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McLean, VA

Center for Advanced Aviation System Development

Executive Summary: NextGen Independent Assessment and Recommendations

FAA Request for NextGen Independent Assessment and Recommendations

The Next Generation Air Transportation System (NextGen) is a transformation of the nation's Air Traffic Management (ATM) system developed in response to the Vision 100—Century of Aviation Reauthorization Act. While the Federal Aviation Administration (FAA) and aviation community have made considerable strides toward this transformation, it is time to take stock of where NextGen is today, and refine plans and expectations for further development. Consequently, the FAA directed The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) to conduct an independent assessment of NextGen and provide recommendations to achieve a realistic set of capabilities by 2020, reset NextGen expectations for 2020, and influence planning for post-2020 NextGen operations. The assessment first determined progress made to date toward achieving NextGen capabilities and infrastructure as documented in the FAA's "NextGen Mid-term Concept of Operations" and NextGen Implementation Plan of 2009. Next, MITRE assessed what NextGen capabilities could reasonably and realistically be implemented by 2020. Our assessment did not consider detailed cost information. However, our recommendations include FAA cost-effectiveness as an objective. The recommendations were developed using the results of the assessment and MITRE's insights into the status of FAA and aviation community activities toward NextGen and the needs and priorities of the FAA and the aviation community. Achieving NextGen benefits will take many years, and the assessment and recommendations are intended to inform the FAA and stakeholder community deliberations on needed actions. This report summarizes the findings and documents the recommendations.

Summary of Findings and Recommendations

The FAA and the aviation community have made substantial progress toward achieving the NextGen foundation since 2008, and National Airspace System (NAS) infrastructure modernization is well underway. Most spending up to this point has been on infrastructure; most of the transformation and foundational infrastructure will achieve an initial baseline by 2015, with data communications services and others by 2020. We found that the FAA and the aviation community have made progress in delivering enhanced operational capabilities and services for airports and metropolitan areas (e.g., more efficient airport arrival, departure, and approach procedures) that are starting to provide benefits to many stakeholders. However, these capabilities and services are not yet widely available and not all aircraft operators have chosen to equip their aircraft with the necessary avionics to fully leverage them; thus the benefits are not accruing uniformly across the community. Consequently, there are different perceptions within the community about the amount of progress the FAA has made on NextGen implementation.

We found that there are many gaps between the FAA's documented descriptions of NextGen and what can reasonably be accomplished by 2020.

These expected gaps are due largely to three fundamental challenges:

1. **Operational Transition:** There is a need for more effective transition planning for maturing NextGen capabilities (including training on intended operational use and the development of procedures and best practices for their use) synchronized with the user community. This is the largest gap affecting operational use and delivery of benefits.
2. **User Adoption:** Aircraft owners and operators need to equip their aircraft with new avionics that provide aircraft capabilities needed for the planned NextGen operational capabilities and service to be used effectively.

3. **Technical Maturity:** Some concepts and technology are not mature enough to meet the complete NextGen vision outlined in 2008. These elements are not yet ready for implementation by 2020.

The evolution of the NAS will have to be scalable, affordable, and resilient to accommodate a wider range of aircraft operations. The future operations include unmanned aircraft vehicles, changes in domestic and international air traffic, more seamless global operations, higher efficiency and predictability benefits expectations from current operators of the NAS, and more cost-effective service delivery for the United States (U.S.) government and the aviation community.

Recommended actions either remedy the gaps or acknowledge the gaps and suggest adjustments to the plans for the FAA, along with aviation stakeholders, to consider in developing an achievable plan for moving forward with NextGen.

As a result, our recommendations reflect what is required to build a sustainable NAS for all current and future types of operators within six strategic focus areas, for 2020 and beyond:

1. **Deploy transformational and foundational systems.**
    - The FAA has made substantial progress replacing highly constrained legacy infrastructure. The FAA must ensure to complete the transition to the new infrastructure.
    - Certain aspects of the transformational and foundational infrastructure that are not sufficiently mature (specifically, data communication using Aeronautical Telecommunication Network Baseline 2 and surface data communication, future aeronautical information management and common weather enhanced services, and surface modeling) require additional standards or concept development prior to committing resources toward implementation.
    - For non-safety-critical operational services, the recommendations include a transition to the use of agile development and acquisition approaches to improve operational transition and allow less mature capabilities to be matured through field engagement.
2. **Maximize operational use of available aircraft and ground capabilities.**
    - The largest gap affecting operational use and delivery of benefits is the operational transition of NextGen capabilities. Focus is required to achieve operational use, including for the priority NextGen Advisory Committee recommendations.
    - Airspace redesign and procedural enhancements should be implemented to address most known operational and efficiency needs for Metroplex and priority airports. This includes completing existing Metroplex activities, expanding Metroplex activities to the most beneficial additional locations, integrating metering operations as part of these Metroplex improvements, and implementing mature multirunway procedures at priority airports.
    - At the current pace of equipage, the aviation community will not meet the 2020 mandate for Automatic Dependent Surveillance-Broadcast. The FAA must clearly communicate consequences of mandate non-compliance and work with the operator community to increase equipage.
3. **Procedurally permit initial operations of new entrants (unmanned aircraft systems [UAS] and Commercial Space Vehicles [CSVs]) leveraging existing policy, and introduce new rules to enable their evolving operations.**
    - The transition path and plan for integration in the NAS for CSVs and UAS needs community buy-in.

- By 2018, the FAA and stakeholders should reach agreement on a detailed roadmap for defining the policy, equipage standards, operational concepts, and automation requirements that can be achieved through 2025 and beyond to enable routine integration of UAS operations.
- Procedural solutions should be developed with early adopters to address both operational transition and user adoption gaps.

4. **Eliminate surplus capabilities and services to promote transition to new NextGen services and reduce costs.**
    - The key gaps are operational transition, specifically efforts to discontinue legacy services as new NextGen services come on line, and concept maturity for the future work environment. The planned facility streamlining (i.e., consolidation and realignment) process should be executed using available funds as soon as possible, as should additional facility realignment authority beyond that provided by Section 804 of the FAA Modernization and Reform Act of 2012. In addition, remote operations for selected tower services should be implemented to further reduce FAA operating costs.
    - Future plans for automation infrastructure replacement and technology refresh should be aligned with development and demonstrations of NextGen service delivery in the future environment.
5. **Integrate NAS-wide operations and performance management to deliver expected end-to-end service.**
    - Current NextGen efforts will result in optimized operations from a local facility perspective. The NextGen vision includes utilizing NextGen capabilities to achieve operational improvements that enhance the end-to-end performance and predictability of the NAS. To achieve the vision, the FAA needs to align its structure, policies, incentives, and procedures to address system-wide issues associated with integrating new operational capabilities into the NAS. This activity should leverage the leadership and innovative ideas of today's Air Traffic Control workforce to deliver high-performing NAS operations through use of new NextGen capabilities by tomorrow's workforce.
    - The FAA should develop an integrated (i.e., holistic) approach for air traffic controller training to ensure its alignment with NextGen operations.
    - The FAA should defer the development of requirements for flexible airspace improvements and future facilities until the key NextGen concepts for the future work environment are demonstrated.
6. **Integrate advanced aircraft-centric[1] operations to coincide with the next major forward fit of the fleet.**
    - The key gap in this area is the lack of user adoption of required avionics technologies, due largely to the lack of maturity in the concept and business case for advanced operations. The FAA should develop an integrated CNS air-ground plan in the next 12 to 18 months to ensure a realistic and coordinated approach to having the needed CNS

[1] Aircraft-centric operations allow ATC to take advantage of the capabilities on the aircraft and in automation rather than compensate for the limitations of today's system. Aircraft reliably and predictably execute instructions communicated digitally and fly precisely as intended, making their flight paths more reliable and their movements more predictable. Controllers and traffic flow managers have more flexibility to route traffic, giving them greater flexibility for unexpected conditions like weather because they can rely on being able to communicate changes to traffic flows more quickly and efficiently.

concepts and standards defined no later than 2022 to influence the next phase of aircraft purchases and maintain global leadership.

- The FAA should defer development and implementation activities for Trajectory-Based Operations (TBO[2]) with integrated avionics until the concept is mature and implementation plans are aligned with fleet forward fit.

Clearly, the FAA and industry have achieved good progress with measurable benefits at this point in NextGen's implementation, though much work remains. Many significant NextGen operational improvements are still needed. The years 2014 and 2015 are critical for the FAA. In these years, many acquisition decisions about the NextGen transformational programs and other key infrastructure programs must be made to deliver NextGen operational capabilities and services by 2020. Furthermore, the FAA's focus must broaden from one of deploying infrastructure to one of transitioning the new and enhanced capabilities into effective operational use.

[2] TBO leverages aircraft-centric operations along with conflict resolution and other controller tools to change the way airspace and aircraft are managed in the future work environment.

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NextGen—A National Priority

NextGen is a long-term transformation that relies on emerging Communications, Navigation, and Surveillance technologies onboard aircraft.

Much remains to be done, and the landscape has changed significantly since the original vision and plans were drafted.

The Next Generation Air Transportation System (NextGen) is a transformation of the nation's Air Traffic Management (ATM) system developed in response to the Vision 100—Century of Aviation Reauthorization Act, with a target date for completion of 2025. The goals of this large-scale transformation are to improve the level of safety, security, efficiency, and affordability of the National Airspace System (NAS). In addition to these direct benefits, NextGen operations will accommodate a wider range of aircraft operations, including Unmanned Aircraft System (UAS) operations, and alignment with international operations.

Recognizing that Vision 100 relies on Communications, Navigation, and Surveillance (CNS) technologies onboard aircraft, the act compels participation of experts from government agencies and the private sector to develop the concepts and plans for NextGen. The private sector participants include commercial aviation, general aviation, aviation labor groups, aviation research and development entities, aircraft and Air Traffic Control (ATC) system suppliers, and the space industry. Each stakeholder owns a part of this transformation.

The NextGen challenge is to balance the transformation to new, improved services while simultaneously delivering ongoing benefits, such as reducing delays, saving fuel, and lowering aircraft exhaust emissions. Achieving this transformation entails integrating new and existing technologies, and updating ATM policies and procedures.

Much work remains, and the landscape has changed significantly since the original NextGen vision and plans were drafted. The nation's financial situation has made aviation-related budgets challenging, with an ever-increasing emphasis on government cost efficiencies. The nation's aviation needs also fluctuate with changes in demand, fuel prices, and security events. In addition, rapid advances in technology are constantly presenting new opportunities for developing enhanced capabilities that did not seem possible just a few years ago, including the development of new kinds of aircraft. Therefore, maintaining and investing in a consistent vision of the future have proved difficult.

NextGen is approaching the midpoint in the envisioned 20-year transformation (2005–25). The Federal Aviation Administration (FAA), along with aviation stakeholders, needs to develop an achievable plan for moving forward with NextGen, given all the change factors mentioned above. Once the FAA communicates this plan, the aviation community, along with oversight organizations, can work together more effectively to make NextGen a reality.

Taking Stock of NextGen: An Independent Assessment

The FAA directed The MITRE Corporation to conduct an independent assessment.

MITRE's three-step approach considered infrastructure deployment, fleet equipage readiness, and operational service realized as key factors in determining NextGen progress.

Our recommendations for how to proceed toward 2020 and beyond are the culmination of our independent assessment of NextGen performed at the direction of the FAA's NextGen Office. The work began with an assessment of NextGen progress to date, and grew to include a projection of what NextGen will likely be by 2020, and an analysis of changes that have occurred in the plans.

The recommendations resulting from these assessment steps are intended to inform and influence FAA planning for what can be achieved for NextGen by 2020. This NextGen progress can only be made with the active participation of the aviation community and by acting now.

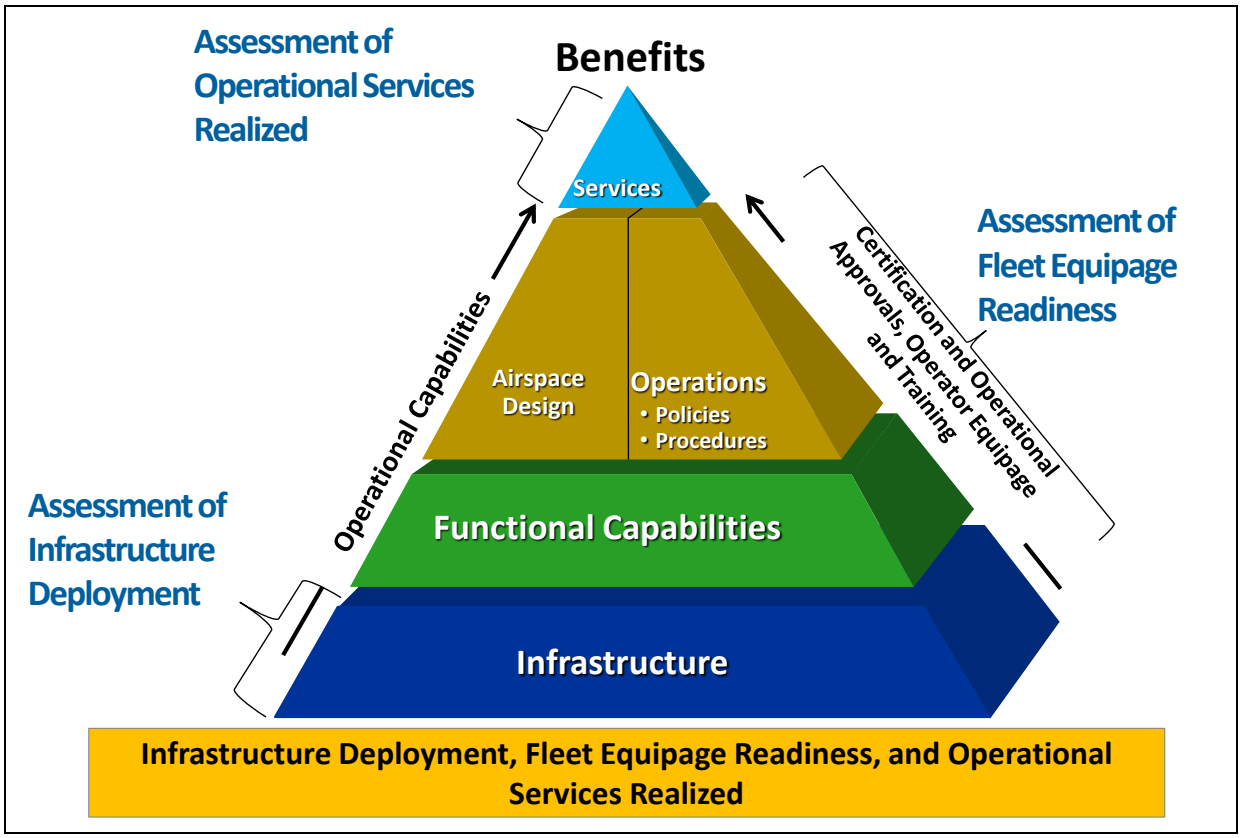
We used a three-step approach to accomplish the independent assessment. First, we assessed NextGen progress to date (2014). We looked at which operational services and transformational/modernization infrastructure programs the FAA and aviation community have already implemented.

Second, we projected what the FAA and aviation community would likely accomplish toward the NextGen vision by 2020 in terms of both realizing operational services and completing infrastructure modernization. We based our assessment and definition on existing FAA documents such as the NextGen Implementation Plan, Capital Investment Plan, and NAS Enterprise Architecture and Operational Improvements. We also relied on the FAA's NextGen Mid-Term Concept of Operations, and our own insights, as the basis for developing that realistic vision of NextGen operations by 2020.

Third, based on assessment results and the context of the current environment, we developed recommendations for the FAA to ensure success in getting to NextGen capabilities by 2020. Our recommendations account for various external and internal factors affecting implementation, such as aircraft fleet readiness and program maturity.

Figure 1 depicts the areas we assessed.

Figure 1: Assessment Framework



The three key areas of our assessment were:

- **Infrastructure Deployment:** We used the FAA's NAS Enterprise Architecture, other planning artifacts, and our own insights about specific infrastructure programs to present both current status and a projection for 2020 deployment.
- **Fleet Equipage Readiness:** For many proposed NextGen improvements, aircraft-based capabilities are critical to operational services success. We used our understanding of the current and future state of fleet readiness to project realistic expectations of what can be deployed by 2020, and what is likely to be deferred beyond that date.
- **Operational Services Realized:** In addition to FAA planning and status documents, such as the NextGen Segment Implementation Plan, we used our insights into operations to analyze progress on specific capabilities that are being deployed by 2020.

We did not consider detailed cost information in our assessment. However, our recommendations do include FAA

cost-effectiveness as an objective. The remainder of this document contains the following sections:

- **NextGen: Progress to Date and Remaining Gaps**: Summary of the NextGen progress assessment results
- **NextGen: Maintaining a Strategic Focus**: Description of a strategic framework for achieving NextGen
- **Recommendations: Making NextGen Happen, for 2020 and Beyond**: MITRE recommendations for moving forward on NextGen

We provide a prioritized list of proposed NextGen capabilities to inform the FAA's consideration of investment trade-offs in the final section. Appendices A through C document the details of our assessment efforts.

- **Appendix A:** Summary of Findings from the Independent Assessment of NextGen
- **Appendix B:** Additional Background and Rationale for the Recommendations
- **Appendix C:** An Operational View of NextGen by 2020 and the Path Beyond

NextGen: Progress to Date and Remaining Gaps

The FAA and aviation community have made good progress toward achievement of the NextGen vision, but significant gaps and challenges remain

Our assessment showed that the FAA and the aviation community have made substantial progress toward achievement of the NextGen foundation since 2008. NAS infrastructure modernization is well underway, and enhanced operational capabilities, procedures, and services are delivering some targeted operational benefits today. Aircraft capabilities are well advanced in some areas, but have been slow to advance in others. This section highlights, through selected examples, our assessment findings on the progress to date and on the gaps that are expected to remain by 2020. Appendix A of this report provides a more detailed summary of our findings, and a separate report, *Independent Assessment of the NextGen Plans-Revised*,[3] fully documents them.

The assessment evaluated our estimate of expected progress by 2020 to the NextGen capabilities and infrastructure as documented in the FAA's "NextGen Mid-term Concept of Operations" and NextGen Implementation Plan of 2009. In cases where the mid-term concept did not address key evolving operations (e.g. increased use of the NAS by UAS and commercial space vehicles [CSVs]), we extended the assessment to include those operations. The assessment did not include an assessment of relative importance, practicality, nor benefits. The recommendations documented in this report were informed by the assessment results, but also took other information and factors into account.

The gaps discussed in this section are limited to those that we found most pertinent to the recommendations. One example of an identified gap that is not pertinent to the recommendations is the concept of "generic airspace." FAA service analysis of this concept has not resulted in a compelling business case; hence, the FAA has deferred the concept indefinitely. Though it is a gap relative to the mid-term concept, it is not a gap that needs to be addressed.

We found that many of the gaps are due to the three fundamental challenges:

1. **Operational Transition:** There is a need for more effective transition planning for maturing NextGen capabilities (including controller/pilot training on intended operational use, the development and integration of procedures, mixed equipage environments, international harmonization, and best practices for use and benefits) synchronized with the user community. This is the largest gap affecting operational use and delivery of benefits.

[3] The MITRE Corporation, "Independent Assessment of the Next Generation Air Transportation System (NextGen) Plans – Revised," F150-B14-002, 27 August 2014, The MITRE Corporation, McLean, VA.

2. **User Adoption:** Aircraft owners and operators need to equip their aircraft with new avionics that provide the capabilities needed for the planned NextGen operational capabilities and services to be used effectively.

3. **Technical Maturity:** Some concepts and technology are not mature enough to meet the complete NextGen vision as outlined in 2008. These elements are not yet ready for implementation by 2020.

We did not assess the adequacy of the FAA's budgets for NextGen capability development, deployment, and operational transition. Although FAA budget shortfalls have contributed to some of the gaps, many of the identified gaps exist for other reasons. The formulation of solutions to address the gaps must consider both fiscal resources and other means, such as policy generation or prioritizing and focusing development and deployment on a smaller number of select capabilities.

Infrastructure progress and gaps

The assessment showed that the FAA and the aviation community have made substantial progress toward achievement of the NextGen foundation since 2008 and that NAS infrastructure modernization is well underway. Most spending up to this point has been on infrastructure; most of the transformation and foundational infrastructure will achieve an initial baseline by 2015, with Data Comm and others by 2020. Of particular positive note is the completed deployment and nearly completed integration of the Automatic Dependent Surveillance-Broadcast (ADS-B) ground infrastructure, and the substantial deployment of Collaborative Air Traffic Management Technologies (CATM-T). In addition, good progress has been made on other key infrastructure programs:

- The En Route Automation Modernization (ERAM) and Time-Based Flow Management (TBFM) programs will complete their baseline capability deployment by 2015.
- Ground-Based Augmentation System (GBAS) development for Category (CAT) I operations is complete; the capability is ready and the remaining action is airport authority procurement and installation.

However, there are infrastructure modernization gaps that will not be fully closed by 2020:

- Flexibility to reallocate (i.e., redistribute) communications, surveillance, and flight trajectory data needed for more collaborative strategic traffic management

- Automation enhancements for probabilistic constraint prediction and development of more effective Traffic Management Initiatives (TMIs)
- Staffed NextGen Towers for increased service delivery efficiency
- Automation enhancements for metering, merging, and sequencing in terminal airspace
- Transitioning NAS automation systems to use of NextGen weather infrastructure services, and the concomitant decommissioning of legacy weather processors and interfaces
- Completed standards for GBAS CAT II and CAT III approaches

ATM operations progress and gaps

In regard to ATM operational capability and service enhancement, several significant improvements that leverage existing aircraft capabilities are delivering operational benefits at one or more sites:

- Closely Spaced Parallel Operations (CSPO) improvements are increasing capacity and efficiency during low-visibility conditions at airports that have closely spaced parallel runways, such as San Francisco International Airport.

- Aircraft spacing improvements have resulted from wake turbulence analysis and changes to the separation criteria. These improvements are increasing arrival and departure capacities at several airports, including those in Boston, Cleveland, Houston, Louisville, Memphis, Miami, Philadelphia, San Francisco, and St. Louis.

- New procedures, restructured routes, reduced separation criteria, and tailored arrivals are reducing fuel consumption for some flights traversing the Pacific Ocean and the Gulf of Mexico.

- New airspace designs and Performance-Based Navigation (PBN) procedures implemented through the FAA's Metroplex and other redesign initiatives are improving overall system efficiency in several busy areas, including Denver, Houston, and Washington, DC.

- The continued shift to PBN throughout the NAS is improving safety, access, capacity, predictability, operational efficiency, and environmental effects. Included in this shift are new Area Navigation (RNAV)

and Required Navigation Performance (RNP) approach procedures.

- Increased use of existing automation system capabilities is improving operations. For example, the Converging Runway Display Aid (CRDA) is improving operations in additional terminal areas that involve intersecting or converging arrival runways or approaches.

However, there are ATM operations gaps that remain in 2020, some that involve aircraft capabilities where early adopters who have equipped will not accrue benefits and other capabilities where the overall flexibility and predictability of the NAS will not experience the improvements envisioned in the midterm concept:

- Use of flight plan data to determine which routes best meet user needs based on aircraft equipage and performance capabilities
- Use of higher complexity, more dynamic collaborative capabilities for strategic traffic management
- Use of ADS-B In capabilities for CAT I and CAT II Paired Approach operations
- Flight deck-based Interval Management-Spacing (IM-S) operations to high-density airports
- Pairwise delegated aircraft-to-aircraft separation
- Time-of-arrival control operations integrated within broader metering concepts
- Complex, data-linked clearances to enable precise metering and four-dimensional (4D) trajectory management in en route and terminal airspace

Aircraft capability progress and gaps

In regard to aircraft capability advancement, our assessment showed that the Air Transport fleet is primarily being equipped via forward fit opportunities as new aircraft replace older aircraft. This is particularly evident today for PBN capabilities. The U.S. Air Transport fleet is nearly completely equipped and capable to perform most PBN procedures, including RNP 10, RNP 4, RNAV 2, and RNAV 1. more than half the fleet is equipped and capable to perform Vertical Navigation (VNAV), RNP 1 with Curved Path, and RNP Authorization Required (AR) procedures. Retrofitting legacy aircraft is not nearly as robust, although various FAA-funded pilot programs, such as for Data Comm, are enabling some near-term equipage.

The long-term picture is unclear. To date, there is very little (less than 3 percent) ADS-B Out equipage in the Air Transport fleet, despite the January 2020 effective date of the FAA's equipage mandate. Based on similar historical retrofit programs and considering that some fleets of aircraft do not yet have certified ADS-B systems available for purchase, the remaining time may not be sufficient for all operators to equip their aircraft. Gaps also are expected in fleet equipage for low-visibility operations via Enhanced Flight Vision Systems and Synthetic Vision Systems, cockpit situational awareness via ADS-B In capabilities, precision approach operations via GBAS capabilities, and complex clearance delivery via Data Comm. As a result of differences in level of equipage across the fleet and capabilities by location, perceptions within the community about the amount of progress the FAA has made on NextGen implementation vary.

Summary

Clearly, the FAA and industry have made good progress to date implementing NextGen, though much work remains to be done. Many significant NextGen operational improvements are still needed. The years 2014 and 2015 are critical for the FAA. In these years, many acquisition decisions about the NextGen transformational programs and other key infrastructure programs must be made to deliver NextGen operational capabilities and services by 2020. Furthermore, the FAA's focus must broaden from one of deploying infrastructure to one of transitioning the new and enhanced capabilities into effective operational use. The next section describes a recommended framework for maintaining the needed strategic focus, and the subsequent section presents our specific recommendations for ensuring successful NextGen implementation.

NextGen: Maintaining a Strategic Focus

Six strategic NextGen themes to build a "sustainable" NAS for all.

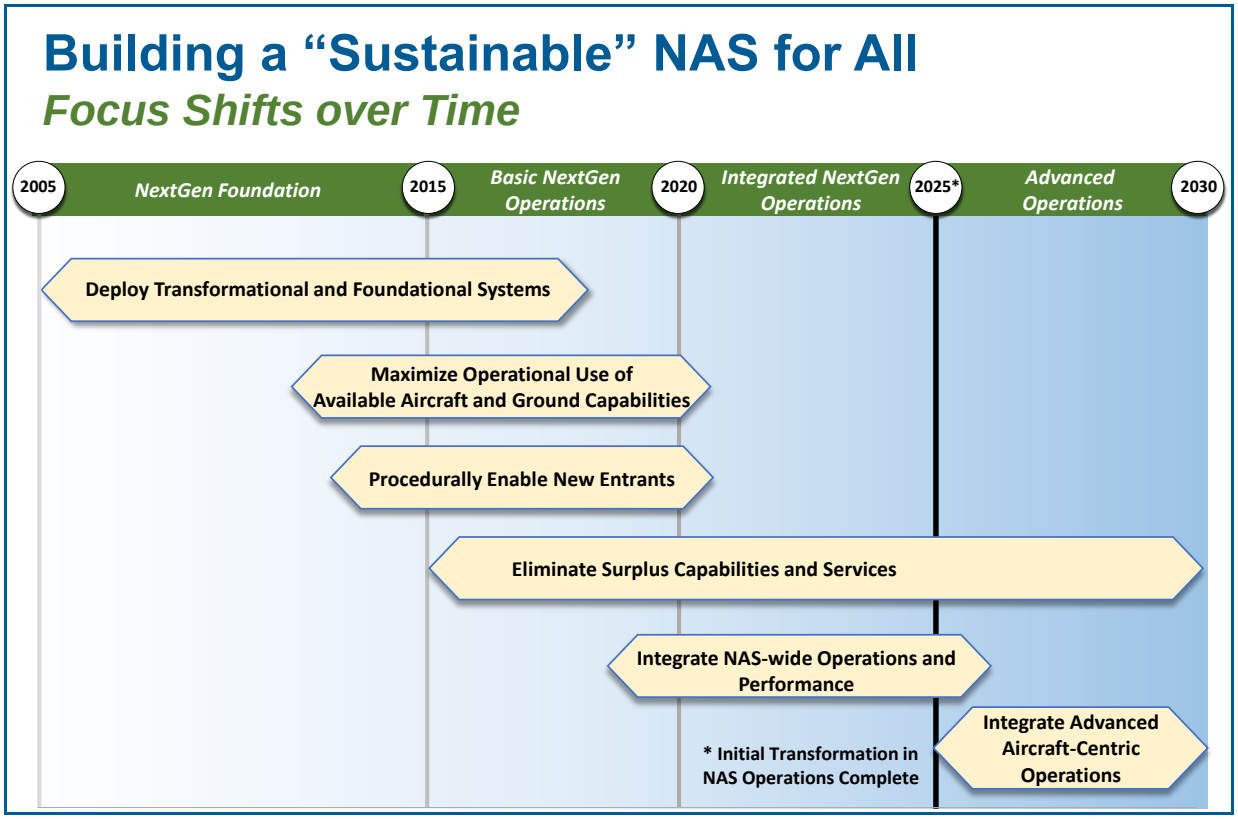
Achieving NextGen and realizing its benefits will take many years. Evolving a transformational change in infrastructure and operations between the government and the aviation community must ensure safety and economic viability through the transition.

During our assessment, we developed a framework to look strategically at the NextGen transition. Figure 2 presents the framework, titled "Building a 'Sustainable' NAS for All." By "sustainable," we mean a scalable and resilient NAS that delivers capabilities and benefits to current operators of the NAS, is adaptable to serve new entrants in the NAS, and is cost-effective for the U.S. government and the aviation community. Sustainability of the NAS also includes maintaining the nation's safety, security, and economic viability.

The framework offers a top-level view of where and when to focus on implementing NextGen over time, and may prove useful in gaining stakeholder agreement on the why, what, and when of NextGen implementation.

Moving forward, NextGen success will depend on the FAA completing deployment of key infrastructure, making better use of current operational capabilities, and then pursuing advanced concepts that eventually enable the full realization of NextGen operations. The initial transformation of NAS operations, enabled by the use of integrated NextGen capabilities, is expected to be achieved by 2025. The next part of the transformation originally defined in the NextGen vision will be through advanced aircraft-centric operations that are dependent on the fleet replacements expected in the post-2025 timeframe.

Figure 2: Building a "Sustainable" NAS



Deploy Transformational and Foundational Systems

The FAA must complete the replacement of automation that supports all phases of flight and transition to a more flexible CNS system so that it can develop future operations that are scalable and independent of specific facility locations. The FAA must use modern technologies to exchange business-essential information across the NAS and airspace users.

Achieving NextGen depends on implementing significant new automation-enabled operational capabilities (this would have been very difficult and more costly with the legacy ATM automation systems). Upgrading the infrastructure will enable the FAA to focus on developing advanced capabilities that achieve operational benefits for the FAA and aviation stakeholders.

Maximize Operational Use of Available Aircraft and Ground Capabilities

Because of progress made, the aviation community can address the most pressing local shortfalls, such as surface, multi-runway, and airspace inefficiencies at key Metroplex areas, by better leveraging the current ground-based (e.g., ATM automation) and aircraft-based navigation capabilities to see the initial benefits of NextGen. However, near-term gains will not be fully realized without instituting new procedures and policies, such as flow management practices, that integrate existing capabilities and new tools for metering, merging, and rerouting to enable NextGen operations today.

Procedurally Enable New Entrants

Between now and 2020, a primary source of demand growth will come from new airspace users, such as UAS, CSV, and the evolving passenger aircraft fleet, all bringing new demands to the NAS. Enabling these operations requires developing operational specifications for use of the NAS. Between now and 2020, procedural and policy solutions, such as new flow/airspace management techniques, will allow a minimal capability to balance access of new entrants with legacy air traffic operations. After 2020, these techniques will lead to automation system requirements for full integration as demand grows.

Eliminate Surplus Capabilities and Services

As the FAA and the aviation community implement and deploy capabilities necessary to achieve NextGen, there must be a greater focus on phasing out surplus capabilities, procedures, and services. Between now and 2020, the focus is on discontinuing legacy capabilities; longer term, the strategy must shift to restructuring the inventory to deliver more scalable, adaptable, and resilient services. The rationale for this is twofold: 1) ensuring cost efficiency of the FAA and operators, and 2) ensuring that both the FAA and operators adopt NextGen capabilities and realize NextGen operational and efficiency benefits.

Integrate NAS-Wide Operations and Performance

Maximizing operational use of available aircraft and ground capabilities is the focus until 2020. The emphasis should then shift to transitioning to an environment focused on predictable NAS-wide system performance. Predictability will be achieved through an integrated approach across domains, to meet possible ranges of future demand from all airspace users. It requires that the FAA decouple facility locations from their controlled airspace. Then, the FAA should develop ATM decision-making approaches to ensure that operational decisions align with other operational decisions. Integrating the initial elements of NextGen should be the focus of the 2020–2025 transition to the work environment of the future.

Integrate Advanced Aircraft-Centric Operations

Many of the proposed advanced operational capabilities in NextGen have significant dependencies on integrated ground-based and advanced aircraft-based capabilities. These capabilities must consider aircraft fleet evolution. Therefore, the FAA should develop a realistic plan, with manufacturers and other stakeholders, for post-2020 implementation of advanced aircraft-centric operations. The long lead time for fleet equipage of new capabilities means standards and concept development for these advanced operations must continue. The challenge of changing international requirements represents risk for operators and manufacturers, so harmonization efforts must continue as well.

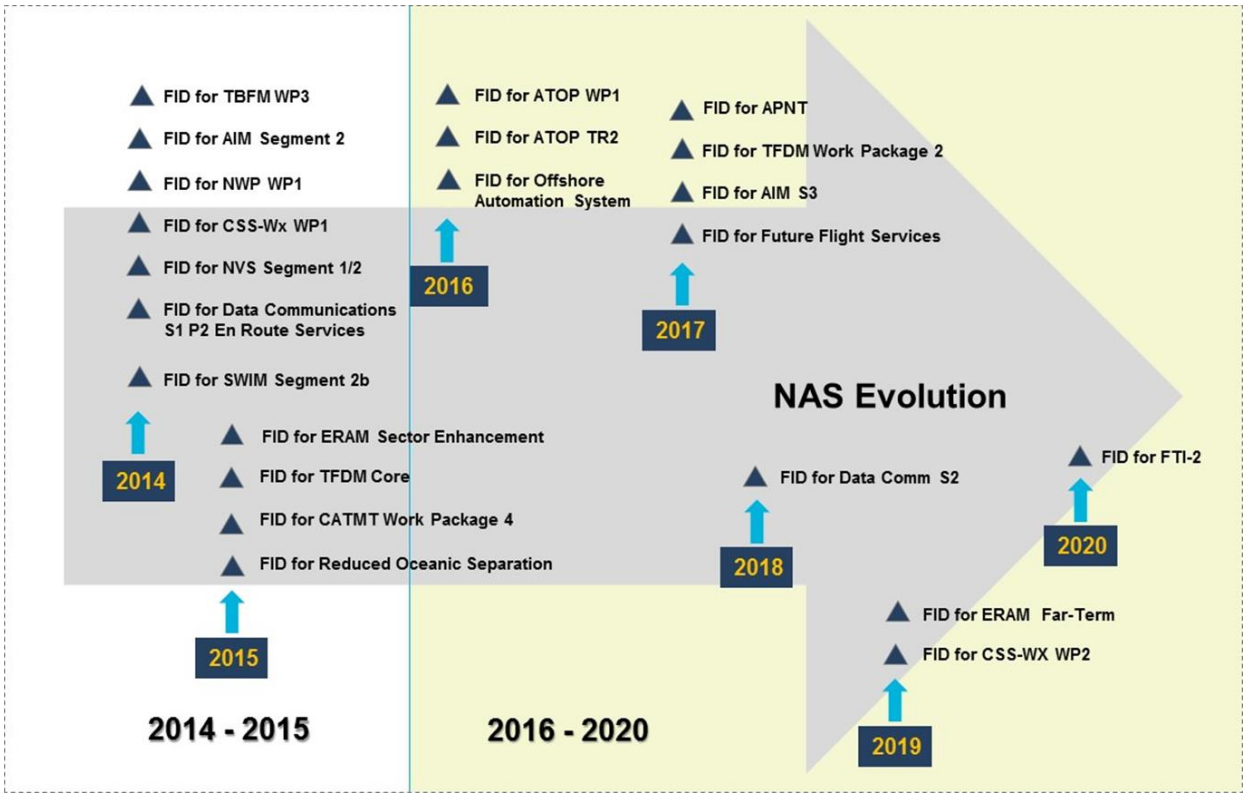
Recommendations: Making NextGen Happen, for 2020 and Beyond

The years 2014 and 2015 are critical for making decisions on moving forward with other key operational capabilities.

This section presents our recommendations for moving forward with NextGen, based on the assessment findings, context of the current environment, and achieving the objectives highlighted in Figure 2. Appendix B contains additional details, background, and rationale to support these recommendations. Recommendations that relate to a NextGen Advisory Committee (NAC)[4] priority are noted.

The years 2014 and 2015 are critical for making decisions on moving forward with other key operational capabilities. Figure 3 provides an overview of critical investment decisions that are scheduled through 2020. The FAA must determine, within the available and projected budgets, how to proceed on each program. This determination should consider the dependencies among these decisions, the priorities of different stakeholders, and potential benefits. Our infrastructure recommendations focus on establishing the infrastructure necessary to support the operational changes envisioned for NextGen, for 2020 and beyond.

Figure 3: Overview of Upcoming Investment Decisions



[4] RTCA NextGen Advisory Committee, *NextGen Prioritization*, September 2013.

Deploy Transformational and Foundational Systems

The FAA has made substantial progress in replacing highly constrained legacy infrastructure. Several key NextGen transformational programs and foundational infrastructure components are underway. The FAA should fully fund and complete the following programs to enable future NextGen operational capabilities:

Several key programs are foundational for enabling future NextGen operational capabilities.

- En route automation national deployment (En Route Automation Modernization [ERAM] Release 3 [R3])
- Time-based metering infrastructure (Time-Based Flow Management [TBFM] Work Package 2 [WP2])
- Terminal automation for large Terminal Radar Approach Controls (TRACONs) (Terminal Automation Modernization Replacement [TAMR] Phase 3 Segment 1 [P3S1])
- System-wide Information Management (SWIM) (Segments 1 and 2A)
- Collaborative ATM (CATM) infrastructure (CATM Work Package 3 [WP3])

A1: Complete Future Air Navigation System (FANS)-based Data Communications. *(NAC Priority)*

The FAA should ensure that FANS-based Data Communications is fully operational for the planned 57 Airport Traffic Control Towers and 20 Air Route Traffic Control Centers (ARTCCs) consistent with NAC recommendations. This deployment should include a national policy for the use of the capability, along with consensus from the user community on the benefits of data communications.

Achieving NextGen depends on implementing significant new automation-enabled operational capabilities and upgrading the NAS infrastructure.

A2: Pursue Aeronautical Telecommunication Network Baseline 2 (ATN B2) as the global standard for future Data Comm applications and align operational transition with integrated avionics and ATC services availability. (*Data Communications Segment 2)*

The FAA should focus on deploying FANS-based data communications for en route Data Comm services consistent with the NAC recommended priorities. The FANS implementation will be a revolutionary change in FAA domestic operations and will demonstrate global leadership in air-to-ground data communications en route service delivery. The experience gained from this effort will mitigate the risk of more complex Data Comm use over ATN B2.

Concurrent with Segment 1 FANS implementation, the FAA must continue to develop the global ATN B2

standards. The standards work must combine with efforts to develop mature integrated operational concepts. The FAA should aggressively pursue and complete the standards development and concepts work, which are the keys if avionics and ground system implementation are to be complete in the planned FAA timeframe. The FAA should continue to work with users and manufacturers on operational benefits of integrated functions and alignment of implementation schedules to meet ATC service availability objectives.

A3: Transition to networked voice services at high-priority towers/TRACONs and all en route facilities to maintain services and enable UAS new entrants.

The FAA should focus on implementing a limited-scope NAS Voice System (NVS) Segment 2 at high-priority terminal facilities and all ARTCCs by 2025 to maintain service and enable new aircraft entrants. The FAA should give priority to replacing legacy voice switches that are reaching end of service. This networked voice capability will be a key enabler for UAS integration and migration to Internet Protocol (IP).

A4: Rapidly field tower/surface electronic data sharing at high-priority sites to deliver airport-specific benefits. *(Modified Terminal Flight Data Manager [TFDM]). (NAC Priority)*

The FAA should emphasize early implementation of a limited set of key surface capabilities (electronic flight strips, surface viewers, and surface data sharing) at high-priority airports. This action includes reducing the scope of TFDM and deferring introduction of new capabilities, and shifting from the current acquisition process to an agile acquisition process. An agile development process would take advantage of available prototypes and allow efficient implementation of other surface capabilities. Surface data exchange is needed to enable airports or operators to develop surface traffic management tools to meet their needs.

A5: Replace automation at select small TRACONs to provide a common platform at future facilities. *(Modified TAMR Phase 3 Segment 2 [P3S2])*

The FAA should accelerate decisions on rightsizing TRACONs, and on closing low-volume towers, to inform decisions on where and when to discontinue legacy ATM automation infrastructure or replace it with the Standard Terminal Automation Replacement System (STARS) ELITE.

Transitioning to a more flexible communication, navigation, and surveillance system will enable the FAA to develop future operations that are scalable and independent of specific facility locations.

A6: At an enterprise level, **transition to secure information services to improve cybersecurity and reduce FAA cost.**

The transition initiative must include an enterprise-level plan and funding to ensure that foundational and transformational systems will use SWIM services. These services are critical to improving information security across the NAS for all categories of data. If this enterprise-level plan is not instituted, no further investments should be made in related NAS net-centric infrastructure capabilities (e.g., enhanced SWIM services, weather, and aeronautical information). As part of this recommendation, the enhanced Flight Data Publication Service capability should be deferred until a concept and plan for a flight data authoritative source is approved and adopted across the NAS.

A7: Based on establishing the above agency commitment to SWIM-based dissemination, **transition to replacement aeronautical and weather information services to reduce FAA cost.** *(Aeronautical Information Management Modernization [AIMM] Segment 2, Common Support Services-Weather [CSS-Wx] Work Package 1 [WP1], NextGen Weather Processor [NWP] WP1)*

The FAA must compel NAS-wide conformance with these net-centric services and aggressively decommission legacy interfaces. In addition to infrastructure transition, the FAA should execute a NAS-wide operational transition to use the enhanced aeronautical information and National Weather Service-provided NextGen common weather information base for ATM decision making. Defer future aeronautical information management services (AIMM Segment 3) until concept and policy exist for operational use as an authoritative source.

A8: Defer future common weather enhanced services until concepts for integration are clear. *(CSS-Wx WP2 and NWP WP2)*

The FAA should focus on implementing the above NextGen weather capabilities, and use experience gained to determine what additional weather services might be needed.

Maximize Operational Use of Available Aircraft and Ground Capabilities

Significant improvements have occurred where avionics, automation, and procedural changes are in alignment. The focus of this strategy should be on achieving operational improvements at airports and the Metroplex level, and for en route and traffic management operations. NextGen success relies on shifting from deploying infrastructure to focusing on operational capability implementation and operational use. This includes maximizing the benefits from investment airlines have made in aircraft capabilities.

Significant improvements have occurred where automation lines up with procedural changes.

The FAA is currently implementing new automation capabilities. It is important to develop procedures and training in a timely manner to integrate these capabilities into operations. The FAA must focus on the operational transition of capabilities and ensure a joint implementation effort with stakeholders. Accomplishing envisioned NextGen operations will require sustained and substantial FAA and operator investments out to 2020 and beyond to change and train practices, procedures, and new operations for Air Navigation Service Providers (ANSPs) and pilots. We suggest that the FAA Air Traffic Operations Council take the lead in ensuring the full use of existing and planned NextGen capabilities.

The following are our recommendations for ensuring operational use of available capabilities and aircraft equipage that realize the most significant benefits for Metroplex and non-Metroplex operations:

B1: Implement redesigned airspace and PBN procedures at initial Metroplexes to deliver airport-specific benefits where stakeholder commitments have been made. *(NAC Priority)*

> The FAA should maintain current stakeholder design commitments on the initial Metroplex activities. Where appropriate, mature NextGen CSPO, TBFM arrival/departure operational practices, and PBN procedures should all integrate with surface and departure practices and procedures to enhance user benefits.

B2: Implement multi-runway procedures at priority airports (e.g., Enhanced Lateral Separation Operations [ELSO], CSPO, Wake) to deliver airport-specific benefits.

> The FAA should fully fund the transition to use Wake Categorization and CSPO for all high-benefit sites. Where multiple procedures and improved spacing may address the same shortfall, the FAA should reconcile the best use of available procedures and solutions.

B3: Initiate additional Metroplex redesign and non-Metroplex PBN procedure designs to deliver airport-specific benefits. *(NAC Priority)*

As new capabilities and issues arise, the FAA must prioritize further site selection based on the most pressing NAS-wide needs. The redesign processes should reflect the NextGen capabilities. The aviation community must collaborate in prioritizing the next round of national and local needs beyond 2018.

B4: Develop a phased approach to deploy metering capabilities as they mature to support Metroplex redesigned operations for airport-specific benefits. (TBFM WP3)

The FAA should accelerate activities to mature those elements of terminal metering that would increase the benefits from planned Metroplex and non-Metroplex PBN implementations. We suggest that the Airspace Program Office and the TBFM Program Office conduct a joint initiative to validate those highest priority elements.

Available capabilities and aircraft equipage are sufficient to provide significant benefits for Metroplex and local operations at major airports.

The following are our recommendations related to the NAS-wide use of other key NextGen operational capabilities:

B5: Develop policy for, and clearly communicate consequences of, non-compliance with the ADS-B mandate to increase equipage.

At the current pace of equipage, the aviation community will not meet the 2020 mandate. MITRE acknowledges NAS-wide benefits to the U.S. aviation community for the FAA to maintain its commitment on the rule's effective date. To encourage community action, the FAA should clarify the requirements for compliance, the consequences of non-compliance, and the limited conditions under which waivers might be granted. These measures will provide increased assurance to the community that the FAA will transition to ADS-B Out as the standard means of surveillance by 2020, with radar as backup. Industry should plan to comply with the mandate in order for NextGen to deliver planned benefits.

B6: Implement national use policies for collaborative routing and time-based metering to realize more predictable flows. *(TBFM/CATM)*

The FAA should implement collaborative routing and time-based metering national use policies, procedures, practices, and training, to complete the operational

transition for currently deployed capabilities. The FAA should focus on developing national use policies, as well as procedures, practices, and training, to use currently deployed capabilities more effectively. Doing so will ensure that the benefits of collaborative routing and time-based metering are maximized. This includes Traffic Flow Management System WP3 and related ERAM and tower automation changes. For time-based metering, the metering applications should be aligned with all other procedures and capabilities implemented at the same sites.

B7: Implement en route capabilities for improved trajectory modeling and flight planning to obtain ADS-B Out and Optimized Profile Descents (OPD) benefits, and enable UAS operations. *(ERAM Sector Enhancement)*

A near-term FAA focus should be on enhancing en route trajectory modeling and flight planning automation capabilities to take advantage of ADS-B Out data. These capabilities will help to enable new airspace entrants, provide benefits from tighter separation through the use of ADS-B Out data, and increase benefits from OPD operations.

Procedurally Enable New Entrants

In the near term, focus on expediting procedural mechanisms that enable new entrants.

Significant growth is forecast for UAS operations and commercial Space Vehicle Operations (SVO), but there is uncertainty about where, when, and the actual levels of growth. However, demand is already growing for greater access before 2020. Permitting access to the NAS by such new entrants has been a key objective of the government's multi-agency NextGen long-term vision. Much will need to be learned between now and 2020 to understand the impact of requirements to integrate UAS operations and SVO into the NAS safely and efficiently. In the near term, the focus should be on expediting procedural mechanisms that enable new entrants. In parallel, initiatives are needed to provide fuller integration. We suggest that the UAS and SVO operational teams take the lead in considering the recommendations below.

The following are our recommendations for the procedural enabling of new entrants:

C1: Fast-track across government small UAS (sUAS) rulemaking to enable routine sUAS operations.

The FAA should release the Notice of Proposed Rulemaking (NPRM) on sUAS by 2014 and finalize the rule rapidly to enable commercial sUAS operations on a routine basis. Until the sUAS rule is final, the FAA should maximize the use of the FAA Modernization and Reform Act Section 333 authorizations to address user demand and to increase external confidence.

C2: Execute a cross-organizational plan to incrementally expand commercial UAS access into the U.S. aerospace system by adapting existing policies, regulations, and procedures.

By 2018, the FAA and stakeholders should reach agreement on a detailed roadmap for defining the policy, equipage standards, operational concepts, and automation requirements that can be achieved through 2025 and beyond to enable routine integration of UAS operations. This roadmap should use interpretations of existing policies in combination with establishment of new regulations. Early adopters should work directly with the FAA to develop their operations. The FAA should begin to incorporate these new entrants through interpretation and clarification of procedures for a few types of UAS operation and incrementally expand the number of operation types for which service can be offered.

C3: Execute a cross-agency plan that standardizes approvals and streamlines operations to better accommodate CSVs in the U.S aerospace system.

This effort should include developing policies and procedures, as well as the technical, operational, and certification requirements, to procedurally create correctly sized protected airspaces for launch and recovery of space vehicles.

Eliminate Surplus Capabilities and Services

To date, the FAA has focused more on deploying NextGen capabilities to modernize the NAS, and less on eliminating the surplus NAS capabilities, infrastructure, and services. As part of this NextGen focus area, the agency needs to understand service expectations, look critically at the NAS footprint, legacy, and redundant procedures and execute a plan to eliminate surplus capabilities, procedures, and services that are costly and inhibit the full transition to NextGen. This focus will be critical to realizing the cost efficiencies in the operation of the NAS envisioned with NextGen. We suggest that the Strategic Implementation Group take the lead in considering these recommendations.

Between now and 2020, the focus is on discontinuing legacy capabilities; longer term, the strategy must shift to restructuring the inventory to deliver more scalable, adaptable, and resilient services.

The following are our recommendations for elimination of surplus capabilities and services:

D1: Reallocate ATC services and streamline operations across TRACONs, towers, and en route facilities to reduce costs.

The FAA should accelerate action on Section 804 of the FAA Modernization and Reform Act of 2012 to transition out of TRACONs and towers that are underutilized. The results of these efforts should then align with decisions on scoping TAMR P3S2 and TFDM functionality, and with minimizing development/ deployment costs.

D2: As part of the streamlining recommended in D1, **implement remote operations for selected tower services to reduce costs.**

The FAA should make a priority effort to validate and implement a concept of remote operation controlled arrival/departure services as an alternative to low-volume towers.

D3: Transition to minimum navigation infrastructure to reduce FAA costs.

The FAA should aggressively move to define a policy for a minimum level of navigation services in the event of a short-term Global Positioning System (GPS) service outage. This will inform the definition of an implementation solution that should minimize the ground-based navigation infrastructure and redundant procedures in all phases of flight.

D4: The FAA should aggressively move to **eliminate legacy point-to-point data telecommunications and information interfaces to reduce FAA costs.**

The objective of this action is to eliminate outmoded, costly information interfaces and legacy delivery systems. As part of interface modernization, the FAA should prioritize on migrating to a predominately IP-based NAS infrastructure by 2025. The objective of this cost-effectiveness initiative is to replace today's inflexible and outmoded dedicated infrastructure with an agile and commodity-based IP-enabled infrastructure, to avoid obsolescence and take advantage of IP-network flexibility.

D5: Align oceanic and terminal automation technology refresh with future platform convergence plans to reduce FAA cost (Modified Advanced Technologies and Oceanic Procedures [ATOP]). *(ATOP and TAMR Technology Refresh)*

The FAA has conducted numerous studies of the pros and cons of having a common NAS automation infrastructure. Given the upcoming decisions on technology refresh for several NAS systems (e.g., ATOP and TAMR), it is time for the FAA to make a firm decision on platform convergence and move accordingly.

D6: Transition FAA-provided Continental U.S. (CONUS) flight services to the private sector to reduce costs.

The private sector already provides many of the flight services that the FAA has traditionally provided. The FAA should revalidate its need to provide these types of services, and then be aggressive in divesting services that are not necessary given the FAA's role. Over time, the private sector will further determine, based on demand, the required services for today's information environment.

Integrate NAS-Wide Operations and Performance

The 2015–20 focus will primarily be on realizing maximum benefits at airports or Metroplexes through available NextGen capabilities and aircraft equipage. Beyond 2020, the focus should shift toward maximizing NAS-wide efficiencies and predictability. A higher degree of integration of the NextGen capabilities will be necessary for the collaborative environment of the future. We suggest that the Air Traffic Organization (ATO) and workforce representatives take the lead in carrying out these recommendations.

NAS-wide efficiencies and predictability will be achieved through an integrated approach across domains.

The following are our recommendations for the integration of NAS-wide operations and performance:

E1: Implement a strategy that aligns the future ATC workforce with NextGen capabilities to deliver high-performing NAS-wide operations.

> The FAA should focus on aligning structure, policies, practices, and procedures for the NextGen environment with future performance objectives. These performance objectives should include NAS operational reliability, scalability, and productivity in a human-centered NextGen concept. This should include practical field demonstrations of NextGen service delivery that achieves this concept and integrates proposed individual NextGen capabilities.

E2: Related to recommendation E1, **defer flexible airspace improvements and future facilities until NextGen capabilities in a future work environment are demonstrated.** *(Future ERAM Enhancements)*

> In particular, the FAA should focus on validating post-2020 NextGen sector and facility concepts to gain a better understanding of desired future NextGen operations and capabilities needed to support them. These validation efforts will lay the foundation for setting requirements for facility and sector upgrades. The FAA should proceed with the N90 physical plant replacement.

E3: Modify CATM Work Package 4 (WP4) to focus on implementing applications to improve demand prediction, NAS-wide performance, and predictability. *(Modified CATM WP4)*

> The FAA should give priority to developing specific capabilities to provide a systematic approach to NAS-wide performance management. The approach should integrate collaborative capabilities for decision makers so they understand the impact of their actions on others, and on operational performance across the NAS. This

will enable a better understanding of NAS-wide implications of local actions and decisions. Other flow management capability investments should be deferred until concepts mature, and until there is traction on making better use of available CATM capabilities.

NextGen requires the integration of automation enhancements, updated procedures and airspace design, and controller training.

E4: Integrate controller training approaches and methods to match future operations concepts and to reduce FAA costs.

The FAA should give priority to integrating ANSP training methods to enable flexible and expedited training for recurrent training needs, as well as operational transition to new NextGen concepts and capabilities.

E5: Identify airspace and ATM modifications required for routine UAS and commercial SVO. *(ERAM Sector Enhancement)*

Except for initial sector enhancements to UAS-related operations, the FAA should defer more advanced enhancements until initial lessons are learned from early procedural UAS integration. The lessons will inform decisions on implementing required changes to airspace and ATM infrastructure for full integration of UAS operations in the 2020+ timeframe. The FAA should take a similar approach to integration of CSV.

E6: As an initial effort to explore advanced NextGen concepts, **implement oceanic enhancements to support user-preferred 4D airborne routing.** *(Modified ATOP WP1)*

The FAA should re-scope this work package to focus on enabling equipped aircraft to fly as close as possible to their preferred 4D oceanic trajectory. This will provide user benefits and also enable the advancement of, and experience with, future TBO concepts. This initiative would take advantage of highly equipped aircraft—making use of existing aircraft capabilities is a continuing user priority.

Integrate Advanced Aircraft-Centric Operations

Significant evolution of today's fleet to one that supports aircraft-centric operations is not likely to occur until 2025 and beyond.

NextGen research on advanced aircraft-centric capabilities cannot substantially outpace the community development of operating concepts and business case. Significant evolution of today's fleet is not likely to occur until 2025 and beyond. Therefore, the alignment of the advanced concepts to the major forward fit of the fleet will allow for improved integration of investments by the airlines and the FAA. This means deferring implementation of advanced aircraft-centric operations until:

- They better align with aircraft operators' readiness to equip.
- The maturity of the concepts and technology are established.
- Operational priorities are established and benefits are understood.

We suggest that the integrated CNS team (AVS/ATO/ANG) take the lead in considering these recommendations.

The following are our recommendations for enabling advanced aircraft-centric operations:

F1: Complete standards and concepts for secure, integrated CNS by 2022 to maintain global leadership.

There is a need for an approach to planning for aircraft-dependent, advanced NextGen applications that recognize and leverage the next major forward fit of the fleets in 2025 and beyond. The FAA should develop an integrated CNS plan in the next 12 to 18 months to ensure a realistic and coordinated approach to defining the needed CNS concepts and standards with industry no later than 2022 to influence the next phase of aircraft purchases and maintain global leadership. The aviation community must contribute to the concept and business case development to ensure that a credible set of aircraft-centric operations result to aid their investment decisions.

F2: Defer TBO with integrated avionics until the concept is mature and implementation is aligned with fleet forward fit.

Much research has been done on this concept. Elements of the concept, such as airborne rerouting, will exist in the 2020 timeframe. However the full concept of the use of 4D trajectory needs to be worked out. The avionics for these functions must also exist in large enough numbers to support operational use.

The long lead time for fleet equipage of new capabilities means standards and concept development for these advanced operations must continue today.

F3: Move forward on initiatives to implement aircraft-to-aircraft technologies using ADS-B In and procedures at select locations to realize benefits.

There is a need to close the user adoption gap related to ADS-B In. To address this gap, the FAA should expand lead carrier agreements at additional locations to use existing standards, services, and procedures for ADS-B applications (e.g., oceanic In-Trail Procedure, Cockpit Display of Traffic Information [CDTI]-Assisted Visual Separation). These efforts will help the FAA and operators to realize a return on investments, and may promote early adoption of equipage.

F4: Defer navigation infrastructure for degraded services during GPS outages until requirements are mature. *(Alternative Positioning Navigation and Timing [APNT])*

The FAA should defer APNT implementation until requirements are validated and aligned with advanced NextGen concepts, which require further development.

F5: Defer integrated arrival-departure operations with aircraft-centric procedures until trajectory-based procedures are used consistently and the concept is mature. *(Modified TBFM WP4)*

The FAA should defer implementation of these concepts until operational needs are better understood and the environment for operational benefit is understood.

F6: Defer advanced surface TBO and associated avionics-dependent surface capabilities.

The FAA should focus on implementing the revised scope of TFDM (per recommendation A4).

Achieving NextGen Operations for 2020 and Beyond

By 2020, most Metroplex needs will be met. The remaining need is in NAS-wide performance and predictability.

This paper presents our recommendations to inform the FAA's NextGen development and implementation of NextGen. A picture emerges of operations in 2020 in which the core infrastructure and procedures for surveillance, data communications, and navigation have changed. These infrastructure and operational changes address the current airport and Metroplex shortcomings through a combination of the following:

- Improved use of parallel and converging runways.
- Enhanced surface operations coordination and flows.
- Redesigned flows and flight path efficiency in and out of metro areas that are optimized through ATC automation.
- Better low-visibility operations to and from airports.

By 2020, NextGen will begin NAS-wide performance management, with greater flexibility and collaboration among aircraft operators on routing and delays. This includes the use of data communications and PBN procedures to better manage flights around weather and congestion. The earliest types of UAS operations will be able to participate routinely in the NAS. By integrating new entrants and focusing on NAS-wide performance—after meeting airport and Metroplex needs—the initial transformation to NextGen can be fully in operation by 2025.

Recall that Figure 2, "Building a 'Sustainable' NAS," represents competing and complementary means to achieve value to the community as a series of focus areas with the rough time windows for operational use. Recommendations describe what investments in the capabilities that make up these focus areas are ready for action by the community. In some cases preliminary steps to further mature a capability have been recommended. Each of the recommendations was then prioritized within its focus area. The approach to rank the recommendations included the following considerations:

- Value delivered in terms of legacy users' benefits, new entrants served, or cost efficiency for the FAA:
  - Is it aligned to a NAC Tier 1 Recommendation?
  - Is it critical to enabling new NAS entrants?
  - Will the investment help reduce future FAA costs?
- Risk of ensuring the realized benefits will be achieved:
  - Is the concept mature?

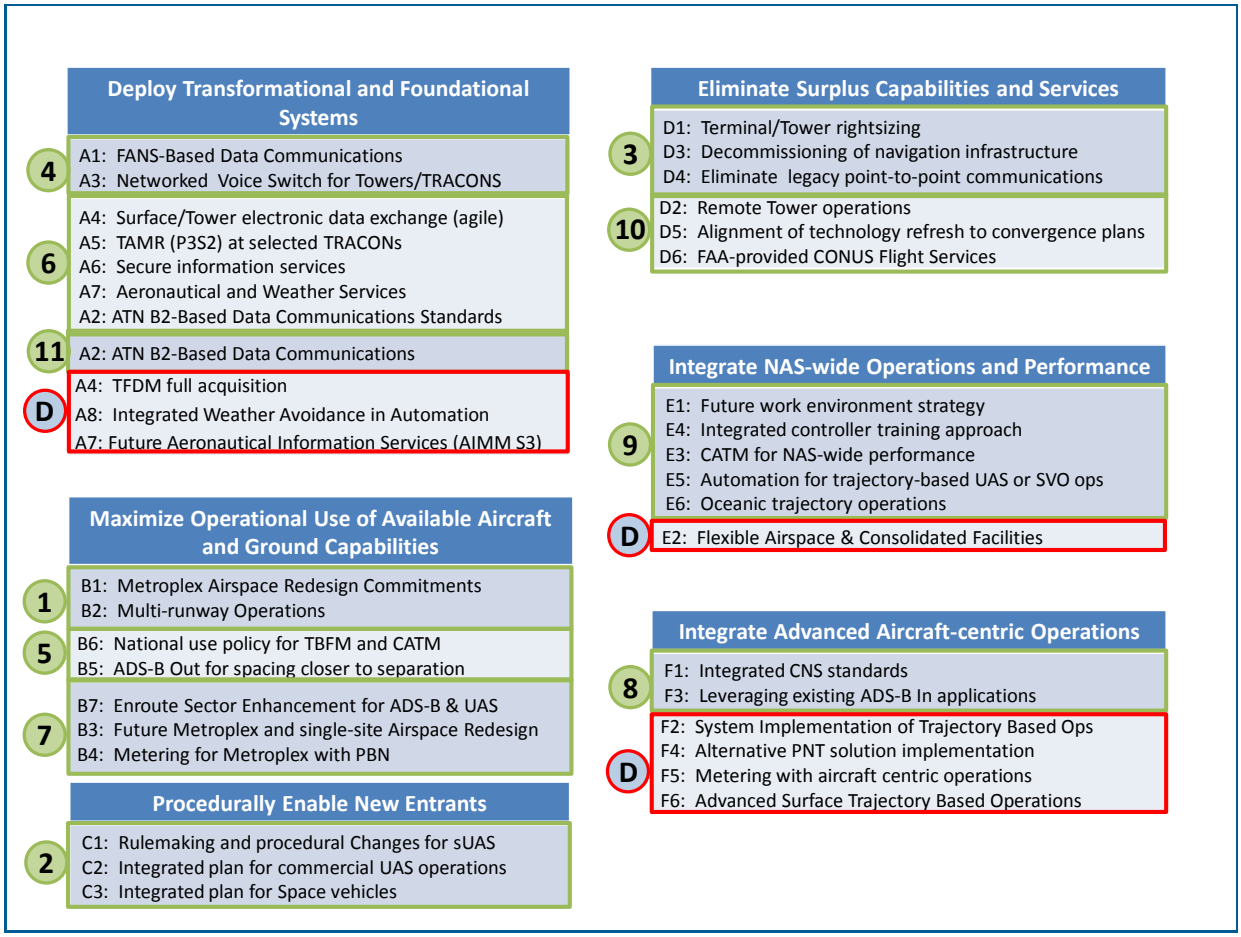
  - Will 2020 user equipage be adequate to realize benefits?
  - Is funding and scoping required to complete the capability?
- Interdependencies of the recommendations and investments:
  - Is additional investment required to deliver significant benefits?
  - What is the potential impact following FAA rightsizing?
  - Are there internal FAA bandwidth issues (people, system, infrastructure)?

Figure 4 represents the portfolio view of the recommendations and associated key investments and NextGen capabilities in priority order from highest to lowest. We grouped similar priority-level recommendations to enable prioritization across the six focus areas. The priority comparison across the six focus areas is represented by the numeric labels next to groups of investments. Recommendations to defer implementation investments are labeled with a "D."

The key elements deferred in the recommendations represent the future that would create a more flexible and scalable operating environment, with greater dependence on aircraft capabilities, knowledge of weather incorporated into recommended solutions, and reliance on serving individual aircraft according to their capabilities. The portfolio view preserves through 2025 the foundational elements, targeted needs of local problem sites, an end-to-end management of NAS performance and the long lead items to create that future.

Our independent assessment and resultant recommendations are captured here as a vehicle for ongoing dialogue with the FAA and external NextGen stakeholders on development and implementation priorities for NextGen. We stand ready to support efforts to consider these recommendations and action plans for addressing them, where appropriate.

Figure 4: MITRE Recommendations for a Sustainable NAS



Appendix A: Summary of Findings from the Independent Assessment of NextGen

In this appendix, we summarize the findings of our independent assessment of NextGen. The complete documentation of the assessment has been provided separately to the FAA.[5] The summary is divided into three sections:

- **Overview of NextGen Progress to Date:** We provide details about key NextGen improvements that have occurred since 2008. These lay the foundation for further enhancements to be added by 2020 and beyond.
- **Key Investment Decisions:** The next few years will be crucial to development of NextGen, as decisions will be made on further investments. We present a summary of those key decisions, which were instrumental to the development of our recommendations related to informing FAA investment decisions.
- **Analysis of Gaps Affecting NextGen Implementation:** We identified three categories of gaps that will impact the "what" and "when" of implementation of NextGen capabilities. These categories are technical maturity, operational transition, and user adoption.

We also present a summary of our analysis of the effects that the timing and extent of aircraft equipage will have on achieving NextGen operations.

NextGen Progress to Date

The Assessment of NextGen Plans showed that substantial progress has been made since 2008. Most spending up to this point has resulted primarily in infrastructure changes. However, some significant improvements have occurred where automation aligned with procedural changes. The following examples are significant NAS improvements that have been accomplished primarily via procedural changes enabled by both Air Traffic Control (ATC) and Performance-Based Navigation (PBN). These operational improvements were also enabled by leveraging existing capabilities on board the aircraft.

- Closely Spaced Parallel Operations (CSPO)
- Wake Turbulence Separation Reductions
- Oceanic Airspace Operations
- Airspace Redesign
- PBN Procedures
- Better Leveraging of Existing Automation

Closely Spaced Parallel Operations

Operating Closely Spaced Parallel Runways (CSPRs) significantly improve capacity and efficiency during low-visibility conditions. As traffic levels increase, the positive effect on operations will become even more significant. The distance between parallel runways, airport surveillance capabilities, and supported procedures determine whether independent or dependent operations are permitted. The FAA

[5] The MITRE Corporation, "NextGen Assessment Briefing," F150-B14-001, 30 August 2014, The MITRE Corporation, McLean, VA.

has focused on increasing arrival and departure services to airports with CSPRs in low-visibility conditions. The following are two accomplishments within CSPO.

- **Lower Simultaneous Offset Instrument Approach (SOIA) minima at San Francisco International Airport (SFO)—2012:** Lowered the SOIA weather minima to 1,600 feet. These have been in effect since September 20, 2012. Over the 2012–13 timeframe, 15 days exhibited the type of weather that called for SOIA minima. On those days, there were about 67 hours when the minima were between 1,600 feet and 2,100 feet. During that period, arrival capacity increased on average by 3.8 flights per hour, and actual arrivals increased on average by 4.5 flights per hour. Airborne holds and duration decreased by 1 and 60 seconds, respectively.
- **Independent Approaches—2013:** Lowered runway separation standard from 4,300 feet to 3,600 feet for independent parallel runways, with no Precision Runway Monitor (PRM)/high-update radar required. This is forecast to result in a NAS-wide increase of 36 arrivals per hour. When the FAA applies the lowered standard to triple approaches, it can remove the need for PRM radar at Hartsfield–Jackson Atlanta International Airport (ATL).

Wake Turbulence Separation Reductions

The FAA has enabled user benefits related to reducing wake separation criteria, and has accomplished the following:

- **Joint Order 7110.308** (*Nautical Miles [NM]-Dependent Approaches to Parallel Runways Spaced Less than 2,500 Feet Apart*)**—2008:** This order increases throughput for dual arrival streams for two CSPRs in Instrument Meteorological Conditions by allowing wake mitigation using the staggered geometries of runways. Seattle–Tacoma International Airport used it at a runway closure in 2009, leading to an 11 percent increase in called arrival rates. The FAA has currently approved it at Cleveland Hopkins International Airport (CLE), Logan International Airport (BOS), Philadelphia International Airport (PHL), and Lambert–St. Louis International Airport (STL). SFO/Northern California Terminal Radar Approach Control (TRACON) (NCT) expects to begin use in August 2014, with an increased arrival rate of four to six arrivals per hour based on simulations done at NCT.
- **Wake Re-categorization (RECAT) Phase 1—2012/2013:** Using modern data and analytic techniques, this effort created new wake turbulence categories for aircraft, allowing for separation reductions behind some aircraft. Memphis International Airport (MEM) served as a key first site implementation, and initial post-implementation analysis during peak hours has shown a 15 percent reduction in departure separations, more than 35 percent reduction in taxi-out delay, and an 8 percent decrease in the time spent and distance flown in TRACON airspace for arrivals during constrained operations. Additional airports are scheduled to begin use of RECAT Phase I standards in 2013, including SFO, Louisville International Airport (SDF), and Miami International Airport (MIA).
- **Wake Turbulence Mitigation for Departures (WTMD) at SFO, George Bush Intercontinental Airport (IAH), and MEM:** The FAA is conducting demonstrations of WTMD at three airports. WTMD is a procedure that allows air traffic controllers (during certain wind conditions) to depart aircraft off of CSPRs without delays for wake turbulence on the adjacent runway. The airports and the start dates of their operational demonstrations are:
  - SFO started May 15, 2013.
  - IAH started July 16, 2013.
  - MEM started December 17, 2013.

Oceanic Airspace Operations

The FAA has enabled user benefits related to oceanic airspace operations, and has accomplished the following:

- **Automatic Dependent Surveillance-Broadcast/Contract (ADS-B/C) In-Trail Procedures/Climb Descend Procedures (ITP/CDP)—2011:** These new procedures allow for climb/descend through blocking traffic with 15 NM separation instead of the standard 30 NM separation. The FAA implemented ADS-B/C ITP in Oakland Air Route Traffic Control Center oceanic airspace, with an estimated $15.2 million in fuel savings from 2014 to 2035 for ADS-C alone.
- **Gulf of Mexico Area Navigation (RNAV) Route Restructure and Lateral Separation Reduction—2013:** The FAA reduced lateral separation from 100 NM to 50 NM, with projected daily savings of 33,000 pounds of fuel and an estimated savings of $1.5 million for a 31-day period in March 2011.
- **Tailored Arrivals—2009:** Tailored Arrivals are fuel-efficient, environmentally friendly arrival clearances delivered via data link. The FAA implemented Tailored Arrival procedures at SFO in December 2007, MIA in June 2009, and Los Angeles International Airport in November 2009, with fuel savings estimated between 490 and 1,180 pounds per arrival.

Airspace Redesign

The Metroplex redesign initiative is a systematic, integrated, and expedited approach to implementing PBN procedures and associated airspace changes. It takes into account all airports and airspace supporting metropolitan area operations, including connectivity with other Metroplexes. Developed in direct response to the recommendations in the RTCA's Task Force 5 report on midterm NextGen implementation, the Metroplex process considers numerous factors, including safety, efficiency, capacity, access, and environmental considerations. This program aims to reduce fuel burn, emissions, and number of controller transmissions. Multiple sites are in development. The Washington, DC, Metroplex site has implemented several procedures through an independent utility, the National Environmental Policy Act (NEPA) Categorical Exclusion (CATEX) waiver process.

- **Washington, DC, Metroplex—2010:** The Washington Metroplex study team proposed multiple RNAV Standard Terminal Arrival Routes (STARs), RNAV Standard Instrument Departures (SIDs), Required Navigation Performance (RNP) approaches, and multiple PBN en route procedures for the primary, adjacent, and satellite airports, with coordinated airspace realignment. Predictive benefit modeling showed an estimated annual benefit to the users of $6.4 to $19.0 million in fuel burn savings. Five RNAV Optimized Profile Descent (OPD) STARs were implemented in 2012, and updated in 2013, to support arrival operations into Washington Dulles International Airport (IAD) and Ronald Reagan Washington National Airport (DCA). Post-implementation analysis of the FRDMM, TRUPS, and GIBBZ OPD STARs showed an estimated annual benefit to the users of $2.3 million in fuel burn savings.
- **Denver Metro Area RNAV/RNP—2013:** Denver implemented 51 new RNAV/RNP procedures designed to provide more direct routes, deconflict operations, save fuel, and reduce emissions. These included RNAV STARs with OPDs, RNAV SIDs, and RNP Authorization Required (AR) approaches. The 12 new RNP AR procedures provide stabilized curved-path approaches, resulting in shorter flying distances. United Airlines conservatively estimated that it would save between four million and nine million gallons of fuel annually, and that those savings would increase as use of the RNP procedures increased.

- **Houston Metroplex—2014:** Houston implemented 61 new or modified procedures in May 2014, including RNAV STARs, RNAV SIDs, and RNP AR approaches for the primary and satellite airports. These new procedures provide both lateral and vertical efficiency gains, which reduce fuel burn and emissions. Of note are the dual feed OPDs, which provide for an orderly and efficient feed to IAH. Predictive benefit modeling showed an estimated annual benefit to the users of $9.2 to $26.1 million in fuel burn savings. Post-implementation analysis is underway.

Performance-Based Navigation Procedures

The FAA has achieved several important accomplishments and has seen benefits from activities through implementation of PBN procedures. RNAV and RNP procedures facilitate efficient use of airspace which collectively result in improved safety, access, capacity, predictability, operational efficiency, and environmental effects. Over the past several years, the FAA has implemented many PBN procedures designed to:

- Increase safety by using three-dimensional approach operations with course guidance to the runway, which reduce the risk of controlled flight into terrain.
- Improve airport and airspace access in all weather conditions and the ability to meet environmental and obstacle clearance constraints.
- Enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors. Flight Management Systems (FMSs) will then be poised to save operators time and money by managing climb, descent, and engine performance profiles more efficiently.
- Improve efficiency and flexibility by increasing use of operator-preferred trajectories NAS-wide, at all altitudes. This will be particularly useful in maintaining schedule integrity when convective weather arises.
- Reduce ATC task complexity and improve productivity of air traffic controllers.

The following describes different aspects of PBN procedure success because of new arrival, approach, or departure flow designs, as well as the application of new technologies for navigation.

- **RNAV SID and STAR Procedures:** Many RNAV SID and STAR procedures have been implemented across the NAS. The following examples detail some site-specific accomplishments in this area:
  - **Charleston International Airport (CHS) Eight RNAV STARs and Five RNAV SIDs—2009:** In 2009, the FAA implemented eight RNAV STARs with OPDs and five RNAV SIDs at CHS. Separate STARs were developed to accommodate the United States Air Force C-17 descent profile. Benefits include a more predictable flight path and fuel savings from reduced level-offs.
  - **Henderson Airport (HEN) RNAV Procedures—2011:** Seven RNAV procedures were implemented at HEN in 2011. These procedures reduce the chance of communication errors and provide controllers a less complex and more efficient airspace in the Las Vegas, NV, area. These procedures enable better access during special events that result in airspace utilization spikes, such as the National Business Aviation Association convention.
  - **Honolulu International Airport RNAV STARs initial implementations—2011:** This effort implemented three RNAV STARs.
  - **SDF RNAV STARs Initial Implementation and Amendments—2012:** This effort implemented five new and amended two RNAV STARs. Four of those RNAV STARs (the

two amended plus two of the new procedures) account for approximately 76 percent of operations into SDF. Post-implementation analysis showed vertical profile benefits.

  - **STL RNAV SIDs Initial Implementation—2012:** This project implemented 13 RNAV SIDs. Post-implementation analysis of operations already has exhibited few to no level-offs applied on the climb.
  - **DCA LAZIR RNAV SID Amendments—2012:** LAZIR2/LAZIR3. Analyses focused on conformance and reduction of P56 airspace infringements. Testing and refinement are ongoing to incorporate user limitations and charting/criteria clarity.
  - **Raleigh-Durham International Airport (RDU) RNAV STARs and RNAV SIDs Initial Implementation—2012:** In 2012, the FAA implemented three RNAV STARs with OPDs and seven RNAV SIDs at RDU. The FAA developed and implemented four RNP Z approaches to connect with the OPD STARs. Benefits include a more predictable flight path, reduced track miles, and fuel savings from reduced level-offs.

- **RNAV OPD Procedures:**
  - **Phoenix Sky Harbor International Airport (PHX) EAGUL Amendment—2008:** This effort implemented an amendment to the EAGUL RNAV OPD STAR (making it EAGUL2) to allow for "descend-via" clearance and improve the vertical profile of the procedure. Post-implementation analysis showed an estimated annual benefit to users of $2.25 million for aircraft being issued "descend-via" from the DOJOE waypoint.
  - **ATL RPTOR Initial Implementation—2011:** This procedure has been revised to the current RPTOR3. Challenges to implementation and utilization have centered on spacing aircraft to a high-volume airport.
  - **STL KAYLA, AARCH, LORLE, BOOSH Initial Implementation—2012:** This effort implemented four new RNAV OPD STARs. Post-implementation analysis of three of the procedures (KAYLA, AARCH, and LORLE) highlighted an issue with procedure design to accommodate non-Vertical Navigation-equipped aircraft. This has identified a need for further guidance on procedure design.

- **RNP AR Approaches:** The first FAA-published RNP approaches were Special Aircrew and Aircraft Authorization Required Projects in 2004. The first airports with these RNP approaches were Portland International Airport (PDX), John F. Kennedy International Airport (JFK), DCA, CLE, Palm Springs International Airport (PSP), and IAH. There are currently 367 RNP ARs in the NAS. A unique feature of RNP AR approaches is curved paths, which allow for repeatable and predictable flight paths while reducing mileage and allowing greater access.

- **Equivalent Lateral Spacing Operations (ELSO) Departure Procedures at ATL:** ELSO reduces the angle between the departure routes in ATL from 15 degrees, which is the minimum at other airports, to as little as 10 degrees without the aircraft flying closer together. ATL is the first airport to gain approval for use of the new standard because the majority of aircraft that depart from ATL have the ability to navigate more precisely using Global Positioning System (GPS)-guided navigation. The standard enables additional departures, which mean that aircraft spend less time burning fuel on taxiways and in line for takeoff. It translates to an estimated annual savings of $10 million in fuel costs and a reduction in aircraft exhaust emissions.

- **RNAV (GPS) Approaches—Localizer Performance with Vertical Guidance (LPV):** The FAA has implemented RNAV (GPS) approaches using LPV at a rate of ~500/year, providing increased access and safety for many locations. As of January 15, 2009, the FAA had published 1,445 LPV approaches at 793 airports. This is greater than the number of published Category I Instrument Landing System (ILS) procedures. LPV is the highest precision GPS (Wide Area

Augmentation System [WAAS] enabled) aviation instrument approach procedure currently available without specialized aircrew training requirements, such as RNP. Landing minima are usually similar to those in an ILS procedure, that is, a decision height of 200 feet (61 meters) and visibility of ½ mile. LPV is designed to provide 16-meter horizontal accuracy and 20-meter vertical accuracy 95 percent of the time. Actual performance has exceeded these levels.

- **Greener Skies:** Greener Skies is a collaborative project among the FAA, airlines, the Port of Seattle, and the Boeing Corporation to introduce PBN technology that takes advantage of user investments in aircraft avionics. It includes adding 10 new instrument flight procedures and expanding use of OPD RNAV STAR procedures and RNP approaches.

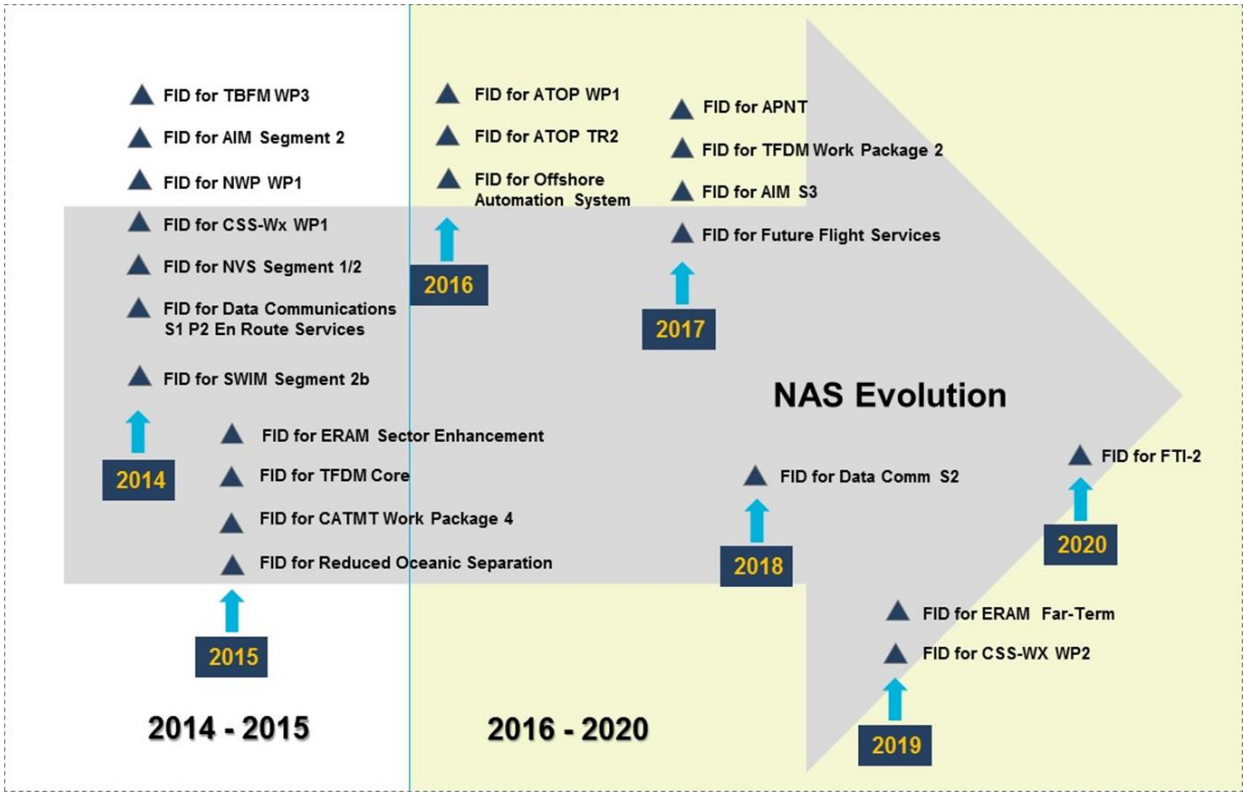
Better Leveraging of Existing Automation

User benefits continue to increase as the FAA deploys existing automation enhancements to additional sites. For example, the FAA is leveraging the Converging Runway Display Aid (CRDA). CRDA is a situational awareness tool, available in terminal automation systems today, that helps controllers stagger the spacing of aircraft in operations with intersecting or converging arrival runway or approaches. New site-specific applications for CRDA have been identified in recent years, resulting in significant benefits at BOS, PHL, Newark Liberty International Airport, and MEM.

Key Investment Decisions

The assessment revealed that most significant operational changes enabled by automation will be realized by 2020. In particular, 2014 and 2015 are the critical years to make decisions for these new capabilities; a "bow wave" of important Final Investment Decisions (FIDs) for major Transformational and key infrastructure systems will take place in that timeframe. Most of the Transformational and key infrastructure programs need to make additional progress to meet enterprise architecture infrastructure goals. Figure 5 depicts the FID schedule for key programs and is followed by a brief description of the program investment decisions listed organized by year. This information was instrumental to the development of our recommendations related to informing FAA investment decisions.

Figure 5: Timeline Depiction of Current Enterprise Architecture Decision Points



In 2014, there are important FIDs related to both NextGen Transformational and key infrastructure programs. Major program FIDs are planned for the following:

- **Data Communications Segment 1 Phase 2:** Implementation of a full set of en route data communications services in the NAS is planned by 2022.
- **Common Support Services Weather (CSS-Wx) Work Package 1 (WP1) and NextGen Weather Processor (NWP) WP1:** Together they will provide a System-Wide Information Management (SWIM)-enhanced weather distribution capability (CSS-Wx) and a common weather processing platform (NWP), respectively.
- **NAS Voice System (NVS):** NVS will replace older technology voice switches in en route and terminal facilities with highly flexible and resilient Voice over Internet Protocol (VoIP) networked voice capabilities.

- **Aeronautical Information Management Modernization (AIMM) Segment 2:** AIMM 2 will implement the Aeronautical Common Service (ACS). ACS is an enterprise-based, service-oriented architecture that will be the trusted Aeronautical Information source for both internal and external consumers and that includes Special Activity Airspace (SAA) and airport data necessary to achieve shared situational awareness.
- **SWIM Segment 2b:** SWIM 2b will build upon earlier segments of SWIM to provide the status of NAS infrastructure and service-oriented architecture services, certificate-based authentication/authorization, enhancements to the SWIM Terminal Data Distribution System, and enhancement of the Flight Data Publication Service.
- **Time-Based Flow Management (TBFM) Work Package 3 (WP3):** TBFM WP3 will extend time-based metering further out in en route airspace as well as into the terminal area. Candidate TBFM capabilities for WP3 include Metering during Reroute Operations, Path Stretching, Terminal Sequencing and Spacing, and Integrated Departure and Arrival.

In 2015, major FIDs are planned for the following:

- **En Route Automation Modernization (ERAM) Sector Enhancement:** ERAM will improve the accuracy of modelled aircraft trajectories and of Conflict Probe, especially in congested airspace.
- **Terminal Flight Data Manager (TFDM):** TFDM will implement capabilities to optimize surface operations and the movement of aircraft off the airport surface and into the high-altitude stream of air traffic at selected facilities.
- **Collaborative Air Traffic Management Technologies (CATM-T):** CATM-T will be the primary planning and execution mechanism for traffic management in the NAS. CATM involves NAS operators and FAA traffic managers, along with advanced automation, in managing demand and capacity issues for airspace and airports, including weather impacts, traffic congestion, and SAA.
- **Reduced Oceanic Separation:** The FAA is considering whether there are cost-effective operational benefits with reducing horizontal separation standards in some regions of U.S.-managed oceanic airspace and what planned technology with appropriate procedures could enable those reductions.

In 2016, major FIDs are planned for the following:

- **Advanced Technologies and Oceanic Procedures (ATOP) WP1:** By 2020, ATOP will be enhanced (ATOP WP1) with controller tools, coordination upgrades, capabilities for surveillance airspace, SWIM and Aeronautical Information Manual services, and service continuity enablers. ATOP WP1 will build upon Technology Refresh 2, which will provide a more solid infrastructure for some of the WP1 capabilities.
- **ATOP Technology Refresh 2:** ATOP Technology Refresh 2 is planned to include virtualization and a possible change in operating system, reducing overall life-cycle costs, refreshed hardware that allows the baseline to remain current with advances in processor, display, storage, and network technologies, and architectural and software changes that will better align the system with FAA NextGen initiatives such as SWIM.

In 2017, major FIDs are planned for the following:

- **Alternate Positioning, Navigation, and Timing (APNT):** The APNT service is intended to mitigate a Global Navigation Satellite System interference event that negatively impacts multiple

en route sectors and/or a major metropolitan airspace area, including the operations at satellite and reliever airports, for a period ranging from a few minutes to several days.

- **TFDM WP2:** TFDM WP2 will build on the functionality of TFDM by improving on one or more of the following capabilities: Flight Data Capabilities, Surveillance Data Capabilities, Tower Management Capabilities, Aeronautical and Weather Information Capabilities, and Decision Support Tools.
- **AIMM Segment 3:** AIMM 3 will expand on Segment 2 by adding the ability to dynamically update the status of SAA and airport configuration data and processing of static airspace constraints and business intelligence services to provide data products on demand to end user applications.

In 2018, a major FID is planned for:

- **Data Communications Segment 2:** Segment 2 will enable advanced NextGen operations, to include initial trajectory-based operations that would not be possible using the existing voice systems. To implement these capabilities, Data Comm is planning on software upgrades to the FAA Tower Data Link Services (TDLS) and ERAM systems.

In 2019, a major FID is planned for:

- **CSS-Wx WP2:** It will extend the capabilities of CSS-Wx WP1 and enable the retirement of the Weather Message Switching Center Replacement, the Automated Lightning Detection and Reporting System, and the Automated Weather Observing System Data Acquisition System.

In 2020, a major FID is planned for:

- **FAA Telecommunications Infrastructure 2 (FTI-2):** FTI-2 will be the follow-on to the FTI program. Today, FTI services provide an integrated suite of telecommunication products, services, and business practices that meet the FAA operational and NAS mission support requirements for dissemination of voice, video, and data products at an acceptable quality of service and bandwidth, and under a common data convention. FTI-2 may have scope similar to that of the present FTI program, along with updated services to meet NextGen and FAA telecommunications requirements for the decade of 2020 and beyond.

NextGen Concept of Operations: Gaps Impacting Full Implementation

As part of the Assessment findings, progress in many areas anticipated by 2020 relative to that described by the FAA's Mid-Term Concept of Operations was determined incomplete based on the following three root causes or gaps:

- **Technical Maturity:** Some concepts and technology are not mature enough to meet the NextGen vision outlined in 2008.
- **Operational Transition:** There is a need for more effective transitioning to maturing capabilities, including training on intended operational use and developing procedures and best practices.
- **User Adoption:** Aircraft operators need to equip their aircraft with new avionics for the changes to take place.

The following three tables provide examples of each gap area: technical maturity gaps (Table 1), operational transition gaps (Table 2), and user adoption gaps (Table 3). The first column in each table indicates a chapter in the NextGen Mid-Term Concept of Operations (CONOPS). The identified gaps are listed for each CONOPS chapter.

Table 1: Technical Maturity Gaps

Concept of Operations Chapter	Expected Technical Maturity Gap by 2020
Flight Planning	• Lack of flight-specific feedback with specific information on constraints pertinent to the intended flight • No application of early intent from flight plan options to allocate resources within or between sectors/facilities • Limited application of information from the flight plans to determine which routes best support user needs based on user equipage and performance capabilities (i.e., "best equipped, best served") • No automation enhancements that can define selective routes and enable the identification of optimal alternative routes for a user (based on equipage and certification) • Partial (or limited) availability of real-time, dynamic SAA scheduling to minimize the impact of CSV or military operations, as well as other events requiring SAA, upon the NAS
Reduced Weather Impact	No significant gaps identified
Strategic Traffic Management	• Lack of improved post-operations analysis to directly feed airspace design models (i.e., Airspace Resource Management System) • Reallocation of communications, surveillance, and trajectory data limited to predefined configurations in adaptation; concepts that rely on more flexible reallocation (e.g., generic airspace, flexible airspace) will not be realized. • Delivery of services tied to geographic location of ATC specialist and aircraft • Unavailable or limited use of higher complexity and more dynamic collaborative capabilities (e.g., Collaborative Airport and Airspace Configuration Management, Collaboration with Flight Operators) • Unavailable probabilistic techniques used for constraint prediction and development of Traffic Management Initiatives (TMIs)

Concept of Operations Chapter	Expected Technical Maturity Gap by 2020
Airport Operations and Services	• Limited use of CAT I Paired Approaches using ADS-B In • Unavailable CAT II Paired Approaches using ADS-B In • The following will be in limited use:[6] – Enhanced Flight Vision System (EFVS) for takeoff – Synthetic Vision System (SVS) for lower than standard approach minima operations – EFVS to touchdown – Low-visibility landing and taxi with advanced visual systems • Staffed NextGen Towers not implemented • Many aspects of the Surface Trajectory Based Operations concept will not be available. This includes the following specific capabilities for surface operations: – Automated generation of suggested Taxi Routing options – Automated Conformance Monitoring for pilot deviations from taxi clearances – Improved automated Conflict Alerting of potential runway incursions or other taxi routing conflicts – Generation of four-dimensional trajectories (4DTs) for the surface
Arrival and Departure Operations	• No implementation of single facility control service • No implementation of bi-directional routing • No use of complex, data-linked clearances to enable precise metering and 4DTs in en route and terminal (e.g., Dynamic RNP) • No use[7] of ground-automation enabled flight deck-based Interval Management-Spacing (IM-S) operations to high-density airports • Limited use of flight deck-based IM-S operations enabled via procedures in the en route environment and some terminal environments • No pairwise delegated aircraft-to-aircraft separation (Note: The FAA has focused spacing applications on interval management operations, not delegated separation.) • Deployment not completed at planned sites and no regular, continuous use of ground-based automation metering, merging, and sequencing enhancements in terminal airspace

[6] This finding assumes standards development will proceed on its current pace. In some cases, manufacturers will develop commercial products before standards are developed. If commercial product availability precedes standards development, these capabilities may be available earlier than projected. This finding assumes that the market (product availability) does not lead the standards development activity.

[7] This finding assumes ground automation dependencies and new ATC procedures to enable and integrate equipped and non-equipped operations.

Concept of Operations Chapter	Expected Technical Maturity Gap by 2020
En Route Cruise Operations and Services	• Time-of-arrival control operations not integrated within broader metering of operations • No segregated high-altitude airspace that incorporates aircraft equipage requirements (i.e., performance-based airspace) • No ability to use complex, data-linked clearances to enable precise metering and 4DTs in en route and terminal (e.g., Dynamic RNP) • No generic/high-altitude airspace capabilities • No operational use of conflict resolution advisories
Oceanic Operations and Services	• No pre-oceanic trajectory coordination prior to the flight's entry into oceanic airspace (predeparture or in flight)

Table 2: Operational Transition Gaps

Concept of Operations Chapter	Expected Operational Transition Gap by 2020
Flight Planning	• Partial (or limited) availability of dynamic SAA scheduling to minimize the impact of CSV or military operations, as well as other events requiring SAA, upon the NAS
Reduced Weather Impact	• Incomplete transition of NAS automation systems to NextGen weather infrastructure (and the implied decommissioning of legacy weather processors and interfaces) • Incomplete integration of enhanced weather information into NextGen decision making and advanced automation tools across operational domains
Strategic Traffic Management	No significant gaps identified
Airport Operations and Services	No significant gaps identified
Arrival and Departure Operations	• Deployment not completed at planned sites and no regular, continuous use of ground-based automation metering, merging, and sequencing enhancements in terminal airspace • Limited PBN procedures with curved path segments to provide optimized aircraft guidance during peak and non-peak traffic conditions at various NAS airports (core and less busy airports)
En Route Cruise Operations and Services	• Time-of-arrival control operations not integrated within broader metering of operations
Oceanic Operations and Services	No significant gaps identified

Table 3: User Adoption Gaps

The user adoption gaps listed are based on the findings of the NextGen Fleet Readiness Assessment performed by MITRE as part of its assessment of NextGen plans. Through FAA sponsorship, we assess and report current and forecast NextGen avionics Fleet Readiness with a focus on the Federal Aviation Regulation Part 121 scheduled air carrier fleet, also referred to as the Air Transport fleet. The assessment of user adoption gaps is based on an analysis we completed on current equipage trends and the potential for future standard and optional equipage available through 2025.

Concept of Operations Chapter	Expected User Adoption Gap by 2020
Flight Planning	No significant gaps identified
Reduced Weather Impact	No significant gaps identified
Strategic Traffic Management	No significant gaps identified
Airport Operations and Services	• Limited use of CAT I Paired Approaches using ADS-B In • No CAT II Paired Approaches using ADS-B In • The following will be in limited use:[8] – EFVS for takeoff – SVS for lower than standard approach minima operations – EFVS to touchdown – Low-visibility landing and taxi with advanced visual systems • Ground-Based Augmentation System (GBAS) CAT II and III standards for precision approach operations will likely be available, but operational use at locations where it is needed is unclear (has an airport adoption dependency).
Arrival and Departure Operations	• No use of complex, data-linked clearances to enable precise metering and 4DTs in en route and terminal (e.g., Dynamic RNP) • No use[9] of ground-automation enabled flight deck-based IM-S operations to high-density airports • Limited use of flight deck-based IM-S operations enabled via procedures in the en route environment and some terminal environments • No pairwise delegated aircraft-to-aircraft separation (Note: The FAA has focused spacing applications on interval management operations, not delegated separation.) • Limited use of PBN procedures with curved path segments to provide optimized aircraft guidance during peak and non-peak traffic conditions at various NAS airports (core and less busy airports)
En Route Cruise Operations and Services	• Time-of-arrival control operations will not be integrated within broader metering of operations • No use of complex, data-linked clearances to enable precise metering and 4DTs in en route and terminal (e.g., Dynamic RNP)

[8] This finding assumes standards development will proceed on its current pace. In some cases, manufacturers will develop commercial products before standards are developed. If commercial product availability precedes standards development, these capabilities may be available earlier than projected.

[9] This finding assumes ground automation dependencies and/or new ATC procedures to enable and integrate equipped and non-equipped operations.

Concept of Operations Chapter	Expected User Adoption Gap by 2020
Oceanic Operations and Services	No significant gaps identified

Aircraft Equipage Implications on NextGen Operations

Decisions by operators to adopt and equip their fleets with new avionics are complex.[10] Considering the factors that influence equipage, our assessment shows that the Air Transport fleet is primarily being equipped via forward fit opportunities as new aircraft replace older aircraft. The FAA expects that operators will have the option to acquire enabling NextGen avionics on new aircraft purchases. This is particularly evident with regard to PBN, where suppliers are currently delivering new aircraft with many of the PBN avionics enablers installed and ready for use. Provided with a positive business case for forward fit evolution through optional equipage, operators are expected to exercise these opportunities to enhance new aircraft value and increase fleet readiness for NextGen.

While it is evident that operator fleet evolution is already occurring as part of the normal aircraft retirement/replacement cycle, retrofitting existing aircraft is not nearly as robust. Air Transport retrofits do not appear to be occurring in significant numbers. Of greater concern, the retrofit activity seen within the fleet is often a result of FAA-funded programs, not operator-driven initiatives. Various FAA-funded pilot programs, such as Data Comm, WAAS, and ADS-B, are enabling some near-term success in achieving equipage for these NextGen capabilities. However, the long-term picture is still unclear. For instance, the ADS-B Out rule has resulted in very limited equipage—less than 3 percent of the fleet—despite this mandate's January 2020 effective date. Based on similar historical retrofit programs and considering that some fleets of aircraft do not yet have certified systems for purchase, the remaining time before rule implementation in 2020 may not be sufficient for all operators to equip their aircraft.

Finally, although not the primary focus of our equipage analysis, it is important to note that General Aviation (GA) and Air Taxi (AT) continue to have high GPS equipage levels. Their primary interest is in safety-related NextGen technologies such as Traffic Information Services and Flight Information Services. With high PBN equipage already, the equipage gaps for GA and AT are due to a lack of systems for all aircraft types, primarily in the Data Comm and Low Visibility-related technology domains.

Aircraft equipage, user adoption, gaps, and rationale are as follows (listed by Improvement Area):

- **Low Visibility Operations Improvement Area:** The EFVS and SVS equipage gap is a lack of systems for all aircraft types and the significant cost of the equipment.
- **Situational Awareness Improvement Area:** Cockpit Display of Traffic Information technology is widely available, but remaining challenges for operators to purchase the equipment are a lack of widespread operations, the dependency on ADS-B Out equipage that has not yet materialized, and a lack of technical details for a potential ADS-B In rule.
- **Precision Approach Procedures Improvement Area:** The GBAS equipage gap is primarily due to a lack of systems for all aircraft types, the significant cost of the equipment, the fact that GBAS

[10] Avionics equipage adoption decision making is affected by factors such as specific business considerations, and external factors such as regulatory action or operational considerations outside their markets. With respect to business considerations, new avionics equipage must compete with many corporate needs (e.g., terminal upgrades, new information technology systems, establishment of new markets, upgrades that directly impact the passenger experience or provide the potential for significant cost savings [e.g., more fuel-efficient engines, drag-reducing airframe winglets, etc.]). External factors include limited vendor offerings and—for some large fleet operators—the uncertainty of their future fleet plans due to the "bubble" of aircraft retirements from service projected for the 2018–25 timeframe.

CAT III equipage not expected until after 2020 when standards are completed, and a lack of widespread operational use driving demand.

- **Communications Improvement Area:** The Data Comm equipage gap for complex clearances is due to a lack of systems for all aircraft types, the cost of the equipment, and a lack of widespread operational use driving demand. Additionally, Aeronautical Telecommunication Network (ATN) B-2 final avionics and aircraft capability are not expected to be available until after 2020.

Appendix B: Additional Background and Rationale for the Recommendations

This appendix contains additional information pertaining to each of the recommendations in the body of the report. Each recommendation contains the following information:

- Background gives context to understand the circumstances associated with the recommendation. Examples of the type of information that may be provided include:
  - Existing or projected problems facing the FAA or aviation community.
  - Descriptions of previous, ongoing, or planned events or activities.
  - Characteristics of the current or anticipated operational environment.
  - The state of technology, standards, or the commercial marketplace.
- Detailed Recommendation provides a detailed statement of the recommendation.
- Rationale provides the reasoning behind the recommendation.

A1: Complete Future Air Navigation System (FANS)-based Data Comm Services (Data Comm Segment 1)

Background

Significant development efforts have been completed for tower and en route Data Comm capabilities for FANS-based Data Comm Services. More than 1,900 aircraft will be FANS equipped and able to participate in data communications for predeparture reroutes at 57 towers through Segment 1, Phase 1, as a result of the FAA equipage incentive program. En route Data Comm capabilities correspond to a RTCA NextGen Advisory Committee (NAC) priority recommendation and are foundational elements for achieving NextGen benefits. The current program is on schedule and should be implemented as planned at 57 towers and all 20 Air Route Traffic Control Centers. The FANS implementation will be a revolutionary change in FAA domestic operation and will demonstrate global leadership in air-to-ground data communications en route service delivery. The experience gained from this effort will mitigate the risk of more complex Data Comm use for ATN B2.

Detailed Recommendation

Complete FANS-based data communications for tower and en route (Data Comm Segment 1).

- Deploy FANS-based Data Comm services to all 20 en route facilities and the planned 57 towers beginning in 2019. This deployment should include a national policy for the use of the capability, along with obtaining consensus from the user community on the benefits of data communications.

Rationale

FANS-based Data Comm services provide foundational elements for achieving NextGen benefits and are consistent with the RTCA NAC priority recommendation.

- Data Comm will provide the ability to exchange complex information (e.g., reroutes) between pilots and controllers that is difficult to communicate with existing voice capabilities, thus enabling system benefits not achievable today.
- Data Comm will provide controller and pilot tools that will reduce workload and improve system efficiency and capacity.
- Data message exchange will enhance safety by providing digitized control instructions, avoiding communication errors inherent in today’s voice-only communications.
- The experience gained from this effort will mitigate the risk of more complex Data Comm use for ATN B2.

A2: Pursue ATN B2 as the global standard for future Data Comm applications and align operational transition with integrated avionics and ATC services availability

Background

FANS-based Data Comm will not fully support the advanced operations described in the NextGen Mid-Term CONOPS. (e.g., ADS-B In Pair-Wise procedures and Dynamic Required Navigation Performance with 4D constraints). The Aeronautical Telecommunications Network (ATN) standard is evolving to support future air-to-ground Data Comm requirements, and the current European implementation (ATN B1) is inadequate to support U.S. needs. The FAA is actively working to ensure that the ATN Baseline 2 (ATN B2) final standard supports NextGen advanced aircraft-centric operations, with a Final Investment Decision for ATN B2-based data communications in Segment 2 of the Data Comm Program in 2018.

Detailed Recommendation

The FAA should focus on deploying FANS-based data communications for en route Data Comm services consistent with the NAC recommended priorities. The FANS implementation will be a revolutionary change in FAA domestic operations and will demonstrate global leadership in air-to-ground data communications en route service delivery. The experience gained from this effort will mitigate the risk of more complex Data Comm use for ATN B2.

Concurrent with Segment 1 FANS implementation, the FAA must continue to develop the global ATN B2 standards. The standards work must be combined with efforts to develop mature integrated operational concepts. This must be pursued aggressively if avionics and ground system implementation are to be complete in the planned FAA timeframe. The FAA should continue to work with users and manufacturers on operational benefits of integrated functions and alignment of implementation schedules to meet ATC service availability objectives.

Rationale

The Data Comm Program Segment 1 will deliver significant benefits from FANS-based data communications to both the FAA and user community. To enable these benefits, the FAA has agreements in place to incentivize avionics equipage for a portion of the U.S. domestic fleet. Additional FANS equipage is expected as operations mature and benefits are demonstrated. Continued FAA and industry focus on FANS-based Data Comm implementation in the near term reduces overall data communications risk and will deliver significant value from the FAA's investment in FANS.

FANS, however, will not support the advanced data communications applications envisioned under NextGen. The FAA has been actively engaged with the international standards community to ensure that the ATN standard evolves to meet the complex demands of the NAS, and this effort must continue if U.S. interests are to be preserved. ATN B2 will require integration with other advanced CNS functions (i.e., Advanced Interval Management, Dynamic Required Navigation Performance [RNP], and Winds data) to provide benefits above and beyond FANS. These concepts are not sufficiently mature, and need to be further developed to demonstrate the incremental benefits of ATN B2 over FANS-based data communications and to ensure standards supports the intended uses.

Aligning ATN B2 operational transition with avionics and ATC services availability will maximize the FAA's overall Data Comm program investment and will reduce FANS and ATN B2 implementation risk. In addition, aligning ATN B2 with advanced avionics capabilities and ATC services enables the FAA and industry to:

- Better understand the additional benefits and value over that provided by FANS-based en route Data Comm (Segment 1 Phase 2)
- Adequately plan for the transition from FANS-based en route Data Comm to ATN B2-based services
- Mature the ATN B2 standards and associated operational concepts, as augmented with Advanced FIM and Dynamic RNP
- Build interest in ATN B2 capabilities among airspace users
- Create marketplace demand for ATN B2 avionics

A3: Transition to Networked Voice Services at High-Priority Towers/TRACONs and All En Route Facilities to Maintain Service and Enable Unmanned Aircraft Systems (UAS) New Entrants (NAS Voice System [NVS] Segment 2)

Background

Current-generation voice switches are reaching the end of their usable life across the NAS. The FAA's NVS program is in place to acquire new capabilities to address the obsolescence issue and enable new capabilities needed in upcoming segments of the NextGen. The FAA has selected a contractor to develop those capabilities. The deployment of NVS Voice over Internet Protocol (VoIP) capabilities to control remote sites across the NAS will allow the FAA to begin migrating the majority (roughly 55 percent) of its 21,000 dedicated circuits to IP network transport. Future FAA decisions will determine the deployment plan for delivering those capabilities in the NAS.

Detailed Recommendation

Transition to networked voice services at high-priority towers/TRACONs and all en route facilities to maintain service and enable new entrants (NVS Segment 2).

- Begin deployment at facilities where sustainment is most needed, while also considering where future NextGen capabilities will be initially implemented.
- Give priority to replacing legacy voice switches that are reaching end of service.
- Complete deployment to high-priority terminals and all en route facilities by the 2025 timeframe to enable the full integration of voice communications with UAS operators.

Rationale

As the currently deployed voice switches reach the end of their usable life, a structured replacement program will:

- Address near-term sustainment need for voice switches across the NAS.
- Provide a transition path away from outmoded, high-cost dedicated transmission services, potentially reducing the number of switch types, lowering operations and maintenance costs, and facilitating remote operations through VoIP applications.
- Enable access for new NAS entrants (e.g., UAS) as well as provide for other NextGen capabilities.

A4: Rapidly Field Tower/Surface Electronic Data Sharing at High-Priority Sites to Deliver Airport-Specific Benefits (Modified Terminal Flight Data Manager [TFDM])

Background

A prototype electronic flight strip system, called Advanced Electronic Flight Strips (AEFS), is currently fielded at Phoenix Air Traffic Control Tower (PHX). As part of the TFDM Early Implementation Strategy (EIS), the TFDM program office is planning to sustain AEFS at PHX and field AEFS at additional tower locations. AEFS provides electronic data and data sharing between tower positions and will ultimately be replaced when the TFDM system is deployed. In addition, as part of the TFDM EIS, the TFDM program office is planning to fund efforts to expand the set of data elements shared between the FAA and flight operators via Traffic Flow Management Systems (TFMSs). The TFDM EIS also includes deploying prototype capabilities to share surface position data, referred to as surface situation awareness capabilities, with select TRACONs and the Command Center.

Detailed Recommendation

Continue the TFDM EIS at recommended sites to deliver airport benefits. The FAA should also:

- Reduce the scope of the TFDM to focus on the largest operational shortfalls, which include metering at surface-constrained airports and the need for electronic flight data for internal and external coordination.
- Move to an agile acquisition approach to incrementally deploy the TFDM capabilities, building on the existing prototypes for surface viewer and electronic flight strip.
    - Tower flight data needs a stable infrastructure that can support maturation of the existing prototype capabilities and future applications.
    - Fields and operators should be continuously engaged in maturing the applications—especially to determine what information users need to build their extensions.
- Implement surface data exchange in a way that enables airport users and operators to develop tools to meet their needs.
- Defer future TFDM program builds of new capabilities until concepts for surface modeling and data communications are mature.

Rationale

The current TFDM EIS provides the benefits of electronic flight data, supports risk reduction for TFDM, and promotes early user buy-in of Surface Data Exchange and the improvement of existing Collaborative Decision Making agreements. Fielding surface metering prototypes may also provide additional near-term benefits. Deferring the implementation of immature capabilities reduces the cost and risk of achieving mature capabilities.

A5: Replace Automation at Select Small TRACONs to provide a Common Platform at Future Facilities (Modified Terminal Automation Modernization and Replacement Phase 3, Segment 2 [TAMR P3S2])

Background

TAMR P3S2 is the replacement of the Automated Radar Terminal System (ARTS) IIE with Standard Terminal Automation Replacement System (STARS) ELITE platforms, in support of the FAA's goal to deliver ADS-B service and to converge to a single platform (STARS) at all TRACONs. The recommendation is to modify TAMR P3S2 procurement/deployment plans and funding levels to account for rightsizing facilities and to deliver ADS-B service where needed.

Detailed Recommendation

Accelerate decisions about rightsizing low-volume towers, TRACONs, and combined tower/TRACONs, and modify TAMR P3S2 scope as appropriate to reflect site potential for decommissioning.

- Confirm that all the TRACONs on the TAMR P3S2 deployment list will remain post-rightsizing initiatives.
- Ensure that equipment and telecommunications bandwidth at remaining TAMR P3S2 sites have sufficient capacity and performance to support needed ADS-B operations in the post-rightsizing timeframe.
- Discontinue ARTS-based services for the identified sites as soon as practical, to achieve a single baseline for terminal.

Rationale

Decisions to rightsize tower and TRACON services may impact the TAMR deployment plans and the system requirements.

A6: Transition to Secure Information Services to Improve Cybersecurity and Reduce FAA Cost

Background

Net-centric information dissemination remains a key NextGen capability that enables:

- Efficient, standardized distribution of different categories of NextGen information.
- Less costly additions of new information categories, services, and users.

Current planning by NAS consumer programs to use SWIM-enabled net-centric services is uneven and not gaining traction in many instances. SWIM was designed so individual applications and users can transition naturally during the next upgrade of the other information systems. But there is no enterprise-level governance mechanism to ensure that transitions are done in as timely a fashion as possible. Without a sunset date, prolonged sustainment of legacy systems is likely.

Detailed Recommendation

Transition to secure information services for non-critical data uses to reduce FAA cost (Modified SWIM Segment 2b).

- Ensure implementation and use of the Identity and Access Management (IAM) cybersecurity controls as part of the deployed SWIM Core and On-Ramping Capabilities in Segment 2b.
- Fully implement SWIM 2b only when there is an enterprise-level plan and funding to ensure that the foundational and transformational systems will use SWIM 2b capabilities.
- Defer enhanced Flight Data Processing System (FDPS) until a concept and plan for NAS-wide flight data authoritative source and distribution becomes mature.
- If this enterprise-level plan is not instituted, make no further investments in related NAS net-centric infrastructure capabilities (e.g., enhanced SWIM services, weather, and aeronautical information).

Rationale

The SWIM program provides an opportunity to implement IAM capabilities and improve the NAS security posture. The retirement of legacy, one-of-a-kind interfaces and dissemination systems will help reduce operations and maintenance costs. Without a forcing function (e.g., sunset date or security policy), legacy systems will perpetuate inefficient and unsecured data operations. Without a mature, enterprise-level concept for NAS-wide flight data authoritative source and distribution, it is not prudent to go forward with enhanced FDPS.

A7: Transition to Replacement Aeronautical and Weather Information Services to Reduce FAA Cost (Aeronautical Information Management Modernization [AIMM] Segment 2, Common Support Services-Weather [CSS-Wx] Work Package 1 [WP1], NextGen Weather Processor [NWP] WP1)

Background

CSS-Wx will disseminate enhanced weather information to FAA service providers and external users via SWIM and will include direct integration of weather into decision support and ATM planning tools. It will:

- Enable universal access and standardization of weather information.
- Filter weather information by location and time.
- Make weather information available for integration with Decision Support Tools (DSTs).

CSS-Wx WP1 is planned to replace the functionality of:

- Weather and Radar Processor (WARP) communication components—Weather Information Network Server.
- FAA Bulk Weather Telecommunications Gateway.
- Corridor Integrated Weather System, Data Distribution System, and Integrated Terminal Weather System dissemination functions.

The planned FID for CSS-Wx WP1 is 2014. The Initial Operational Capability (IOC) is planned for 2017, and Full Operational Capability (FOC) is planned for 2019.

NWP will develop products for publication via CSS-Wx. NWP will:

- Replace legacy weather processor systems.
- Employ information from FAA and National Oceanic and Atmospheric Administration (NOAA) radar and sensors, and NOAA forecast models.
- Create aviation-specific current and predicted weather products that will not require meteorological interpretation.
- Perform Weather Translation, enabling use of weather information by automated DSTs.

The planned FID for NWP WP1 is 2014. The IOC is planned for 2017, and FOC is planned for 2019.

The AIMM program modernizes the collection, integration, and distribution of Aeronautical Information (AI). It will build the Aeronautical Common Service (ACS), an enterprise-based, service-oriented architecture that will be the trusted AI source for both internal and external consumers. The ACS includes Special Activity Airspace (SAA) and airport data necessary to achieve shared situational awareness, including its fusion with Notice to Airmen data.

AIMM Segment 2 ACS will:

- Improve distribution of SAA-relevant information.
- Provide access to Airports Geographic Information System data for information about airports.
- Leverage SWIM capabilities.

The planned FID for AIMM Segment 2 is 2014. The planned FOC for AIMM Segment 2 is 2017.

Detailed Recommendation

Transition to replacement aeronautical and weather information services to reduce FAA cost.

- Compel NAS-wide conformance by transitioning to these net-centric services, and aggressively decommission legacy information sources. Implement CSS/Wx WP1 and NWP WP1 and include a transition plan and funding for modernization of weather common service user program interfaces and platforms to achieve cost avoidance.
- Implement AIMM Segment 2 and include a transition plan and funding for modernization of ACS user program interfaces and platforms to achieve cost avoidance.
- Consequently, defer future aeronautical information services (AIMM Segment 3) until concept and policy exist for operational use as authoritative source.

Rationale

Going forward with CSS-Wx WP1, NWP WP1, and AIMM Segment 2 will:

- Reduce the number of NAS interfaces for common weather and AI and enable the retirement of outmoded legacy interfaces.
- Begin the process of retiring outmoded systems such as Weather Message Switching Center Replacement and WARP.
- Lower long-term operations and maintenance costs.

A8: Defer Future Common Weather Enhanced Services Until Concepts For Integration Are Clear (CSS-Wx WP2 and NWP WP2)

Background

CSS-Wx and NWP programs were recently split into two work packages. WP1 capabilities generally support initial integration of weather information into NAS automation and decision-making systems, whereas WP2 capabilities generally support 1) improved weather information and dissemination, and 2) full integration of weather information into NAS automation and decision-making systems. FID for CSS-Wx WP2 is in 2019. FID for NWP WP2 is in 2020.

Detailed Recommendation

Defer CSS-Wx WP2 and NWP WP2 until there are mature concepts for integration of weather information into NAS automation.

Focus on implementing CSS-Wx WP1 and NWP WP1, and use experience gained to determine what additional weather services might be needed.

Rationale

Planning by NAS consumer programs for transition to net-centric weather services is uneven, and the FAA does not have a mature concept nor requirements for the integration of weather information into NAS automation and decision-making systems. Consequently, until the capabilities of CSS-Wx WP1 and NWP WP1 are complete, being used, and the concept for integration is well formulated, it is not prudent to go forward with CSS-Wx WP2 or NWP WP2.

B1: Implement Redesigned Airspace and Procedures at Initial Metroplexes to Deliver Airport-Specific Benefits Where Stakeholder Commitments Have Been Made

Background

In response to recommendations from the aviation community through RTCA's NextGen Mid-Term Implementation Task Force, the FAA is putting integrated NextGen capabilities in place to improve air traffic flow for an entire region, or Metroplex. The FAA initially identified 21 Metroplexes—geographic areas that include several commercial and general aviation airports in close proximity serving large metropolitan areas. Then it combined some sites with highly connected procedures (e.g., Cleveland - Detroit), and deferred sites with active legacy airspace or Performance-Based Navigation (PBN) projects (e.g., Denver), resulting in a list of Metroplexes for initial optimization. By optimizing airspace and procedures in these Metroplexes, the FAA addresses efficiencies on a regional scale, rather than focusing on a single airport or set of procedures.

Using a consistent, repeatable approach, study teams of FAA and aviation stakeholder experts analyze the operational challenges of Metroplexes and explore airspace and procedures optimization opportunities. Collaborative design and implementation teams then put in place the solutions the study teams recommend, including PBN procedures and airspace redesign.

Detailed Recommendation

Continue with industry stakeholder coordinated plans already identified and in progress to complete the development and implementation of the selected Metroplex projects.

For each location, the teams need to consider and align with other operational improvements that will impact Metroplex operations. These include:

- Mature Closely Spaced Parallel Operations (CSPO) capabilities that will be implemented in the same timeframe.
- Time-Based Flow Management (TBFM) arrival and departure operational practices.
- Performance-Based Navigation (PBN) procedures.
- Surface and departure practices and procedures.

Rationale

The FAA should maintain current stakeholder implementation commitments on Metroplex activities until the end of Fiscal Year 2018. Meeting these commitments delivers significant operational benefits in the near term using existing capabilities while allowing the NAS to continue to evolve and adapt to emerging safety or efficiency issues related to changes in demand, fleet mix, aircraft performance, or other factors.

B2: Implement Multi-runway Procedures at Priority Airports (e.g., Enhanced Lateral Separation Operations [ELSO], Closely Spaced Parallel Operations [CSPO], Wake) to Deliver Airport-Specific Benefits

Background

The FAA's initiatives toward multiple runway procedures are focused on increasing arrival and departure throughput and efficiencies at airports. Many of the near-term changes take advantage of better data and/or improved aircraft navigation precision (e.g., spacing, dependent operations, wake Re-categorization [RECAT], and ELSO) to improve throughput and operational efficiencies. Other initiatives are focused on regaining the loss of capacity that occurs during low-visibility conditions at airports. Since 2008, there has been significant research, standards development, the implementation of wake concepts (for runway spacing less than 2,500 feet) and for independent and dependent parallel runway operations concepts (for runway spacing between 2,500 and 4,300 feet), as well as improved navigation precision and flight path repeatability through PBN and increased aircraft equipage.

Detailed Recommendation

Implement multi-runway procedures (e.g., ELSO, CSPO, wake RECAT) at priority airports to deliver airport-specific benefits.

- For mature concepts (RECAT Phase I, dependent stagger distance reduction, Joint Order 7110.308), implementation should continue at the current or an accelerated pace.
- As new concepts mature (e.g., divergent departure [ELSO], RECAT Phase II), determine the appropriate sites for implementation.
- Where multiple procedural solutions are being developed to address the same shortfall, reconcile the best use of those solutions.

Rationale

Making better use of increased efficiencies of parallel runway operations using mature procedures, new operational standards, and controller aids provides significant benefits, as identified by the NAC.

B3: Initiate Additional Metroplex Redesign and Non-Metroplex PBN Procedure Designs to Deliver Airport-Specific Benefits

Background

The PBN Metroplex activity provides a focused and repeatable development and implementation process for the highest priority locations in the NAS. The potential separation methods, enabled by PBN, require additional development and research before they can be implemented across the NAS.

Detailed Recommendation

Initiate additional Metroplex redesign and non-Metroplex PBN procedure design to deliver airport-specific benefits. The site selection process for the next locations should reflect the most pressing NAS-wide needs (including safety issues) and should account for the benefits from new capabilities. The redesign processes should reflect the NextGen capabilities.

The FAA should apply the PBN Metroplex process to the next set of priority airports. It should also continue the development of PBN capabilities at additional sites to address specific safety and efficiency issues. PBN can provide new methods to reduce separation between aircraft and achieve additional throughput and flight efficiencies.

Rationale

PBN Metroplex and non-Metroplex design activities address safety and efficiency issues in the NAS, allowing users to benefit from their avionics investments. As other NextGen capabilities evolve and are implemented, the redesigns should leverage these capabilities to further increase operational benefits.

B4: Develop a Phased Approach to Deploy Metering Capabilities as They Mature to Support Metroplex Redesigned Operations for Airport-Specific Benefits

Background

Metroplex redesign operations provide a way of aligning aviation services to a large geographic area, serving multiple municipalities, many airports, many stakeholders, and a diverse set of aviation customers. Operational problems in this context are complex, such as flow congestion, inefficient routing and altitudes, airports in close proximity, and other limiting factors such as environmental constraints. These complex problems may require an integrated portfolio of solutions, including application of available and emerging technologies, efficient airspace and procedures, airfield enhancements, and regulatory and policy changes. Time-based metering via TBFM provides prerequisite consistency for aircraft flows to a Metroplex and enables the application of PBN capabilities to optimize aircraft and system performance. Metering capabilities have evolved from facility-specific to inter-facility applications, requiring additional training and expertise from the Traffic Managers. The successful Houston Metroplex deployment of 60+ new PBN procedures required changes to TBFM parameters to ensure implementation success. The next TBFM system enhancement (WP1) calls for four specific enhancements.

Detailed Recommendation

Move to an incremental, agile development approach to deliver metering capabilities as they mature to support Metroplex redesigned operations for airport-specific benefits.

- As part of this approach, proceed with the activities to deploy the Integrated Departure/Arrival Capability, which is mature.
- Defer less mature capabilities until proven through agile development with the field to ensure operational success.

Accelerate activities to mature those elements of terminal metering that would increase the benefits realized from planned Metroplex and non-Metroplex PBN implementations. We suggest that the Airspace Program Office and the TBFM Program Office conduct a joint initiative to validate those highest priority elements.

Rationale

The TBFM program continues to attempt to procure additional capabilities. For TBFM WP3, new capabilities seek to advance the state of metering. In the case of TBFM WP3, three of the four capabilities presented for decision may carry a higher risk to achieving success based only on the schedule. Metering during Reroute Operations brings together the Traffic Flow Management options of metering and rerouting. The high-level concept and specific capabilities are not clear, nor have the benefits been clearly determined. The Path Stretch concept relies upon route changes in the en route environment and has not been sufficiently validated; alternative concepts are also being considered. The Terminal Sequencing and Spacing concept is continuing under development, and the aggressive timeline is precluding necessary concept engineering work and evaluation of off-nominal scenarios and applications. These three capabilities carry a higher risk to achieving success based only on the schedule.

B5: Develop Policy for, and Clearly Communicate Consequences of, ADS-B Mandate Non-compliance to Increase Equipage

Background

The FAA has issued an airspace rule (14CFR-§91.225) requiring that by January 1, 2020, all aircraft operating in high-density airspace and airspace above 10,000 feet be equipped with ADS-B transmitters (ADS-B Out) that comply with a set of performance requirements published by the FAA in 2010 (14CFR-§91.227). There is increasing concern that the aircraft owners, operators, and suppliers are not acting with the lead time required to meet this deadline. Uncertainty about rule compliance by aircraft operators has resulted in low-volume sales. Currently only 3 percent of the 6,000 U.S. Air Transport fleet and 1 percent of the 150,000 General Aviation (GA) and Air Taxi (AT) fleet are equipped with rule-compliant ADS-B Out systems. The operators are not purchasing mandate-compliant solutions, and suppliers are observing limited demand for these solutions and are therefore not investing in creating competitive options to lower the cost. Ambiguity in the performance requirements may be contributing to the lack of action by the industry.

Surface conformance monitoring was considered in the development of the initial standards but is no longer a 2020 envisioned capability; yet the rule does not distinguish the performance requirements for operations above 10,000 feet. In addition, the rule addresses ATC-authorized deviations on a flight-by-flight basis, but the FAA has not clearly stated the circumstances under which those deviations will be granted.

The FAA has completed the deployment of the ADS-B infrastructure and is on track to complete the necessary automation upgrades to provide separation services using ADS-B in conjunction with radar and ADS-B alone in non-radar airspace. The FAA has also provided funding to some suppliers and operators to overcome the technical challenges of developing avionics and completing the Special Supplemental Type Certificate (STC) process. This has resulted in three suppliers capable of producing equipment for a successful STC on six Air Transport aircraft types. Similarly, the FAA has worked closely with the GA industry to certify equipment for many common types of small aircraft and helicopters.

Detailed Recommendation

MITRE acknowledges that there are NAS-wide benefits to the U.S. aviation community for the FAA to hold to the commitment on the rule date. MITRE recommends that the FAA communicate its commitment to the rule date by clarifying:

- The performance requirements of mandated equipage, to enable avionics suppliers to offer options for complying with greater certainty.
- The consequences of operators not complying with the mandate, to minimize operator confusion about ADS-B value.
- The conditions (however rare) under which deviations are likely to be granted.

Rationale

To maintain the 2020 rule date without negatively impacting transport and GA operations, near-term action is required to clarify both avionics requirements and the consequence of non-compliance.

- Clarifying ADS-B mandate equipage performance requirements and clarifying implications of non-compliance should motivate operator preparation and potentially stimulate market offerings.

- Operators should know which supplier choices will clearly comply with the rule, and should clearly understand whether a new aircraft purchase will not be compliant without retrofit activities.
  - Transport aircraft airlines and Boeing/Airbus believe the SA-aware Multi-Mode Receiver (MMR) can meet the rule, and they are willing to equip the 60 to 70 percent of their fleet that does not have it on board. They need the FAA to clarify officially that SA-aware MMR meets the rule requirements.
- The FAA needs to be proactive to provide clarity and resolve other uncertainties facing the community that must make purchasing decisions on how to comply. Examples include:
  - Work with international Air Navigation Service Providers (ANSPs) that have their own ADS-B and other CNS capability plans to align the timing and requirements to the extent practical.
  - Articulate the service changes for conforming and non-conforming flights, including benefits that will become available before 2020 (e.g., Ground-based Interval Management, ERAM R-side conflict probe, ADS-B In applications).
  - It is highly likely the some operators or even whole segments of the industry will ask for deviations from the rule. The FAA needs to understand this potential outcome and begin preparing its policies for addressing the requests before they happen.

B6: Implement National Use Policies for Collaborative Routing and Time-Based Metering to Realize More Predictable Flows (TBFM/CATM)

Background

The implementation of Traffic Flow Management (TFM) capabilities is pivotal to improving efficiency. Many flow management tools have been and continue to be deployed with minimal training and information on intended use. This is true of some CATM capabilities (e.g., Reroute Impact Assessment) and TBFM in general, including capabilities that continue to be added to the field. In the case of TBFM, an initiative is underway to align TBFM resources, training, and national policy to ensure that TBFM achieves the capability to support PBN and other NextGen efforts. The CATM program is deploying significant tools for collaborating on routing during flight planning, predeparture, and airborne. Discussions are underway on how best to use these capabilities, but plans for procedures and training cover only the basic use of the tools.

Detailed Recommendation

Review TFM programs individually by system, and then collectively in the context of TFM problem solving, to determine if deployed capabilities are being used in the field and if the envisioned benefits are being realized before adding enhancements.

- Develop national policy on the best operational use of TBFM capabilities to realize the benefits from currently deployed and new systems.
- Provide procedures and training for best operational use of functions associated with the new routing and scheduling applications.

Rationale

In April 2014, the Air Traffic Organization (ATO) commissioned a Time-Based Metering Assessment to survey TBFM use across the NAS and discovered a wide variance in its operational use and effectiveness across facilities. The study identified seven issue areas that prevented greater TBFM success. It showed that significant improvement of TBFM effectiveness would require the development of a national use policy, updates to FAA Orders, alignment of procedures with updated policies, and NAS-wide training. AJV-8 is assuming the lead role in coordinating the ATO collaborative effort and is instituting an action plan to align efforts and enhance wider standardized use and coordination of TBFM.

The CATM program can leverage the lessons learned from the TBFM assessment to improve on capabilities that have been underutilized, such as the Reroute Impact Assessment capability deployed in January 2011. From the Post Implementation Report, "…the full benefit of the [ReRoute Impact Assessment] RRIA enhancements is not being realized due to a lack of hands on training and a failure to incorporate RRIA usage into standard operating procedures for reroute planning." Its use is sporadic at best, and in many facilities, the Traffic Managers are not even aware of its existence. Three other key tools for collaborative routing are currently being deployed as part of the CATM work package but have not yet been assessed for best use practices.

B7: Implement En Route Capabilities for Improved Trajectory Modeling and Flight Planning to Obtain ADS-B Out and Optimized Profile Descent (OPD) Benefits, and Enable UAS Operations

Background

A set of key enhancements is planned for foundational NextGen capabilities or en route ATC Sector enhancements. Candidate capabilities that relate to Separation Management include:

- Improvements in the accuracy of modelled aircraft trajectories and the Conflict Probe functionality will reduce nuisance Conflict Probe alerts and provide sufficient accuracy for displaying Conflict Probe information on the radar position. This improvement will leverage the modified Wake Separation standards (NAC Tier 1A priority). It will provide the controller with improved information to manage reduced and variable separation standards (e.g., 3 NM separation in transition airspace) more effectively, as well as enabling strategic resolutions and efficient maneuvers, increased use of direct-to clearances, and better management of OPDs. It provides the last necessary piece to achieve the ADS-B Out $900 million in projected benefits already claimed (by operating closer to the separation standards).
- Improvements in controller access to aircraft flight data and equipage information will allow controllers to make informed and timely decisions related to CNS eligibility of aircraft.
- Improvements in the display of strategic information on the Radar Controller position, including Conflict Probe alerts, and tactical information on the Radar Associate Controller position will facilitate the use of strategic problem solving and improve efficiency.
- Improvements in processing flight plans containing increased length of routes associated with UAS will indicate to the controller when a UAS is in a lost-link condition, and assigning type (and sub-type) designations will allow controllers to distinguish specific UAS aircraft weight class and performance limitations.

Detailed Recommendation

Implement en route capabilities for improved trajectory modeling and flight planning to obtain ADS-B Out and OPD benefits, and enable UAS by including in future ERAM releases the capabilities to:

- Improve the accuracy of modelled aircraft trajectories and Conflict Probe.
- Incorporate unique flight plan features for UAS.
- Improve the display of strategic information on the Radar Controller position.
- Achieve 3-mile separation outside the 40 NM radar coverage area and Wake Separation standards (*NAC priority*).
- Provide controller access to aircraft flight data and equipage information to allow controllers to make informed and timely decisions related to CNS eligibility of aircraft.

Rationale

The current scope of ERAM Sector Enhancements reflects recent agency reprioritization of capabilities that are mature and have FAA stakeholder buy-in. These are the minimum changes needed to incorporate UAS flights routinely in the NAS and provide the ADS-B Out benefits from improved accuracy. They also enable future plans for a policy of “best equipped, best served.”

C1: Fast-track across Government small Unmanned Aircraft System (sUAS) Rulemaking to Enable Routine sUAS Operations

Background

Today, the general public has an unprecedented level of access to sUAS, as these airframes have become very affordable, and innovative uses, such as package delivery, are being explored. However, there is no legal framework for commercially operating sUAS. While there is a draft rule that will likely apply to UAS weighing less than 55 pounds and operating at low altitudes away from populated areas, the FAA has not yet issued a Notice of Proposed Rulemaking (NPRM). The FAA has been working with the White House over several years to craft an acceptable NPRM, but public impatience may result in ever-increasing levels of unregulated operations that could affect aviation and public safety. The Pirker vs. Huerta ruling highlights the problem the FAA faces, with users arguing that lack of regulations is insufficient to prevent commercial operations.

Detailed Recommendation

Apply FAA resources and institutional influence to fast-track all activities across government toward sUAS rulemaking to enable routine sUAS operations:

- Release the NPRM on sUAS by 2014.
- Issue an initial rule on sUAS in 2015 to enable commercial sUAS operations on a routine basis. Until the rule is issued, maximize use of FAA Modernization and Reform Act Section 333 authorizations to address user demand and to increase external confidence in the FAA's ability to move forward.
- Research and identify future expansions of the rule to procedurally allow other mission profiles or even larger UAS to operate legally in airspace not actively managed by ATC.

Internal to FAA, fast-tracking means ensuring that all needed resources are available and applied to expedite the operational use of the new rule. Externally, the FAA may need to increase the transparency of the process to get the NPRM released and communicate directly with Congress and the administration about the consequences of delays.

Rationale

Operations of sUAS with commercial aspects are on the rise and are occurring without a legal framework. There is also growing confusion and a lack of understanding on the part of the public as to the limitations of the existing laws. The FAA is spending an increasing amount of energy in reaction to these sUAS operations. As a result, there is increasing risk of introduction of legislative regulations that could lead to further confusion and affect the FAA's ability to fulfill its safety mandate. A significant portion of the market demand for UAS operations could be met with a rule or via early exemptions allowed by Section 333 authorization—such action can go a long way to address the issues discussed above. In addition, early experience and monitoring of these operations will provide guidance on further expansion of access and will increase overall confidence in the FAA's ability to implement sound and useful regulations.

C2: Execute a Cross-Organizational Plan to Incrementally Expand Commercial UAS Access into the U.S. Aerospace System by Adapting Existing Policies, Regulations, and Procedures

Background

The FAA must first accommodate, and then integrate, a broad range of UAS operations with varying levels of complexity into the NAS. Current budget constraints limit which new services the FAA can offer and negatively impact the extent and speed with which it can safely integrate new types of operations. Issuing a sUAS rule will address only a portion of the demand for commercial UAS operations. Agency resources to expand the base of UAS operators are limited. Currently, there is no single authority within the FAA to prioritize UAS-related activities. Each Line of Business (LOB) prioritizes its activities based on a combination of its budget authority and its other primary responsibilities. Establishing procedural integration of commercial UAS, however, will require dedicated resources from most LOBs, including Safety, Air Traffic, Mission Support, Legal, Policy, and others. No single LOB can make this happen. Furthermore, the FAA/Aviation Safety organization can approve an operation only after an applicant submits a request for that operation.

Detailed Recommendation

Develop a prioritized set of operational milestones that incrementally expand UAS access on a procedural basis. This includes adapting existing policies and regulations that were developed without UAS in mind and identifying methods of ensuring the safety of other flight operators and the general public. Once these milestones are reached, the FAA should internally align and commit resources to ensure progress. In this context, we recommend that the FAA develop an integrated budget for UAS by 2015.

By 2018, the FAA and stakeholders should reach agreement on a detailed roadmap for defining the policy, equipage standards, operational concepts, and automation requirements that can be achieved through 2025 and beyond, and that will enable routine integration of UAS operations. This roadmap should use interpretations of existing policies and new regulations in combination with airspace adaptation, while maintaining public safety. The FAA should begin to incorporate these new entrants through interpretation and clarification of procedures for one or more types of UAS operation and incrementally expand the number of operation types for which service can be offered. The types of UAS operations should include:

- Small UAS (including operations not covered by the sUAS rule).
- Small package delivery in both populated and remote locations.
- Operation within fixed volumes (power line/pipeline patrol, agriculture).
- High-altitude long endurance (e.g., for communications or surveillance).

While the FAA accommodates UAS operations procedurally, basic infrastructure changes, such as the flight plan capability and other NAS automation enhancements, will need to be incorporated through planned ERAM Sector Enhancements.

Rationale

While there is a long-term goal of having integrated, “file-and-fly” operations in the NAS, many UAS missions will not need this level of integration, and the airframes may not be suitable for fully meeting airspace requirements. Further, draft U.S. House appropriations language calls for an “integrated budget”

for UAS. Establishing an integrated, prioritized plan will both assist in clarifying the budget needs for NextGen to Congress and serve as a basis for consistent communications to stakeholders. Lessons learned from procedural implementation of services, including a better knowledge of the actual demand, will also be instrumental in informing future investment priorities.

C3: Execute a Cross-Agency Plan that Standardizes Approvals and Streamlines Operations to Better Accommodate Commercial Space Vehicles in the U.S. Aerospace System

Background

Commercial Space Vehicle Operations (SVOs) are the newest entrant into our nation's aerospace system, and demand from this segment is expected to grow rapidly. The FAA has enhanced its mission and goal statements to reflect the need to support these operations, but it has only begun the long process of identifying all the work to be done to first accommodate and ultimately integrate these vehicles into daily operations. From experience with UAS, it is evident that this work will require focused effort across the FAA, as it will be difficult, lengthy, and involve other aerospace users. The FAA must fully embrace this task and get out in front of these new operators and the resulting demand on aerospace resources.

Detailed Recommendation

Develop and execute a cross-agency plan that standardizes approvals and streamlines operations to better accommodate commercial space vehicles in the NAS. This should include developing policies and procedures, as well as the technical, operational, and certification requirements, and should specifically address:

- Establishing a repeatable and transparent Space Vehicle Launch and Recovery Request, Analysis, and Approval Process.
- Creating an Enterprise SVO Roadmap with milestones and timelines, including expectations from other agencies.
- Sizing the protected airspaces for SVO launch and recovery operations to the vehicle and the hazards presented to the system by 2020.

Rationale

The FAA, in concert with other agencies, must improve its processes in the near term in order to procedurally accommodate the expected increase in SVOs. In the longer term, SVOs will need to be more fully integrated into the aerospace system. Roadmaps for this integration need to be developed, and FAA infrastructure capability enhancements to support SVOs need to be researched. Lessons learned from procedural accommodation of SVOs, including a better knowledge of the actual demand, will also be instrumental in informing future investment priorities.

D1: Reallocate ATC Services and Streamline Operations Across TRACONs, Towers, and En Route Facilities to Reduce Costs

Background

Terminal traffic is down nearly 20 percent, on average, from its peak levels of 2000, and some sites are down by more than 50 percent. There are hundreds of FAA TRACONs and towers, which are the most costly facilities to maintain and operate in the NAS ($300M more than operating the en route centers).

The FAA intends to submit its plan for facility consolidation and realignment under Section 804 of the FAA Modernization and Reform Act of 2012. The strategy is to start slow (crawl-walk-run). This represents only an initial step in rightsizing the number of TRACONs and towers. Facility consolidation and realignments may alter workloads at certain en route, terminal, and tower facilities. There is a 30-day period over which Congress can review and override aspects of the FAA plan.

Detailed Recommendation

Initiate the facility streamlining process immediately following the 30-day expiration period for congressional response using available funds. Pursue additional facility realignment authority in the pending FAA reauthorization.

- The practical effect of closing towers or TRACONs will be the need to determine which remaining en route or TRACON facilities will deliver services to affected locations, adjust service delivery practices, and determine relocations for personnel or equipment.
- Align subsequent steps with requirements to implement NextGen capabilities to deliver high-performing NAS-wide operations. The results may effect TAMR P3S2, TFDM, and ERAM deployment waterfalls and site implementation details.

Rationale

Decisions to rightsize tower and TRACON services face significant potential resistance from outside the agency. Any delay in exercising the authority may result in directed changes from Congress beyond the 30-day period. The FAA should seek and exercise authorization again in short order to secure further adjustments.

Subsequent efforts to transition toward a more dynamic and integrated work environment in the future depend on the success of streamlining in this stage of NextGen implementation.

These changes require significant operations and maintenance expenditures to ensure successful transition for future cost savings. If inadequately addressed, transition issues in this first “crawl” phase may derail any hope of establishing a more scalable, cost-effective, and robust future work environment.

D2: Implement Remote Operations for Selected Tower Services to Reduce Costs

Background

The FAA has initiated an effort to revise the tower establishment and discontinuance criteria based on updated data about airport operations and other factors. This work is underway, and once completed, it will influence future decisions about whether or not an airport has a tower and how that tower is funded. In addition, the FAA is working with the State of Colorado to research a concept of providing remote arrival/departure services to airports that currently do not have a tower but experience periods of peak demand. The concept includes providing a subset (or select set) of tower services from an off-site location using surveillance and procedural changes.

Detailed Recommendation

Implement remote operations for selected tower services to reduce costs. More specifically:

- Continue efforts to update and apply FAA policy for tower establishment and discontinuance criteria, which should include defining cost-sharing ratios for towers.
- Accelerate work to validate and implement the concept of providing remote arrival/departure services as an alternative to staffing low-volume ATC towers.
- Define the service expectations and public/private cost-sharing options for application of remote services to meet shortfall needs at currently non-towered airports.

Rationale

For towers that will be closed based on the new tower establishment and discontinuance criteria, the FAA can provide selected arrival/departure services for the airport from a remote location to mitigate the impact and support cost avoidance. For currently non-towered airports with peak periods of high demand, providing selected arrival/departure services remotely will create an efficiency benefit.

D3: Transition to Minimum Navigation Infrastructure to Reduce FAA Costs

Background

The Global Positioning System (GPS) has become the primary means of navigation for aircraft in the NAS. Most of the existing ground-based navigation aids were installed in the 1960–75 period. However, as satellite signals are extremely low power, they are susceptible to interference. The only alternative form of navigation available to most GA aircraft is Very High Frequency (VHF) Omnidirectional Range (VOR). Most of the airliner fleet has Distance Measuring Equipment (DME)-DME-Inertial Reference Unit as backup to GPS for RNAV operations. The purpose of these ground-based navigation aids must change from a primary navigation service to a backup form of navigation when GPS is denied.

Detailed Recommendation

Aggressively move to define the minimum level of service in the event of a short-term GPS outage (i.e., sufficient to safely land vice continued level of efficiency). Based on that definition:

- Execute the VOR Minimum Operational Network (MON) program and reduce other navigation aids accordingly.
- Cancel existing conventional routes, leaving an adequate mix of direct routing and new PBN routes.
- Either cancel or amend existing instrument procedures to eliminate the dependency on the VORs planned for removal.
- Streamline the existing safety process for VOR removal via a holistic VOR MON-wide Safety Management System approach.

Rationale

The cost of recapitalizing these nearly obsolete assets has been estimated at between $1 billion (B) and $3B. For the aviation community to fully embrace the benefits of GPS, the legacy navigation services need to be discontinued. This will encourage the move from conventional routing to PBN routing and ADS-B Out equipage.

D4: Eliminate Legacy Point-to-Point Data Telecommunications and Information Interfaces to Reduce FAA Costs

Background

The FAA should migrate from the inflexible and outmoded dedicated infrastructure for data communications to the agile and commodity-based Internet Protocol (IP)-enabled infrastructure to avoid obsolescence and take advantage of IP network flexibility.

- The FAA is a major user of carrier services and infrastructure. Approximately 90 percent of NAS telecommunications services today use dedicated circuits that interconnect voice, radar, weather, automation, and other important systems.
- Commercial telecommunications carriers are quickly migrating toward a single, unified network structure based on the use of IP as the network transport standard to lower costs and maintain sustainability.
- Use of separate networks for dedicated point-to point services ("circuits") and for Internet services (IP-based) is disappearing from the telecommunications carrier infrastructure.
- Emerging (and not fully baselined) programs (e.g., FAA Telecommunications Infrastructure 2, NAS Voice System [NVS], Surveillance Interface Modernization, En Route Communications Gateway Replacement) are opportunities for modernizing many NAS system interfaces and allow the use of IP for network transport.

Detailed Recommendation

- Eliminate legacy point-to-point telecommunications and information interfaces to reduce FAA costs and avoid reliance on old technology that will likely begin to be phased out of the marketplace by the end of the decade. The FAA should plan for IP migration well in advance of when dedicated services begin to disappear from the commercial marketplace, and should target having a predominately IP-enabled NAS infrastructure by 2025.
- Explore options for addressing the possible discontinuance of telecommunications carrier support for dedicated services as early as 2020.

Rationale

- IP migration allows the FAA to stay ahead of changes in the telecommunications marketplace and services while taking advantage of the opportunities that an IP-enabled infrastructure can offer.
- An IP-enabled infrastructure will cost-effectively facilitate important capabilities such as UAS Integration, Business Continuity Services, Flexible Airspace Management, and Remote Operations.
- An IP-enabled infrastructure will also allow the FAA to reduce NAS telecommunications costs due to greater use of commercial-off-the-shelf technologies and services, make available a wider range of information for sharing with the aviation community, and maximize the benefits of investments in NVS, surveillance interface modernization, and SWIM.

D5: Align Oceanic and Terminal Automation Technology Refresh with Future Platform Convergence Plans to Reduce FAA Cost (Modified Advanced Technologies and Oceanic Procedures [ATOP] (ATOP and TAMR Technology Refresh)

Background

- Current Capital Investment Plan wedges for technology refreshes appear on a system-by-system basis.
- The FAA is exploring how domain mission needs (e.g., terminal/en route low altitude, en route and ocean, tower and terminal) become more similar in future operations.
- The FAA is exploring common components such as operating systems, cloud services, and backroom processing.
- Future work environments may result in different functional allocations between positions and systems.
- The ATOP Technology Refresh (TR) is planned to be completed in the 2017–18 timeframe. The decision on pursuing NAS automation convergence would certainly influence what is done. Refreshing of TAMR has similar considerations.
- There is an overlap in the following areas that perform the same functions across different systems:
  - Flight data processing capabilities
  - Networks
  - Displays

Detailed Recommendation

Align future oceanic and terminal automation technology refresh with future platform convergence plans to reduce FAA cost (Modified ATOP and TAMR TR).

- Decisions planned in 2018–20 should be informed by any plans for convergence in operations, capabilities, or components.
- Develop an approach to converge across the coming technology refresh cycles and replace system-based decisions with Key Decision Points at natural convergence opportunities that are based more on services (e.g., flight information services).

Rationale

The FAA's current practices do not accommodate the potential for looking at re-architecting its automation infrastructure, but the FAA is contemplating reducing its infrastructure across operational domains (Common Automation Platform).

D6: Transition FAA-Provided Continental U.S. (CONUS) Flight Services to the Private Sector to Reduce Costs

Background

The primary user group for flight services is the GA community, to include Part 91, some Part 135, and some military operators. Primary service focus is on providing aeronautical and meteorological information to pilots for safe and efficient flight operations. Users have varying experience levels and operate a diverse aircraft fleet with widely varying equipage profiles. FAA services are free to users and include these delivery modes: telephones (voice services), dedicated VHF radios (voice services), and the Internet (automated self-service).

Demand for FAA voice services is down 42 percent since 2008, and demand for FAA automated services is up 5 percent. Growth in other commercially available services since 2008 (more than 74 providers) has resulted in users continuing to abandon FAA services. Many users have even opted for fee-based commercially provided services, as users recognize the added value, ease of use, and integrated functionality they offer. The FAA has determined that its cost to deliver flight services in CONUS is too high, given these change factors.

Flight services key facts:

- In 2004, in A-76 action, flight services were deemed "not inherently governmental."
- Flight services are not considered an "essential" service, though an important safety element.
- The FAA adheres to the International Civil Aviation Organization (ICAO) Chicago Convention of 1944; aeronautical and meteorological services are necessary if offering air navigation services.
- GA pays taxes on aviation fuel purchases, which contributes to the General Fund.
- Federal Aviation Regulation 91.103 requires pilots to be properly informed for their planned flight.
- The FAA does not require pilots to use FAA-provided flight services.

Key risks the FAA must mitigate:

- **Delivery of voice services:** The requirement remains until digital connectivity is available in all locations and in all aircraft flown by GA. Mitigation is possible through a tiered service model and eventual new technology providing airborne access to digital services.
- **Data management:** Data management supports search and rescue, accident/incident analysis, and general system performance analysis. A commercial provisioning model will introduce challenges to maintaining an integrated capability.
- **Access to NAS automation:** The FAA has controlled access, necessary to file flight plans, through its contracted vendors. Most commercial providers today are using an FAA contract provider to access the NAS.

Detailed Recommendation

- Initiate transition to commercially provided flight services. Preflight services can be transitioned first, followed by inflight services. Retain, but outsource, NAS services (Notice to Airmen processing, weather observations processing, and pilot reports processing).

- Establish policies on commercialization of services, to include enabling tiered service models and alternative revenue streams.
- Determine minimum service needs and how to ensure delivery in a commercial model.
- Establish data standards, service performance standards, and provider certification requirements (oversight) commensurate with provisioning needs.
- Assess, plan, and implement an inflight communications infrastructure transformation to include alternatives such as remote communications outlets migration to IP-based technology, disposal, or transition to commercially provided VoIP technology.

Rationale

The commercial marketplace is best suited to providing most of these services long term. Providers have demonstrated the ability to deliver innovative, better integrated solutions rapidly across a wide variety of user-preferred delivery platforms. Users have already moved in this direction.

E1: Implement a Strategy that Aligns the Future ATC Workforce with NextGen Capabilities to Deliver High-Performing NAS-Wide Operations

Background

NextGen efforts will result in the steady introduction of new capabilities alongside existing capabilities that have been optimized from a local facility perspective. Benefits achieved through local optimization of existing capabilities may be diminished as related new capabilities are functionally or operationally integrated. For example, benefits achieved through local arrival metering at one location may diminish when applied against aircraft subject to en route and departure metering from other locations.

These capabilities will change the intra-facility and inter-facility relationships among FAA personnel, pilot and controller applications, skills, and context of downstream operations. Experience has shown that benefits anticipated from new capabilities are frequently not achieved. This is due to multiple factors, including capabilities not being applied as intended, insufficient training for the FAA and the airline (pilots and dispatchers), unanticipated issues with integration with other systems (local, regional, national), and changing roles and responsibilities of FAA and industry players directly and indirectly associated with using the new capability.

Detailed Recommendation

Develop and implement a strategy to align structure, policies, incentives, and procedures to address the system-wide issues associated with the functional and operational integration of new capabilities into the NAS. That strategy should:

- Leverage the leadership and innovative ideas the workforce can provide to integrate a human-centered concept for ATM and ATC with new capabilities.
- Establish NAS-wide performance objectives and translate them into organizational and individual incentives.
- Establish realistic expectations for service reliability, scalability, and productivity.
- Identify operational co-dependencies for capabilities being introduced.
- Identify changes to procedures, training, and roles and responsibilities needed to ensure that anticipated benefits are not diminished because of the identified operational co-dependencies.
- Create a field environment for validating the art of possible future/updated procedures and practices and socialize new operations across the workforce.

Rationale

After delivering NextGen capabilities to the field, the FAA should consider the cultural changes involved for the workforce to use the new capabilities. Without comprehensive training and changes to policies and procedures, the FAA will risk diminished payback on its investment due to the workforce bandwidth and cultural influences over adapting operational practices. A large portion of this risk will be due to training or procedures, including associated roles and responsibilities that do not properly account for the full range of other competing procedures and technologies.

Developing best practices and procedures in an intense and focused manner increases the potential for earlier and greater benefits from fielded NextGen capabilities. Paying attention to the full operating environment should reveal opportunities for maximizing the benefits achieved from existing and newly

introduced capabilities. Additionally, end-to-end performance management will materialize only with a concerted effort to align organizational and individual goals and roles with a common purpose.

E2: Defer Flexible Airspace Improvements and Future Facilities Until NextGen Capabilities in a Future Work Environment Are Demonstrated

Background

The FAA originally planned to create multiple NextGen integrated control facilities that would operate with the capabilities envisioned in the mid-term concept, including better coordination through an expanded terminal transition airspace volume. This was de-scoped to be a single Integrated Control Facility for New York (NY) Center and TRACON as the first Future Facility. Given the current FAA budget and the urgency driven by the deterioration of the physical facility at NY TRACON (N90), the FAA recently shifted priorities and decided to move forward with a new facility to replace N90. The FAA is looking for a site for N90 that will allow future expansion.

The monetary savings from consolidated facilities are dependent on both future facility locations and labor work rules. The FAA needs a location selection process that is objective and non-partisan. Current labor work rules are based on the existing facility infrastructure. NextGen capabilities offer the potential to redefine that infrastructure to the benefit of both labor and management. Management and labor will need to renegotiate infrastructure work rules to obtain these benefits.

The FAA Enterprise Architecture still includes en route sector enhancements beyond those planned for 2020. These improvements could provide additional flexibility in the future work environment. These changes would start about 2018 using significant funds for changes not yet defined.

Detailed Recommendation

Defer developing requirements for further en route sector automation improvements (e.g., dynamic airspace) and future facilities until NextGen capabilities in the future work environment are demonstrated. The FAA should proceed with the N90 physical plant replacement.

The FAA should focus on validating post-2020 NextGen sector and facility concepts to gain a better understanding of future NextGen operations and capabilities needed to support them. These validation efforts will lay the foundation for setting requirements for facility and sector upgrades. Specifically, the FAA should:

- Defer other en route sector improvements beyond those identified in recommendation B5 (planned improved tracking, probe, UAS identification, and data communications).
- Focus those resources on defining the future work environment.

Rationale

A more fluid operating environment that reduces barriers across terminal, en route, and oceanic services would potentially result in a more sustainable NAS, assuming labor and infrastructure issues are successfully resolved. The future facility plan should reduce the barriers between types of facilities and reflect the expected changes to the NAS and opportunities resulting from NextGen.

In addition, en route sector research has explored concepts that would allow a controller in one facility to control a sector in another facility and would allow dynamic redefinition of sector boundaries. The research in these areas is incomplete.

The FAA should re-examine funds committed to specific ERAM Sector changes to ensure that they contribute to the vision of a future work environment that is more sustainable (scalable, robust, and cost-effective).

E3: Modify CATM-T WP4 to Focus on Implementing Applications to Improve Demand Prediction, NAS-Wide Performance, and Predictability

Background

CATM-T WP4 investment is the fourth segment of enhancements to the modernized TFMS. WP4 is the final segment currently identified in the FAA's NAS Enterprise Architecture. The work package emerged as a set of five additional flow management tools. The tools were selected based on their relative maturity rather than on the potential benefit they could provide to NAS-wide performance or predictability. This set of tools does not necessarily complement the tools from prior work packages and has no unifying concept of operations. Instead, it contributes individually to separate facets of the flow management tasks. De-scoping through the acquisition process has lowered the impact and developmental maturity of some WP4 tools.

- The arrival route availability planning concept, Arrival Route Status and Impact, has been evolving continuously, without considering the consequences of applying a departure-based weather tool to flight-specific arrival flows. As such, the design requires significant adaptation.
- The Integrated Traffic Management Initiative (TMI) modeling concept was intended to address significant shortfalls, which have been identified in air traffic operations for some time. However, major de-scoping has occurred over the development cycle, altering the usability of the concept. As the concept currently stands, it is uncertain how it will be used, since it is targeted primarily for the Air Traffic Control System Command Center, whereas many TMIs occur at the local level.

The process for acquiring traffic flow management decision support capabilities has fallen behind the pace of technological advancements. The current processes are hindering the FAA's ability to adapt to evolving operational needs. For example, in the days of Enhanced Traffic Management Systems, new capabilities were fielded every six months, and user teams were intimately connected to the concept engineering process. Currently, work capabilities take many years to define and deploy.

Detailed Recommendation

Focus on implementing applications to improve demand prediction, NAS-wide performance, and predictability. Specifically, this should be accomplished by doing the following:

- De-scope CATM-T WP4 to focus on the largest shortfalls related to NAS-wide performance management (demand prediction and TMI modeling are most important).
    - Transition CATM to use an agile development approach for continuous incremental growth of a mature flow management operation "an app at a time."
    - Develop off-line capabilities to learn from operations and develop training for flow managers based on TFM initiative use policy and practices.
- Focus future work packages on achieving integration across the tools so decision makers can predict the effect of their actions on others and on NAS performance as a whole.
- Develop concepts for managing performance to target levels.
- Defer other flow management capability investments until concepts mature, and until there is traction on making better use of available CATM capabilities

Rationale

CATM WP4 no longer contains capabilities to advance the operation toward an environment where "Operations are planned from a system-wide perspective and information is shared among users, applications, and platforms to support collaboration among decision makers"[11] to drive predictability and performance. This was the premise for CATM in prior task force recommendations and the FAA's mid-term concept.

[11] NextGen Mid-Term CONOPs, page 14, Table 1, describing mid-term change for CDM.

E4: Integrate Controller Training Approaches and Methods to Match Future Operations Concepts and to Reduce FAA Costs

Background

The FAA must address two key training areas to provide effective NextGen training:

- Curriculum development
- Training delivery

A complete and comprehensive training curriculum for each new NextGen operational capability is necessary to ensure a correct and consistent level of operation and achievement of benefits. The curriculum should include the functional description, as well as the required and recommended operational use, of the new capabilities. The controller workforce must understand the goals of these operational changes, as well as the specific recommended use, and realize that the achievement of benefits is dependent on the intended use of the capabilities as defined in the Concept of Operations and Concept of Use descriptions.

Improved training technology and delivery methods are needed for the NextGen controller workforce. Research has proven that advanced training capabilities and methods are necessary for improving training efficiency and availability, particularly for a new curriculum. These capabilities might include game technology, Intelligent Training System design, and varying levels of simulation, interactive design, real-time coaching, and performance assessment utilizing automated speech synthesis and speech recognition.

Detailed Recommendation

Adopt an integrated air traffic controller training approach to ensure alignment with future operations concepts. The enhanced curriculum will assist the workforce in understanding how new operational concepts fit into the system, as opposed to how to functionally manage these systems. This comprehension will be a key enabler of the benefits associated with these concepts. Enhanced delivery mechanisms will assist in managing the depth and breadth of new training needs. Additionally, enhanced delivery mechanisms and self-guided adult learning techniques may reduce the need for formal, instructor-led classroom training. This may also reduce the cost to train new operational concepts.

Rationale

Research has shown that advanced training capabilities and methods can increase retention of material, and that on-demand, self-guided training is effective in the air traffic controller workforce.

E5: Identify Airspace and ATM Modifications Required for Routine UAS and Commercial Space Vehicle Operations

Background

UAS and SVOs are two of the newest entrants into our nation's aerospace system. Forecasted demand from the proponents of these two operator communities is high, and long-term economic opportunities will certainly help to drive additional growth. The FAA must take deliberate steps to identify all the work required to first accommodate and ultimately integrate these vehicles into daily operations.

Detailed Recommendation

Identify airspace and ATM modifications required for routine UAS and CSV operations. (ERAM Sector Enhancement)

Except for initial sector enhancements to UAS-related operations, defer more advanced enhancements until initial lessons are learned from early procedural UAS integration. The lessons will inform decisions on implementing required, major changes to airspace and ATM infrastructure for full integration of UAS operations in the 2020+ timeframe. The FAA should take a similar approach to integration of CSV operations.

Specifically, the FAA should:

- Create an Enterprise SVO Roadmap with milestones and timelines synchronized and integrated with other Roadmaps in the Enterprise Architecture.
- Identify and research required changes to airspace structures for UAS and SVO.
- Identify ATC policies and procedures as well as PBN procedures and requirements for UAS and SVO.

Rationale

Proponents of UAS and SVO are pointing to forecasts of near-exponential growth opportunities for these emerging industries. These proponents are well organized and funded to promote their causes and demands for access to the NAS. Interestingly, there may be an operational blurring of the lines between UAS and SVO, as vehicle designs, performance characteristics, and mission profiles may begin to overlap.

The FAA should develop and execute an integrated plan to advance and lead in this area to enable operators and the missions that these vehicles will fly in the NAS. This is an economic imperative, as operators will take their business elsewhere if the United States cannot accommodate them.

The FAA has made significant changes to its core commitments to the American people:[12]

- **Mission:** Provide the safest, most efficient **aerospace** system in the world.
- **Vision:** The Strategic Imperative….Great technological advancements require the FAA to safely integrate new types of user technologies, such as **UAS and SVO,** into the airspace.
- **Safety is the Mission:** We work so all air and **space travelers** arrive safely at their destinations.

[12] The FAA Mission statement: http://www.faa.gov/about/mission/

E6: Implement Oceanic Enhancements to Support User-Preferred Four-Dimensional (4D) Airborne Routing (Modified ATOP WP1)

Background

The FAA's ATOP system currently enables the application of various horizontal separation standards, including the smallest defined by the International Civil Aviation Organization (ICAO) (i.e., 30 NM lateral, 30 NM longitudinal, and 1,000 feet vertical separation). These reduced separation standards depend on aircraft equipage along with the ICAO-approved separation standards for the oceanic subregion. Equipage of U.S. oceanic aircraft that are qualified for the smallest separation standards and procedures varies from 9 percent to 88 percent, depending on the oceanic subregion. By 2016, in-trail climb and descent procedures and automation (via ADS-C and ADS-B) for short-term application of 15 NM longitudinal separation will be available for highly equipped aircraft.

By 2020, ATOP will be enhanced (ATOP WP1) with controller tools, coordination upgrades, capabilities for surveillance airspace, SWIM and Aeronautical Information Manual services, and service continuity enablers. The FID for WP1 is scheduled for early 2016.

Detailed Recommendation

Implement oceanic enhancements to support user-preferred 4D airborne routing (Modified ATOP WP1 as currently defined). These enhancements include the following:

- Enhanced controller coordination to improve the exchange of key information with other ANSPs to facilitate data accuracy.
- Expanded oceanic international interfaces to improve international harmonization.
- Data exchange via SWIM to improve information exchange.
- Enhanced conflict probe in ATOP surveillance sectors to facilitate early detection and resolution of potential conflicts.
- ATOP in stratified surveillance airspace to improve the aircraft transitions within FAA and other ANSP airspaces.

Re-scope this work package to focus on enabling equipped aircraft to fly as close as possible to their preferred 4D oceanic trajectory. This will provide user benefits and also enable the advancement of, and experience with, future Trajectory-Based Operations (TBO) concepts. This initiative would take advantage of highly equipped aircraft—making use of existing aircraft capabilities is a continuing user priority.

Rationale

With conflict probe enhancements from flight trajectories, the current scope of ATOP WP1 reflects the initial use of trajectories for separation management. Recent agency reprioritization of capabilities centers around those that are mature and have FAA stakeholder buy-in for providing benefits and improved services. The operational use of these capabilities will provide some initial experience with advanced, NextGen trajectory-based operations concepts.

F1: Complete Standards and Concepts for Secure, Integrated Communications, Navigation, and Surveillance (CNS) by 2022 to Maintain Global Leadership

Background

The FAA has defined an initial set of aircraft enablers for the implementation of NextGen. Considering the operational requirements for the future, this set of CNS-based capabilities will be necessary to fully enable the NextGen benefits. Those enablers include:

- **Advanced Required Navigation Performance/NextGen Flow Management System:** As the NAS moves to a trajectory operations-based construct, new requirements will be allocated to aircraft navigation systems. The widespread use of trajectory operations will require aircraft navigation systems to perform to a new degree of standardization.
- **Advanced Interval Management:** Where the current Interval Management would provide spacing on a single arrival stream, Advanced Flight Interval Management would enable more consistent spacing from multiple arrival streams to multiple runways. Precise winds information will be available to improve overall performance.
- **Aeronautical Telecommunications Network Baseline 2 Data Communications:** RTCA Special Committee 214 and the European Organization for Civil Aviation Equipment Working Group 78 are jointly developing standards to define the safety, performance, and interoperability requirements for air traffic services supported by data communications. Data communications will also need to accommodate still evolving navigation, surveillance, and aeronautical information service requirements to support the air-ground functional integration.
- **Airborne Collision Avoidance System X (ACAS-X):** ACAS-X is a family of collision avoidance systems. ACAS-X_A is intended to fill the role of the current Traffic Alert and Collision Avoidance System, serving as a collision avoidance system for large transport and cargo aircraft. ACAS-X_O is intended for specific flight operations of those same users when normal separation may result in excessive nuisance alerts, such as closely spaced parallel operations.
- **Alternative Positioning, Navigation, and Timing (APNT):** The FAA is exploring means to reduce the existing VOR network and a limited number of secondary surveillance radar facilities. APNT would provide a means to reduce GPS dependency.

The avionics required to support these enablers are expected to be “bundled” because aircraft and avionics suppliers have increasingly switched to integrated system platforms that accomplish multiple functions rather than separate equipment allocated for discrete capabilities. An additional goal of bundling the avionics is that aircraft operators only have to upgrade every five to seven years for aircraft avionics supporting all CNS/ATM functionality. The continued integration of these functions is essential to the long-term success of NextGen, as the operational capabilities are dependent on how the various enablers work together.

Detailed Recommendation

Develop an integrated CNS air-ground plan in the next 12 to 18 months to ensure a realistic and coordinated approach to having the needed CNS concepts and standards defined no later than 2022 to influence the next phase of aircraft purchases and maintain global leadership. This integrated plan needs to include the completion of operational concepts, avionics standards, safety and security analyses, cost and benefits case, and ground system capabilities. This plan needs to be coordinated with industry. The

cost and benefits case needs to reflect justification of additional investments toward integrated CNS capabilities from previous equipage investments. In addition, it should account for fleet retirements and evolving fleet profiles. The stakeholders will understand the operational needs provided in the integrated plan and motivate a joint effort to mature the specific set of CNS concepts, capabilities, and actions going forward.

Rationale

Integrating the complex set of CNS avionics, with an integrated set of complementary ground system capabilities in a way that delivers operational benefits, is a significant undertaking. The FAA is currently on a very aggressive schedule for pursuing the integration of the CNS capabilities. However, it is unclear how all the necessary activities will come together. It is also unclear how the projected benefits of an integrated CNS solution relate to benefits anticipated for existing and in-process equipage investments. An integrated solution is needed in time to influence the phase of fleet retirements and replacements that is expected to start within the next decade. This phase is expected to begin in the 2023 to 2025 timeframe. Therefore, an integrated CNS air-ground plan is necessary to ensure a realistic timeline to having the needed CNS concepts and standards defined with industry no later than 2022 to influence the next phase of aircraft purchases and to maintain global leadership.

F2: Defer Trajectory-Based Operations (TBO) with Integrated Avionics Until the Concept Is Mature and Implementation Is Aligned with Fleet Forward Fit

Background

The NextGen mid-term concept envisions a shift to the management of traffic by trajectories (TBO) throughout the operation, including initial flight planning, all phases of the flight, and post-flight analysis. In that vision, every Instrument Flight Rule (IFR) aircraft is represented by a four-dimensional trajectory (4DT) either provided by the user or derived from a flight plan by the ground system. Trajectory management allows for articulation of user needs and provides for user participation in a timely and efficient process of strategy development, evaluation, decision making, and adjustment as the playing out of uncertainties requires. The level of specificity of the trajectory and the nature of the aircraft's adherence to the trajectory are based on the aircraft's capabilities and the type of operation being conducted. The 4DT gets refined over time as it is used for flight planning through separation management. Flight operations in cruise airspace are increasingly trajectory based (a precise path projection with conformance bounds that define the route of flight). Ultimately, 4DTs are the means through which all changes to the flight (aside from time-critical safety clearances) are communicated via amendments to the intended trajectory. Operational management of 4DTs enables efficient control, spacing, and optimization of individual flights.

Much of this concept will not be achieved by 2020, nor will the aircraft fleet exist to support it. Data-linked trajectory clearances (i.e., airborne rerouting) uploaded directly to the flight deck of appropriately equipped aircraft will be available by 2020 but will not fully support the complete TBO concept. En Route Data Comm capabilities are on schedule to be implemented by 2020.

Detailed Recommendation

Defer TBO with integrated avionics until the concept is mature and implementation is aligned with fleet forward fit.

- Complete the FANS-based Segment 1 as a first step toward uploading trajectories directly to the flight deck and conducting reroutes.
- Articulate user TBO service needs and refine the related concepts for the specific operations requiring 4DT to carry out control, spacing, and flight optimization.

Rationale

Research on individual aspects of TBO has identified a few cases where controlling one or more dimensions of a clearance through a precise trajectory may be beneficial. Apart from these isolated cases (e.g., required time of arrival, airborne rerouting with data communications around weather), there is not a concept for integrated advanced CNS functions (i.e., Advanced Interval Management, Dynamic Required Navigation Performance, and Winds data) to perform TBO, nor is there equipage to do so. Mature concepts, standards, and avionics for these functions do not yet exist.

F3: Implement Aircraft-to-Aircraft Technologies Using ADS-B In and Procedures at Select Locations to Realize Benefits

Background

Certain ADS-B In applications that have been explored with aircraft operators through lead carrier agreements have shown benefit. The perceived value to operators of the mandated ADS-B Out may be augmented with any value from ADS-B In if the two capabilities can be incorporated in the same outfitting of the aircraft. It should be noted that there are significant benefits projected, and few ground automation dependencies and integration challenges, for Interval Management-Spacing (IM-S) operations on Final Approach (i.e., IM-S Final Approach Spacing enabled by ADS-B In).

Detailed Recommendation

Implement aircraft-to-aircraft technologies and procedures at select locations to realize benefits. Develop and implement high-benefit and low-risk ADS-B In applications as an incentive to close the user adoption gap related to the ADS-B mandate. To address this gap, we recommend that the FAA:

- Expand lead carrier agreements at additional locations to use existing standards, services, and procedures for ADS-B In applications (e.g., oceanic In-Trail Procedure, Cockpit Display of Traffic Information [CDTI]-Assisted Visual Separation) to realize return on investment and promote early adoption of equipage.
- Focus avionics standards development on ADS-B In applications to bring aircraft spacing closer to visual separation standards with less dependency on ground automation (e.g., IM Final Approach Spacing, IM Paired Approach, and IM Defined Interval).

Rationale

If basic ADS-B In services can be shown to realize return on investments and can be included in the same version with ADS-B Out, then the FAA and operators can use that incentive to promote early adoption of equipage for the mandate.

F4: Defer Navigation Infrastructure for Degraded Services During GPS Outage Until Requirements Are Mature (Alternative Position, Navigation, and Timing [APNT])

Background

GPS has become the primary means of navigation for aircraft in the NAS. However, as satellite signals are extremely low power, they are susceptible to interference. Existing ground-based navigation aids such as VOR and DME currently provide a resilient backup. Various FAA systems rely on precise timing, and many of these systems use GPS as the primary timing source. However, most of these timing systems can also use network-based timing services to remain in synchronicity. The FAA's Global Navigation Satellite System Intentional Interference and Spoofing Study Team has identified multiple threats and mitigations for GPS. ADS-B currently depends on GPS for position information with a backup of Secondary Surveillance Radar (SSR).

Detailed Recommendation

The FAA should come to an agency-wide consensus on the requirements for an improved backup PNT service. An APNT could either meet a higher performance requirement or provide sufficient performance at a lower cost than existing backups to either FAA or NAS users. Research should continue, but implementation should wait for a defined need or opportunity.

APNT implementation actions should be deferred until requirements are validated and aligned with advanced NextGen concepts, which require further development.

Rationale

There is no currently identified shortfall for a backup to GPS, as VOR, DME, SSR, and network timing provide backup for these essential services. RTCA Minimum Operational Performance Standards (MOPS) and equipage will take significant time and effort for any new system to be fully deployed. APNT could allow further reduction of the older ground-based navigation aids and/or SSR. A clear benefit account for this significant change should be identified.

F5: Defer Integrated Arrival-Departure Metering Operations with Aircraft-Centric Procedures Until Trajectory-Based Procedures Are Used Consistently and Concept Is Mature (Modified TBFM WP4)

Background

Implementation of capabilities planned for TBFM WP3 are expected to introduce many changes in NAS operations, some of which will result in cultural shifts in how operations are managed. The terminal area will especially be affected as it moves toward the use of time/schedule-based metering. Additionally, the investments of TBFM WP2 (which includes use of automation-provided speed advisories and extended metering) and WP3 (which includes deployment of an integrated arrival/departure capability, and ground-based automation-provided path stretch advisories for en route, sequencing, and spacing capabilities for terminal) are expected to enable substantial operational change and benefits. For example, they will improve the use of PBN, RNAV Standard Terminal Arrival, and OPD procedures in moderate to heavy traffic conditions, improve the use of Required Navigation Performance Authorization Required (RNP AR) procedures in mixed-equipage environments, and enable benefits intended by Metroplex airspace redesign initiatives. Furthermore, TBFM WP2 and WP3 investments address the prioritized requests of the users, since TBFM WP2 and WP3 capabilities map directly to an NAC Tier 1a recommendation. This high-priority status reflects the prevalence of RNAV equipage throughout the fleet, which is required to enable efficiency benefits afforded by TBFM.

Recently, a near-term initiative (TBFM study group) has found various field challenges with the current use of TBFM. Execution of a plan to address the issues identified for TBFM, through an NAS-wide agreed-to operational policy, ATC procedures, and adaptation development and training strategies, spans the next 12 to 18 months. The objective is to strengthen the foundation for consistent and continuous use of TBFM across the NAS to improve opportunities for successful operational transition of TBFM enhancements reflected by WP2 and WP3.

While TBFM WP4 is yet to be defined, it would presumably include requirements to enable metering via aircraft-centric operations. Applications for TBFM include operations such as Flight Deck-Based IM-S (FIM) during cruise, arrival, and approach (enabled by ADS-B In) and metering via Time of Arrival Control, which is enabled via the Required Time of Arrival (RTA) capability. For IM-S, the Surveillance and Broadcast Services Program Office is pursuing an Investment Analysis Readiness Decision for the initial IM-S application ground requirements in 2014, with an FID planned for 2016. For Time of Arrival Control operations, standards for the use of RTA will be defined prior to 2020, but implementation is not expected in that timeframe.

Detailed Recommendation

Defer integrated arrival-departure metering operations with aircraft-centric procedures until trajectory-based procedures are used consistently and concept is mature (Modified TBFM WP4).

- First, achieve successful operational transition of capabilities defined by TBFM WP3.
- Defer advanced metering operations via aircraft-centric capabilities past 2020 to allow time to mature the aircraft-centric concepts for FIM (enabled by ADS-B and RTA).

It should be noted that there are significant benefits projected, and few ground automation dependencies and integration challenges, for IM operations on Final Approach (i.e., IM-S Final Approach Spacing enabled by ADS-B In); the development and implementation of those operations should be pursued.

Rationale

There are likely major implementation bandwidth issues for TBFM (and other ground automation systems such as ERAM and TAMR) that would make it challenging to introduce ground automation requirements to enable advanced metering operations prior to 2020. Plans depict that ground automation (such as TBFM) to support FIM MOPS v1 will be operationally available in 2019, with ground automation supporting FIM MOPS v2 operationally available post-2020. These dates may produce bandwidth issues with TBFM WP3 deployment and other investments such as Data Comm Segment 1 and en route sector enhancements for ERAM. Additionally, human bandwidth issues (i.e., how much change for the controller can be reasonably introduced over a period of time) are expected, given the controller workforce operational transition objectives planned to baseline TBFM and leverage capabilities introduced by WP2 and WP3 (currently scheduled for implementation in 2015 and 2018, respectively).

Implementation in a post-2020 timeframe will better leverage ADS-B equipage availability among operators in the NAS due to the 2020 mandate. While there is a mandate for ADS-B Out equipage by 2020, ADS-B In fleet readiness, which is required to enable aircraft-centric spacing management and metering operations, is not expected to be high (less than 5 percent by 2020 for the Air Transport fleet) within the next five-plus years. This state of low equipage readiness among the users is likely reflected in the fact that the NAC did not rate IM operation as a high priority.

F6: Defer Advanced Surface TBO and Associated Avionics-Dependent Surface Capabilities

Background

The NextGen mid-term concepts include surface operations where appropriately equipped aircraft are able to provide and/or share surface traffic management information, while automation monitors aircraft conformance with taxi instructions and updates departure clearance times. In this environment, decision support is shared between cockpit and ground to create departure schedules and update aircraft status information for more efficient taxi and departure sequencing to maintain throughput, and surface automation supports decisions concerning optimal runway configuration.

NAC priorities focused on basic capabilities that use what is already available on board the aircraft. The implementation of surface management has considered surface metering as either providing times for entry to movement area or numbers of flights in a window that can push back. More complex surface instructions with time controls and conformance monitoring have not been discussed.

Detailed Recommendation

Defer advanced surface TBO capabilities and associated avionics-dependent surface capabilities.

- Defer any decisions on advanced surface TBO scheduling capabilities (4DTs and multiple RTAs on the surface) until performance of more basic surface departure metering is understood and taxi instruction capability and conformance monitoring are matured.
- Defer the need for surface conformance monitoring (including high-accuracy ADS-B reporting) until the need is validated.

Rationale

Departure control time compliance has greatly improved with both prototype use of electronic flight data (PHX) and site-specific surface management tools (JFK). Changes from higher level compliance have not been evaluated. Once these changes are better understood, it will be possible to establish a more accurate value for tighter control of taxi times and surface movement conformance.

Aircraft are not equipped for the more stringent surface control times and monitoring. Required changes should be bundled with other desirable changes for improved trajectory accuracy or cockpit involvement in decision making.

Appendix C: An Operational View of NextGen by 2020 and the Path Beyond

NextGen is a long-term transformation of the NAS. The expectations are to provide incremental improvements to efficiency and the level of safety, security, and affordability of the NAS; accommodate a wider range of aircraft operations including UAS; scale to accommodate substantial growth in domestic and international transportation; and align to enable seamless global operations.[13] The FAA directed The MITRE Corporation to identify what can be achieved toward NextGen by 2020. This appendix describes NAS operations in 2020 considering the combined effects of our recommendations.

Over the next five years, the recommended changes to the NAS include completing deployment of the transformational and foundational systems, maximizing operational use of existing capabilities, procedurally enabling new entrants, and eliminating surplus capabilities and services. These changes are described in terms of their implications for aircraft operations and their interactions with the FAA.

Operational Effects of the Transformational and Foundational Systems in 2020

Infrastructure changes in the NAS significantly affect aircraft operator plans for aircraft equipage, operating practices, and procedures and training for flight crews. The most direct impacts are from the transition away from radar and ground-based navigation aids to satellite-based surveillance and navigation. These changes will be in progress by 2020 and will eventually be used throughout the NAS. Aircraft operator equipage, procedures, and training will account for the transition to routing based on satellite-based navigation in lieu of conventional routes based on ground navigation aids. With ADS-B from aircraft as the nominal source for surveillance separation services, and radar as backup, aircraft equipment will change but operational changes from the aircraft's perspective will be minimal. Those who are equipped to receive broadcast (ADS-B In) will benefit from the automatic traffic information service on aircraft in their vicinity. This may be especially useful where manned and unmanned aircraft are flying in close proximity to one another.

Aircraft operators will also have the option to participate in data communications. A substantial portion of the fleet is expected to participate. Equipped flights can receive digitized frequency changes, altitude assignments, and predeparture or airborne reroutes that have been pre-coordinated with their dispatch office. These changes combined with other changes in FAA automation have a less obvious, indirect impact of reducing some of the circumstances that lead to en route congestion and flow constraints. The transition to system-wide information and the use of ADS-B to improve the accuracy of modelled aircraft trajectories and achieve reduced aircraft spacing in operational practice are key elements of reducing congestion events.

Operational Effects of Maximizing Use of What Has Already Been Developed in 2020

Aircraft operator and FAA interaction in the preflight stage is between flight dispatch and flow management. During active flight, real-time pilot-controller interactions begin once the flight is ready for pushback. Figure 6 depicts the key changes in operational interactions by maximizing the use of available capabilities in the NAS of 2020.

[13] Public Law 108–176—Dec. 12, 2003, Vision 100—Century of Aviation Reauthorization Act.

Figure 6: MITRE Recommendations for a Sustainable NAS

In preflight, dispatch will receive searchable, digital constraint information, including advanced indications of Special Activity Airspace. Through collaborative routing, dispatch can provide the FAA routing preferences to address airspace congestion. Once the routing option is selected, the flight plan can be filed and dispatchers can access more detailed, flight-specific digital constraint information such as scheduled arrival times, en route departure constraint times, and so on. Operator and Air Traffic Management personnel will collaborate more closely with ground control, which shares detailed surface information such as pushback times or entry times for movement areas. With better departure scheduling and routing information, controllers are more able to merge departures off adjacent airports and enter them into the overhead streams and provide more reliable release times.

Pilot and controller interaction begins with the predeparture route clearance. A revised predeparture clearance can be issued if conditions change enough to warrant an update. For flights with data communications, these route clearances can be automatically loaded into the FMS, reducing the time and risk associated with the lengthy read-back process. Flights bound for a Metroplex (where multiple high-volume airports are in close proximity) may be scheduled for an arrival time. These airspaces have also been redesigned to use optimum descent profiles as traffic permits, and procedures that reduce the controller interaction/instructions to the flight crew throughout the descent. For flights that are being metered to an arrival airport, controllers can manage the arrival sequence and spacing further away from the airport and primarily use speed control while the aircraft are at high altitudes. By maintaining spacing more continuously to the runway, the pilot, once assigned an Area Navigation procedure, can stay on the

procedure with minimal additional ATC interactions and instructions in the terminal. This is possible in part because ADS-B Out and fused radar data allows controllers to monitor spacing with greater accuracy, manage compression over a longer phase of flight, and account for pair-wise wake spacing requirements sooner. Pilots may be instructed to fly a specific parallel or converging runway procedure, but this should be largely transparent. In some cases, a pilot may be equipped to continue operating in marginal conditions flying a low-visibility procedure.

Operational Effects of Procedurally Enabling New Entrants in the NAS

While forecasts show potential for hundreds of daily commercial UAS operations in the NAS navigable airspace in many different classes of operations, their actual operation depends on the plans and operational specifications under which the commercial operators intend to fly. The FAA will work with those trailblazers who develop operational specifications for a class of UAS operations and define procedures that establish routine access for their operations. During the next few years, the FAA will gain experience and will better understand the operational requirements for integrating these operations, which will allow the FAA to mature its procedures. CSV operations for other than classic rocket launches are similar. The operational effects will depend on how takeoff and recovery operations parallel or differ from other aircraft operations. Working with the trailblazers, the FAA can determine access rights for these classes of flights in the NAS without the need for Certificates of Waiver or Authorization or for Special Activity Airspaces.

Operational Effects of Eliminating Surplus Capabilities and Services by 2020

The FAA has more than 35,000 pieces of equipment that make up the NAS infrastructure. FAA initiatives to make the NAS more scalable and affordable by eliminating surplus capabilities and services are part of the consolidation and realignment of FAA services and facilities directed in the FAA authorization act. Services and facilities will be reviewed against criteria and performance expectations to determine where to adjust the scope, scale, and means of delivery for services. Some approach, departure, and surface control services may be delivered from alternative facilities. This should be largely transparent to aircraft operators. As already discussed, the legacy capabilities for surveillance and navigation will become the backup capabilities. Consequently, a reduction in secondary surveillance radar or ground-based navigation aids will be well underway for the locations where multiple layers of redundancy exist and are no longer required. The result may be more stringent criteria for operators without ADS-B to be granted a deviation for surveillance separation service.

Delivering on NextGen Objectives by 2020

Reviewing the operational changes described above, the following conclusions can be drawn about which NextGen objectives will be met by 2020 as the basis for engaging the aviation community on realistic expectations for the NextGen evolution. The NextGen focus for the next five years largely follows the current course of action underway by the aviation community and the FAA. The goals are efficiency and flexibility benefits for legacy users, while enabling access for new entrants. The FAA will also complete the transformational infrastructure programs as the first step toward a more affordable and scalable NAS. Substantial progress on end-to-end predictability and performance will not likely be achievable until the 2020–25 timeframe.

Measurable gains will be visible where:

- Flow and flight path inefficiencies in and out of metro areas are addressed with redesigned airspace and procedures. Ten Metroplex redesigns, where multiple airports experience

inefficiencies or interactions, are already under development. Performance will depend on participation. Current environmental assumptions may limit which efficiencies can be addressed.

- Improved arrival and departure throughput is expected at airports with multiple or closely spaced runways, especially during poor-visibility conditions. Operational benefits for NextGen 2020 depend on targeting the deployment of new procedures and airspace design at key locations. Sustained availability and use of these procedures depends on the traffic demand and frequency of applicable weather conditions. The NextGen Advisory Committee (NAC) is recommending locations and needs.
- Surface data exchange and coordination of surface events and times can improve taxi efficiency, runway utilization, and departure rates. The improvement in departure time accuracy and compliance should reduce the need for other flow management initiatives, including the scale of ground delay programs. The NAC, airport authority, or aircraft operators have considered applying such capabilities at several sites. The results will depend on aircraft operators' commitment to participate.
- Marginal- or low-visibility operations result in lost throughput that could be recaptured by expanding the conditions under which flights can use airports with runway visual range capabilities and enhanced vision systems. Performance gains will go to equipped aircraft operators.

Aircraft operators will also benefit from greater flexibility in routing options when the system is congested. In general, there should be fewer TMIs as meeting spacing requirements becomes more automated and increasingly effective. Sector operations are enhanced as improved demand information is realized and airport acceptance rate decision support is implemented. The current level of controller/pilot voice communications is reduced, leading to improved throughput and system flexibility. Select Metroplex arrival route constraint information will provide air traffic flow blockage information with route options. Operators that collaborate on routing, especially those with data communications, will have a direct input in routing options and delay distribution. These gains would not be fully measurable across the NAS since only the aircraft operator can identify the value of favoring one flight over another or one route over another.

By 2020, the community will only be at the exploration stage for NAS-wide performance management and end-to-end predictability. The Metroplex improvements will enhance performance at the arrival and departure ends, but decision makers will lack the means to understand how local problem resolutions affect end-to-end NAS performance. As a result, performance may improve on a local or per-flight basis, with the NAS-wide results being less clear. The community and the FAA should leverage these local advances to develop a capability to manage end-to-end predictability and performance across the NAS. This capability will mature through evaluations and experiments with airborne route management and metering/scheduling at different phases of flight. The benefits of end-to-end predictability will follow based on what can be learned from collaboration on surface, arrival, and departure scheduling and rerouting around weather.

Progress on the second NextGen objective, to enable new entrants to operate in the NAS, will be observable and measurable in terms of the numbers of daily operations granted access.

Progress on the third NextGen objective, to make the NAS more scalable and affordable, will be measurable if services can be defined, the capacity of the NAS to scale up or down can be characterized, and cost can be attributed. The gains will be on the margin in this timeframe, but significant progress should be visible in terms of the criteria and performance expectations to determine where to adjust the scope, scale, and means of delivery for services.

Appendix D: Acronyms

Acronym	Definition
4D	Four-Dimensional
4DT	Four-Dimensional Trajectory
AARCH	STL airborne fix name
ACAS-X	Airborne Collision Avoidance System-X
ACS	Aeronautical Common Service
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AEFS	Advanced Electronic Flight Strips
AI	Aeronautical Information
AIMM	Aeronautical Information Management Modernization
ANSP	Air Navigation Service Provider
APNT	Alternative Positioning Navigation and Timing
AR	Authorization Required
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
AT	Air Taxi
ATC	Air Traffic Control
ATL	Hartsfield–Jackson Atlanta International Airport
ATM	Air Traffic Management
ATN B2	Aeronautical Telecommunication Network Baseline 2
ATO	Air Traffic Organization
ATOP	Advanced Technologies and Oceanic Procedures
B	Billion
BOS	Boston Logan International Airport
CAT	Category
CATM	Collaborative ATM
CATM-T	Collaborative Air Traffic Management Technologies
CDTI	Cockpit Display of Traffic Information
CHS	Charleston International Airport
CLE	Cleveland Hopkins International Airport

Acronym	Definition
CNS	Communications, Navigation, and Surveillance
CONOPS	Concept of Operations
CONUS	Continental United States
CRDA	Converging Runway Display Aid
CSPO	Closely Spaced Parallel Operations
CSPRs	Closely Spaced Parallel Runways
CSS-Wx	Common Support Services-Weather
CSV	Commercial Space Vehicle
DCA	Ronald Reagan Washington National Airport
DME	Distance Measuring Equipment
DST	Decision Support Tool
EFVS	Enhanced Flight Vision System
EIS	Early Implementation Strategy
ELSO	Enhanced Lateral Spacing Operations
ERAM	En Route Automation Modernization
FANS	Future Air Navigation System
FDPS	Flight Data Processing System
FID	Final Investment Decision
FIM	Flight Deck-Based Interval Management-Spacing
FMS	Flight Management System
FOC	Full Operational Capability
FTI-2	FAA Telecommunications Infrastructure 2
GA	General Aviation
GBAS	Ground-Based Augmentation System
GPS	Global Positioning System
HEN	Henderson Airport
IAH	George Bush Intercontinental Airport
IAM	Identity and Access Management
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IM-S	Interval Management-Spacing

Acronym	Definition
IOC	Initial Operational Capability
IP	Internet Protocol
ITP	In-Trail Procedures
JFK	John F. Kennedy International Airport
KAYLA	STL Airborne Navigation Fix
LOB	Line of Business
LORLE	STL Airborne Navigation Fix
LPV	Localizer Performance with Vertical Guidance
M	Million
MEL	Minimum Equipment List
MEM	Memphis International Airport
MIA	Miami International Airport
MMR	Multi-Mode Receiver
MON	Minimum Operational Network
MOPS	Minimum Operational Performance Standards
N90	New York TRACON
NAC	NextGen Advisory Committee
NAS	National Airspace System
NCT	Northern California TRACON
NextGen	Next Generation Air Transportation System
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NPRM	Notice of Proposed Rulemaking
NVS	NAS Voice System
NWP	NextGen Weather Processor
OPD	Optimized Profile Descents
P3S1	Phase 3 Segment 1
P3S2	Phase 3 Segment 2
PBN	Performance-Based Navigation
PHX	Phoenix Sky Harbor International Airport
PRM	Precision Runway Monitor

Acronym	Definition
R3	Release 3
RDU	Raleigh-Durham International Airport
RECAT	Re-categorization
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
SAA	Special Activity Airspace
SDF	Louisville International Airport
SFO	San Francisco International Airport
SID	Standard Instrument Departure
SOIA	Simultaneous Offset Instrument Approach
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival
STARS	Standard Terminal Automation Replacement System
STC	Supplemental Type Certificate
STL	Lambert–St. Louis International Airport
sUAS	small UAS
SVO	Space Vehicle Operations
SVS	Synthetic Vision System
SWIM	System-wide Information Management
TAMR	Terminal Automation Modernization Replacement
TBFM	Time-Based Flow Management
TBO	Trajectory-Based Operations
TDLS	Tower Data Link Services
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
TMI	Traffic Management Initiative
TR	Technology Refresh
TRACON	Terminal Radar Approach Control
U.S.	United States
UAS	Unmanned Aircraft System

Acronym	Definition
VHF	Very High Frequency
VoIP	Voice over Internet Protocol
VOR	VHF Omnidirectional Range
WAAS	Wide Area Augmentation System
WARP	Weather and Radar Processor
WP1	Work Package 1
WP2	Work Package 2
WP3	Work Package 3
WP4	Work Package 4
WTMD	Wake Turbulence Mitigation for Departures
Wx	Weather

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