexican airspace.

- Implement ADS-B In-Trail Procedure (ITP) Application. The FAA chartered the ADS-B In Aviation Rulemaking Committee (ARC) to provide a forum for the US aviation community to define a strategy for incorporating ADS-B In technologies into the NAS. In September of 2011, the ARC produced a report detailing a prioritized set of applications. The most near-term ADS-B In application proposed was the In-Trail Procedure (ITP). The objective of this application is to enable more frequent approval of flight level requests between properly equipped aircraft using a reduced separation standard in Oceanic Airspace, thereby improving flight efficiency and safety.

**SBS Future Segments FY20-FY25**

On May 27, 2019 the JRC made a final investment decision for ADS-B Baseline Services Future Segments for FY20 to FY25. Implementation is intended to be accomplished in three groups:

- **Group 1** - Oversees and manages the contract to ensure continuity of service. Group 1 focus areas include:
  - Subscription Fees
  - Program Management
  - FID Planning for 2025 JRC
  - Service Contract Re-compete
  - Gulf Asset Relocation
  - ADS-B Minimum Operational Performance Standards (MOPS) Changes.

- **Group 2** - Implements system upgrades to preserve baseline services and meet new security requirements. Address obsolescence and field issues. Group 2 focus areas include:
  - Sustainment
  - ADS-B Resiliency Assessment.

- **Group 3** - Improves existing capabilities/services to effectively manage the enforcement of the ADS-B Rule. Group 3 focus areas include:
  - Radar Removal
  - SAPT Enhancements
  - Performance Monitor Enhancements
  - STARS Fusion Phase 3
  - 1090 Spectrum Congestion Mitigation.
b. Benefit Estimates

The SBS benefits were estimated relative to the existing ATC system, with established procedures currently in effect. Historical data were combined with traffic projections to describe the baseline from which benefits could be measured. This reference point was modified, prior to estimating benefits, to reflect any approved future improvements to the baseline that are scheduled during the analysis time period. System effectiveness measures (e.g., a reduction in either accident rates or typical delay times) were applied to the estimated baseline level in order to derive expected benefits. The system effectiveness, the percent of the population equipped, and the percent of infrastructure installed are key drivers in all the benefit estimates. These factors combine to represent the level of benefits that are expected in the future.

The benefits are primarily associated with FAA cost avoidance and enhancements to safety, capacity and efficiency. FAA cost avoidance comes from a divestiture of certain primary and secondary surveillance radars across the NAS, and a reduction in vendor subscription charges due to value added services.

The radar divestiture strategy has evolved over time. The 2007 estimate suggested that approximately 190 secondary surveillance radars (SSRs), or around half, would be removed, and that the others along with primary radars would provide the backup for ADS-B surveillance and fulfill the requirements of the Department of Homeland Security (DHS). The cost avoidance estimate also assumed that 49 Surface Movement Radars (SMRs) from ASDE-X and ASDE-3 sites would eventually be removed.

The 2012 estimate assumed 175 SSRs and 49 SMRs would be removed, and that all en route SSRs and 42 terminal SSRs would be retained for backup.

In 2018, a PMO analysis identified 122 radars that can be removed from the NAS due to redundant coverage:
- 7 Primary Surveillance Radar (PSR) removals
- 65 SSR removals
- 25 full-site radar removals (25 PSR + 25 SSR).

The full-site and primary site removals will be funded by SBS and the SSR removals will be funded by the Spectrum Efficient National Surveillance Radar (SENSR) program. Removal of SMRs will no longer be pursued. It may be possible to remove additional radars if the SENSR program provides sufficient overlapping surveillance coverage.

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The safety benefits include reductions in accidents (e.g., midair collisions, weather-related accidents, runway collisions, Controlled Flight Into Terrain incidents) and improved Search and Rescue and medical evacuation for areas where there is limited surveillance in the current environment. The safety enhancements are associated with air-to-air capabilities, TIS-B/FIS-B services, and expanded surveillance and IFR services, both en route and on the airport surface. The efficiency benefits include reductions in weather deviations, reduced cancellations resulting from increased access to some Alaskan villages during reduced weather conditions, additional controller automation, and additional aircraft-to-aircraft applications. The efficiency benefits translate to savings in both aircraft direct operating costs and passenger travel time.

The historical baselines for the safety benefits were based on a careful review of National Transportation Safety Board (NTSB) aviation accident reports. Appropriate database search methodologies were developed for each accident type for which reductions are expected. The set of accidents identified for each category were compared to ensure that specific incidents were not counted more than once towards the potential benefits. The total historical number of accidents for each accident type was tabulated by category of operation or accident composition and compared with traffic counts over the same time period to estimate accident rates. Existing mandates for certain aircraft classes (such as the Terrain Awareness Warning System) were accounted for prior to estimating the effectiveness of ADS-B capabilities.

The efficiency baseline is primarily defined in terms of flight hours, delay hours, and fuel burn. Flight and delay times were estimated for each user group and by location in order to reflect the baselines associated with each benefit element. Flight and schedule data from the Traffic Flow Management System (TFMS) were combined with weather observations from the National Centers for Environmental Information (NCEI) to generate baselines under differing operating conditions. The FAA Aviation System Performance Metrics (ASPM) database integrates this information and was accessed to generate the baseline metrics needed to accurately portray the potential efficiency benefits. Some of the benefits rely on future schedules produced by the FAA NextGen organization and results from a discrete simulation of the NAS called the System Wide Analysis Capability (SWAC). SWAC is currently used by the NextGen Systems Analysis and Modeling Office to model the combined impact of proposed future NextGen improvements.

### c. Cost Estimates

The cost estimate addresses the acquisition, implementation, operations and maintenance costs for the Surveillance and Broadcast Services Program as well as the costs to the user community. The cost estimate is based on historical actuals, known prime contractor subscription costs, and program office inputs. For
budgetary purposes, the maximum potential cost for performance incentive fees is included, equating to an additional seven percent of the subscription costs.

The estimate is based on the continuation of baseline services to include Subscription Fees, Gulf Asset Relocation, Program Management, Service Contract Re-compete, JRC Planning, Sustainment, Radar Removal, ADS-B MOPS Changes, 1090 Spectrum Congestion, ADS-B Resiliency Assessment, Changes to SAPT, Changes to Performance Monitor, and Fusion Phase 3.

User costs are comprised of the procurement and installation of avionics equipment needed to comply with the airspace rule, which requires ADS-B Out by January 1st, 2020 as well as optional equipment to support FIS-B/TIS-B services and ADS-B In applications. Cost estimates were developed for all user groups (Air Transport, General Aviation and Air Taxi, DOD, and vehicles) based on assumed levels of adoption over time as well as unit cost inputs from avionics vendors and Original Equipment Manufacturers (OEMs).

The Air Carrier & Commuter as well as the General Aviation and Air Taxi cost estimates are comprised of updated inputs for both unit costs and equipage rates. Air Carrier & Commuter costs reflect recent inputs from the OEMs. Recent market data was compiled to refresh the estimate for the General Aviation and Air Taxi community. The DOD cost estimates were based on inputs from the DOD to the original 2007 business case. There are no DOD ADS-B In costs because the original inputs suggested they would not use ADS-B In services or applications. Many DOD aircraft have onboard radar that provide some of the capabilities of ADS-B In.

d. Return on Investment Estimate

Using the results of the benefits analysis and the completed cost estimate, programmatic metrics (i.e., B/C ratio and NPV) were calculated to determine the economic value of the SBS program. The estimates were also adjusted for risk.

Table 1 presents the risk-adjusted results for Segments 1 and 2 across the program lifecycle of FY07 to FY35 as documented in the “SBS BCAR report” dated August 27, 2007.

| Table 1 |
|----------------------|------------------|
| Net Present Value (FY07$M) | $ 552.0 |
| B/C Ratio | 1.1 |
| Payback Year | 2032 |

e. Changes from Previous Estimates

As described in the Program Description section above, the ADS-B program has expanded beyond its initial baseline; accordingly, additional return on investment information has been produced and is reported in this section.
Table 2 presents the risk-adjusted results for SBS Future segments FY14-FY20 from the “SBS BCAR report” dated May 9, 2012.

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Table 3 presents the risk-adjusted results for SBS Future segments FY20-FY25 from “ADS-B Baseline Services Future Segments (BSFS) Final Investment Decision (FY20-FY25)” briefing, dated May 19, 2019.

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AIMM

a. Program Description

The Aeronautical Information Management Modernization (AIMM) Program is designed to provide the Federal Aviation Administration (FAA) and aeronautical information (AI) stakeholders with digital aeronautical data that is authoritative, transformable and secured. To ensure full utilization by stakeholders, AI data needs to be fully integrated (fused) with other domain information including flight and flow, surveillance, and weather to provide a common operational picture of the NAS. The JRC made a Final Investment Decision (FID) for AIMM Segment 2 in August 2014. The program is now in the solution implementation phase. The AIMM Segment 2 (S2) Program meets these needs and is scheduled to be complete in July 2020.

AIMM S2 will deliver a software system developed on modular service-oriented architecture principles. FAA and NAS stakeholders will access integrated AI in multiple formats and customize delivery and visualization. AIMM S2 will support more intelligent use of the NAS through analytics, thereby improving operational efficiency. As a result of the capabilities developed by AIMM S2, an infrastructure will be established for the creation of an "information view" across the entire NAS. AIMM S2 is included in the NAS Enterprise Services Roadmap of the NAS Enterprise Architecture (EA).

AIMM S2 will modernize the ingestion, integration, management, maintenance, and distribution of AI by establishing the Aeronautical Common Services (ACS) and a One-Stop-Shop (OSS) portal. AIMM S2 will become the single trusted access point of AI, for internal and external NAS consumers, moving the FAA from a simple product-centric environment to true AI management. AIMM S2 AI includes Notices to Airmen (NOTAMs), Special Activity Airspace (SAA) definitions, SAA schedules, airport data, and other NAS infrastructure data. AIMM S2 will create a solid foundation for future AIMM segments, delivering greater access, integrity, and extensibility of AI systems to users across the NAS. The AIMM S2 design will leverage the System Wide Information Management (SWIM) investment by using the NAS Enterprise Messaging Service (NEMS) for data collection and AI distribution, thus providing a net-centric enterprise architecture.

AIMM S2 will modernize the NAS Resource (NASR) system by giving it access to the capabilities and services being developed in AIMM S2. This will provide for improved efficiency and operations at the National Flight Data Center and improve the management and integrity of key aeronautical data.

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4 This summary is primarily based on “Final Business Case for Aeronautical Information Management Segment (AIMM S2)”, August 2014.
The AIMM S2 system will not retire or eliminate existing systems. Rather, it will enable more efficient and reliable connectivity with legacy systems while also providing a new avenue for the ingestion of aeronautical data, and access to operationally essential AI.

AIMM S2 will expand access to AI for the Department of Defense (DOD), air traffic control facilities, airlines, general aviation, and other authorized NAS users. The AI will be made available to all users in a standardized digital format using web-service-based, system-to-system interfaces and a single portal human-to-system interface. The AIMM S2 capabilities will improve and provide enhancement to the current processes for consuming AI. Each of the capabilities provided by the AIMM S2 program are designed to permit FAA and NAS stakeholders to consume integrated AI in multiple formats with customized delivery and visualization.

b. Benefit Estimates

The AIMM S2 Program has a portfolio of benefits that are based on the ACS capabilities, and various operational efficiencies derived from upgrading or consolidating current operations within the AIMM Program. The AIMM S2 ACS provides the following capabilities:

- Aeronautical Information Data Analytics (AIDA): A capability enabled by integration of aeronautical data permitting the ability to perform analytics
- Aeronautical Information Query and Subscription Service (AIQS): The ability for consumers to pull or receive pushed (on demand, and/or at requested intervals) aeronautical data
- One-Stop-Shop (OSS) Capability: A single web portal designed to bring AI together from diverse sources in a uniform way
- Spatial Information Mapping (SIM): Ability to display digitalized data in a geo-referenced map view, providing integration and layering of information within a spatial context
- Aeronautical Information Integration (AII): Translation of information from disparate sources into a single consistent format, permitting integration and flexibility of consumption.

The AIMM S2 benefits portfolio consists of:

- Temporary Flight Restriction (TFR) Violation Reduction: TFR notices are currently distributed en masse through disparate dissemination, resulting in occasional input errors and commonly delayed dissemination of data. AIMM S2 Aeronautical Information Subscription Service (AISS) will provide the ability for consumers to pull, or have pushed (at requested intervals), specific TFRs (based on the consumer’s need), providing timely updates of critical data in a consumable format.
• EnRoute Violation Reduction: With the AISS, AI consumers will receive easier to read information directly into smart systems that map the information, and assist pilots with identifying NOTAMs that affect their particular flight.

• Aeronautical Information Management (AIM) Systems Help Desk: AIM Systems Help Desk Benefit consists of the consolidation of the AIM Legacy Help Desks (NAS Aeronautical Information Management Enterprise Systems II Help Desk) with the AIMM Segment 2 Help Desk. The consolidation of the AIM legacy Help Desks with the AIMM Segment 2 Help Desk will result in overall help desk efficiencies.

• Infrastructure Enablement: AIMM S2 benefit provided to all future AIM Segments to leverage key components of the AIMM S2 infrastructure components, reducing the costs of future AIM Segments. In addition, other programs (programs in development over the next ten years) will be able to leverage the AIMM S2 infrastructure.

• Airport Violation Reduction: AIMM S2 will permit consumers of AI (using the ACS) to produce geospatial displays of airport schematics.

• Special Activity Airspace (SAA) Flight Path Savings: The SAA schedules will be made available to NAS users through ACS (via static schedules). The flight path savings will include reduced flight time, flight distance, and fuel usage.

• Better Management of SAA: AIMM S2 Aeronautical Information Data Analytics (AIDA) will enable stakeholders to analyze historical SAA operations. As a result, continuous process improvement opportunities will be identified and realized based on the analysis of SAA usage data.

• Aeronautical Information Safety Enhancements Benefit: AIMM S2 will improve the ability of consumers accessing, viewing, and integrating relevant AI. This will reduce the number of Near Midair Collisions (NMACs) and accidents.

• ACS Subsumption of the NASR: AIMM S2 will modernize the NASR system by giving it access to the capabilities and services being developed in AIMM S2. The ACS will provide the consumer with a single source of information from the Authoritative Source, to include SAA definitions from NASR, and procedures data from NAVLean. This will provide for improved efficiency and operations at the National Flight Data Center and improve the management and integrity of key aeronautical data. The AIMM S2 system will not preempt nor disable any existing legacy systems. It will enable more efficient and reliable connectivity with those legacy systems while also providing a new avenue for the ingestion of aeronautical data, and access to operationally essential AI.

c. Cost Estimates

The AIMM S2 Lifecycle Cost Estimate (LCCE) for FID was developed following the approach summarized below. The LCCE relies on the proposal pricing provided by the vendor (Northrop Grumman), which submitted a technical solution that
combined a mix of COTS/Freeware and custom software to meet the AIMM S2 software release requirements. The program assumed a life-cycle of FY 2014-2035.

The AIMM S2 Life Cycle Cost Estimate was developed using inputs from four primary sources:

Risk-adjusted summary data from contractor: Contractor costs by Contract Line Item (CLIN) were mapped to the FAA WBS using information from the Contract Work Breakdown Structure (CWBS). Contractor phasing of cost was used to ensure alignment with the CWBS. Contractor pricing was risk adjusted using inputs from the cost evaluation team, PMO subject matter experts (SMEs), and both the AIMM S2 Program Team and Investment Planning & Analysis’ (IP&A) experience from previous programs.

Program Management Office staffing study: A detailed study to assess the FAA and support contractor staffing necessary to provide oversight and evaluation during Solution Implementation and In-Service management was conducted by the Investment Analysis support staff. Functional groupings with specific skill sets were defined following the groupings from the Acquisition Workforce Study (Acquisition Workforce Staffing Analysis and Proposed Acquisition Workforce Staffing Model – 2008). A detailed list of activities to be performed by the staff was derived from the Contract Data Requirements Lists (CDRLs) and program reviews required per the Statement of Work (SOW). Hours of effort by skill set (both government and support contractor) were assessed by a team of SMEs with extensive experience supporting acquisition/delivery of numerous similar programs. Hours were converted to average annual FTEs and the appropriate government or contractor labor rate applied. Staffing was assigned the appropriate WBS based on the activity being performed.

Cost estimates for Telco and SWIM: The AIMM S2 Engineering Team worked with Telco and SWIM representatives to determine if the requirements developed for the IID were still relevant. Changes were made to reflect the final selection of the operating locations: Atlanta Air Route Traffic Control Center (ARTCC) for the primary and Salt Lake City ARTCC for the backup. Additionally, it was determined that AIMM S2 would not have to acquire a new NAS Enterprise Messaging Service (NEMS) node. The Communications, Information, and Network Programs (CINP) office provided costs for FY14-FY24. The estimate was extended through FY35 by extending the FY24 value. The expectation is that costs will remain constant or decline; AIMM S2 uses the more conservative value.

FAA Cloud Services: FAA Cloud Services (FCS) costs were provided by the FCS Program Management Office using their Independent Government Cost Estimate (IGCE) as the source of costs. Capacity requirements were taken from the AIMM S2 IID hardware profile and include growth through FY35. Requirements for reliability and back-up (failover and remote back-up) were provided by the AIMM S2 engineering team. The FCS cost estimate covers the period FY19-FY24. FY24 costs
were reduced by 20 percent beginning in FY25 and extended through FY35 based on the recommendation of the FCS staff.

General: Contractor labor rates are used to assess the labor hours. Rates from other CLINS were used to derive rates for Fixed Price CLINs. Government rates follow the guidance in Economic Information for Investment Analysis (EIIA) (April 2013). PMO support contractor rates are based on actuals from other FAA programs.

Inflation rates are from Economic Information for Investment Analysis (EIIA) (May 2014).

d. Return on Investment Estimate

The AIMM S2 Program Management Office conducted an economic analysis on the time-phased, economically adjusted costs and benefits. The economic analysis compared discounted risk-adjusted costs and discounted risk-adjusted benefits to determine the investment’s benefit/cost (BC) ratio to summarize the overall value for money for the AIMM S2 Program. The economic analysis followed the guidelines of OMB Circular A–94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs (Revised) (October 29, 1992), as well as the standards defined by the Office of Investment Planning and Analysis (IP&A).

The economic analyses present the value of cost and benefits over the life of the program. Per FAA Office of Investment Planning and Analysis guidance, the costs reflect an 80th percentile confidence level, indicating that there is an 80 percent chance that actual costs will be below the estimated costs. The benefits reflect the 20th percentile confidence level, indicating that there is an 80 percent chance that actual benefits will be greater than the estimated benefits.

The NPV indicates an investment’s net value in today’s dollars. The investment time period is FY2014 - FY2035. The first year with a positive cumulative discounted cash flow is 2027.

Table 4 summarizes the AIMM S2 economic analysis results.

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<td>Net Present Value (FY14$M)</td>
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<td>B/C Ratio</td>
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<td>Payback Year</td>
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e. Changes from Previous Estimates

FAA Security review of AIMM S2 Release 2 identified security threats and resulted in a change to the AIMM S2 architecture. The AIMM S2 program has experienced performance issues with the prime vendor in the development of the third release resulting in delays to testing and development. Additionally, the 35-day break in non-essential operations resulted in the loss of the prime vendor’s primary
development and test personnel adding an additional 7 months to the schedule completion.
CSS-Wx

a. Program Description

Two weather programs were established to accomplish NextGen goals: Common Support Services – Weather (CSS-Wx), formerly known as NextGen Network Enabled Weather (NNEW); and Weather Forecast Improvements-NextGen Weather Processor (NWP). The CSS-Wx Program covers the improvements needed to enable universal access to weather information specific to user needs, while the NWP Program covers the improvements in weather information quality.

The CSS-Wx System will be the single publisher of aviation weather information via System Wide Information Management (SWIM) to all FAA users. It will publish improved weather products from the NWP and the National Oceanic and Atmospheric Administration (NOAA) using the Open Geospatial Consortium (OGC) standards and extensions, as well as other weather sources. The CSS-Wx System will provide filtering and extraction of weather information by user-specified criteria, as well as mapping/projection, formatting, unit conversion, and product quantization. It will provide storage, archiving and retrieval of weather products. It will support FAA end user systems such as Traffic Flow Management System (TFMS), Time Based Flow Management (TBFM), and En Route Automation Modernization (ERAM).

The CSS-Wx System will have the following high level capabilities:

- Filter weather information geospatially and temporally to provide only the specific data requested by a user (e.g., along a flight path);
- Provide weather information via Web Coverage Service (WCS), Web Feature Service (WFS), and Web Map Service (WMS);
- Perform weather data management;
- Standardize weather information in common formats identified by the OGC;
- Store, archive, and retrieve weather information; and
- Manage discovery of information in real time.

The CSS-Wx System will publish improved weather products provided by NWP, NOAA, and other weather sources to FAA and National Airspace System (NAS) users for input into collaborative decision making. Consumers of CSS-Wx information will include air traffic, commercial aviation, general aviation, and the flying public. CSS-Wx will make weather information available for NextGen’s enhanced decision support tools. Other consumers will include the Department of Defense, the Department of Homeland Security, and NOAA.

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5 This summary is primarily based on “Final Business Case for Common Support Services – Weather, Version 1.2”, September 2014.
b. Benefit Estimates

The CSS-Wx System will provide network-enabled weather information services that will improve weather access capabilities and facilitate integration of weather information into Air Traffic Management (ATM) Decision-Support Tool (DST). It will define, develop, and provide capabilities for universal access to weather information from multiple government and industry sources in a SWIM-compatible network. It will define common standards for weather services and weather data formats and provide the capability for the extraction of weather information by user-specified criteria.

These enhanced capabilities will produce more efficient management of weather information through:

- Discovery, caching, advanced filtering, and compression;
- Reducing development costs for tools requiring weather data through the development of global and open standards;
- Improving safety by reducing the number of encounters with weather hazards through greater situational awareness; and
- Aiding in reducing weather impact in the NAS.

The benefits analysis focused on the following benefit categories:

- Reduced future infrastructure costs to support forecast data bandwidth needs;
- Reduced costs to develop future custom weather interfaces;
- Improved operational ATM decision-making from enhanced access to weather products;
- Increased weather access leading to reduced accidents; and
- Legacy system cost avoidance.

The CSS-Wx Program’s Final Investment benefits analysis utilized a separate approach to estimate each benefit area. There are several benefits categorized into three main elements: cost avoidance, flight efficiency, and safety. The cost avoidance benefits are monetized based on the estimated future costs to the FAA that can be avoided if the CSS-Wx System is implemented. The flight efficiency benefits are quantified in terms of fuel savings and/or delays (airborne, ground, gate) and monetized using values for fuel cost, Aircraft Direct Operating Cost (ADOC), and Passenger Value of Time (PVT). The safety benefits are quantified in terms of projected accidents and monetized using values for avoided fatalities, injuries, and aircraft damage. All benefit metrics were risk-adjusted in coordination with the Office of Investment Planning and Analysis (IP&A) to account for a wide range of uncertainties in data, approach, and models used.

c. Cost Estimates

The CSS-Wx life-cycle costs were estimated starting in year FY 2014 and ending in FY 2040. The FAA standard WBS, version 5.1, was used to model the costs. Each WBS
element within the cost estimates was estimated in Base-Year 2014 dollars, time-phased, and inflated using the latest Office of Management & Budget (OMB) inflation indices to calculate the Then-Year point estimate. Risk analysis was then performed to calculate the High-Confidence Life-Cycle Cost (HCLCC) estimate for the Legacy Case and the new system.

A variety of estimating methodologies were used to derive point estimates for the system. The following paragraphs summarize the various techniques and data sources used to estimate the cost elements and calculate the high-confidence life cycle estimate.

The CSS-Wx system consists of a Facilities and Equipment (F&E) and an Operations and Maintenance (O&M) component. These costs include the costs of materials and Contractor/ Federal labor required to develop, test, and support the CSS-Wx system. The F&E component breaks down FAA labor as its own cost element, with the rest consisting of contractor labor and materials costs. The support contractor labor rate was based on the analogous FAA Program Office labor costs. Federal salaries were based on the government service schedule for estimating purposes and adjusted by the standard benefits factor. Risk analysis was performed to calculate the High-Confidence Life-Cycle Cost estimate for the two cases.

Cost inputs for non-prime contractor costs were provided by other organizations within the FAA. Level of effort inputs for Testing and Second Level Engineering activities were provided by persons within the appropriate departments within the FAA’s Technical Center. Initial and recurring telecommunication costs were provided by the Future Telecommunications Infrastructure (FTI) program. Implementation costs for the system were based on input from Engineering Services (ES) and implementation Subject Matter Experts (SMEs). Logistics support costs (Federal and Support Contractor) were provided by Logistic subject matter experts.

In regard to the maintenance of the system, it is important to note that a contractor will provide software/hardware maintenance support not only through full deployment of the system, but also for the remainder of the lifecycle. The FAA’s Second Level Organization role is that of oversight and support in regard to software maintenance. The FAA’s TechOps will oversee the maintenance of the associated hardware.

The CSS-Wx Prime Contractor costs for the solution were based on the successful offering of the CSS-Wx competitive procurement. These costs were provided by the vendor in twenty independent Contract Line Item Numbers (CLINs). These costs were then mapped into the appropriate CSS-Wx WBS elements for F&E and Operations and Support (O&S) costs. Prime Contractor activities will include Hardware Procurement, Software Development, Testing, Implementation, and In-Service maintenance (Corrective Maintenance, Logistics and 2nd Level Engineering).

The costs associated with the winning vendor’s bids were much lower than the IGCE. The reason for this difference is that the IGCE assumed the vendor would have a far
greater amount of software development and testing to perform. However, the selected proposal is leveraging a significant amount of previous work and a large amount of commercial-off-the-shelf items.

d. Return on Investment Estimate

Using the results of the benefits analysis and the completed cost estimate, programmatic metrics were calculated to determine the financial returns for the CSS-Wx System investment. The business case lifecycle is from 2014 to 2040.

The economic analysis compares the incremental cost to the incremental benefit. The incremental cost includes the development, operation, and support of the CSS-Wx System. The incremental benefit includes the legacy cost avoidance as well as the other quantified benefit categories.

The cost and benefit values represent a “high confidence” estimate from an underlying distribution of possible cost and benefit outcomes. In order to obtain similarly “high-confidence” economic analysis metrics, the full distributions of costs and benefits were statistically combined using a Monte Carlo simulation. These statistically combined results are presented in Table 5 below. The statistical combination of the cost and benefit distributions results in a different NPV and benefit-cost (B/C) ratio than would result from simply subtracting the “high-confidence” risk-adjusted present value costs from the risk-adjusted present value benefits or from taking the ratio of the two values.

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<td>Payback Year</td>
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e. Changes from Previous Estimates

The CSS-Wx Program is undergoing a re-plan due to a delay in the implementation associated with factors which include not completing software development. As part of the re-plan, the program is determining cost and schedule impacts.
Data Comm

a. Program Description

Data Comm\(^6\) provides data communications services between pilots and air traffic controllers. Data Comm provides a direct link between ground automation and flight deck avionics for safety-of-flight ATC clearances, instructions, traffic flow management, flight crew requests and reports. Data Comm is critical to the success of NextGen operations, enabling efficiencies that are not possible using the current voice-based system.

These improvements to the NAS are delivered by Data Comm in two segments. Segment 1 delivers the initial set of data communications services integrated with automation support tools, which provide NAS benefits and lay the foundation for a data-driven NAS. Segment 1 is divided into two phases: Segment 1 Phase 1 (S1P1) implements departure clearance services in the air traffic control tower (baselined in May 2012), and Segment 1 Phase 2 (S1P2) addresses the En Route deployment of Data Comm. S1P2 includes En Route Initial Services (baselined October 2014) and En Route Full Services (baselined in August 2016).

The Data Comm program office achieved a positive initial investment decision (IID) in July 2008 which allowed final investment activities to begin, and the program office received an authorization to proceed with development of some key portions of Segment 1 services in November 2010. Data Comm is being deployed through a phased deployment approach that began with providing the Revised Departure Clearance service at 55 airports.

This phase was deployed in 2015-2016, 29 months ahead of schedule. The JRC approved deployment to an additional seven airports in February 2017 using program underrun funds. The deployment to these seven additional airports was completed in 2017-2018, 13 months ahead of the original baseline schedule for the 55 airports.

S1P1 required software enhancements to the existing Tower Data Link Services (TDLS) and En Route Automation Modernization (ERAM) platforms, as well as development of the Data Comm network infrastructure. The benefits of Tower Data Comm Services to the user and the flying public include a reduction in gate and taxi departure times, communication times between pilot and controllers, readback/hearback errors, and environmental emissions. The reduced communications time is reducing overall delays in the NAS and is allowing for more efficient use of available capacity. In addition, Data Comm Tower Services are

\(^6\) This summary is primarily based on “Business Case Analysis Report for Data Communications Segment 1 Services” and “Final Business Case for Data Communications En Route Services (Segment 1, Phase 2)”
supporting a more rapid recovery from adverse weather events, which are reducing delays and enhancing overall predictability in the NAS.

S1P2 En Route Initial Services focuses on delivering additional services in the en route domain. S1P2 En Route Initial Services is scheduled to deploy 2019-2021. S1P2 En Route Full Services will implement additional capabilities in the en route domain, such as holding instructions and advisory messages, and is scheduled for deployment in 2022-2023.

The major elements of the S1P2 implementation are:

- ERAM enhancements to establish Controller-Pilot Data Link Communications (CPDLC) capability in the En Route domain
- TDLS software enhancements to provide additional services to tower controllers
- Data Comm Network Service (DCNS) expanded coverage and capacity
- FAA Telecommunications Infrastructure (FTI)
- Future Air Navigation System (FANS) 1/A avionics.

S1P2 En Route Initial Services achieved a successful Final Investment Decision (FID) in October 2014 and is currently in implementation. S1P2 En Route Full Services will leverage the existing infrastructure and equipage to deliver additional services in the En Route domain. S1P2 En Route Full Services achieved a successful FID in August 2016, and is scheduled to be deployed in 2022-2023.

Segment 2 will further build upon the Departure Clearance and En Route services by enabling the transfer of complex clearances and more advanced NextGen operations that are not possible using voice communications, such as four-dimensional trajectories, optimized profile descents, and advanced flight interval management.

Data Communications services require operators to have applicable avionics installed and enabled on their aircraft. The S1P1 Tower Services and the S1P2 Initial and Full En Route services will all utilize the currently available FANS 1/A standard via Very High Frequency (VHF) Data Link – Mode 2 (VDL-2). Data Communications will support Baseline 2 avionics in Segment 2.

b. Benefit Estimates

Data Comm transforms communication between the ground and the cockpit, providing services which enhance the efficiency of the NAS by enhancing airspace throughput and shortening flight times. The program enables controllers to send text-based air traffic messages, and enables flight crews to acknowledge and accept those messages with the push of a button, resulting in:

- Improved controller and flight crew efficiency as a result of automated information exchange
- Improved rerouting capabilities
- Delivery of more efficient routes for aircraft
• Decreased congestion on voice channels and provision of an alternative communications capability
• Improved NAS capacity and reduced delays associated with congestion and weather
• Improved communication accuracy and safety with digital communication (i.e., reduced read/hear back errors, reduced loss of communications events)
• Reduced environmental impact due to decreased fuel burn and emissions
• Direct operating cost savings from increased throughput realized through reduced delays and improved communications.

S1P1 Data Comm Tower Services have been readily adopted by the operators, with 13 domestic mainline air carriers, 54 international air carriers, and over 1,900 business jet and general aviation users utilizing Data Comm Tower Services across 67 different aircraft types.

In August 2019, Data Comm S1P1 Tower Services crossed over 61,000 operations per week, which is a 2,276 percent increase in operations over the past three years. As of July 2019, Data Comm S1P1 Tower Services has cleared over six million flights (over 829 million passengers) resulting in:
• Over 1.0 million minutes of reduced delay
• Over 1.6 million minutes of communication time saved
• Over 8.9 million kilograms of carbon dioxide emissions prevented
• Over 94,100 readback errors prevented.

S1P2 Data Comm En Route Initial Services are in the early stages of field implementation and currently are available in the Indianapolis and Kansas City Air Routes Traffic Control Centers (ARTCC). So far, S1P2 En Route Initial Services has been utilized by 40 operators across 46 different aircraft types, resulting in:
• Over 20,600 minutes of communication time saved
• Over 5,400 read back errors prevented.

**Segment 1 Phase 1**

The primary benefits measure for this analysis was air traffic delay reduction (gate, ground, and airborne). Convective weather impact reduction benefits were examined as well.

In order to evaluate the benefits of Data Comm S1P1, specific measures were derived to capture and quantify the impact of the operational effects. The documented controller productivity efficiencies were determined to produce increased system capacity, which would yield benefits best measured in terms of delay reduction (gate, ground, and airborne).

Delay reduction results from an increase in controller communication efficiency enabled by Data Comm functionality. The controller can use this additional time to
work more traffic and/or provide better service to airspace users, thus reducing delays.

In addition to the benefits described above, data communications also provides a safety benefit due to:

- Reduced number of readback/hearback errors
- Fewer stepped-on communications
- Enduring information on clearances at both the controller position and the cockpit, decreasing misunderstanding
- An alternate communication path when pilot is on the wrong frequency, there is a stuck microphone, or a radio is inoperative.

The full impact of these safety enhancements is hard to monetize, but the impact of data communications on operational errors was examined explicitly to provide quantification of a portion of these benefits.

All benefit analyses are documented in the Benefits Basis of Estimate (BOE) and in other Data Comm benefits documents and briefings.

**Segment 1 Phase 2**

With S1P2, Data Comm's service offerings expand into the En Route environment, modernizing the way controllers communicate with aircraft. The foundation of this transformation is the shift from an analog, voice-based communication platform to a data-driven approach that supports improvements for maintaining situational awareness. Using Data Comm, controller teams can leverage one-to-many communications and fully use the radar associate and tracker positions during periods of high volume or adverse weather. Furthermore, En Route Initial Services reduce communication time for routine and repetitive communications, allowing time to handle additional aircraft and provide advanced services. The airborne reroute and direct-to-fix message sets provided with S1P2 also improve the efficiency with which aircraft route around weather and congestion. With the improved fidelity of reroutes transmitted over Data Comm, controllers can respond more quickly and provide personalized reroutes that accommodate operator preferences better than current capabilities allow.

As performance-based navigation, advanced traffic management concepts, and time-based flow management continue to improve the NAS, Data Comm becomes even more vital. Airborne reroute and direct-to-fix message sets further improve controller flexibility to provide advanced services and more optimal routing. Frequency congestion and controller workload is further reduced through the use of Data Comm for additional routine and repetitive messages, such as advisory messages and holding instructions. In addition to the direct benefits of Data Comm and the portfolio impacts on other NextGen programs, Data Comm is a game-changer that provides the NAS with a whole new platform for innovation. The advent of a capability to uplink perfectly accurate instructions directly into an aircraft’s flight management system (FMS) will transform air traffic management.
The S1P2 benefits metrics were initially validated and accepted by the JRC at the S1P1 FID in 2012 as part of the larger Data Comm business case. The benefits for En Route Services were refined and presented again as part of the S1P2 FID for En Route Initial Services in 2014, and again in 2016 at the FID for En Route Full Services. At each decision point, the JRC concluded that, in order to realize full benefits of Data Comm, both the Tower and En Route phases of the program need to be implemented.

The Data Comm En Route Services benefit estimates have been updated to support a subsequent FID for a baseline of funding for Full Services. All benefit metrics were risk-adjusted in coordination with FAA’s Investment Planning & Analysis (IP&A) operations research group to account for a wide range of uncertainties in data, approach and models used. The Benefits BOE provides additional details on the methodologies for each analysis.

For the Full Services benefits update, key services were monetized, but many of the benefits were described qualitatively and supported with data on the frequency of occurrence, duration, and the safety impact.

c. Cost Estimates

Data Comm cost estimation covers all of Segment 1 - S1P1 Tower and S1P2 for all En Route activities, both Initial Services and Full Services. The life cycle cost estimates encompass design, development, test, training, and implementation of Data Comm services. Costs are grouped into the following system and functional areas:

Segment 1 Phase 1

- ERAM Enhancements – Includes protocol gateway (PGW) and "Log on" development, implementation, and operations and maintenance
- TDLS Enhancements – Includes departure clearance (DCL) development, implementation, and operations and maintenance
- Data Comm Integrated Services (DCIS) – Includes Data Comm Network Services (DCNS), end-to-end systems integration and engineering (I&E) support, and avionics equipage
- FAA Telecommunications Infrastructure (FTI) – Includes the necessary infrastructure for interfacility terrestrial communications
- FANS 1/A Avionics – includes the capabilities in the aircraft to support Data Comm services in the cockpit
- Systems Engineering and Program Management (SEPM) – Includes all program office aspects of planning activities (program management, systems engineering, acquisition planning and management, business and financial management)
- Test, Training, and Implementation – Includes all non-prime contractor requirements for system test and evaluation, site implementation, acceptance and training. Air Traffic user training is included here as well.
Segment 1 Phase 2

- ERAM Enhancements – modifications to the ERAM system required to deliver National Single Data Authority (NSDA) functionality, En Route Initial Services and En Route Full Services
- TDLS Enhancements – TDLS modifications required to deliver NSDA functionality as part of the Initial Services scope
- DCIS/DCNS – DCIS, including integration, engineering, and test support, and DCNS, including VDL Mode 2 air-to-ground network coverage of En Route airspace
- FAA Telecommunications Infrastructure (FTI) – Includes the necessary infrastructure for interfacility terrestrial communications
- FANS 1/A Avionics – includes the capabilities in the aircraft to support Data Comm services in the cockpit
- System Engineering and Program Management – Includes all program office aspects of planning and support activities (e.g., program management, contract management, outreach, flight standards, security, safety engineering)
- Test, Training, and Implementation – Includes all non-prime contractor requirements for system test and evaluation, site implementation, acceptance and training. Air Traffic user training is included here as well.

The following general ground rules and assumptions were applied across cost categories and are not specific to one cost area:

- Inflation: 2015 OMB inflation indices are used for all costs except for the ERAM prime vendor costs. For the ERAM prime vendor, escalation is applied based on trends in their Forward Pricing Rates combined with assumptions about shifts in labor mix as the program is executed.
- Risk Adjustment: Risk adjustment is conducted via Monte Carlo simulation using @RISK and assigning triangular distributions for all cost elements.
- Acquisition: ERAM services will be provided via contract modification to the existing ERAM contract with Lockheed Martin. The DCIS acquisition involves ordering services based on the previously negotiated DCIS contract with Harris Corporation. TDLS enhancements (for Initial Services only) will be conducted by the Interfacility Communications Engineering Team (IFCET).

All cost estimates have been prepared by FAA personnel and support staff. Cost and pricing information contained in prior vendor proposals for prior Data Comm phases, as well as information from past contract negotiations and historical vendor performance, were used in development of the estimates. Estimates were updated in May 2016 due to changes in the S1P2 En Route Full Services scope necessitated by changes in program funding levels.
d. Return on Investment Estimate

**Segment 1 Phase 1**

Table 6 shows the results of the economic analysis of S1P1, both with and without passenger time savings benefits included.

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**Segment 1 Phase 2**

The programmatic metrics were updated with the results of the Full Services benefit, cost, and schedule analysis to revise the economic metrics for Data Comm S1P2 for each equipage scenario.

Table 7 shows the results of the economic analysis of S1P2, both with and without passenger time savings benefits included.

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ERAM

a. Program Description

En Route Automation Modernization (ERAM) is the en route automation system and the foundation of the FAA ATC environment. In concert with other programs, ERAM replaced aging NAS equipment and modernized the en route infrastructure to provide an open standards-based system that will be the basis for future capabilities and enhancements. ERAM serves as the platform through which air traffic control services evolve from legacy technology, procedures, and policy to NextGen. ERAM is a secure, modular, and expandable system that is information technology standards-based and International Civil Aviation Organization (ICAO)-compliant.

The ERAM system ingests, processes, coordinates, distributes, and tracks information on en route aircraft movement throughout the domestic and international airspace. ERAM provides automation services for the en route domain at the 20 Continental United States (CONUS) ARTCCs. ERAM support, test and training capabilities are provided at each ARTCC, as well as at the William J. Hughes Technical Center (WJHTC) and the Mike Monroney Aeronautical Center (FAA Academy). National support services, en route air traffic system maintenance and system deployment test and verification functions for ERAM reside at the WJHTC. The FAA Academy provides training services for Technical Operations and Air Traffic personnel.

The initial investment in the baseline ERAM system funded deployment to all 20 ARTCCs within the continental United States, which was completed in Fiscal Year (FY) 2015. By 2016, ERAM included the baseline functionality plus en route support for:

- Airborne and Pre Departure Traffic Flow Management (TFM) reroutes initiatives
- Air-To-Ground Tower Controller Pilot Datalink Communications (CPDLC) initiatives
- Timed-Based Flow Management (TBFM) enhancements including Ground-Based Interval Management – Spacing (GIM-S) initiatives

To accommodate NAS-wide changes described by the NextGen Implementation Plan (NGIP), the hardware and software systems that make up the ERAM platform need to periodically be upgraded and refreshed.7

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7 This summary is primarily based on “Business Case Analysis Report for to En Route Automation Modernization System Enhancement and Technical Refreshment – September 2013”, “Final Business Case for En Route Automation Modernization (ERAM) Sector Enhancements (SecE Segment 1) Segment 1 – November 2016” and “Final Business Case Analysis Report for ERAM Technology Refresh 2 – November 2016”.
ERAM System Enhancements and Technical Refreshment (SE&TR)

ERAM System Enhancements consisted of capabilities above and beyond core ERAM functionality. The enhancements addressed the needs identified by users of ERAM and FAA stakeholders after ERAM was deployed and became fully operational in 2015.

System Enhancements consist of the following:
- Test and Training System (TTS) improvements;
- Controller usability enhancements;
- Tracking and correlation processing enhancements; and
- Improvement of overall system management, analysis and monitor and control functions.

The Technology Refresh portion of the ERAM SE&TR program was necessary because many of the ERAM components, which were procured in 2006, were at end-of-life and required replacement.

The Initial Technology Refresh under this segment consisted of the following:
- AIX Operating System Version Update;
- En Route Communications Gateway (ECG) Router Firewall replacement;
- En Route Information Display (ERIDS) Hardware replacement;
- Support Environment Operating System replacement.

SE&TR were the first Post ORD enhancements and tech refresh for the original ERAM software and hardware deployment. They are commonly referred to as EE1 and TR1.

A complete business case analysis was not performed for SE&TR, as it largely addressed sustainment items of the ERAM platform. Thus benefits and return on investment were not estimated. A thorough cost analysis was performed. SE&TR received Final Investment Decision for ERAM System Enhancements and Technology Refreshment in September 2013 and completed in September 2017.

ERAM Enhancements 2 (EE2)

The ERAM Enhancements 2 (EE2) investment addresses the following deficiencies:
- Unacceptable levels of missed and false alerts from tactical and strategic conflict probe alerting functions. A series of improvements to reduce false alerts have been identified.
- Aircraft trajectory modeling inefficiencies result in trajectories that are not accurate enough to support NextGen PBN initiatives. This is limiting the use of Optimized Profile Descents and will restrict the agency’s ability to make use of future PBN investments such as Interval Management, Dynamic RNP, and others.

8 ERAM SecE Segment 1 is now referred to as ERAM Enhancements 2.
The manual process of amending the ICAO code information is cumbersome and can be work intensive for controllers. Amended ICAO code information is not being adequately maintained or entered into ERAM, creating problems of loss of Reduced Vertical Separation Minima (RVSM) / Non-RVSM and PBN (RNAV1, 2, 3 and RNP1) routing capability.

- Lack of ERAM automation support for coordination and exchange of flight data and track control with international Air Navigation Service Provider (ANSP) is limited, adding workload burden on controllers and increasing the likelihood for human error. International Common Harmonization expands the automated coordination of flight data and aircraft control with the Canadian Air Navigation Service Provider (Nav Canada).

- ERAM periodic local adaptation changes are embedded within the national releases, leading to significant delays to the implementation of local changes.

- Lack of UAS aircraft performance characteristics in ERAM result in trajectory modeling errors ultimately increasing workload, adversely impacting situational awareness, and degrading predictability in operations.

- Increasing the information available to the National ERAM Technical Operations Team will improve their ability to diagnose and address ERAM software and hardware problems in a timely and efficient manner.

- The current automation capabilities lack the requisite accuracy, consistency, and usability needed during high demand situations for the efficient use of airspace. As air traffic levels and the need to allow more fuel efficient flight profiles increase, the Air Traffic Controllers' ability to maintain safe aircraft separation becomes a limiting factor, often resulting in the establishment of traffic restrictions that yield sub-optimal airspace capacity utilization. The need to provide new and enhanced automation assistance in the NAS to enable Air Traffic Control personnel to handle traffic growth without increasing restrictions, delays, and controller workload becomes critical.

These deficiencies affect the quality of the information available to the controllers as well as the safety and efficiency of the operational services.

**ERAM Sustainment 2 (ES2)**

The ERAM Sustainment 2 (ES2), scheduled for Calendar Year (CY) 2018, addresses high priority ERAM sustainment issues. Namely, it addresses key sustainment risks that stem from the current critical ERAM display subsystem equipment end-of-service life and technology obsolescence, as well as backroom flight data processing capacity limitations.

ES2 includes the following key system updates:

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9 ERAM TR2 is now referred to as ERAM Sustainment 2.
• Replace IBM Power PC/RISC processors that drive ERAM displays with new x86-based processors
• Replace existing analog Barco radar position flat-panel monitors and graphical processing units (GPUs) with digital displays and video graphics cards
• Refresh Keyboard/Video/Mouse (KVM) switch to support transition to digital display
• Migrate AIX Operating System (OS) to Linux
• Add supplemental servers to augment Flight Data Processing (FDP) and Surveillance Data processor core.

Within the 20 ARTCCs, the Display System (DS) subsystem function provides the interface with other ERAM subsystems and provides a consistent and accurate picture of local and surrounding airspace with respect to aircraft traffic, weather conditions, and airspace characteristics. Each ARTCC breaks its blocks of airspace down into smaller sectors. Controllers use Radar (R-Position) and Data (D-Position) to control traffic in sectors.

The (R) and (D) Positions at ARTCCs are currently powered by IBM Power PC/RISC processors. IBM no longer manufactures the RISC processor, so these particular parts will have to be upgraded as supply stocks eventually run out. Compounding this end-of-life issue is the observed exponential increase in failure rates for the backplane spare. This in turn could affect the continuity of ATC operations because (R) and (D)-Position would no longer display information, interfering with the most basic aircraft separation function of ATC.

A replacement of IBM-based processors with new Hewlett Packard Enterprise (HPE) Proliant Modular Line (ML-30) processors, that have projected long-term supply availability, was required. Other peripherals (KVM accessories, record/playback technology) will also be upgraded as part of the processor swap in support of the transition from an analog to digital display.

Additionally, the Barco high resolution GPUs that are critical to the display of air traffic information on the controllers’ situation display are no longer produced or supported by the vendor as of August 2016. The 20” x 20” BARCO analog monitor will be replaced with the E210 43” Ultra High Definition (UHD) monitors.

Finally, the backroom processors are facing a capacity shortfall. As new data sources are ingested by ERAM as part of the NextGen updates, additional backroom processing capacity will be required. An additional argument for including these in this Tech Refresh is provided by the recent observed increase in failures in the field.

A complete business case analysis was not performed for ES2, as it only addressed sustainment items of the ERAM platform. Thus benefits and return on investment were not estimated. A thorough cost analysis was performed.
b. Benefit Estimates

**ERAM Enhancements 2 (EE2)**

The benefits of ERAM Enhancements 2 are broken up by the six capability areas:

1. Trajectory Modeling and Conflict Probe Enhancements
2. Flight Plan Processing improvements
3. International Common Harmonization (with NAV Canada)
4. Adaptation Refinement
5. Incorporation of UAS Operational Performance
6. Continued support of Technical Operations Problem Trouble Reports (PTR)

Each capability is broken up into several sub-capabilities; for the most part the benefits at the lower level were not addressable due to significant overlap and dependencies. This includes significant and complex software changes and procedures. These changes were proposed and recommended as beneficial to the ERAM users (controllers, trainers), FAA HQ, and international ANSP partners.

**Ground Rules and Assumptions**

1. Most benefits will accrue starting with the final year of implementation in 2024, with ANSP (Nav Canada only) harmonization providing initial benefits in 2022
2. Life-cycle benefits are from FY24 to FY33, with 10 full years after final IOC (mid-FY23)
3. All ADOC, PVT, Inflation, and other economic factors are applied based on the August 2015 factors provided by IP&A
4. Traffic forecasts are provided by the FAA Policy Office (APO) Terminal Area Forecast (TAF) and AJR-G1 (detailed schedules)
5. Risk adjustment of the future traffic demand is done based on IP&A guidance using a triangular distribution on demand growth (0, 50, and 100 percent) applied to the TAF.

c. Cost Estimates

**ERAM SE&TR**

Program life-cycle costs for ERAM System Enhancements and Tech Refresh were estimated from FY14 to FY17. The last funding year for the SETR program was Fiscal Year 2016 and implementation completed in 2017. The FAA standard Work Breakdown Structure (WBS), version 5.0 is utilized to model these costs. Costs for each WBS element were estimated using Base Year 2013 (BY13) dollars, then time phased and inflated using the latest OMB inflation indices to calculate the Then Year (TY) point estimate. The Life-Cycle Cost estimate was then risk adjusted with an 80 percent Confidence Level.
Only F&E costs are included in the SETR estimate. The existing O&M baseline funds are expected to cover the maintenance of the ERAM program, hence there are incremental O&M costs to the existing ERAM O&M baseline throughout the operational life cycle.

A variety of estimating methodologies were used to derive the point estimate. The following paragraphs summarize the various techniques and data sources used to estimate the cost elements and calculate the life cycle estimate:

**Hardware** – The ERAM System Enhancement and Tech Refresh hardware estimate was based on a component buildup from the vendor. The hardware components consist of: (1) AIX Operating Systems Upgrade, (2) ECG Router Firewall, and (3) ERIDS Hardware & non repairable components. The prime developer proposed several hardware options to the FAA, and an Independent Government Cost Estimate (IGCE) was developed based on those options. The Program conducted proposal solicitation, evaluation, negotiation, and contract award, and followed all Acquisition Management System processes to ensure procurement integrity.

**Software** – The ERAM System Enhancement and Tech Refresh hardware estimate was based on a Source Lines of Code (SLOC) estimate provided by the developer during the request for proposal phase. A list of the functional need requirements was provided to the prime developer during the Request For Proposal. The prime reviewed and provided an assessment of the amount of SLOC necessary to deliver those functions in their proposal with detail work necessity. The cost per line was derived based on actuals from the existing ERAM program.

**Program Office Federal and Support Contractor labor** – Program office Federal and Support contractor labor estimates were based on FY13 ERAM staffing levels and the work plan provided by the program office. Past and current actuals were then used to project future costs such as program management, systems engineering, second level engineering, training and logistics planning. The support contractor labor rate was set based on the existing actual labor rates. Federal salaries were based on the Government Service schedule for estimating purposes and adjusted by the standard benefits factor.

**ERAM Enhancements 2 (EE2)**

**Ground Rules and Assumptions**

- The Life Cycle Cost Estimate analysis timeframe is from FY17-FY23.
- The existing O&M baseline funds will cover the maintenance of this program. No additional O&M funding is required for Preventive Maintenance, Corrective Maintenance, Logistics, Telecommunications, and Utilities.
- Software costs are estimated using an $1,870 cost per SLOC, which is based on historical data of the recently completed ERAM builds and cross-checked against other program proposals from the same vendor.
- Technology Refreshment is not part of the scope for the EE2 program, hence no costs are included for any tech refresh hardware or activities.
- Program Office (PO) and Support Contractor costs for the program are included in the estimate. These levels of effort estimates are based on staffing levels on current contracts, and adjusted for the EE2 needs.
- Training development costs are included in the cost estimate via the SLOC metric, and are not shown separately.
- No additional training conduct costs are expected. Training will follow the current ERAM release training which consists of briefing packages developed by the prime contractor and administered using the FAA Electronic Learning Management System (ELMS), which is at no additional cost.
- Second Level Engineering (SLE) prime contractor activities in support of the EE2 work are included in the SLOC metric. Historical data shows that this work is accounted for in the SLOC metric through the prime vendor Contract Line Numbers (CLINs).
- It is assumed that additional software maintenance costs will not be necessary due to the commonality of the code being added. Hence no impact to software maintenance is expected.
- A risk analysis was performed using a Monte-Carlo simulation in the Crystal Ball risk tool. Variables on which risk was applied include SLOC cost, SLOC quantity, hardware cost, all salaries, and travel.

Program life-cycle costs for EE2 are estimated from FY17 to FY22. The FAA standard WBS, version 5.1 is utilized to model these costs. Cost for each WBS element is estimated using Base Year 2016 (BY16$) dollars, then time-phased and inflated using the latest OMB inflation indices to calculate the Then Year (TY) point estimate. The Life-Cycle Cost estimate was risk adjusted with an 80 percent confidence level.

**ERAM Sustainment 2 (ES2)**

The cost estimate analysis timeframe is FY17-FY21. All prime costs were based on the proposal submitted by Leidos in July 2016. Prime contractor costs include the costs to procure the hardware needed for technology refreshment, associated installation, deployment, training, engineering, travel, and software upgrades.

With the exception of the larger R-Position Display, Tech Refresh will not introduce “look and feel” changes for ATC users and will minimize the “look and feel” changes for other users such as Tech Ops. Tech Refresh will provide equivalent function and capacity to that which is available today. There are no functional or performance requirements for TR2. Any improvements to baseline capabilities/performance are solely based on the technology advances of the new equipment.

ERAM implements ES2 in a two-phase deployment approach:
- Early D: an accelerated deployment to address Display Processor Sysplanar Board failures. Replaces D-Position processor with new Linux Operating System HPE ML30
- Full Deployment: replaces the R-Position Processor, Keyboard Video Monitor (KVM) and display at all 20 ARTCC and the FAAAC
The prime contractor will develop the training courses and deliver the training, and one day of controller orientation will be provided on the larger R-Position monitor. The associated costs are included in the proposal. Air Traffic Controllers will see no appreciable change in form or function as a result of Tech Refresh. Air Traffic Controllers do not need additional training. Non-prime costs include government FTEs and support contractors and their travel.

Contractor salary rates are based on existing contracts, and cover travel costs since they are based on the total cost of the contract, which includes travel. The existing ERAM O&M baseline funds are expected to cover the maintenance of this program. No additional Operations funding is required for Preventive Maintenance, Corrective Maintenance, Logistics, Telecommunications, and Utilities.

d. Return on Investment Estimate

**ERAM Enhancement 2 (EE2)**

An economic analysis using the FAA Economic Analysis Tool (FEAT) was performed for each capability that has monetized benefits. FEAT performs a statistical analysis combining cost and benefits to create metrics (e.g., B/C ratio, NPV, etc.) at the selected confidence level (typically 80 percent).

The inputs include the uncertainty ranges around the total cost and benefits, typically a Cumulative Probability Distribution (CDF) in 5 percent increments, along with the annualized cost & benefits. The process runs a Monte-Carlo simulation with a default of 5,000 iterations. Economic Analysis guidelines on the IP&A Website provide the methodology utilized.

Table 8 provides a summary of the total program ROI metrics. As shown, the overall B/C ratio is 0.39, however several of the EE2 capabilities are infrastructure-related, with no monetized benefits. The one primary monetized capability (Trajectory & Conflict Probe enhancements) shows significant returns: B/C ratio of 1.05, net present value of $3M, payback in 2033, and an internal rate of return of 7.7 percent.

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e. Changes from Previous Estimates

In December 2018, an updated version of the BCAR report\(^\text{10}\) was developed for ERAM SeC E Segment 1, now referred as ERAM Enhancements 2. Cost and benefit

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\(^{10}\) Final Business Case for En Route Automation Modernization (ERAM) Enhancements 2 (EE2), December 2018.
values had been adjusted using baseline year 2018. Table 8a provides a summary of the adjusted ROI metrics.

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NWP

a. Program Description

NextGen Weather Processor (NWP)\textsuperscript{11} will establish a common weather processing platform that will consolidate weather product generation from legacy weather processing systems, and will produce new advanced aviation specific weather products to benefit ATC users. NWP will improve the weather information needed by decision makers and DSTs to help improve flight efficiency, provide the opportunity to increase the capacity of air transportation operations, and increase the margin of Air Traffic (AT) safety. NWP will help reduce operations and maintenance costs by consolidating weather processing functions, enabling the decommissioning of Corridor Integrated Weather System (CIWS), Integrated Terminal Weather System (ITWS), and Weather and Radar Processor (WARP).

NWP will generate consistent weather products that will provide real-time, expanded, and more accurate geographic coverage to a wider range of users. NWP will produce advanced aviation weather data, including long-lead weather products (up to eight hours), Convective Weather Avoidance Fields (CWAFs), flexible floor weather mosaics, and more timely weather products with higher accuracy. NWP will perform weather translation, an automated feature that identifies potential weather constraints in a format understandable to non-meteorologists and ingestible directly into automated NextGen DSTs. The users of the NWP weather products will be traffic flow managers, supervisors, DSTs, ANSPs, AT controllers, and the aviation community.

NWP will transition advanced prediction capabilities from the latest aviation weather research into operational use by producing rapid analysis and frequently updated, accurate convective weather products useful for both tactical and strategic AT management. NWP will improve the utility of convective weather information by extending it further into the planning period (up to eight hours), and by providing better information on individual weather hazards caused by convection (e.g., low-level wind shear and micro bursts).

NWP will produce accurate analyses (e.g., mosaics) and predictions for all operational uses within the AT community, significantly reducing the potential for conflicting convective information from a variety of sources. NWP will provide users of the NAS with accurate convective weather information upon which to base decisions.

NWP will provide weather products enabling the controller to better manage sector volume/complexity, route capacity, and aid in balancing controller workload. The

\textsuperscript{11} This summary is primarily based on Final Business Case for NextGen Weather Processor (NWP) Version 1.2, 9/9/2014.
weather information provided by NWP will greatly serve the needs of Traffic Flow Management (TFM) by decreasing the need for such TFM programs as altitude restrictions, miles-in-trail restrictions, speed restrictions, airborne holding, sequencing programs, reroutes, ground delay programs, and ground stops. DSTs using NWP products include TFMS/Route Availability Planning Tool (RAPT) and TBFM.

NWP will support the Convective Weather Avoidance Model (CWAM) and the determination of Weather Avoidance Fields (WAFs). These automated applications will enable the traffic flow manager to identify airspace that is not impacted by severe weather, thus permitting the optimization of reroutes, while maximizing AT capacity and efficiency of operations.

NWP will expand the availability of real-time weather information in support of the collaborative decision-making process and the concept of common situational awareness, primarily through the implementation of a Web display. The Airline Operations Centers (AOCs), flight dispatchers, airport authorities, airlines, as well as general aviation will have access to the NWP weather products. The availability of NWP weather information will lead to increased capacity, flight efficiency, and enhanced safety within the NAS.

b. Benefit Estimates

NWP will replace/consolidate legacy weather processor systems into a single weather processing platform with advanced capabilities. NWP will produce advanced aviation specific weather information and will integrate NWS forecast models with real-time radar extrapolation to produce convective weather products out to 8 hours. NWP will also perform weather translation that will be used by DSTs. NWP will translate analysis and predictions into airspace constraint information that decision makers and DSTs will use to determine if and when adverse weather will impact airspace and/or airport operations. These enhanced capabilities will produce a greater situational awareness of the timing, location, and severity of weather that will allow controllers to more efficiently manage air traffic around weather hazards and improve safety by reducing the number of encounters with weather hazards.

NWP benefits accrue in the following categories:

- Improved NAS-wide routing/resource convective weather impact management
- Improved Airspace Flow Program (AFP) execution/management
- Enhanced Playbook reroute planning/execution
- Improved DST performance from the integration of NWP data
- Improved planning of airport utilization surrounding winter weather events
- Improved operational ATM decision-making from enhanced access to weather products (technology/display)
- Enhanced weather products leading to reduced weather accidents
- Legacy system cost avoidance.
The NWP benefits analyses relied upon a number of programmatic assumptions and ground rules including:

- The business case lifecycle for NWP is from FY2014 to FY2040, to reflect a 20-year post implementation lifecycle.
- Safety benefits are quantified in terms of projected accidents and monetized using FAA standard values for avoided fatalities, injuries, and aircraft damage.
- Flight efficiency benefits are quantified in terms of delay reduction and/or reduction in cancellations and diversions. These metrics are monetized (unless otherwise stated) using FAA standard treatment of PVT plus ADOC which considers the cost of fuel, crew, and maintenance.
- Delay avoidance will grow at least linearly in proportion to traffic growth. Projected growth in traffic was obtained from the FAA Terminal Area Forecast (TAF) issued February 2014, although growth predicted by the TAF after 2025 was not applied.
- Weather patterns do not change over the NWP lifecycle.

The NWP Final Investment benefits analysis utilized a separate approach to estimate each benefit area. There are several benefits categorized into three main elements: flight efficiency, safety, and legacy system cost avoidance. The flight efficiency benefits are quantified in terms of fuel savings and/or delays (airborne, ground, gate) and monetized using values for fuel cost, ADOC, and PVT. Changes in the number of cancellations and diversions were also quantified where applicable and monetized using standard values. The safety benefits are quantified in terms of projected accidents and monetized using values for avoided fatalities, injuries, and aircraft damage. The legacy system cost avoidance benefits are derived from the cost analysis. All benefit metrics were risk-adjusted in coordination with FAA’s Office of Investment Planning and Analysis (IP&A) to account for a wide range of uncertainties in data, approach and models used.

c. Cost Estimates

The NWP life-cycle cost estimates encompass the period starting in FY 2014 and ending in FY 2040. The FAA standard Work Breakdown Structure (WBS), version 5.1, was utilized to model the costs. Each WBS element within the cost estimates was estimated in Base-Year 2014 dollars, time phased, and inflated using the latest OMB inflation indices to calculate the Then-Year point estimate. Risk analysis was then performed to calculate the High Confidence Life-Cycle Cost estimate for the Legacy Case and the new system.

The NWP investment consists of a Facilities and Equipment (F&E) and an Operations and Maintenance (O&M) component. These costs include the costs of materials and Contractor/Federal labor required to develop, test, and support the NWP system. The F&E component breaks out FAA labor as its own cost element, with the rest consisting of contractor labor and materials costs. The support contractor labor rate was based on the analogous FAA Program Office labor costs. Federal salaries were
based on the Government Service schedule for estimating purposes and adjusted by the standard benefits factor. Risk analysis was performed to calculate the High-Confidence Life-Cycle Cost estimate for the Legacy Case and the point estimate.

Cost inputs for non-prime contractor costs were provided by other organizations within the FAA. Level of effort inputs for Testing and Second Level Engineering activities were provided by persons within the appropriate departments within the FAA’s Technical Center. Implementation costs for the system were based on input from Engineering Services and implementation SMEs. Logistics support costs (Federal and Support Contractor) were provided by Logistic SMEs.

A contractor will provide software/hardware maintenance support not only through full deployment of the system, but also for the remainder of the lifecycle. The FAA’s Second Level Organization role is that of oversight and support for software maintenance. The FAA’s TechOps will oversee the maintenance of the associated hardware.

The Prime contractor costs for the solution were based on the successful offering of the NWP competitive procurement. These costs were provided in twenty independent Contract Line Item Numbers (CLINs). These costs were then mapped into the appropriate NWP WBS elements for F&E and Operations and Support (O&S) costs. Prime Contractor activities will include Hardware Procurement, Software Development, Testing, Implementation, and In-Service maintenance (Corrective Maintenance, Logistics and 2nd Level Engineering).

The costs associated with the winning vendor’s bids were much lower than the IGCE. The reason for this difference is that the IGCE assumed the vendor would have a far greater amount of software development and testing to perform. However, the selected proposal is leveraging a significant amount of previous work and a large amount of commercial-off-the-shelf items.

d. Return on Investment Estimate

Using the results of the benefits analysis and the completed cost estimate, programmatic metrics were calculated to determine the financial returns for the NWP System. The costs and benefits in the tables below are in discounted present value (PV) units to facilitate comparison across alternatives. The business case lifecycle is from 2014 to 2040.

The cost and benefit values represent a “high confidence” estimate from an underlying distribution of possible cost and benefit outcomes. In order to obtain similarly “high-confidence” economic analysis metrics, the full distributions of costs and benefits were statistically combined using a Monte Carlo simulation. These statistically combined results are presented in Table 9. The statistical combination of the cost and benefit distributions results in a different NPV and B/C ratio than would result from simply subtracting the “high-confidence” risk-adjusted present value costs from the risk-adjusted present value benefits or from taking the ratio of the
two values. Generally, the statistically combined NPV and B/C ratios will be slightly larger, as lower cost and higher benefit values from the rest of the distributions are included in the final estimate.

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<th>Table 9</th>
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<td>Net Present Value (FY14$M)</td>
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<tr>
<td>B/C Ratio</td>
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<tr>
<td>Payback Year</td>
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If all quantified benefits are included, NWP results in a NPV of $918 million, a benefit-cost ratio of 5.88, and a payback period of two years after Initial Operating Capability (IOC).

e. Changes from Previous Estimates

The NWP Program is undergoing a re-plan due to a delay in the implementation associated with the interdependencies with CSS-Wx and completion of software development. As part of the re-plan, the program is determining cost and schedule impacts.
SWIM

a. Program Description

The System Wide Information Management (SWIM) Program\textsuperscript{12} is an advanced technology program designed to facilitate greater sharing of ATM system information with far less expense and complexity than required by current methods. SWIM supports NextGen goals by facilitating its data sharing requirements and improving the way the FAA creates and leverages new and existing systems in the NAS. SWIM enables increased common situational awareness and improves NAS agility to deliver the right information to the right people at the right time.

SWIM is transforming NAS application interfaces from tightly coupled, point-to-point interfaces into a Service Oriented Architecture (SOA) by deploying common software throughout the NAS that allows interfaces to be re-used, by improving information security and supporting responses to new security initiatives, and by facilitating data integration through SWIM Governance. SWIM-enabled systems will have the ability to request and receive information when they need it, subscribe for automatic receipt, and publish information and services as appropriate.

SWIM will leverage existing systems and networks to the extent practicable, and be based on technologies that have been proven in both operational and demonstration environments to reduce cost and risk. SWIM will be developed incrementally based upon the needs of various data communities and maturity of concepts of use, and will be developed in segments that are sized to fit reasonable cost, schedule, and risk thresholds.

In each segment, a set of NAS enterprise services is developed and enterprise infrastructure is added to support the implementation of capabilities associated with the segments.

Segment 1

SWIM Segment 1 includes the following participating programs: ERAM, TFMS, Terminal Data Distribution System (TDDS), Integrated Terminal Weather System (ITWS), Corridor Integrated Weather System (CIWS), AIMM, and Weather Message Switching Center Replacement (WMSCR). These programs will develop and deploy SWIM capabilities in accordance with the SWIM Program Requirements and in accordance with SWIM Governance; however, SWIM does not impose new

\textsuperscript{12} This summary is primarily based on Business Case Analysis Report for System Wide Information Management (SWIM) Segment 1, 6/14/2007; Final Business Case Analysis Report for System Wide Information Management (SWIM) Segment 2A, 7/3/2012; and Final Business Case Analysis Report for System Wide Information Management (SWIM) Segment 2B, 11/16/2015.
development or management strategies on the programs. The development of SWIM capabilities is in accordance with each program’s existing strategies.

**SWIM Segment 2A**

The Segment 2A approach is based on the need to satisfy midterm (FY 2012-2016) NextGen Operational Improvements (OIs). As detailed in the Implementation Strategy and Planning Document (ISPD), Segment 2A includes the following key elements:

- Development, deployment, and maintenance of SOA Core Services comprised of Enterprise Messaging, Enterprise Service Management, Interface Management, and Security services
- NAS SOA Governance
- Acquisition, management and maintenance activities for the hardware and software associated with developing and deploying those capabilities that will result in a consolidated SOA infrastructure.

Programs subscribing to Segment 2A capabilities are responsible for development of their SWIM compliant services. Hardware and software associated with SOA capabilities hosted outside the SWIM consolidated infrastructure will be the responsibility of the stakeholders hosting the capabilities.

**SWIM Segment 2B**

SWIM Segment 2B builds upon the capabilities and functionality developed and implemented by previous SWIM Segments. The existing capabilities will continue to provide data products and service-oriented architecture functionality.

SWIM Segment 2B will provide four capabilities. These capabilities include two systems categorized within the Enterprise Architecture (EA) as support services. The remaining two are categorized as either an Enterprise Service management or Technical infrastructure capability:

- Support services capabilities:
  - SWIM Terminal Data Distribution Service (STDDDS phase 2)
  - NAS Common Reference (NCR).
- Enterprise service management service capability:
  - Enterprise Service monitoring (ESM).
- Technical infrastructure Service capability
  - Identify and access management (IAM phase 2).

**b. Benefit Estimates**

**Segment 1**

Today’s hard-wired infrastructure and systems cannot readily support the addition of new data, systems, data users, and/or decision makers as NextGen requires. In general, they are connected directly to support yesterday’s decision making needs. Each of these interfaces is custom designed, developed, managed, and maintained.
individually at a significant cost to the FAA. NextGen relies upon a new decision construct that brings more data, systems, customers, and service providers into the process. Data will be needed at more places and for more purposes, and it must be made available in a timely manner in common formats and structures to ensure consistent use. These new “data customers” need to be accommodated by providing the governance and policy that tells them how to connect to existing, open interfaces instead of designing, developing, testing, and implementing new ones from scratch. Network technology and data management software must use commercial equipment and current industry standards, reducing developmental and upgrade costs and simplifying maintenance. Today’s point-to-point architecture does not support these goals. This situation represents a performance gap that must be bridged for NextGen to be successful.

SWIM Segment 1 includes no user benefits – rather, the business case depends on the avoided costs and FAA cost savings realized by deployment of SWIM capabilities. The main cost avoidance comes from TFM RVR Data Interface, Host/ATM Data Distribution System (HADDS), Flight Data Input/Output (FDIO) and ERAM/TFM Data Exchange.

**SWIM Segment 2A**

Quantified SWIM benefits are exclusively in the domain of FAA cost avoidance. Benefits are estimated based on the assumption that the services in the FAA Enterprise Services Roadmap must be provided and the products of those services must be shared with multiple programs, both inside and outside of the FAA. SWIM’s role is to provide the enterprise infrastructure core service capabilities needed to share this information. This leads to cost avoidance by creating an efficient, governed communication infrastructure instead of program specific interfaces. Those program specific interfaces would be developed in isolation by individual programs that, for purposes of interoperability, would likely require future rework as new requirements for data exchange evolve or require multiple, point-to-point interfaces if there were no Enterprise message switching capability.

With or without SWIM Segment 2A, the FAA will need to increase the amount of data exchanged and the number of connections between systems as the agency moves toward NextGen. The Reference Case acknowledges the costs that the agency would incur if SWIM Segment 2A did not exist, but the data provided by NextGen programs still needs to be made available to other NAS Programs and non-NAS communities.

The NAS programs and estimated number of services that were used as a basis for the cost estimate are identical between the Reference Case and the Preferred Alternative. The cost difference between the Reference Case and Preferred Alternative results from the increased cost burden that individual programs would incur if they did not have access to an enterprise solution that allows for a more efficient development and implementation of the required data exchange between the planned services.
**SWIM Segment 2B**

SWIM Segment 2B capabilities provide cost avoidance benefits by deploying services identified in the FAA Enterprise service roadmap and providing them to multiple producers and consumers. This relieves individual producers and consumers from the need, and thus costs, to develop, implement and support these services in isolation.

In Segment 2B, monetized benefits are associated with this cost avoidance. The Segment 2B IAM and NCR capabilities provide significant cost avoidance benefits. To the extent possible, cost avoidance estimates have been calculated based on knowledge gained with regard to the SWIM Segment 2B cost estimates.

STDDS Phase 2 and ESM benefits have not been monetized. STDDS Phase 2 provides insignificant telecommunications cost avoidance benefits. STDDS Phase 2 has been addressed in Segment 1. In Segment 2B STDDS Phase 2 supplements its Segment 1 benefits by enabling current customers of terminal data products to reduce their telecommunications costs by adopting SWIM.

ESM, as an infrastructure capability, does not provide monetized benefits. ESM is integrated with NEMS and contributes to the SWIM Segment 2A NEMS benefits and service objectives.

NCR cost avoidance benefits derive from relieving the TFM, TBFM, TFDM and FSS systems from the requirement to develop a capability to generate tailored, filtered, cross-domain data products.

IAM Phase 2 cost avoidance benefits result from 49 locations adopting the IAM Phase 2 capability, thereby avoiding the cost to independently develop similar security capabilities.

c. Cost Estimates

**Segment 1**

SWIM support to the participating programs assumes existing management structure and, for ongoing programs such as ERAM and TFM-Modernization, SWIM costs include only the incremental costs of development and deployment of SWIM capabilities.

The SWIM Investment Analysis Team (IAT) developed F&E cost estimates using three different methodologies:

- Staffing Build-up: subject matter experts from the participating programs provided “bottom up” cost estimates based on actual experience with the Program.
- Vendor quotes: software and hardware costs were estimated based on vendor quotes, GSA pricing, and prices for products identified on a vendor’s internet site.
- Historical: costs were estimated based on historical record of costs required to develop new capabilities under the AIM, ITWS, CIWS, and WMSCR Programs.

Costs were inflated using the OMB’s latest published inflation rates (January 2007). FAA labor rates were inflated 5 percent annually. In addition, costs were risk-adjusted by WBS to reflect the uncertainties of SWIM design and development.

Core Services for SWIM will be supported via a commercial software package. The package selected for estimating purposes is provided by TIBCO. The cost of procuring an Enterprise License Agreement (ELA) from TIBCO in FY10 is included in the SWIM Cost Estimate, with maintenance costs included in all successive years. In FY09, the costs for development licenses for these products are included in the Cost Estimate. The SWIM program office will provide the required software to each participating program, along with necessary training and documentation. Maintenance of the ELA is the responsibility of the SWIM Program Office.

Any additional user training required for Segment 1 capabilities has been identified and included in the SWIM Cost Estimate. Training is the responsibility of the participating program and will be conducted in accordance with existing Training Development Plans and Integrated Logistics Support Plans.

Costs to perform a Tech Refresh of the SWIM Segment 1 hardware are included in the cost estimate. These costs assume that a Tech Refresh is performed every five years.

**SWIM Segment 2A**

The SWIM Segment 2A cost estimate is based upon a proposal from the Harris Corporation to a FAA Request for Proposal (RFP) dated February 20, 2012. Additional costs include SWIM program office resources and telecommunications.

The Base Year cost estimate covers the years FY11 through FY16 for F&E costs and FY11 through FY33 for O&M costs.

The cost estimate uses FY12 as the Base Year. Four escalation rates are in effect: FAA compensation is escalated at 3.9 percent per year per IP&A guidance; support contractor costs are escalated using OMB guidance (generally 1.6 to 1.8 percent each year); Harris contract costs are escalated at the rate of 3.2 percent for contract items dated 2011 and prior (Domain Name Service and Network Time Protocol) and 3.0 percent for contract items dated 2012 and after (NAS Enterprise Messaging Service).

**SWIM Segment 2B**

The SWIM Segment 2B Investments Analysis Team (IAT) developed life cycle cost estimates for the preferred alternative using Excel and Crystal Ball. Individual cost estimates were prepared for each Segment 2B capability and the SWIM program management office (PMO) and costs funded by other FAA programs.
The SWIM PMO provided requirements to the system integrators, Volpe National Transportation Systems Center and WJHTC, to develop system architectures for each individual capability. Architecture costs were then estimated. Estimates for commercial hardware and software items were developed using vendor quotes. Software development cost was estimated using parametric models based on SLOC counts for the software architecture provided. Each estimate includes support contractor costs, FAA labor, and associated non-labor costs (for example travel).

The IAT organized all costs in accordance with FAA WBS version 5.1. Costs were inflated using OMB inflation rates for 2015 except for FAA Federal employees, which used an annual inflation rate of 2.25 percent as recommended by the FAA Office of Labor Analysis, and on-ramping and telecommunications costs covered by the FAA FTI contract, which includes a contractual rate of 3 percent.

Costs were risk adjusted by WBS, using risks developed by the Risk, Issues and opportunities (RIO) team and estimated uncertainties. The RIO team developed risks for each Segment 2B alternative.

In addition to incorporating the potential impacts of program risks on costs, uncertainty ranges and probability distributions were applied to the quantitative inputs of each cost model. For example, even though the estimates use vendor quotes and published catalog costs, the quotes will expire years before the orders are placed. Hence there is uncertainty with respect to future hardware costs independent of inflation. This uncertainty extends to the expected value of the cost impacts of program risks, in as much as these are expressed as ranges.

d. Return on Investment Estimate

**Segment 1**

The economic analysis, summarized in Table 10, includes calculation of the B/C ratio, NPV, and payback period for this investment. The analysis was based on risk-adjusted, then-year cost and benefits (avoided costs and cost savings) estimates. Per guidance from OMB provided in January 2007, a discounting factor of 5.1 percent was applied to the FAA avoided costs and cost savings. There are no user benefits claimed for SWIM Segment 1. Also, inflation rates were used in accordance with the guidance provided by OMB in January 2007. (All calculations use 2007 as the base year.)

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<td>Payback Year</td>
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**SWIM Segment 2A**

The economic analysis, shown in Table 11, includes calculation of the B/C ratio, NPV, and payback period for this investment. The analysis was based on risk-adjusted,
then-year cost and benefits (which consisted of avoided costs) estimates. Per guidance from OMB, a discounting factor of 3.5 percent was applied to the FAA avoided costs. There are no user benefits claimed for SWIM Segment 2A. Also, inflation rates were used in accordance with the guidance provided by OMB in February 2012. (All calculations use 2012 as the base year.)

**Table 11**

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**SWIM Segment 2B**

The SWIM Segment 2B economic analysis, shown in Table 12, includes calculation of the B/C ratio, NPV, and payback period for this investment. The analysis was based on risk-adjusted, then-year cost and benefits (which consisted of avoided costs) estimates. A discount rate of 7 percent was applied to the FAA avoided costs. There are no user benefits claimed for SWIM Segment 2B.

**Table 12**

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TBFM

a. Program Description

Time Based Flow Management (TBFM)\textsuperscript{13} is a vital part of the NAS and a key component of NextGen. It enhances air traffic operations by reducing delays and increasing efficiency of airline operations. The TBFM system, which evolved from the earlier Traffic Management Advisor (TMA), is a currently available ARTCC-based decision support tool that enables the use of time-based metering to optimize the flow of aircraft as they approach and depart congested airspace and airports.

For arrivals approaching a congested airport, TBFM determines how the multiple streams of incoming flights can be sequenced and scheduled to fully utilize the runway and other airport resources while avoiding unnecessary delay and complying with all operational constraints. For departures, TBFM schedules departure times that blend the flights into slots in the traffic flows through departure fixes or other metering points in en route airspace.

TBFM is deployed to all twenty domestic ARTCCs, where it provides arrival services for the thirty-five largest NAS airports. Its schedule timelines and traffic plan views are installed in the Traffic Management Units (TMU) at each ARTCC, and are provided to one or more Terminal Radar Approach Control (TRACON) facilities and towers associated with each ARTCC.

TBFM is also a key Traffic Flow Management (TFM) decision support tool in use at the Air Traffic Control System Command Center (ATCSCC). In its National Traffic Management Office, the ATCSCC has operational TBFM displays from all of the ARTCCs. TBFM also provides flight plan information and associated metering data to external entities.

TBFM WP2 and Enhancement 1 (formerly known as TBFM WP3)

The FAA’s AJM-2 has the mission to extend the capabilities of the TBFM system. Beginning in 2010, enhancements began under TBFM WP2 to evolve the earlier TMA into the current TBFM system. A new generation of enhancements is now planned under TBFM Enhancement 1 to further expand the role and scope of time-based metering operations to provide its benefit more broadly throughout the NAS.\textsuperscript{14} TBFM Enhancement 1 adds new capabilities that will:

\textsuperscript{13} This summary is primarily based on “Business Case Analysis Report for TBFM – April 2010” and “Business Case Analysis Report for TBFM WP3 – May 2015”.

\textsuperscript{14} TBFM WP3 is now referred to as TBFM Enhancements 1.
- Extend the scheduling capability into the terminal area through new Terminal Sequencing and Spacing (TSAS) tools provided to terminal controllers and traffic managers at nine sites
- Expand the deployment of the Integrated Departure/Arrival Capability (IDAC), begun under WP2, to an additional five Centers and additional airports.

TSAS provides arrival management guidance to TRACON controllers consistent with the schedule that en route controllers are striving to attain at arrival meter fixes. TSAS uses published definitions of Standard Terminal Arrival Routes (STARs) and approach procedures as the basis for its sequencing and scheduling. With TSAS, more precise arrival delivery can be achieved.

Furthermore, Required Navigation Performance (RNP) Radius-to-Fix (RNP-RF) approaches are anticipated to become more available. These curved paths provide increased efficiency. TSAS will enable controllers to accommodate RNP-capable aircraft along those procedures while efficiently managing non-RNP capable aircraft, even during high-traffic periods.

IDAC automates the approval request process between Air Traffic Control Towers (ATCT) and ARTCC TMUs. IDAC provides for the identification of flights requiring TBFM departure scheduling and graphic depictions of available departure slots. IDAC provides situational awareness to ATCTs so that they can select from available departure times, request a release time, and plan their operation to meet these times. This situational awareness will be provided for various TBFM environments, including a standard single departure fix and departures merging into an overhead flow.

IDAC supports traffic managers at ATCT facilities, TRACON facilities, and ARTCC facilities. Traffic managers can also use IDAC at the ATCSCC to monitor TBFM assigned delays at departure airports across multiple system constraints. IDAC provides traffic managers access and insight into scheduling of a departure into TBFM’s arrival and departure capabilities through common situational awareness, decision support, and the ability to automate phone-based communication.

b. Benefit Estimates

**TBFM WP2**

TBFM provides automation, communication, and decision support tools to:

- Increase efficient use of existing capacity
- Reduce manual workload
- Increase common situational awareness
- Reduce delay in the terminal and en route airspaces.

TBFM capabilities provide additional residual benefits for the environment. The assessment quantifies specific benefits to NAS users.
Benefits to the FAA take the form of reduced workload, increased common situational awareness, improved communications, increased ease of use, and improved infrastructure. These types of benefits, however, are difficult to assess and quantify. Therefore, the benefits assessment primarily focused on the quantifiable benefit to users and passengers. These quantitative benefits manifest themselves in reduced ground delay and reduced airborne holding. The following capabilities are expected to provide delay saving benefits:

- Integrated Departure/Arrival Capability (IDAC)
- Flexible Scheduling
- Additional Deployment (ACM and TMA).

**TBFM Enhancement 1**

The TBFM program is implemented in an incremental way through work package deployments. The latest TBFM Enhancement 1 will provide two capabilities to the existing TBFM system:

- Expanded Deployment of IDAC (IDAC 2)
- TSAS

IDAC automates the coordination of departures from multiple airports over shared and congested NAS resources via improved decision support capabilities and web-based communications. Traffic managers in the ARTCC coordinate the overall process, which includes monitoring departure and en route demand, initiating IDAC departure procedures, and monitoring the traffic flow. IDAC communicates the allocated departure times from the ARTCC to airports, and the traffic managers or controllers at the airports assign the times to individual flights at their facilities. By reducing the verbal coordination time between ARTCC TMU and tower, IDAC increases the departure flow efficiency through more effective utilization of available space over a departure fix or in the overhead flow.

IDAC was developed under WP2; TBFM Enhancement 1 expands the development of IDAC to five additional centers and additional airports. No additional development of IDAC will be performed as part of TBFM Enhancement 1.

TSAS extends scheduling and metering capabilities into the terminal area and provides metering automation tools to terminal controllers and terminal traffic managers. Those controllers and traffic managers become active participants in time-based metering operations as they work to deliver aircraft accurately to Constraint Satisfaction Points (CSPs) within terminal airspace, to include the runway, in accordance with scheduled times at those points. A higher level of coordination takes place with the overlying center regarding the overall metering operation, potentially reducing terminal controller workload. Through TSAS, terminal controllers are better able to support and enable improved operations, such as RNP-RF, through tools that support the merging of mixed equipage traffic flow (such as merging aircraft flying RNP-RF and non-RNP procedures). Terminal traffic mangers
will have improved situation awareness through the use of displays that allow for the monitoring of terminal metering operations, similar to the displays used today by center traffic managers to monitor en route metering operations.

This analysis focuses on the following benefits mechanisms:

- Reduced delay resulting from a reduction in missed slots in the overhead stream
- Reduced flight time and fuel burn resulting from more optimal trajectories from the meter fix to the assigned runway threshold
- Reduced delay resulting from more accurate runway delivery
- Increased safety resulting from fewer amendments.

c. Cost Estimates

**TBFM WP2**

The AJR-4 Investment Analysis Team (IAT) developed a LCCE for the Preferred Alternative encompassing both F&E and O&M costs. Costs were developed using several different methodologies:

- Function point analysis – Used to derive the costs associated with software development. A function point analysis was performed based on the requirements for each capability to determine the appropriate effort involved.
- Parametric models – Function point analysis served as inputs into SEER-SEM. Results were used to estimate much of the development required for software, throughout the entire lifecycle.
- Historical Estimate – Costs were estimated based on the AJR-4 historical record of costs required to develop new capabilities.
- Build Up – A combination of historical costs, vendor quotes, and independent studies to identify configuration and hardware requirements for TBFM architecture.
- Historical Costs - used factors and actuals derived from Contractor Reporting formats (EVM data, C/SSR formats), both for TMA as well as analogous efforts (e.g., TFMS).

Costs were inflated using the OMB’s latest published inflation rates. In addition, costs were risk adjusted by WBS to reflect uncertainty associated with the estimate. The IAT conducted a risk assessment to identify several areas of the program that have the potential to impact costs, including requirements uncertainty, uncertainty of cost and schedule estimates, human factors risk, and technical dependencies on other programs. To account for estimation uncertainty, the risk team identified low, most likely and high ranges for selected WBS elements. Finally, the SEER-SEM modeling effort included risk ranges which were incorporated into those elements.
**TBFM Enhancement 1**

The TBFM Enhancement 1 lifecycle encompasses the period from FY15 to FY39, with the program baseline from FY15 to FY22. The FAA standard WBS version 5.1 is utilized to model the costs. Each WBS element within the cost estimate is in Base-year 2014 dollars, time-phased, and inflated using the latest OMB inflation indices to calculate the Then-Year point estimate. Risk analysis was then performed to calculate the High-Confidence Lifecycle Cost.

A variety of estimating methodologies are used to derive point estimates for the TBFM system. The following paragraphs summarize the various techniques and data sources used to estimate the cost elements and calculate the high-confidence lifecycle estimate.

The TBFM Program Office provided FAA and Support contractor staffing level estimates for Program Office activities such as program management and system engineering. These include the cost of materials and Contractor/Federal labor required to develop, test, and support the TBFM system. The support contractor labor rate is based on estimates for pay scale levels. Federal salaries are based on the Government Service schedule for estimating purposes and adjusted by the standard benefits factor. Level of effort inputs for Testing and Second Level Engineering activities were provided by persons within the appropriate departments within the FAA’s Technical Center. Initial and recurring Telecommunication costs were provided by the FAA Telecommunication Infrastructure (FTI) Program Office. Implementation costs for the system were based on input from Engineering Services and implementation SMEs. A logistics estimate for TBFM Enhancement 1 integration with the Standard Terminal Automation Replacement System (STARS) program was provided by that program office.

It is assumed that the contractor will provide software/hardware maintenance support not only through full deployment of the system, but also for the remainder of the lifecycle. The FAA’s Second Level Organization role is that of oversight and support for maintenance of software and associated hardware.

TBFM Enhancement 1 hardware costs are based on historical actuals from TBFM WP2 and the projections for future hardware requirements. Software development costs are estimated using the SEER-SEM (Software Estimation Module). Knowledge bases reflecting the system design and functionality were loaded into the model, and the level of effort and schedule of development were calculated and integrated into the lifecycle cost model.

For lifecycle cost risk, the Program Office identified multiple risks associated with the schedule as well as technical and programmatic areas that could impact costs. For each risk, a triangular risk range was applied to appropriate WBS elements. These ranges were then input into a Monte Carlo simulation with a run of 10,000 iterations using the identified risk ranges to establish the risk adjusted costs.
d. Return on Investment Estimate

*TBFM WP2*

As part of the economic analysis, B/C ratio, NPV and payback period were calculated. The analysis was based on risk-adjusted cost and benefit estimates. The B/C ratio and the NPV are calculated using a discount rate based on OMB guidelines, which is 7 percent for user benefits and 2.35 percent for cost avoidance/cost effectiveness.

Table 13 provides a summary of the results of the economic analysis.

<table>
<thead>
<tr>
<th>Table 13</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Present Value (FY10$M)</td>
<td>$ 101.38</td>
</tr>
<tr>
<td>B/C Ratio</td>
<td>2.36</td>
</tr>
<tr>
<td>Payback Year</td>
<td>2013</td>
</tr>
</tbody>
</table>

*TBFM Enhancement 1*

Using the results of the benefits analysis and the completed cost estimate, programmatic metrics were calculated to determine the financial returns for TBFM Enhancement 1. The costs and benefits presented in Table 14 are in discounted present value units to facilitate comparison. The business case lifecycle is from FY15 to FY39.

<table>
<thead>
<tr>
<th>Table 14</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Present Value (FY15$M)</td>
<td>$ 291.0</td>
</tr>
<tr>
<td>B/C Ratio</td>
<td>2.84</td>
</tr>
<tr>
<td>Payback Year</td>
<td>2026</td>
</tr>
</tbody>
</table>

The economic metrics for the individual components of TBFM (IDAC 2 and TSAS) were calculated using 80th percentile for cost and 20th percentile for benefits. The total TBFM Enhancement 1 metrics were calculated using the FAA Economic Analysis Tool (FEAT), which statistically integrates costs and benefits.
TFDM

a. Program Description

Terminal Flight Data Manager (TFDM) is a NextGen program that improves surface management and efficiency. TFDM supports new services that provide automation to current, manually-intensive operations and replaces critical, outdated systems in the NAS. TFDM shares electronic data among controllers, air traffic managers, aircraft operators, and airports. It enables stakeholders to more efficiently stage arrivals and departures and manage surface traffic flow. Stakeholders will have a shared awareness of flights on the ground and in the air; the ability to exchange data electronically; a constantly updated picture of traffic volume; and more accurate predictive modeling tools to make flights more efficient from gate to gate.

The TFDM system will be deployed to a subset of NAS Air Traffic Control Towers (ATCTs). Other FAA facilities will also have access to the TFDM data, including TRACONS, ARTCCs, and ATCSCC. The TFDM contract was awarded in 2016 to Lockheed Martin, which subsequently merged with Leidos. TFDM capabilities will be implemented incrementally at 89 sites in a phased approach, beginning in 2020 and ending by 2028. TFDM program plans include early implementation of a surface display capability, enhanced flight operator data exchange, and electronic flight strips to selected NAS facilities in advance of TFDM system deployment. The business case lifecycle extends 20 years following the last deployment.

b. Benefit Estimates

The major benefits of TFDM include the following:

- Introduces electronic flight strips with electronic flight data (EFD), thereby eliminating the need for paper flight strips. TFDM also integrates electronic data from other automation systems within the tower. This offers the potential to reduce errors created with the printing, marking, distribution, and updating of paper flight strips and other tower data.
- Develops and provides data and user interfaces to existing ATC tools from other FAA domains. This supports an environment of integrated surface, arrival/departure, and traffic flow decision processes to maximize airport throughput and reduce delays.
- Improves data exchange with stakeholders. Provides the timely sharing of accurate operational data with all stakeholders, which provides a collaboration capability to predict and manage demand as well as mitigate constraints.

15 This summary is primarily based on “Final Business Case for Terminal Flight Data Manager (TFDM)”, RPT-PMO-02-TFDM-16-001, June 15, 2016.
- Implements a new ATCT suite of capabilities. These tools and interfaces increase operational efficiency and reduce controller workload so that controllers can support increased traffic volumes. These tools also will monitor surface movements and capture surface state changes by displaying changes on EFD displays, e.g., displaying a state change when an aircraft moves from a taxi state to line-up and wait (LUAW) state. Shared Flight Operator flight intent data with these ATCT functions will increase situational awareness and predictability. Surface state movement data will be shared with other domains.

- Establishes infrastructure changes to allow initial airport surface collaboration with other FAA facilities. This lays the foundation for full Airport Surface Collaborative Decision Making among all airport surface stakeholders.

- Establishes interfaces to other TFM programs to exchange TFM data to support collaboration. The ability to exchange information between TFM systems and share the data improves situational awareness and collaborative decision making with all affected stakeholders.

- Provides a situational display shared by multiple Air Traffic Control (ATC) domains. A common situational display will ensure that all domains have the same view of current and projected conditions thereby improving coordination and reducing coordination workload.

The primary benefit mechanisms for TFDM include:

- Departure queue management
- Increased opportunity for flight prioritization
- Increased opportunity to take CFR delay at gate
- Improved off-time compliance related to controller departure times
- Improved runway load balancing
- System consolidation and elimination of paper flight strips
- Reduced incidents/accidents on the surface.

TFDM also has additional benefits that are recognized in this analysis but are not monetized, including:

- Emissions savings
- Controller time savings
- Reduced strip mishandling and ATC miscommunication
- Automated traffic count and delay recording
- Providing data and analysis tools for real-time and post-operational assessment
- Meeting national and international commitments for data sharing
- Enabling future Nextgen initiatives.
TFDM benefits were estimated in terms of cost avoidance, flight efficiency gains, and safety. The flight efficiency benefits refer to delay or fuel savings. The delay savings are valued in terms of ADOC and PVT. Safety benefits are derived from the estimated reductions in Operational Incidents (OIs) that result in certain runway incursions. The reduction in these OIs was quantified but not monetized.

Both the safety and efficiency historical baselines are functions of traffic density. The baselines are combined with traffic projections from the FAA Terminal Area Forecasts (TAF) to develop estimates of benefits for each year. In addition, the timeframe for which each benefit starts to accrue is based on when the specific application is to be operationally certified, as well as on user equipage and the commissioning of the necessary ground equipment.

The analysis was performed on an initial set of 89 airports that were planned to have surface surveillance. The list was vetted by the TFDM Program Office and the Surface Operations Office. The set was then expanded to include all airports with the Electronic Flight Strip Transfer System (EFSTS), which the TFDM program plans to subsume. Configuration A benefits were assessed at 27 larger airports that have surface surveillance (i.e., ASDE-X or ASCC). Configuration B benefits were assessed at the 62 remaining sites that were deemed to have too little traffic to merit Configuration B or that lacked surface surveillance. The final set of 89 airports (27 Configuration A and 62 Configuration B) was down-selected using cost-benefit analysis.

c. Cost Estimates

A full risk-adjusted LCCE was performed for TFDM. The estimate consists of F&E and Operations components. The aggregated costs for TFDM include the costs of Materials, Contractor and FAA Federal Labor. The TFDM team collaborated with the FAA Academy, MIT/Lincoln Labs, and the William J. Hughes Technical Center to develop the cost estimates. The key cost driver is the software development.

d. Return on Investment Estimate

Using the results of the benefit and cost analyses, programmatic metrics were calculated to determine the financial benefits for TFDM. The economic analysis values presented in Table 15 represent a “high-confidence” estimate from underlying distributions of possible cost and benefit outcomes using a Monte Carlo simulation. The economic analysis results are based on a lifecycle period of FY16- FY48.

| Table 15 |
|-----------------|--------|
| Net Present Value (FY16$M) | $ 17.00 |
| B/C Ratio | 1.03 |
| Payback Year | 2047 |
TFMS/CATM

a. Program Description

Traffic Flow Management (TFM) is the air traffic management element that provides strategic planning and management of air traffic demand to ensure a smooth and efficient traffic flow through all FAA controlled airspace. To support this mission, traffic managers (TM) at the ATCSCC and at local facilities (ARTCCs, TRACONs, and ATCTs) use a combination of automation systems, decision support tools and procedures to monitor, evaluate, and manage air traffic flows throughout all phases of flight. These software-based tools provide for:

- A common situational awareness of the current and forecast conditions of the NAS
- Collaborative planning among major NAS users and managers
- Performance analysis of traffic management operations to identify and resolve, on a near real-time basis, problems within the NAS and areas for future improvement.

Collaborative Air Traffic Management Technologies (CATMT) provides direct mission support to the FAA to provide greater capacity by ensuring efficient flow of air traffic through the NAS. CATMT program activities are directly tied to TFM systems that increase effective capacity and mobility in the NAS, especially during periods of degraded performance caused by severe weather or excessive demand.

CATMT activities consist of completing the development of the legacy TFM infrastructure programs including the National Traffic Management Log (NTML); and of the Collaborative Decision Making (CDM) programs including Flight Schedule Monitor (FSM), Route Management Tool (RMT), and Post Operations Evaluation Tool (POET). CATMT also incorporates incrementally developed and integrated decision support capabilities for the modernized TFM System (TFMS).

CATM WP2

CATMT Work Package 2 (WP2) includes a portfolio of enhancements to the TFM system to exploit the benefits of the modernized TFM infrastructure. WP2 provides automation and decision support capabilities that leverage the latest available technology and research, enabling more efficient communication and collaboration with aircraft operators. WP2 also modernizes the TFM remote sites now that the

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ETMS hub was replaced and relocated under TFM-M. WP2 contains two capability categories, one cross-domain coordination category, and one infrastructure enhancement category:

**Airport Congestion Management (ACM) suite**
- Arrival Uncertainty Management (AUM)

**Weather integration Suite**
- Integration of automated weather forecasted products
- Collaborative Airspace Constraint Resolution (CACR)

**Domain Integration part 2**
- Airborne Reroute Execution (ABRR).

**CATM WP3**
CATMT WP3 includes enhancements that continue to provide decision support capabilities that leverage the latest technology and research, and enable more efficient communication and collaboration with aircraft operators. WP3 modernizes the TFM remote sites and associated TMU workstations. WP3 contains one cross-domain coordination category, and one infrastructure enhancement category. WP3 capabilities are:

**Domain Integration part 2**
- Collaborative Information Exchange (CIX)

**Tool Suite Enhancements**
- TFM Remote Site Re-Engineering (TRSR).

**TFMS Enhancement 4 (TFMS E4, formerly known as CATMT WP4)**
TFMS E4 is intended to enhance the capabilities of the existing TFMS, by providing enhancements to the demand prediction capabilities and a Decision Support Tool (DST) for managing departures in the presence of convection and high demand. The specific Operational Improvements (OIs) and Investment Increments (II) which this acquisition supports include:

- Full Collaborative Decision Making
- Continuous Flight Day Evaluation.

TFMS E4 aims to provide Traffic Managers with the information and tools that they need to fulfill the TFM mission more effectively. More specifically, CATMT WP4 includes two capabilities:

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17 CATMT WP4 is now referred to as TFMS Enhancement 4.
1. Improved Demand Prediction capability (IDP) - Traffic Managers will have access to more accurate demand predictions and status information presented in an integrated format.

2. Integrated Departure Route Planning tool (IDRP) - Management of departure flows will be facilitated using new, integrated information displays that provide weather, traffic, and airspace resource information to Traffic Managers and Flight Operators.

b. Benefit Estimates

**CATM WP2**

The CATMT WP2 BCAR quantifies specific benefits to NAS users, and enumerates qualitative benefits to the FAA, NAS users and society. Table 16 summarizes the benefits types.

<table>
<thead>
<tr>
<th>Benefit Category</th>
<th>Quantitative</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAA</td>
<td>Cost avoidance and savings</td>
<td>Ensure a viable future</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More efficient use of NAS resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workload reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Common Situational Awareness</td>
</tr>
<tr>
<td><em>NAS Users</em></td>
<td>ADOC and PVT benefits due to:</td>
<td>Users ability to request favored routes and implement their preferred</td>
</tr>
<tr>
<td></td>
<td></td>
<td>business models and strategies</td>
</tr>
<tr>
<td></td>
<td>Reduced ground delay</td>
<td>Reduced diversions and cancellations</td>
</tr>
<tr>
<td></td>
<td>Reduced airborne delay</td>
<td>Common Situational Awareness</td>
</tr>
<tr>
<td><em>Society</em></td>
<td></td>
<td>Environmental</td>
</tr>
</tbody>
</table>

**CATM WP3**

CATMT WP3 builds upon the modernized TFM system, and provides the modernized remote site infrastructure for current and future CATMT capabilities.

CATMT WP3 capabilities provide modernized software infrastructure, automation, and data for display and use in decision support tools to:

- Increase efficient use of existing capacity
- Reduce manual workload
- Increase common situational awareness
- Reduce delay in the terminal and en route airspaces.

Benefits to the FAA take the form of reduced workload, increased common situational awareness, improved communications, increased ease of use, and
improved infrastructure. The benefits assessment primarily focused on the quantifiable benefits to the FAA as well as NAS users and passengers. These quantitative benefits manifest themselves in reduced airborne holding and FAA cost avoidance. CATMT WP3 CIX (Collaborative Information Exchange) is expected to provide delay saving benefits, while the TFM Remote Site Re-engineering effort provides FAA cost avoidance. WP3 capabilities provide additional residual benefits for the environmental.

**TFMS E4**

The benefits for TFMS E4 are delivered by two key capabilities of the program: IDP and IDRP. The benefits analysis for these capabilities was based on 2014 operations, extrapolated to 2020-2032. The extrapolations included accounting for increases in demand using the FAA Terminal Area Forecast Summary for 2013-2040, and for increases in airport capacity using data from FAA Airport Capacity Profiles 2014. This latter source includes capacity increases due to both runway construction and NextGen Operational Improvements.

For cases where demand was projected to grow faster than capacity was added (i.e., demand would exceed capacity), demand growth was limited. This assumes that exponential increases in delay that would otherwise result would not be tolerated. Capping demand to capacity growth likely reduces the overall out-year benefits calculated for each capability.

**c. Cost Estimates**

**CATM WP2**

The ATO-R Investment Analysis Team (IAT) developed a lifecycle cost estimate for the Preferred Alternative encompassing both F&E and O&M costs. Costs were primarily developed using a combination of three different methodologies:

- **SLOC Estimate** - Used to derive the costs associated with software development. A function point analysis was performed, based on the requirements for each capability, to determine the effort involved.
- **Historical Estimate** - Costs were estimated based on the historical record of costs required to develop new capabilities, which were used to determine some of the effort associated with software development.
- **WP 1 Cost Estimate** - Due to the similarities of the investment with WP 1, this approach was used to determine costs for a number of WBS elements (e.g., Program Management, Test & Evaluation) under the assumption that the cost of Software Design and Development is the key driver, and that contactor continuity provides validity to these estimates.

Costs were inflated using OMB’s latest published inflation rates. In addition, costs were risk adjusted by WBS to reflect any uncertainties associated with the estimate. The IAT conducted a risk assessment to identify several areas of the program that
have the potential to impact cost, including: requirements uncertainty, uncertainty of cost and schedule estimates, human factors risk, and technical dependencies on other programs. To account for estimation uncertainty, the risk team identified low, most likely and high ranges for selected WBS elements.

**CATM WP3**

The Investment Analysis Team (IAT) developed a lifecycle cost estimate for the Preferred Alternative encompassing both F&E and O&M costs. Costs were primarily developed using a combination of three different methodologies:

- **SLOC Estimate** – Used to derive the costs associated with software development. A function point analysis was performed, based on the requirements for each capability, to determine the effort involved.
- **Historical Estimate** – Costs were estimated based on the historical record of costs required to develop new capabilities, which were used to determine some of the effort associated with software development.
- **Hardware and COTS software build-up** - Based on system requirements, hardware and COTS software elements were compiled and costs were estimated using vendor pricing.

Costs were inflated using OMB’s latest published inflation rates. In addition, costs were risk adjusted by WBS to reflect any uncertainties associated with the estimate. The IAT conducted a risk assessment to identify several areas of the program that have the potential to impact cost, including: requirements uncertainty, uncertainty of cost and schedule estimates, human factors risk, and technical dependencies on other programs. To account for estimation uncertainty, the risk team identified low, most likely and high ranges for selected WBS elements.

**TFMS E4**

The LCCE identifies the acquisition and sustainment costs for the new WP4 software functionality. The Facilities and Equipment (F&E) costs for new WP4 capabilities cover the FY 2016 through FY 2022 timeframe and O&M costs cover the period from FY 2016 through FY 2032.

d. **Return on Investment Estimate**

**CATM WP2**

As part of the economic analysis, the B/C ratio, NPV, and payback period were calculated based on risk-adjusted cost and benefit estimates. The B/C ratio and the NPV are calculated using a discount rate based on OMB guidelines, which is 7 percent for this analysis.

Table 17 provides a summary economic analysis.
Table 17

<table>
<thead>
<tr>
<th>Net Present Value (FY08$M)</th>
<th>$ 242.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>B/C Ratio</td>
<td>3.41</td>
</tr>
<tr>
<td>Payback Year</td>
<td>2015</td>
</tr>
</tbody>
</table>

**CATM WP3**

The B/C ratio and the NPV are calculated using a discount rate based on OMB guidelines and on the interest rates for treasury notes and bonds, which for this analysis is 7 percent for NAS user benefits and 2.7 percent for FAA benefits.

Table 18 provides a summary of the economic analysis.

Table 18

<table>
<thead>
<tr>
<th>Net Present Value (FY09$M)</th>
<th>$ 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>B/C Ratio</td>
<td>1.06</td>
</tr>
<tr>
<td>Payback Year</td>
<td>2022</td>
</tr>
</tbody>
</table>

**TFMS E4**

Table 19 provides a summary of the economic analysis for TFMS E4.

Table 19

<table>
<thead>
<tr>
<th>Net Present Value (FY16$M)</th>
<th>$ 246.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>B/C Ratio</td>
<td>8.41</td>
</tr>
<tr>
<td>Payback Year</td>
<td>2021</td>
</tr>
</tbody>
</table>
3. **NextGen Priority List**

The objective of the NextGen Advisory Committee (NAC) is to provide independent advice and recommendations to the FAA and to respond to specific tasks received directly from the FAA. The advice, recommendations, and responses to FAA-assigned tasks relate to concepts, requirements, operational capabilities, the associated use of technology, and related considerations to operations that affect the future of the Air Traffic Management System. In addition, the NAC recommends consensus-driven standards for FAA consideration relating to Air Traffic Management System modernization, which the FAA may adopt.

The FAA, in coordination with the NAC, has developed a prioritization of the NextGen programs that considers the need for a balance between long-term and near-term user benefits with a focus on meeting the NAC’s “high benefit, high readiness” criteria.

**a. Evolution and Refinement of NextGen Priorities**

Since 2009, the FAA and the aviation community have been collaborating on the successful implementation of NextGen in the NAS. A milestone event occurred in July 2013 when the FAA requested the NAC to develop recommendations related to the Agency’s NextGen investments. In light of budget pressures and possible sequestration impacts, the NAC was requested to review current FAA plans and activities and develop a prioritized list of Tier 1 (consensus on activities that should continue no matter what) and Tier 2 (consensus on activities that should continue, resources permitting) recommendations. The NAC followed a process that incorporated an analytic, transparent, repeatable, defensible approach to prioritizing NextGen capabilities and related activities. This approach entailed applying a ranked list of weighted criteria against a candidate list of capabilities and activities. After applying these rankings against a list of 36 NextGen capabilities, the result was an outcome consistent with previous NAC recommendations.

Subsequently, the FAA formalized the collaboration process by publishing the Joint Implementation Plan. The joint plan focuses on delivering tangible implementation benefits across all NextGen focus areas, and aligns the agency’s and the aviation community’s priorities.

The FAA presented the original plan to the U.S. Congress in 2014. The plan included the collaborative work between the FAA and NAC industry stakeholders to commit to milestones across four focus areas: Multiple Runway Operations, Performance Based Navigation, Surface and Data Sharing, and Data Comm, which were all

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18 [https://www.faa.gov/nextgen/nac/](https://www.faa.gov/nextgen/nac/)

19 Letter from Michael P. Huerta (FAA Administrator) to Margaret Jenny (RTCA President) dated July 12, 2013.
codified in the original plan. Work began on a fifth focus area, the NEC, in February 2017. Later that year in October, the initial industry recommendations to implement activities over an 18-month period were presented.

In June 2017, the NAC was tasked by the FAA and presented another set of recommendations to include in the NextGen Advisory Committee NextGen Priorities Joint Implementation Plan CY2018-2021, advancing the time period out to 2021.

The result of this government-industry collaboration is a plan that captures FAA implementation, pre-implementation, and industry milestones. The FAA and aviation community are committed to reporting regularly to track the completion of the milestones, identify risks and mitigations, and analyze benefits.

The history of collaboration between the FAA and the aviation community to prioritize NextGen investments is captured in the following documents:

- NextGen Prioritization, approved by the NextGen Advisory Committee, September 2013
- NextGen Priorities Joint Implementation Plan (2014)
- NextGen Priorities October 2015 Joint Implementation Plan, Revision 1
- NextGen Joint Implementation Plan 2016
- NextGen Priorities Joint Implementation Plan, Rolling Plan 2017-2019
- NextGen Priorities October 2017 Joint Implementation Plan Update Including the Northeast Corridor
- NextGen Advisory Committee, NextGen Priorities Joint Implementation Plan CY2019-2021

b. Current NextGen Priorities

The NAC NextGen Priorities Joint Implementation Plan CY2019-2021, published in June 2019, contains milestones agreed to by FAA and industry, for implementation through 2021, in four focus areas: Multiple Runway Operations, Performance Based
Navigation, Surface and Data Sharing, and Data Communications. The Northeast Corridor (NEC), the busy airspace between Washington, D.C., and Boston that includes Philadelphia, New York City, and associated airspace, is also included in the plan as an additional NextGen Priority area, ensuring enhanced operations in the most congested airspace in the NAS.²⁸

The FAA and industry have identified commitments within each of the focus areas and the Northeast Corridor to increase safety; reduce aviation’s impact on the environment; enhance controller productivity; and increase predictability, airspace capacity, and efficiency. The FAA and industry will continue to monitor joint progress and be agile and flexible, making adjustments to commitments as necessary.

**Focus Area: Multiple Runway Operations**

The efficiency of parallel runways, particularly those that are closely spaced, has been limited by the interplay of wake vortices with nearby aircraft. New technology in the cockpit, and due diligence in examining safety standards for closely spaced parallel runway operations (CSPO), have enabled the FAA to advance its procedures and tools to improve runway capacity in all weather conditions. Multiple Runway Operations (MRO) capabilities improve access to these runways and can increase basic runway capacity and throughput by reducing separation between aircraft based on improved wake categorization standards through Consolidated Wake Turbulence (CWT). Improved access will enable more arrivals and/or departures during instrument meteorological conditions, which will increase efficiency and reduce flight delays. These commitments are a subset of the overall series of programs and activities that the FAA has planned to address.²⁹

**Focus Area: Performance Based Navigation**

The FAA is moving to a performance based navigation (PBN) NAS and has published the NAC-endorsed *PBN NAS Navigation Strategy*.³⁰ With PBN, the FAA delivers new routes and procedures that primarily use satellite-based navigation and on-board aircraft equipment to navigate with greater precision and accuracy. PBN provides a basis for designing and implementing automated flight paths and redesigning airspace near obstacles for increased access. Benefits include shorter and more direct flight paths, improved airport arrival rates, enhanced controller productivity, increased safety due to repeatable and predictable flight paths, fuel savings, and a reduction in aviation’s environmental impact. These commitments are a subset of the overall series of PBN activities the FAA is planning to implement.³¹

²⁸ [https://www.faa.gov/nextgen/snapshots/priorities/](https://www.faa.gov/nextgen/snapshots/priorities/)
²⁹ [https://www.faa.gov/nextgen/snapshots/priorities/?area=mro](https://www.faa.gov/nextgen/snapshots/priorities/?area=mro)
³⁰ [https://www.faa.gov/nextgen/media/pbn_nas_nav.pdf](https://www.faa.gov/nextgen/media/pbn_nas_nav.pdf)
³¹ [https://www.faa.gov/nextgen/snapshots/priorities/?area=pbn](https://www.faa.gov/nextgen/snapshots/priorities/?area=pbn)
The FAA has established a network of thousands of precisely defined PBN routes and procedures to improve air traffic flow efficiency to and from airports throughout all phases of flight. A PBN-centric NAS harmonized with Time Based Management (TBM) will enable Trajectory Based Operations (TBO) in the future. TBO is an air traffic management method for strategically planning, managing, and optimizing flights throughout the operation by using TBM, information exchange between air and ground systems and an aircraft’s ability to fly precise paths in time and space through PBN.

**Focus Area: Surface Operations and Data Sharing**

Some of the greatest efficiencies can be gained while an aircraft is still on the ground and at the gate, and when connecting the surface to the en route airspace. The FAA commits to implementing near-term surface improvements, sharing more data with stakeholders, and completing feasibility assessments of some other capabilities of interest. The goal of these enhancements is to measurably increase predictability and surface efficiency. These commitments are a subset of the overall series of programs and activities the FAA is planning to improve operations in these domains.³²

The NAC developed a set of commitments for surface and data sharing including Terminal Flight Data Manager (TFDM), a tower-based system that improves surface management and efficiency. TFDM supports new services that automate current manually-intensive operations and replaces outdated systems in the tower. The introduction of TFDM into the NAS is a key building block for the FAA’s TBO concept.

The remaining commitments involve Airspace Technology Demonstration 2 (ATD-2), the Integrated Arrival/Departure/Surface (IADS) field demonstration at Charlotte Douglas International Airport (CLT). This initiative was launched in collaboration with NASA in September 2017. ATD-2 capabilities will help the FAA increase NAS benefits for TFDM, and aid with implementation of TBO. The FAA’s goal of establishing TBO in the NAS is to maximize airspace capacity and efficiency with more sophisticated and seamlessly integrated information about the future position of aircraft, while maintaining safety and minimizing environmental impacts.

**Focus Area: Data Communications**

The Data Communications (Data Comm) program will provide digital communications services between pilots and air traffic controllers as well as enhanced air traffic control information to airline operations centers. Data Comm will provide a direct link between ground automation and flight deck avionics for safety-of-flight clearances, instructions, traffic flow management, flight crew requests and reports.

³² [https://www.faa.gov/nextgen/snapshots/priorities/?area=sops](https://www.faa.gov/nextgen/snapshots/priorities/?area=sops)
Data Comm technology is critical to the success of NextGen, enabling efficiencies in both technology and human factors not possible with the current voice system. These services will enhance safety by reducing communication errors, increase controller productivity by reducing communication time between controllers and pilots, and increase airspace capacity and efficiency while reducing delays, fuel burn and carbon emissions.\(^{33}\)

**Focus Area: Northeast Corridor**

The Northeast Corridor (NEC) is defined as the airspace that spans from Washington, D.C. to Boston, including Philadelphia and the New York area. The NEC contains the most congested airports and airspace in the United States, and has a significant effect on the daily operations of the NAS. Nearly 50 percent of aviation delays in the NAS are attributable to the Northeast Corridor. Given the complex and compact nature of NEC operations, and its connection to the rest of the NAS, single operational improvements can have significant savings in time, particularly during weather events. These enhancements establish a foundation and framework for longer-term implementation of NextGen using time-based management techniques and precise, repeatable PBN procedures for a more predictable and efficient operation.

Applying TBO capabilities in the NEC is a key part of the FAA’s implementation strategy for TBO. TBO is expected to result in more efficient use of system capacity by maximizing airspace and airport throughput, improving operational predictability through more accurate gate-to-gate strategic planning, enhancing flight efficiency through integrated operations, and increasing operational flexibility through increased user collaboration regarding trajectories and priorities.

The recommended implementations for the NEC are designed to address key issues that negatively impact operational performance today. This includes mitigations that address adverse weather, a major issue in the NEC. Each implementation includes both FAA and industry commitments. Because of interdependencies among the NEC initiatives, and the associated impact on the national aviation system, it is important to continually assess and address, as needed, to ensure that system improvements are occurring and dependent milestones are being met. Some primary themes for the NEC recommendations are deconflicting arrivals into the New York area, improving arrival and departure throughput, easing congestion points, and addressing community noise.\(^{34}\)

\(^{33}\) [https://www.faa.gov/nextgen/snapshots/priorities/?area=dcom](https://www.faa.gov/nextgen/snapshots/priorities/?area=dcom)

\(^{34}\) [https://www.faa.gov/nextgen/snapshots/priorities/?area=nec](https://www.faa.gov/nextgen/snapshots/priorities/?area=nec)
4. Conclusions

In response to Section 503 of H.R. 302, the FAA Reauthorization Act of 2018, this report has documented the ROI of each major acquisition program within the NextGen Facilities and Equipment budget:

- ADS-B (Automatic Dependent Surveillance – Broadcast), which includes Surveillance Broadcast Services (SBS) Future Segments
- AIMM (Aeronautical Information Management Modernization) Segment 2 (S2)
- CSS-Wx (Common Support Services – Weather)
- Data Comm (Data Communications) Segment 1 Phase 1 (S1P1) and Segment 1 Phase 2 (S1P2)
- ERAM (En Route Automation Modernization) Enhancements 2 (EE2)
- NWP (NextGen Weather Processor)
- SWIM (System Wide Information Management) Segments 1, 2A, and 2B
- TBFM (Time Based Flow Management) Work Package 2 (WP2) and Enhancement 1
- TFDM (Terminal Flight Data Manager)
- TFMS (Traffic Flow Management System) / Collaborative Air Traffic Management Technologies (CATMT) Work Package 2 (WP2), Work Package 3 (WP3), and Enhancement 4 (E4)

With the exception of EE2, each of these programs, as baselined, indicated a positive return on investment. EE2 increases the safety and efficiency of ERAM’s operational services; these capabilities were requested by ERAM users and our international ANSP partners, and are primarily infrastructure enhancements for which benefits were not monetized.

This report also summarizes the most recent NextGen priority list that reflects the need for a balance between long-term and near-term user benefits. The current priorities consist of five focus areas:

- Multiple Runway Operations
- Performance Based Navigation
- Surface and Data Sharing
- Data Communications
- Northeast Corridor

The FAA and industry have identified commitments within each of the focus areas to increase safety; reduce aviation’s impact on the environment; enhance controller productivity; and increase predictability, airspace capacity, and efficiency.