October 31, 2012

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Office of NextGen
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Mr. David Grizzle
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Ms. Margaret Gilligan
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Aviation Safety Organization
Federal Aviation Administration
800 Independence Avenue SW.
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Subject: Automatic Dependent Surveillance–Broadcast In Aviation Rulemaking Committee — Recommendations in Response to Federal Aviation Administration May 30, 2012, Tasking

Dear Ms. Cox, Ms. Gilligan, and Mr. Grizzle:

The Federal Aviation Administration (FAA) chartered the Automatic Dependent Surveillance–Broadcast (ADS–B) In Aviation Rulemaking Committee (ARC) on June 30, 2010, to provide a forum for the U.S. aviation community to define a strategy for incorporating ADS–B In technologies into the National Airspace System (NAS). The ARC was tasked to provide recommendations that clearly define how the community should proceed with ADS–B In while ensuring compatibility with ADS–B Out avionics standards defined in §§ 91.225 and 91.227 of Title 14, Code of Federal Regulations. The ARC submitted its recommendations to this tasking on September 30, 2011.

On May 30, 2012, the FAA extended the ARC's charter to submit additional recommendations on how to frame an ADS–B In equipage mandate such that the benefits exceed costs before 2035. The ARC was tasked to identify (a) in what airspace, and/or (b) at what airports, and/or (c) by what other criteria the FAA could apply to frame an ADS–B In mandate. In addition, the ARC was tasked with providing feedback on a 2020 compliance date for a potential ADS–B In mandate.

The ADS–B In ARC remains supportive of ADS–B In and believes it is essential that the FAA, as a key component of the NextGen program, prioritize the development of the key ADS–B In applications to the point of being NAS-enabled. The FAA should encourage voluntary ADS–B In equipage through financial and operational incentives.

Consistent with the ARC report dated September 30, 2011, the ARC continues to find that ADS–B In technical, operational, and financial uncertainties preclude proposing any ADS–B In mandatory equipage rule until those uncertainties are resolved. In addition, given the continued challenges surrounding future funding streams for NextGen technology investments, the ARC's position remains that in light of these strategic uncertainties, there is not yet a compelling business case for any operator equipage mandates of ADS–B In technologies.

The ARC finds the funding decision made by the FAA in the Fiscal Year (FY) 2012 Joint Resource Council (JRC) adds uncertainty and delay to establishing business cases for key ADS–B In applications, and more certain availability of the key applications is essential for industry to develop a business case to endorse regulatory action by the FAA requiring ADS–B In equipment. The ARC finds a subset of airports with high air traffic density in their terminal airspace and surface domain will generate most of the economic benefits from ADS–B In applications.

Because of funding uncertainty, the need for mature MOPS and TSOs for key applications, and the length of time needed to develop and deploy equipage for affected aircraft, the ARC finds that any ADS–B In required equipage is unachievable by 2020.

The ARC recommends the FAA focus funding on accelerating the development of equipment standards, certification guidance, operational approval guidance, ground automation, and any necessary policy adjustments to enable operational implementation (NAS-enabled) of key ADS–B In applications and/or enabling capabilities. If ADS–B In technology reaches an acceptable level of maturity, the FAA conducts flight trials for a sufficient number of ADS–B In applications to validate the utility of operational concepts and validate the benefits case, and the FAA contemplates proposing an equipage rule for ADS–B In for those specific applications, then this ARC recommends the FAA establish a new ARC early enough in the process to leverage the industry's view of a proposed equipage rule for ADS–B In. At this time, the ARC recommends no ADS-B In equipage mandate be proposed by the FAA.

The ARC urges the FAA to seek, and Congress to provide, the funds needed to reduce these uncertainties and thus build confidence in the substantial related investments by the operator community if a future mandate is considered.

We trust this report will be helpful in your decision making process. The ADS–B In ARC stands ready to help the FAA with any additional tasks as needed.

Sincerely,

Steven J. Brown
ADS–B In ARC Co-Chair
National Business Aviation Association, Inc.

Thomas L. Hendricks
ADS–B In ARC Co-Chair
National Air Transportation Association

Enclosure
Copy to Mr. Doug Arbuckle, ADS–B In ARC Designated Federal Official, and all ARC members.

A Report from the

ADS–B In Aviation Rulemaking Committee to the Federal Aviation Administration

Recommendations in Response to the Federal Aviation Administration May 30, 2012, Tasking.

October 31, 2012

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EXECUTIVE SUMMARY

The Federal Aviation Administration (FAA) Modernization and Reform Act of 2012 (Public Law 112–95) provided direction from Congress to the FAA on implementing Automatic Dependent Surveillance–Broadcast (ADS–B) services in the National Airspace System (NAS). Section 211 of the Act requires the FAA initiate rulemaking by February 14, 2013, to issue guidelines and regulations relating to ADS–B In services. Section 211 also requires the FAA identify the ADS–B In technology that will be needed under the Next Generation Air Transportation System (NextGen). Reflecting Congressional concern about a premature mandate, the statute required any equipage requirement be subject to a readiness verification; the FAA ensure the necessary ground infrastructure is installed and functioning properly, and certification standards have been approved; and appropriate operational platforms interface safely and efficiently.

The ADS–B In Aviation Rulemaking Committee (ARC) remains supportive of ADS–B In and believes it is essential that the FAA, as a key component of the NextGen program, prioritize the development of the key ADS–B In applications to the point of being NAS-enabled. The FAA should encourage voluntary ADS–B In equipage through financial and operational incentives.

Consistent with the ARC report dated September 30, 2011, the ARC continues to find that ADS–B In technical, operational, and financial uncertainties preclude proposing any ADS–B In mandatory equipage rule until those uncertainties are resolved. In addition, given the continued challenges surrounding future funding streams for NextGen technology investments, the ARC's position remains that in light of these strategic uncertainties, there is not yet a compelling business case for any operator equipage mandates of ADS–B In technologies. The ARC, in the findings and recommendations summarized below, urges the FAA to seek, and Congress to provide, the funds needed to reduce these uncertainties and thus build confidence in the substantial related investments by the operator community if a future mandate is considered. This report contains expanded explanations of the following findings and recommendations.

ADS–B IN ARC FINDINGS

No.	Report Section	Finding
1	2.0	The funding decision made by the FAA in the Fiscal Year (FY) 2012 Joint Resource Council (JRC) adds uncertainty and delay to establishing business cases for key ADS–B In applications.
2	2.0	More certain availability of the key ADS–B In applications is essential for industry to develop a business case to endorse regulatory action by the FAA requiring ADS–B In equipage.
3	2.0	At this time the ARC cannot support the FAA proposing an equipage rule for ADS–B In due to lack of data and information about its use in the NAS, including operator benefits.
4	3.2	The ARC found a subset of airports with high air traffic density in their terminal airspace and surface domain will generate most of the economic benefits from ADS–B In applications.

No.	Report Section	Finding
5	3.3	Because of funding uncertainty, the need for mature MOPS and TSOs for key applications, and the length of time needed to develop and deploy equipage for affected aircraft (see recommendation 10), the ARC finds that any ADS–B In required equipage is unachievable by 2020.

ADS–B In ARC Recommendations

No.	Report Section	Recommendation
1	2.0	The ARC recommends the FAA focus funding on accelerating the development of equipment standards, certification guidance, operational approval guidance, ground automation, and any necessary policy adjustments to enable operational implementation (NAS-enabled) of key ADS–B In applications and/or enabling capabilities. The program funding profile (from the May 2012 JRC) since the ARC's recommendation September 30, 2011, is insufficient to meet the schedule for application development proposed by the ARC. Consequent delays in ADS–B In application development inhibit individual operator impact analysis and the strategy for the FAA Surveillance and Broadcast Services (SBS) Office to establish whether there is a positive operator business case. These facts indicate the FAA will lack the necessary elements to contemplate or justify proposal of an ADS–B In equipage rule for an extended period of time.
2	2.0	The FAA should prioritize improving NAS operations through the use of ADS–B In by approving FY 2013 SBS JRC funding to further develop, to the point of being NAS-enabled, the five key ADS–B In applications with the greatest potential to positively affect the ADS–B In business case: • Flight-deck-based Interval Management–Spacing (FIM–S), • Cockpit Display of Traffic Information (CDTI)-Assisted Visual Separation (CAVS) and CDTI-Assisted Pilot Procedure (CAPP), • Flight-deck-based Interval Management–Defined Interval (FIM–DI), • Interval Management Defined Interval–Oceanic (IMDIO), and • FIM–DI for Closely Spaced Parallel Runway Operations (CSPO)
3	3.4	If ADS–B In technology reaches an acceptable level of maturity, the FAA conducts flight trials for a sufficient number of ADS–B In applications to validate the utility of operational concepts and validate the benefits case, and the FAA contemplates proposing an equipage rule for ADS–B In for those specific applications, then this ARC recommends the FAA establish a new ARC early enough in the process to leverage the industry's view of a proposed equipage rule for ADS–B In.
4	4.1	At the present time, both the costs and benefits of ADS–B In need further definition. As a result, the ARC continues to recommend the FAA not propose an ADS–B In mandate.

No.	Report Section	Recommendation
5	4.2	The ARC recommends the FAA determine— • If operator benefits will be obtained only in certain airspace. • If operator benefits would include fewer delays, more direct flight routes and climbs to cruise altitudes, and associated fuel savings. • What assurances of benefits operators that equip would receive. • The operational impact to operators that cannot equip. • If the FAA would have the necessary resources to certify and approve the technology and operators in a timely fashion.
6	4.4	The ARC recommends the FAA continue to promote the voluntary equipage of ADS–B In capability for traffic, weather, and other situational awareness benefits through various operational and financial incentives and educational programs for the general aviation community.
7	4.5	The ARC recommends, if any ADS–B In equipage requirement is considered, the FAA should provide a State (for example, military, customs, and police services) aircraft exemption.
8	4.5	The ARC recommends FAA Order JO 7110.65, Air Traffic Control, should provide guidance to air traffic controllers clearly articulating that State aircraft not equipped with ADS–B In will be accommodated without undue operational consequence.
9	4.5	If any proposed ADS–B In regulation is considered for State aircraft, the ARC recommends the FAA further analyze and quantify the impact of State aircraft not equipped with ADS–B In on civil traffic at capacity-constrained airports or any other location where ADS–B In regulations are under consideration. Quantifying the impact of State non-equipage on civil traffic will provide inputs to a specific cost-benefit analysis supporting the exemption of State aircraft as a cost-beneficial solution.
10	4.6	The ARC recommends any FAA rulemaking consider that a minimum of 2 years from the availability of validated minimum operational performance standards, advisory circulars, technical standard orders, and other U.S. and international certification guidance will be necessary before equipment can be assumed to be commercially available. Further, a subsequent equipment installation cycle of approximately 6 years for major airlines should also be considered.
11	4.6	The ARC recommends any proposed regulation for ADS–B In equipage on in-service aircraft show a positive cost-benefit for operators using data that accurately reflect the significant costs of retrofitting the existing aircraft systems and interfaces to include any required capability.
12	4.6	The ARC recommends NAS implementation of ADS–B In applications be harmonized with any global equipment standards that may be in place or considered.
13	4.7	In its September 2011 report, the ARC recommended “the FAA undertake significant efforts to develop global equipment standards after the benefits are also established as achievable and operationally implementable.” The ARC reiterates this recommendation, particularly regarding the need to define ADS–B In applications in a globally interoperable manner.

1.1 BACKGROUND AND TASKING

1.2 ADS–B In Overview

The term "Automatic Dependent Surveillance–Broadcast (ADS–B) In" describes a number of capabilities that promise to enhance safety, capacity, and operations in the National Airspace System (NAS). In its report dated September 30, 2011, the ADS–B In Aviation Rulemaking Committee (ARC) focused attention on 10 applications:

1. Cockpit Display of Traffic Information (CDTI)-Assisted Visual Separation (CAVS),
2. Flight-deck-based Interval Management–Spacing (FIM–S),
3. Traffic Situation Awareness with Alerts (TSAA),
4. Oceanic In-Trail Procedures (ITP),
5. CDTI-Enabled Delegated Separation (CEDS),[1]
6. Ground-based Interval Management–Spacing (GIM–S) with Wake Mitigation,
7. Flight-deck-based Interval Management–Defined Interval (FIM–DI),
8. FIM–DI for Closely Spaced Parallel Runway Operations (CSPO),
9. Oceanic Interval Management (IM), and
10. Airport Traffic Situation Awareness with Indications and Alerts (SURF–IA) at airports with surface multilateration system.

Unlike ADS–B Out, which is enabled by a transponder and a specific Global Navigation Satellite System position source, there is no one ADS–B In avionics implementation that constitutes ADS–B In. Depending on the manufacturer and the application to be performed, ADS–B In implementations may have widely varying characteristics and capabilities, including—

- Different and separate functionality,
- Different requirements defined separately in minimum operational performance standards (MOPS),
- Unique certification standards and requirements,
- Unique crew and/or air traffic controller training requirements,
- Unique procedural and policy accommodations, and
- Unique operational approval requirements.

1.3 Congressional Direction

The Federal Aviation Administration (FAA) Modernization and Reform Act of 2012 (Public Law 112–95) provided direction from Congress to the FAA on implementing ADS–B services in the NAS. Section 211 of the Act requires the FAA initiate rulemaking by February 14, 2013, to issue guidelines and regulations relating to ADS–B In services.

[1] CEDS has been renamed CDTI-Assisted Pilot Procedure (CAPP).

Section 211 also requires the FAA identify the ADS–B In technology that will be needed under the Next Generation Air Transportation System (NextGen). Reflecting Congressional concern about a premature mandate, the statute required any equipage requirement be subject to a readiness verification; the FAA ensure that the necessary ground infrastructure is installed and functioning properly, and certification standards have been approved; and appropriate operational platforms interface safely and efficiently. See appendix D, FAA Modernization and Reform Act of 2012 (Public Law 112–95), Section 211, to this report for the full text of Section 211.

The Act was notable for the numerous extensions to which it was subject that allowed for active discussions with Congress resulting in amendments by both Houses to their competing bills. The commercial airline industry advocated against any mandate for equipage. The manufacturing industry's discussions focused on the "all aircraft" provision[2] and, if Congress maintained interest in requiring rulemaking, how a more flexible approach could be developed through cooperative work between the FAA and industry. The broader aviation industry also took the position that Congress should not prescribe how to deploy ADS–B In, but instead provide the FAA flexibility to work with industry while the technology was being further matured, and to provide discretion regarding the types of airspace, airports, and aircraft, as well as the types of operations that would be required to install and operate ADS–B In equipage.

1.4 FAA Engagement with Industry Through the ADS–B In ARC

In parallel to the activities on Capitol Hill, the ADS–B In ARC provided its recommendations to the FAA in September 2011, clearly opposing an equipage mandate at that time, but endorsing the continued development of ADS–B In applications the ARC believed would provide an opportunity to generate safety and capacity benefits. The ARC report was published in the Federal Register on November 17, 2011.[3] The ARC's recommendations underscored industry's support for ADS–B as the primary mechanism to provide future surveillance for air traffic control (ATC) in the NAS and recognized the technology as foundational for NextGen. However, the report also stated a significant amount of work was needed to convince industry the ADS–B In technology was sufficiently mature to justify investment. The ARC reviewed existing ADS–B In situational awareness applications and over a dozen applications in various stages of development. The ARC strongly endorsed continued development of ADS–B In for NextGen. To clarify industry's needs, the ARC recommended the FAA develop additional regulations, certification guidance, and specifications to manage business uncertainty and risk. The ARC also identified specific work to be funded by the FAA that will enable more rapid development of ADS–B In applications and envisioned continued efforts by the ARC once the FAA responds to these initial inputs.

The ARC identified specific milestones for the ADS–B program, which if met, should enable specific benefit-generating ADS–B In operations to be conducted in the NAS by 2015, with additional capabilities entering into service over the following 5 years. These applications are in addition to several ADS–B In applications that will enter into service in the NAS over the

[2] "all aircraft operating in capacity constrained airspace, at capacity constrained airports, or in any other airspace deemed appropriate by the Administrator to be equipped with ADS–B In technology by 2020"
[3] 76 FR 29668.

next 2 years. The initial applications were planned as part of the Joint Resource Council (JRC) baseline through 2014. In addition, the ARC provided a prioritized list of applications to help the FAA understand the applications industry believes will provide the most benefit soonest.

1.5 FAA Engagement with Industry Through New Task to ADS–B In ARC Based on Section 211

In May 2012, the FAA presented its 2014-2020 plan for ADS–B deployment in the NAS to the JRC for funding. A detailed review of the results and implications of the FAA's 2012 JRC decision is included in chapter 2 of this report.

Additionally, in response to Section 211 and feedback from the ARC, the FAA provided a new task for the ADS–B In ARC in May 2012 to provide "recommendations by October 31, 2012, on how to frame an ADS–B In equipage mandate such that the benefits exceed costs before 2035," including "(a) in what airspace, and/or (b) at what airports, and/or (c) by what other criteria the FAA could apply to frame an ADS–B In mandate (examples including, but not limited to, by operator class or aircraft class). In addition, the ARC is requested to provide feedback on a 2020 compliance date for a potential ADS–B In mandate."

A copy of the amended ARC charter is included in appendix E, ARC Charter, to this report. It is the ARC's understanding that the FAA will leverage its recommendations to inform its Rulemaking Management Council, which serves as the first step to initiate any formal FAA rulemaking, by February 2013 as required by Section 211.

2.0 FAA FUNDING OF ADS–B IN APPLICATION DEVELOPMENT

One of the September 2011 ARC report's primary goals was to provide industry's view on the FAA's ADS–B funding review, the JRC, that was scheduled for spring 2012. When the FAA originally launched the ADS–B program in 2008, it established a funding plan for fiscal year (FY) 2008 through FY 2014 that supported the deployment of ground infrastructure and the development of a handful of ADS–B In applications including airborne situational awareness, airport situational awareness, and spacing applications.[4]

In 2012, the FAA intended to conduct a 2014-2020 ADS–B program JRC review that would fund not only continued services, but also the development of additional ADS–B In applications beyond the suite of five applications included in the 2008-2014 baseline.

The FAA presented the proposed Final Investment Decision for FY 2014-FY 2020 on May 30, 2012, but due to funding constraints, limited its approval to the expansion of the baseline to include only the implementation of the ADS–B In application for oceanic climbs in non-radar airspace called "In-Trail Procedures" (ITP). The FAA deferred decisions regarding additional ADS–B In applications identified by the ADS–B In ARC to a planned JRC in FY 2013 that would establish funding beginning in FY 2015.

The FAA briefed the ADS–B In ARC on the results of its 2012 funding decision and the plan for an additional program funding review in 2013 (see appendix F, A4A Recommendation to the ARC, to this report). The ARC reviewed the outcome of the FAA JRC on the FAA's plans for application development and the September 2011 ARC recommendations for scheduling 10 ADS–B In applications.[5] The ARC notes that due to FAA funding decisions, the development schedule has been delayed for many ADS–B In ARC applications essential to closing the operator business case.

[4] The SBS program baseline included ADS–B Out ATC surveillance and GIM–S as well as ADS–B In application development for Basic Airborne (AIRB), Basic Surface (SURF), Visual Separation on Approach (VSA), CAVS, TSAA, and Weather and NAS Situation Awareness (WNSA). GIM–S (NAS-enabled) and TSAA (TSO) are scheduled to be complete in 2014. The FAA also funded the deployment of three additional radio stations in Mexico to provide coverage over all of the Gulf of Mexico air traffic routes extended from the Houston Air Route Traffic Control Center into Mexico. (Final Investment Decision FY 2014-2017, Vinny Capezzuto and Arthur Sullivan, May 30, 2012, slide No. 7.) Additionally, the original SBS program baseline included future application development. The FAA funded ITP avionics development and operational benefits validation. The 2012 JRC decision provided the remaining funding needed to complete ITP, by making appropriate modification to Advanced Technologies Oceanic Procedures/Ocean 21 automation platform.

[5] ADS–B In ARC Report, September 30, 2011, Recommendation 8: "The ARC recommends the FAA focus funding on accelerating the development of equipment standards, certification guidance, operational approval guidance, ground automation for the applications, and any necessary policy adjustments to enable operational implementation of the 10 applications and/or enabling capabilities listed… in priority order (with targeted completion date): 1. [CAVS] ([fiscal year (FY)] 2012 ...); 2. [FIM–S] (DI based on current separation standards, to include merging of different traffic streams while increasing arrival throughput) (FY 2015); 3. [TSAA] (2013); 4. Oceanic [ITP] (FY 2013); 5. [CEDS] (ending in a visual approach) (FY 2016); 6. [GIM–S] with Wake Mitigation ... at core airports by end of [calendar year] 2018); 7. [FIM–DI] (Operational trial by FY 2017 with a push to be operational 2 years following completion of the trial); 8. FIM–DI for [CSPO] (FY 2017); 9 Oceanic [IM] (FY 2015); and 10. [SURF–IA] at airports with surface multilaterlation system (FY 2017)."

<u>Recommendation 1: The ARC recommends the FAA focus funding on accelerating the development of equipment standards, certification guidance, operational approval guidance, ground automation, and any necessary policy adjustments to enable operational implementation (NAS-enabled) of key ADS–B In applications and/or enabling capabilities. The program funding profile (from the May 2012 JRC) since the ARC's recommendation September 30, 2011, is insufficient to meet the schedule for application development proposed by the ARC. Consequent delays in ADS–B In application development inhibit individual operator impact analysis and the strategy for the SBS Office to establish whether there is a positive operator business case. These facts indicate the FAA will lack the necessary elements to contemplate or justify proposal of an ADS–B In equipage rule for an extended period of time.</u>

ARC recommended applications

All dates with question marks are current best estimates of FAA based on projected FAA budgets – they do not represent FAA commitments since they are not baselined

Current SBS Baseline
Proposed Baseline
[illegible]

	Requirements Definition	Requirements Validation	NAS Enabled	NAS Implementation
CDTI-Assisted Visual Separation (CAVS)			FY14	FY17
Flight-deck-based Interval Management-Spacing (FIM-S) supported by ATC Automation		FY18?	FY18?	FY20?
Traffic Situation Awareness with Alerts (TSAA)	FY13	FY14	FY14	FY14
Oceanic In-Trail Procedures (ITP)			FY15-16	FY17
CDTI-Assisted Pilot Procedure (CAPP) *[[redefined variant of CEDS]]*	FY14	FY18?	FY18?	FY20?
Ground-based Interval Management-Spacing (GIM-S) with Wake Mitigation	No current plan [illegible]			
Flight-deck-based Interval Management-Defined Interval (FIM-DI) and FIM-DI for Closely Spaced Parallel Runway Operations (CSPO) supported by ATC Automation (TSS)	FY17? [illegible]			
Interval Management Defined Interval – Oceanic (IMDIO) *[[likely to be renamed]]*	FY 18? [illegible]			
Airport Traffic Situation Awareness with Indications and Alerts (SURF-IA)				
- Accuracy Enhancements via Ground Solution		No current plan		
- Accuracy Enhancement via Avionics Solution	No current plan			

Table 1—FAA's New Baseline Following May 2012 JRC[6]

See appendix C, Terminology, to this report for a definition of "NAS implementation."

[6] ADS–B In ARC: 2012 JRC Debrief, June 27, 2012, slide No. 7, FAA Surveillance and Broadcast Services.

Finding 1: The funding decision made by the FAA in the FY 2012 JRC adds uncertainty and delay to establishing business cases for key ADS–B In applications.

Finding 2: More certain availability of the key ADS–B In applications is essential for industry to develop a business case to endorse regulatory action by the FAA requiring ADS–B In equipage.

Finding 3: At this time the ARC cannot support the FAA proposing an equipage rule for ADS–B In due to lack of data and information about its use in the NAS, including operator benefits.

The ARC believes, as stated in its September 2011 recommendations, the FAA should prioritize funding for ADS–B In application development, including development of standards, validation of the standards and benefits through flight trials, and enabling the use of the application through modifications in procedures and the ground automation.

Recommendation 2: The FAA should prioritize improving NAS operations through the use of ADS–B In by approving FY 2013 SBS JRC funding to further develop, to the point of being NAS-enabled, the five key ADS–B In applications with the greatest potential to positively affect the ADS–B In business case:

- Flight-deck-based Interval Management–Spacing (FIM–S),
- CDTI-Assisted Visual Separation (CAVS) and CDTI-Assisted Pilot Procedure (CAPP),
- Flight-deck-based Interval Management–Defined Interval (FIM–DI),
- Interval Management Defined Interval–Oceanic (IMDIO), and
- FIM–DI for Closely Spaced Parallel Runway Operations (CSPO).

Note: The ARC will provide the FAA with a description of CAPP in its November 2012 report.

3.1 CRITERIA AND FINDINGS FOR INITIATING RULEMAKING

The FAA specifically tasked the ARC to look at "how to frame an ADS–B In equipage mandate such that the benefit exceed costs before 2035," including "(a) in what airspace, and/or (b) at what airports, and/or (c) by what other criteria the FAA could apply to frame an ADS–B In mandate (examples including, but not limited to, by operator class or aircraft class). In addition, the ARC is requested to provide feedback on a 2020 compliance date for a potential ADS–B In mandate."

The FAA's mechanism for introducing any required aircraft equipage is through rulemaking. One of the final steps in the FAA's rulemaking process is the publication of a proposed rule as a notice of proposed rulemaking (NPRM), which identifies the agency's reason for conducting the rulemaking, a cost-benefit analysis, and proposed regulatory language. The publication of an NPRM is in no way a guarantee the agency will issue a final regulation, as the NPRM is subject to public comment and a requirement to achieve a positive cost-benefit to move forward.

Through interactions between the FAA and industry, the ARC made the following findings concerning steps the FAA should take before proposing ADS–B In regulations.

3.2 ACHIEVING COST-BENEFIT BEFORE 2035

The FAA cost-benefit analysis for the ADS–B program, which is estimated to become positive by 2035, considers not only industry costs and benefits, but also public benefits such as value of passenger time and reduced FAA cost. The ARC notes that key segments of the operator community, such as scheduled airlines, use a hurdle rate for investments that requires a specified rate of return or payback, which depends on the cost of the capital at the time of investment. Thus, significant differences may exist between a positive cost-benefit analysis by the FAA and one by the operators. An operator's voluntary investment decision will largely be determined by the cost-benefit that will accrue to that operator.

Additionally, the ARC believes any cost-benefit analysis should be validated with actual operations during flight trials before being used in FAA rulemaking. The ARC agrees strategic value exists in FAA preliminary analysis using simulation, modeling, and associated architectural assumptions. These early analytical tools, however, include by necessity operating assumptions frequently proven to be inaccurate by subsequent actual flight trials jointly sponsored by operators and the FAA. This lends further support to the importance of the FAA funding the development and flight trials of key ADS–B In applications identified by industry.

Currently, a number of airlines are working to establish specifications for their single-aisle/ narrow-body fleets for the next several decades as part of significant fleet replacements that are underway. An opportunity exists for the FAA to quickly develop the expected provisioning for ADS–B In equipage to enable operators to make informed equipage decisions as part of these fleet replacements as well as facilitate forward fitting the aircraft with ADS–B In or enabling retrofit at minimal costs.

Additionally, several other obstacles exist to equipping through ADS–B In retrofit, including the ability to amortize the equipage cost over the life of the aircraft; the cost of taking the aircraft out of service; and, for some aircraft models, the retrofit of ADS–B In to support some applications being prohibitive due to the existing aircraft avionics architecture that cannot be economically modified. The ARC specifically notes that for these aircraft, especially those nearing the end of their service life, the FAA should consider exempting any required equipage to help facilitate a reduced cost of the aggregate equipage, as has been done in several European rules.

Finally, it is extremely costly and inefficient for fleet operators, such as scheduled airlines, to manage "sub-fleets" that carry unique equipage, such as ADS–B In, for access to the capacity-constrained airspace. Most operators serve these few capacity-constrained airports with a large number of flights from cities of varying sizes using multiple aircraft types. By equipping entire fleets with all the capabilities needed to serve these markets, operators can achieve service reliability when required to swap aircraft for planned and unplanned maintenance, weather delays, and other frequent uncertainties. The clear objective is to avoid cancellations and provide for fleet flexibility. Because operators are financially constrained to retrofit whole fleet types, the business case will be enhanced by the FAA supporting high-value ADS–B In applications at as many capacity-constrained airports as possible.

3.3 ADS–B In Deployment in Airports

ADS–B In capability creates capacity benefits by minimizing the spacing in arriving and departing aircraft streams in high density airspace. A typical area for use would be in metroplexes or terminal airspace (for example, Los Angeles or New York) where multiple airline hub airports have complex and interrelated traffic flows. These areas also typically have adjacent general aviation (GA) and military airports where ADS–B In applications on board the aircraft would not be essential, as the traffic flows are not near capacity. The ARC believes the various aircraft flows to and from these multiple airports in a metroplex can be evolved to selectively include ADS–B In applications to address future capacity shortfalls. Flows at these airline hubs will likely achieve capacity benefits from ADS–B In capability, while the separate flows at the GA and military airports may achieve benefits at a lower rate. In the event that a non-equipped or State aircraft sought access in the flow of an ADS–B In equipped stream, airspace managers and air traffic controllers would provide access using spacing tools to optimize access and tactically add the non-equipped or State aircraft to the flow with priority similar to an equipped aircraft.

Finding 4: The ARC found a subset of airports with high air traffic density in their terminal airspace and surface domain will generate most of the economic benefits from ADS–B In applications.

3.4 ADS–B In Equipage by 2020 and Beyond

The FAA's currently funded schedule for key ADS–B In applications, such as FIM–S, identifies the availability of mature MOPS and technical standard orders (TSO) by the end of FY 2014. The validation of the FIM–S requirements and attainment of NAS-enabled status for this application might be achieved by the end of FY 2018. This maturation of the application, however, is dependent upon the availability of funding that is planned to be requested at a FY 2013 JRC.

The FAA having matured MOPS and TSOs (including conducted flight trials that prove the benefit) for a sufficient number of ADS–B In applications to validate a positive operator business case would be essential for the FAA to conduct the regulatory analysis required before proposing an equipage rule for ADS–B In.

Finding 5: Because of funding uncertainty, the need for mature MOPS and TSOs for key applications, and the length of time needed to develop and deploy equipage for affected aircraft (see recommendation 10), the ARC finds that any ADS–B In required equipage is unachievable by 2020.

3.5 FAA Leverage of Industry Expertise in Rulemaking

The FAA successfully worked with industry to deploy ADS–B Out within the NAS since the program was established in 2007. The FAA's cooperation with industry through forums such as the Air Traffic Management Advisory Committee and two ARCs allowed for an open exchange of ideas and allowed the FAA to understand the industry's views regarding the program's priorities and how to structure any regulatory requirements.

At this time, ADS–B In is not at a state of maturity that would allow the FAA to propose an equipage rule for ADS–B In by any operator in any airspace or airports.

Recommendation 3: If ADS–B In technology reaches an acceptable level of maturity, the FAA conducts flight trials for a sufficient number of ADS–B In applications to validate the utility of operational concepts and validate the benefits case, and the FAA contemplates proposing an equipage rule for ADS–B In for those specific applications, then this ARC recommends the FAA establish a new ARC early enough in the process to leverage the industry's view of a proposed equipage rule for ADS–B In.

4.0 ARC MEMBER PERSPECTIVES ON CRITERIA TO FRAME ADS–B IN RULEMAKING BY OPERATOR CLASS OR AIRCRAFT

Typically, an ARC would not organize a report by operator segment; however, the ADS–B In ARC's tasking was to respond to the FAA with specific operator perspectives. The recommendations in this section are the consensus of the ARC and are placed at appropriate points within the operator perspectives.

4.1 Major Airline

Airlines for America (A4A) and its member carriers strongly support the modernization of the current air traffic management system and believe that the successful implementation of NextGen is critical to the global competitiveness and viability of U.S. commercial aviation. ADS–B In could be an important piece of NextGen, and offers the promise of increased capacity, safety, and efficiency. However, the FAA needs to demonstrate in operational flight trials that it can deliver capacity, safety, and efficiency benefits with ADS–B In applications.

While the importance of NextGen is clear, the implementation has been complicated, and significant issues remain unresolved. Specifically, with respect to ADS–B In, many of the applications show promise, but additional development is necessary before investment or implementation decisions can be justified. We urge the FAA to continue work to demonstrate the maturity of this technology, as described in appendix F to this report.

The ADS–B In ARC recommendations in the September 2011 report to Mr. Grizzle and Ms. Gilligan stated the following with respect to an ADS–B In mandate:

"The ARC supports ADS–B as the primary mechanism to provide future surveillance for ATC in the NAS and finds there are four primary recommendations on how the FAA should integrate ADS–B In into the NAS. First, the ARC finds, based on the current maturity of ADS–B In applications and uncertainties regarding the achievable benefits, there is not a NAS user community business case for near-term ADS–B In equipage. Therefore, at this time, the ARC does not support an equipage mandate. The ARC recommends the FAA demonstrate to the satisfaction of the user community that equipage benefits are both achievable and operationally implementable in a cost-effective manner."

Recommendation 4: At the present time, both the costs and benefits of ADS–B In need further definition. As a result, the ARC continues to recommend the FAA not propose an ADS–B In mandate.

4.2 Regional Airline

Regional airline support for the NextGen modernization remains strong. NextGen is essential to maintain the regional airline industry's role as a leading air transportation provider and economic connection for the majority of communities and is vital to national and global economic centers. The transition to increased use of space-based technology such as ADS–B will require regional airlines to expend considerable economic resources. Thus, these expenditures must achieve the desired safety and capacity goals. The high cost of modernization coupled with the industry's need to sustain profitability means such investment puts the airlines, their employees, and the communities they service at risk if the benefits do not offset the investments.

As a participant in the ADS–B In ARC, the Regional Airline Industry (RAA) gained a better understanding of the various ADS–B In operational capabilities under consideration. However, RAA remains uncertain about what capabilities will be required. Further, without avionics design and performance specifications, it is not possible to determine the technological or financial feasibility of installing these capabilities on current and future aircraft. In addition to avionics specifications, RAA also needs a better understanding of required ADS–B In operational capabilities. The regional airline industry's comprehension of the associated costs and benefits should continue to increase so RAA, the FAA, and manufacturers are fully prepared to make sound decisions.

It is important to heed the lessons learned from past experience with modernization programs. While the regional airline industry began equipping its aircraft with Global Positioning System-based area navigation systems 18 years ago, it only recently began to achieve the benefits. Consequently, the industry is now retiring many of the aircraft without having realized sufficient benefit to justify the expense. An ADS–B In rulemaking effort or mandate would be even riskier unless the industry identified the required operational capabilities, avionics technical specifications, costs of manufacturing and equipping, and measurable and achievable benefits to the operators. If the industry fails to make prudent, informed investment decisions, the consequences would impact air service and risk losing current and future jobs.

Recommendation 5: The ARC recommends the FAA determine—

- If operator benefits will be obtained only in certain airspace.
- If operator benefits would include fewer delays, more direct flight routes and climbs to cruise altitudes, and associated fuel savings.
- What assurances of benefits operators that equip would receive.
- The operational impact to operators that cannot equip.
- If the FAA would have the necessary resources to certify and approve the technology and operators in a timely fashion.

4.3 INTERNATIONAL AIRSPACE

See appendix G, IATA Letter, for the international airline perspective.

4.4 OTHER CIVIL USER

The GA community is subject to significant costs with limited benefits from the requirement to carry ADS–B Out equipage to continue to operate with current access to the NAS. While the carriage of ADS–B In will generate specific operator benefits, a voluntary approach to ADS–B In equipage is believed to be appropriate for this community. For the purpose of this report, "GA" includes aircraft primarily operated in accordance with Title 14, Code of Federal Regulations (14 CFR) part 91, part 91K, and on-demand part 135.

The direction from Congress specifically points to "capacity-constrained" airports and airspace as the primary reason for asking the FAA to initiate rulemaking for ADS–B In equipage. This explicit direction from Congress drove the ARC to focus on those ADS–B In applications that can directly enhance airspace and airport capacity. The ARC recognizes that the primary congestion occurs around key airline hubs and metro areas.

The ARC reviewed the positions of three segments of GA—small airplane operators (Aircraft Owners and Pilots Association), larger airplane operators (National Business Aviation Association), and helicopters operators (Helicopter Association International)—which are included in appendix H, Other Civil User Perspectives, to this report.

The GA operator community is equipping with ADS–B Out capability to meet the mandate established in the ADS–B Out rule to continue to maintain airspace access, facilitate air-to-ground enhanced surveillance, and enable the deployment of ADS–B In applications that depend on all aircraft in designated airspace being equipped with the transmit capability.

Operational NAS data shows GA aircraft mostly operate in airspace and at airports with limited aircraft operations. Analysis of airport data[7] shows GA is a limited/minimal user at most major airports in the NAS. As a result, the mandatory carriage by GA aircraft of ADS–B In equipage will not significantly increase the overall equipage level by more than a few percentage points, which affects benefits at these airports. The GA industry believes the aggregate cost of equipping GA aircraft with ADS–B In capability would not be offset by the incremental increase in aircraft equipage at these airports or any benefit provided to individual operators.

Further, after reviewing the spacing applications such as FIM–S that enable increased operational arrival rates at airports, the GA industry does not expect these applications will be practical to deploy on most small GA airplanes or beneficial to deploy on helicopters. Several factors drive this assumption, including the FAA's expected requirement for each operator to establish a specific training program and obtain approval from the FAA to conduct the operation (that is, an Operational Specification, Management Specification, or Letter of Authorization, depending on the operator.) The expected requirement of an operational authorization for capacity-enhancing ADS–B In applications would further

[7] Appendix I to this report contains data about GA flight operations at the top 30 airports, which accounted for approximately 7.3 percent of the traffic.

exacerbate the cost to the GA community and drastically restrict the type of operators capable of supporting the authorization.

The ARC does not believe the benefits for equipped operators of ADS–B In will be negatively impacted if some operators (such as GA aircraft that are limited/minimal users in most high-density airspace) are not equipping with ADS–B In, as they will meet the requirements for ADS–B Out equipage, per 14 CFR sections 91.225 and 91.227, and will be transmitting data for use by the ADS–B In equipped aircraft in that airspace or on that airport surface.

Recommendation 6: The ARC recommends the FAA continue to promote the voluntary equipage of ADS–B In capability for traffic, weather, and other situational awareness benefits through various operational and financial incentives and educational programs for the GA community.

4.5 Department of Defense

The U.S. Department of Defense (DOD) provided a "DOD Viewpoint" to the September 2011 ARC report, describing several key points specific to DOD operations and fleet composition:

1. The DOD inventory consists of over 14,000 aircraft, comprised of over 100 aircraft types with distinctive operating profiles.
2. A vast proportion of DOD operations occur outside the Core 30 airports identified by the ARC as having the highest concentration of ADS–B In benefits (see table K.12 in the September 2011 report).
3. The costs to modify and integrate ADS–B In into the DOD inventory will be considerable, given the complexities, differences, average aircraft age, military security requirements, and sheer number of DOD aircraft.
4. DOD's initial assessment is that a positive business case to equip with ADS–B In will likely not be proven for the majority of DOD's fleet.
5. Any FAA mandate must accommodate non-equipped DOD aircraft, ensuring DOD aircraft retain access to routes, airspace, and airports required to test, train, and operate in support of the National Defense mission.

DOD notes—

1. An ADS–B In capability is generally required to increase capacity in capacity-constrained environments. DOD airports are not capacity-constrained. Additionally, DOD represents a very small percentage of traffic in capacity-constrained airports. Of the top 20 busiest airports within the United States, DOD comprises less than 0.3 percent of tower operations (see appendix I, ATADS Traffic Analysis, to this report). It is expected that impacts to civil traffic of daily DOD operations would be extremely minimal, given the infrequency of operations at these locations.

2. The original ADS–B In ARC performed a benefits analysis for ADS–B In benefits at 35 major airports to quantify expected benefits (see table K.12 in the September 2011 report). 99 percent of the cumulative benefits were accrued at the top 30 airports. At these airports, DOD operations comprised less than 0.6 percent of tower operations. It is expected that these minimal operations would have little to no impact on civil traffic.
3. Some DOD aircraft, given the specific mission and aircraft configuration, may equip with ADS–B In to obtain benefits. These aircraft will require a Traffic Collision and Avoidance System and/or transponder development for platform integration and compliance with ADS–B In equipage.
4. Preliminary rough order of magnitude cost estimates developed by DOD have validated the assumption that costs to equip DOD aircraft would be very high. The estimate for modifying less than 60 percent of the current DOD fleet is $2.5 billion. This does not include the modification of DOD's most highly integrated fighter aircraft, which have typically been the most expensive aircraft to modify.
5. Any mandate by the FAA for ADS–B In could lead to similar mandates around the world, and structuring of this mandate could set precedence for other nations. The United States must ensure military operators are appropriately accommodated in all U.S. and foreign airspace.
6. The potential for mandates should occur at locations where *and* when demand exceeds capacity, *and* where increases in capacity cannot be accomplished by means other than aircraft equipage modifications. If procedural, ground system, or regulatory changes can improve capacity while using existing equipage, these changes should be considered before any capability that requires modifications to aircraft equipage goes into effect.

Recommendation 7: The ARC recommends, if any ADS–B In equipage requirement is considered, the FAA should provide a State (for example, military, customs, and police services) aircraft exemption.

Recommendation 8: The ARC recommends FAA Order JO 7110.65, Air Traffic Control, should provide guidance to air traffic controllers clearly articulating that State aircraft not equipped with ADS–B In will be accommodated without undue operational consequence.

Recommendation 9: If any proposed ADS–B In regulation is considered for State aircraft, the ARC recommends the FAA further analyze and quantify the impact of State aircraft not equipped with ADS–B In on civil traffic at capacity-constrained airports or any other location where ADS–B In regulations are under consideration. Quantifying the impact of State non-equipage on civil traffic will provide inputs to a specific cost-benefit analysis supporting the exemption of State aircraft as a cost-beneficial solution.

4.6 Manufacturer

The introduction of new flight deck functionality requires an application has been developed to a mature state. Mature application development, at a minimum, requires the FAA to have validated the MOPS for the application and to have conducted flight trials to prove the functionality and benefit of the application.

Aircraft manufacturers have often pointed to the difficulties of introducing new flight deck functionality including advanced avionics, displays, and aircraft interfaces, such as those required for ADS–B In applications. The manufacturer community is also in a financial position to deploy new technology in production aircraft only with clear operator demand or regulatory mandate. Through years of experience, it has become recognized that only functionality providing clear and demonstrable benefit will be accepted by the operator community and, as a result, meet the criteria for being considered for ADS–B In introduction in the flight deck.

In addition to a positive cost-benefit for any application, it is also important to consider size, weight, power, and other requirements that a new piece of avionics and associated flight deck displays and controls introduces to a production aircraft. After introduction in production aircraft, these same features can then be retrofitted into the in-service fleet of those same aircraft that have been recently produced and contain the same equipage and interfaces as the production aircraft to support the new functionality. Older versions of these same aircraft present a unique set of challenges and costs for inclusion of the new functionality, and the in-service fleet of much older, out-of-production aircraft requires significant additional investment to update supporting functions and interfaces, such as navigation and displays, to sufficiently support the new functionality. A positive cost-benefit should include realistic estimates of the time and labor needed to install the equipage and wiring, including lost revenue for airplane downtime.

When a new application has been deemed necessary to deploy in the NAS through the issuance of an equipage rule, the airplane manufacturer needs a realistic timeline between development and publication of standards/specifications for each model and certification guidance and the equipage rule compliance date to develop and integrate the avionics on each production aircraft type, and conduct the necessary testing and certification activities to obtain approval by the FAA and other civil aviation authorities. The experience is that from the availability of published certification criteria from all pertinent regulatory authorities toward which to build new avionics it typically takes a minimum of 2 years before production aircraft have the capability as standard. This 2-year timeframe applies to installation on production aircraft and does not include the time required for operators to cost-effectively retrofit their fleet.

Recommendation 10: The ARC recommends any FAA rulemaking consider that a minimum of 2 years from the availability of validated MOPS, advisory circulars, TSOs, and other U.S. and international certification guidance will be necessary before equipment can be assumed to be commercially available. Further, a subsequent equipment installation cycle of approximately 6 years for major airlines should also be considered.

Recommendation 11: The ARC recommends any proposed regulation for ADS–B In equipage on in service aircraft show a positive cost-benefit for operators using data that accurately reflect the significant costs of retrofitting the existing aircraft systems and interfaces to include any required capability.

Recommendation 12: The ARC recommends NAS implementation of ADS–B In applications be harmonized with any global equipment standards that may be in place or considered.

Without full harmonization of the equipment standards, the cost implications from developing and deploying multiple sets of avionics and equipping aircraft to meet standards for separate U.S. and international ADS–B In flight environments would quickly become prohibitive, and operator costs would negate any generated benefits.

4.7 GLOBAL INTEROPERABILITY

Recommendation 13: In its September 2011 report, the ARC recommended that "the FAA undertake significant efforts to develop global equipment standards after the benefits are also established as achievable and operationally implementable."[8] The ARC reiterates this recommendation, particularly regarding the need to define ADS–B In applications in a globally interoperable manner.

From the pilot's perspective, the same avionics (both hardware and software) should be usable in the same manner to accomplish the same function, where supported by the Air Navigation Service Provider, and particularly for the air transport community. This level of global interoperability has been achieved for ADS–B Out 1090 MHz extended squitter avionics, notwithstanding somewhat different data items from standardized ADS–B messages being required in the ADS–B Out rulemaking activities of different States.

Global interoperability has also been achieved for initial ADS–B In applications. Definition of globally interoperable ADS–B In applications has, in a number of cases, not been easy. For example, the RTCA, Inc. (RTCA)/European Organization for Civil Aviation Equipment (EUROCAE) effort to develop standards for FIM–S (to be incorporated into RTCA Document (DO)–317B/ED 194A), the second-ranked ADS–B In application in the September 2011 ARC report, has not yet yielded a globally interoperable application concept, largely owing to different approaches to airspace redesign and achieving benefits in different International Civil Aviation Organization (ICAO) regions. The ARC recognizes and endorses ongoing efforts by RTCA, EUROCAE, and ICAO (for example, its Airborne Surveillance Task Force) to develop FIM–S standards and procedures, as well as standards and procedures for other ADS–B In applications, that are consistent on a worldwide basis.

[8] Recommendation 14f.

APPENDIX A—ADS–B IN ARC MEMBERS, SUBJECT MATTER EXPERTS, AND PRESENTERS

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APPENDIX B—ACRONYMS

A4A	Airlines for America
ADS–B	Automatic Dependent Surveillance–Broadcast
ARC	Aviation Rulemaking Committee
ATADS	Air Traffic Activity Data System
ATC	air traffic control
CAPP	CDTI-Assisted Pilot Procedures
CAVS	CDTI-Assisted Visual Separation
CDTI	Cockpit Display of Traffic Information
CEDS	CDTI-Enabled Delegated Separation
CFR	Code of Federal Regulations
CSPO	closely spaced parallel runway operations
DI	defined interval
DOD	Department of Defense (U.S.)
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FIM–DI	Flight-deck-based Interval Management–Defined Interval
FIM–S	Flight-deck-based Interval Management–Spacing
FR	Federal Register
FY	Fiscal Year
GA	general aviation
GIM–S	Ground-based Interval Management–Spacing
HAI	Helicopter Association International
ICAO	International Civil Aviation Organization
IM	Interval Management

IMDIO	Interval Management Defined Interval–Oceanic
ITP	In-Trail Procedures
JRC	Joint Resources Council
MOPS	minimum operational performance standards
NAC	navigation accuracy category
NAS	National Airspace System
NBAA	National Business Aviation Association
NextGen	Next Generation Air Transportation System
NPRM	notice of proposed rulemaking
RAA	Regional Airline Association
RTCA	RTCA, Inc.
SBS	Surveillance and Broadcast Services
SURF–IA	Airport Traffic Situation Awareness with Indications and Alerts
TDOA	time difference of arrival
TSAA	Traffic Situation Awareness with Alerts
TSO	technical standard order
VSA	Visual Separation on Approach
WNSA	Weather and NAS Situation Awareness

APPENDIX C—TERMINOLOGY

The following terminology applies to this report and the Aviation Rulemaking Committee (ARC)'s findings and recommendations:

1090 ES — (1090 MHz extended squitter) — An Automatic Dependent Surveillance–Broadcast (ADS–B) data link operating on the 1090 MHz frequency that uses messages conveying ADS–B information that comply with the format for a Mode S extended squitter. Each extended squitter is 112 bits long, of which 56 bits are allocated to ADS–B information. Typical 1090 ES equipment transmits an average of 4 to 5 ADS–B extended squitters per second. 1090 ES is an unsynchronized data link.

1090 MHz frequency congestion mitigation — A change to the operation of one of the three systems broadcasting on the 1090 MHz frequency (1090 ES, airborne collision avoidance system, and secondary surveillance radar) to reduce the amount of message traffic on the frequency caused by that system and, therefore reduce the amount of interference on the frequency experienced by all three systems.

Availability — The long-term performance of a system, typically defined in years. Typical availability analysis for ADS–B Out considers a pessimistic minimum guarantee of a Global Navigation Satellite System constellation performance (currently 21 healthy Global Positioning System satellites in appropriate orbital positions, 98 percent of the time, with minimum satellite power).

Continuity — The short-term availability, typically in terms of hours or days, required to maintain the minimum performance requirements for navigation accuracy category (NAC) for position, NAC for velocity, navigation integrity category, and surveillance integrity level for a given operation. Continuity can take into account the current satellite constellation and power.

Core 30 airports — These airports represent the top 30 airports in the country in terms of passenger activity (except Memphis, which is a major freight hub) and account for about 70 percent of commercial passengers: Hartsfield-Jackson Atlanta International (ATL), Boston Logan International (BOS), Baltimore/Washington International (BWI), Charlotte Douglas International (CLT), Ronald Reagan Washington National (DCA), Denver International (DEN), Dallas/Fort Worth International (DFW), Detroit Metropolitan Wayne County (DTW), Newark Liberty International (EWR), Fort Lauderdale/Hollywood International (FLL), Honolulu International (HNL), Washington Dulles International (IAD), IAH - George Bush Houston Intercontinental (IAH), New York John F. Kennedy International (JFK), LAS - Las Vegas McCarran International (LAS), Los Angeles International (LAX), New York LaGuardia (LGA), Orlando International (MCO), Chicago Midway (MDW), Memphis International (MEM), Miami International (MIA), Minneapolis/St. Paul International (MSP), Chicago O`Hare International (ORD), Philadelphia International (PHL), Phoenix Sky Harbor International (PHX), San Diego International (SAN), Seattle/Tacoma International (SEA), San Francisco International (SFO), Salt Lake City International (SLC), and Tampa International (TPA).

Defined interval — An operation in which an air traffic controller maintains separation responsibility while assigning pilots a spacing task that must be performed within defined boundaries. This will enable a range of applications where dynamic interval spacing, closer than that currently allowed by traditional separation standards, may be possible.

Delegated separation — ADS–B application in which the air traffic controller transfers separation responsibility and corresponding tasks to the flightcrew, which ensures that the applicable separation minimums are met.

Multilateration, Active — A method of aircraft surveillance using three or more ground receivers using the time difference of arrival (TDOA) of 1090 replies to a 1030 MHz interrogation signal.

Multilateration, Passive — A method of aircraft surveillance using three or more ground receivers using the TDOA of periodic, uniquely identified transmissions, which can include ADS–B transmissions.

NextGen — Next Generation Air Transportation System. See www.jpdo.gov.

Requirements Definition — Requirements are described in a Safety, Performance and interoperability Requirements (SPR) document as well as specifications for affected NAS subsystems. If this is the final maturity level for the application in the 2012 JRC, then key requirements will be evaluated through flight test of prototype avionics and/or prototype ground equipment (otherwise, the Operational Evaluation in the Requirements Validation level serves as the mechanism to "test" the requirements under real-world conditions).

Requirements Validation — Builds on Requirements Definition by adding—

a. For applications requiring new or changed avionics—

    i. Approval of an avionics standard (minimum operational performance standards (MOPS)),

    ii. Certification of a MOPS-compliant system, and

    iii. An FAA policy memorandum basis for installation and operational guidance leading to operational approval for one operator.

b. For applications requiring a change in air traffic control (ATC) automation, all necessary engineering development and FAA Air Traffic Organization operational approval activities to provide the necessary ATC automation functionality in at least an operational prototype configuration.

c. For all applications, an Operational Evaluation[9] performed by one or more operators to validate performance of the system implementation (avionics, air traffic management automation, or both) for the application and to quantify application benefits under realistic operating conditions

[9] An evaluation involving a certified-for-intended-function system built per MOPS, for which use of the system has been granted Operational Approval by the FAA, and where the approved system is used in daily NAS operations for a period of 6-12 months.

NAS-Enabled — Builds on Requirements Validation by implementing required support for the application in all FAA Systems needed to allow daily use at one or more key sites in the NAS. Such "daily use" involves certified, technical standard order (TSO)-authorized avionics and granted Operational Approval by AVS per pertinent 20-series and 90-series advisory circulars, and that the required ATC automation has been declared operationally suitable. For some applications, the Requirements Validation and NAS-Enabled maturity levels may need to be simultaneously met.

NAS Implementation — Builds on NAS-Enabled by implementing required support for the application in all appropriate FAA Systems to allow daily use at all applicable NAS locations. In most cases, this is the "rollout across the NAS" after satisfactory completion of the NAS-Enabled level.

APPENDIX D—FAA MODERNIZATION AND REFORM ACT OF 2012 (PUBLIC LAW. 112–95), SECTION 211

(a) REVIEW BY DOT INSPECTOR GENERAL.—

(1) IN GENERAL.—The Inspector General of the Department of Transportation shall conduct a review concerning the Federal Aviation Administration's award and oversight of any contracts entered into by the Administration to provide ADS–B services for the national airspace system.

(2) CONTENTS.—The review shall include, at a minimum—

(A)) an examination of how the Administration manages program risks;

(B)) an assessment of expected benefits attributable to the deployment of ADS–B services, including the Administration's plans for implementation of advanced operational procedures and air-to-air applications, as well as the extent to which ground radar will be retained;

(C)) an assessment of the Administration's analysis of specific operational benefits, and benefit/costs analyses of planned operational benefits conducted by the Administration, for ADS–B In and ADS–B Out avionics equipage for airspace users;

(D)) a determination of whether the Administration has established sufficient mechanisms to ensure that all design, acquisition, operation, and maintenance requirements have been met by the contractor;

(E)) an assessment of whether the Administration and any contractors are meeting cost, schedule, and performance milestones, as measured against the original baseline of the Administration's program for providing ADS–B services;

(F)) an assessment of how security issues are being addressed in the overall design and implementation of the ADS–B system;

(G)) identification of any potential operational or workforce changes resulting from deployment of ADS–B; and

(H)) any other matters or aspects relating to contract implementation and oversight that the Inspector General determines merit attention.

(3) REPORTS TO CONGRESS.—The Inspector General shall submit, periodically (and on at least an annual basis), to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report on the results of the review conducted under this subsection.

(b) RULEMAKING.—

(1) ADS–B IN.—Not later than 1 year after the date of enactment of this Act, the Administrator of the Federal Aviation Administration shall initiate a rulemaking proceeding to issue guidelines and regulations relating to ADS–B In technology that—

(A)) identify the ADS–B In technology that will be required under NextGen;

(B)) subject to paragraph (2), require all aircraft operating in capacity constrained airspace, at capacity constrained airports, or in any other airspace deemed appropriate by the Administrator to be equipped with ADS–B In technology by 2020; and

(C)) identify—

(i) the type of avionics required of aircraft for all classes of airspace;

(ii) expected costs associated with the avionics; and

(iii) the expected uses and benefits of the avionics.

(2) READINESS VERIFICATION.—Before the Administrator completes an ADS–B In equipage rulemaking proceeding or issues an interim or final rule pursuant to paragraph (1), the Chief NextGen Officer shall verify that—

(A)) the necessary ground infrastructure is installed and functioning properly;

(B)) certification standards have been approved; and

(C)) appropriate operational platforms interface safely and efficiently.

(c) USE OF ADS–B TECHNOLOGY.—

(1) PLANS.—Not later than 18 months after the date of enactment of this Act, the Administrator shall develop, in consultation with appropriate employee and industry groups, a plan for the use of ADS–B technology for surveillance and active air traffic control.

(2) CONTENTS.—The plan shall—

(A)) include provisions to test the use of ADS–B technology for surveillance and active air traffic control in specific regions of the United States with the most congested airspace;

(B)) identify the equipment required at air traffic control facilities and the training required for air traffic controllers;

(C)) identify procedures, to be developed in consultation with appropriate employee and industry groups, to conduct air traffic management in mixed equipage environments; and

(D)) establish a policy in test regions referred to in subparagraph (A), in consultation with appropriate employee and industry groups, to provide incentives for equipage with ADS–B technology, including giving priority to aircraft equipped with such technology before the 2020 equipage deadline.

APPENDIX E—ARC CHARTER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Aviation Rulemaking Committee Charter

Effective Date: 6/30/10
Extended: 5/30/12

SUBJECT: Automatic Dependent Surveillance Broadcast (ADS-B) In Aviation Rulemaking Committee

1. **PURPOSE.** This charter extends the Aviation Rulemaking Committee (ARC) for the Automatic Dependent Surveillance – Broadcast In (ADS-B In) according to the Administrator's authority under Title 49 of the United States Code (49 U.S.C.) 106(p)(5). This charter also outlines the committee's organization, responsibilities, and tasks.

2. **BACKGROUND.** An Automatic Dependent Surveillance – Broadcast (ADS-B) Aviation Rulemaking Committee (ARC) was chartered from July 2007 to July 2009. The ADS-B ARC provided a forum for the U.S. aviation community to discuss and review an NPRM for ADS-B Out, formulate recommendations on structuring the proposed ADS-B mandate, and consider additional actions that may be necessary to implement those recommendations.

   As a part of the ARC's final report, the ARC made 36 summary recommendations to the FAA regarding the ADS-B link strategy, business case, required equipment, security, and privacy. The ARC divided their recommendations into two broad categories; those to be resolved before the rule is enacted, and those for future action.

   One recommendation for future action was number 27 which stated: "The NPRM is focused on ADS-B Out and attempts to establish the requirements of ADS-B Out equipment so that it is compatible with ADS-B In. The FAA, in partnership with industry, should define a strategy for ADS-B In by 2012 ensuring the strategy is compatible with ADS-B Out avionics. The FAA also should ensure this program defines how to proceed with ADS-B In beyond the voluntary equipage concept included in the NPRM."

   Subsequent to the completion of its assigned tasks, the FAA considered whether the original ARC's charter should be modified and expanded to include ADS-B In functionality. The FAA concluded that the original ADS-B ARC should sunset, and a new ADS-B In ARC should be established.

   Public Law 112-095, "FAA Modernization and Reform Act of 2012," section 211 (b) directs the FAA to initiate a rulemaking within a year with guidelines and regulations for ADS–B In technology and requires ADS-B In to be mandated by 2020 for congested airspace, congested airports, or in any other airspace deemed appropriate. The FAA is therefore amending the ADS-B In ARC's charter to facilitate the agency's actions required by the statute.

3. **OBJECTIVES AND TASKS OF THE ARC.** The ADS-B In ARC will provide a forum for the U.S. aviation community to define a strategy for incorporating ADS-B In technologies into the National Airspace System. This ARC's recommendations should provide a clear definition on how the community should proceed with ADS-B In, while ensuring compatibility with the ADS-

Initiated By:AJM-232

B Out avionics standards defined in Title 14 of the Code of Federal Regulations § 91.225 and 91.227.

a. On September 30, 2011, the ARC submitted its recommendations to the Administrator through both the Chief Operating Officer (COO) for Air Traffic Organization (ATO) and the Associate Administrator for Aviation Safety.
b. By October 31, 2012, the ARC will submit additional recommendations on how to frame an ADS-B In equipage mandate such that the benefits exceed costs before 2035. The ARC shall identify: (a) in what airspace, and/or (b) at what airports, and/or (c) by what other criteria the FAA could apply to frame an ADS-B In mandate (examples including, but not limited to, by operator class or aircraft class). In addition, the ARC is requested to provide feedback on a 2020 compliance date for a potential ADS-B In mandate. The ARC will submit these additional recommendations to the Administrator through the Chief NextGen Officer, the COO for ATO, and the Associate Administrator for Aviation Safety.
c. By November 30, 2012, the ARC shall complete all follow on work related to the original submission and prepare a summary report detailing recommended next steps.

4. ARC PROCEDURES.

a. The ARC advises and provides written recommendations to the Administrator through the Chief NextGen Officer, the COO for ATO and the Associate Administrator for Aviation Safety and acts solely in an advisory capacity. Once the ARC recommendations are delivered, it is within the discretion of the Administrator, Chief NextGen Officer, COO for ATO, and the Associate Administrator for Aviation Safety to determine when and how the report of the ARC is released to the public.
b. The ARC may propose additional tasks as necessary to the Administrator through the Chief NextGen Officer, the COO for ATO, and the Associate Administrator for Aviation Safety for approval.
c. The ARC will submit a report detailing recommendations by October 31, 2012, on how to frame an ADS-B In equipage mandate such that the benefits exceed costs before 2035. The co-chairs of the ARC will send the recommendation report to the Administrator through the Chief NextGen Officer, the COO for ATO; the Associate Administrator for Aviation Safety; and the Director of the Office of Rulemaking.
d. The ARC may reconvene following the submission of its recommendations for the purposes of providing advice and assistance to the FAA, at the discretion of the Administrator provided the charter is still in effect.
e. The committee will discuss and present information, guidance, and recommendations that the members of the committee consider relevant to disposing of issues.
f. The Administrator through the Chief NextGen Officer, the COO for ATO, and the Associate Administrator for Aviation Safety may jointly issue additional tasking, including deliverable dates.

5. ARC ORGANIZATION, MEMBERSHIP, AND ADMINISTRATION. The FAA will set up a committee of members of the aviation community. Members will be selected based on their familiarity with ADS-B In, analysis, and regulatory compliance. Membership will be balanced in viewpoints, interests, and knowledge of the committee's objectives and scope. ARC membership is limited to promote discussion. Active participation and commitment by members will be essential for achieving the ARC. Attendance is essential for continued membership on the committee. When necessary, the ARC may set up specialized work groups that include at least one ARC member and invited subject matter experts from industry and government.

This ARC will consist of members from approximately 25 representatives from various Aviation User Groups and segments of Industry and Government.

The Administrator is the sponsor of the ARC and will select an industry chair(s) from the membership of the ARC and the FAA designated Federal official for the ARC. The FAA participation and support will come from all affected lines-of-business.

a. The ARC sponsor is the Administrator who:
   1. Appoints members or organizations to the ARC, at the manager's sole discretion;
   2. Receives all ARC recommendations and reports;
   3. Selects industry and FAA members; and
   4. Provides administrative support for the ARC, through the ATO Program Management Organization

b. The industry chair(s) will:
   1. Coordinate required committee and subcommittee (if any) meetings in order to meet the ARC's objectives and timelines;
   2. Provide notification to all ARC members of the time and place for each meeting;
   3. Ensure meeting agendas are established and provided to the committee members in a timely manner;
   4. Keep meeting minutes;
   5. Perform other responsibilities as required to ensure the ARC's objectives are met; and
   6. Provide status updates in writing to the Administrator through the Chief NextGen Officer, the COO for ATO, and the Associate Administrator for Aviation Safety at 6 months and 12 months from the effective date of this charter.

6. **COST AND COMPENSATION.** The estimated cost to the Federal Government to extend the ADS-B In ARC is approximately $25,000 through November 2012. All travel costs for government employees will be the responsibility of the government employee's organization. Non-government representatives, including the industry co-chair, serve without government compensation and bear all costs related to their participation on the committee.

7. **PUBLIC PARTICIPATION.** ARC meetings are not open to the public. Persons or organizations outside the ARC who wish to attend a meeting must get approval in advance of the meeting from a committee co-chairperson or designated federal official.

8. **AVAILABILITY OF RECORDS.** Consistent with the Freedom of Information Act, Title 5, U.S.C., section 522, records, reports, agendas, working papers, and other documents that are made available to or prepared for or by the committee will be available for public inspection and copying at the FAA Surveillance and Broadcast Services Program Office (AJM-232), 600 Independence Avenue, SW., Washington, DC 20591. Fees will be charged for information

furnished to the public according to the fee schedule published in Title 49 of the Code of Federal Regulations, Part 7.

You can find this charter on the FAA Web Site at:
http://www.faa.gov/about/committees/rulemaking/.

9. **DISTRIBUTION.** This charter is distributed to director-level management in the Office of the Associate Administrator for Aviation Safety, the Office of Aviation Policy and Plans, and the Office of Rulemaking.

10. **EFFECTIVE DATE AND DURATION.** This committee was chartered on June 30, 2010. The committee will remain in existence until November 30, 2012, per the above tasking, unless sooner suspended, terminated or extended by the Administrator.

The effective date of this charter is May 30, 2012.

Michael P. Huerta
Acting Administrator

APPENDIX F—A4A RECOMMENDATION TO THE ARC

Airlines for America (A4A) recommends the Federal Aviation Administration (FAA) pursue development and operational demonstration of the following Automatic Dependent Surveillance–Broadcast (ADS–B) In applications. Predictable and repeatable capacity and efficiency benefits must be demonstrated in actual air carrier line operations before A4A can consider whether ADS–B In is a technology ready for National Airspace System (NAS)-wide Next Generation Air Transportation System (NextGen) implementation.

ARC recommended applications

All dates with question marks are current best estimates of FAA based on projected FAA budgets – they do not represent FAA commitments since they are not baselined

Current SBS Baseline

Proposed Baseline

[illegible]

	Requirements Definition	Requirements Validation	NAS Enabled	NAS Implementation
CDTI-Assisted Visual Separation (CAVS)			FY14	FY17
Flight-deck-based Interval Management-Spacing (FIM-S) supported by ATC Automation		FY18?	FY18?	FY20?
Traffic Situation Awareness with Alerts (TSAA)	FY13	FY14	FY14	FY14
Oceanic In-Trail Procedures (ITP)			FY15-16	FY17
CDTI-Assisted Pilot Procedure (CAPP) *[[redefined variant of CEDS]]*	FY14	FY18?	FY18?	FY20?
Ground-based Interval Management-Spacing (GIM-S) with Wake Mitigation	No current plan [illegible]			
Flight-deck-based Interval Management-Defined Interval (FIM-DI) and FIM-DI for Closely Spaced Parallel Runway Operations (CSPO) supported by ATC Automation (TSS)	[illegible]			
Interval Management Defined Interval – Oceanic (IMDIO) *[[likely to be renamed]]*	[illegible]			
Airport Traffic Situation Awareness with Indications and Alerts (SURF-IA)				
- Accuracy Enhancements via Ground Solution		No current plan		
- Accuracy Enhancement via Avionics Solution	No current plan			

Table F–1—FAA's New Baseline Following May 2012 Joint Resource Council[10]

The following items need to be completed before considering any rulemaking:

1. Completion of any necessary policy adjustments to enable operational implementation and completion of certification guidance, operational approval guidance, and ground automation for a sufficient number of the applications listed above to produce a positive business case.

[10] ADS–B In ARC: 2012 JRC Debrief, June 27, 2012, slide No. 7, FAA Surveillance and Broadcast Services

2. FAA completion of flight test and operational evaluation of mature FIM–S minimum operational performance standards. The demonstration of NAS operational benefit for FIM–S, CAVS, and/or CAPP to, per previous point, achieve a positive business case.
3. Use demonstrated benefits to prioritize capacity-constrained airspace and/or airports and define expected benefits.
4. Determine cost of equipage (forward fit and retrofit).

Operators are more inclined to—

- Install forward-fit equipment that can be included in the purchase price and suffice for the lifespan of the aircraft.
- Equip aircraft that provide a return on investment within a reasonable period (for example, 2 years).

APPENDIX G—IATA LETTER

IATA

October 17, 2012

Mr. Steve Brown
Senior Vice President, Operations
National Business Aircraft Association
1200 18th Street NW, Suite 400
Washington, D.C. 20036

Subject: Recommendation for ARC Position on ADS-B IN Mandate

Dear Steve,

The International Air Transport Association (IATA) and its members strongly support NextGen and its focus on modernizing the current air traffic management system. We believe that the successful implementation of NextGen is critical to the global competitiveness and viability of commercial aviation.

It is in this regard that I write. We fully appreciate that any large undertaking like NextGen can be complicated, especially when it calls for enormous financial investment by industry. In particular, we consider that the applications supported by ADS-B IN show promise, but also believe that additional analysis and development is necessary before investment decisions can be justified. We ask that the ARC work with the FAA to ensure that specific activities take place as part of this continued evaluation, to include:

- Establishing ADS-B technical specifications and standards
- Certification of avionics equipment
- Establishing requirements for operational approvals
- Approval of policy changes to enable operational implementation, such as approval of new separation
- Assurance that ERAM and other ground infrastructure and automation tools are capable of providing benefits from ADS-B In technology
- Flights tests and demonstration projects that will support business case development.

I would underscore again our commitment to work with the FAA and other stakeholders to make NextGen a reality but until the costs and benefits of ADS-B IN are made clear we continue to oppose any mandate to equip.

International Air Transport Association
800 Place Victoria, P.O. Box 113
Montreal, QC Canada H4Z 1M1
Tel: +1 514 874 0202
Fax: +1 514 874 9632

www.iata.org

Thank you for your attention to this issue. I am available to discuss at your convenience.

Sincerely,

Ken Dunlap

Cc: Sharon Pinkerton, A4A

International Air Transport Association
800 Place Victoria, P.O. Box 113
Montreal, QC Canada H4Z 1M1
Tel: +1 514 874 0202
Fax: +1 514 874 9632

www.iata.org

APPENDIX H—OTHER CIVIL USER PERSPECTIVES

Small General Aviation Airplanes

The Aircraft Owners and Pilots Association does not support a proposed equipage rule for Automatic Dependent Surveillance–Broadcast (ADS–B) In for the general aviation (GA) community primarily based on the fact that the deployment of ADS–B should be a benefits-driven equipage where clear, concise benefits provide the incentive for operators to equip voluntarily. In addition, considering the gains ADS–B In could provide in capacity and efficiency, such as at the Core 30 airports, activity data shows GA is not typically a major player and could be accommodated without an equipage mandate based on the low volume of GA operations compared to other operations.

There are approximately 230,000 active GA aircraft of hundreds of different makes and models currently registered by the Federal Aviation Administration (FAA). According to analysis of FAA's Air Traffic Activity Data System data, GA operations at the top 30 airports account for approximately 7 percent of operations.

It is the view of the community that using a best equipped-best served model/scenario, there could possibly be a proposed equipage rule for ADS–B In for some operators at some airports (that is, the core 10 or 30 airports based on further analysis) while allowing for accommodation for those that are not equipped. This could include the accommodation of aircraft based on factors such as time of day and runway availability. In other words, the mandate could include perimeters around access for those not equipped, but access would still be an option.

Larger General Aviation Airplanes

The sense of the operators of larger GA airplanes (such as 14 CFR part 91, subparts F and K) is that the business aviation community would support a narrow proposed equipage rule for ADS–B In in the future. In general, sharing the concerns of the airline community, it would be essential that the same criteria (that is, maturity and schedule for rulemaking) occur for the business aviation community as for the airlines. Additionally, it is the view of the National Business Aviation Association (NBAA) that ADS–B In equipage should only be mandated for the top 10-12 high density capacity-constrained Class B terminal airspace, for instrument flight rule operations, and, as applicable, for oceanic airspace. The NBAA community also believes that only an increase of more than 20 percent in airport and airspace throughput could help justify the investment.

Helicopter Operations

Helicopter Association International (HAI) believes a broad proposed equipage rule for ADS–B In equipage is not warranted for the helicopter community. The vast majority of helicopter operations are conducted off-airport. When helicopters use airports, they do not significantly impact capacity because of the potential for Simultaneous Non-Interfering Operations. If a proposed equipage rule for ADS–B In is applied at the most congested airports, alternative procedures should be provided to allow helicopter access to that airspace. It is further noted that at congested airports the typical helicopter operations occur primarily under visual flight rules conditions and bypass approach paths.

On the other hand, HAI believes that based on the Gulf of Mexico model and experience with operations that leverage ADS–B Out capability, voluntary equipage with ADS–B In could provide tremendous potential benefits for helicopter operations in areas, like the Gulf, with significant air traffic but without current radar coverage, such as remote areas frequented by air tour operators, areas near hospitals using helicopter emergency medical services, or at low altitudes in congested airspace of the largest metropolitan areas such as New York and Los Angeles.

If the ADS-B infrastructure is expanded sufficiently in areas such as this, the potential for enhanced safety and increased operational efficiency benefits, particularly in instrument meteorological conditions, would create significant incentives for voluntary helicopter ADS–B In equipage.

APPENDIX I—ATADS TRAFFIC ANALYSIS

General Aviation (GA) and Military Flights at the Top 20 Busiest U.S. Airports

Calendar Years 2002-2012

Tower Operations

Data Provided by the FAA's Air Traffic Activity Data System (ATADS), https://aspm.faa.gov/opsnet/sys/Main.asp
Period of Report: January 1, 2002, to August 31, 2012
Created by: DOD NextGen Lead Service Office (LSO) (HQ AF/A3O-BAX), October 10, 2012

Calendar Year	Total Tower Operations	Total Military	% Military
CY02	10,912,560	73859	0.68%
CY03	10,764,443	62371	0.58%
CY04	11,441,528	35875	0.31%
CY05	11,596,804	30633	0.26%
CY06	11,296,526	31300	0.28%
CY07	11,259,563	32682	0.29%
CY08	10,889,730	33679	0.31%
CY09	10,325,025	33134	0.32%
CY10	10,466,735	35940	0.34%
CY11	10,545,463	35,262	0.33%
CY12	7,067,613	22199	0.31%

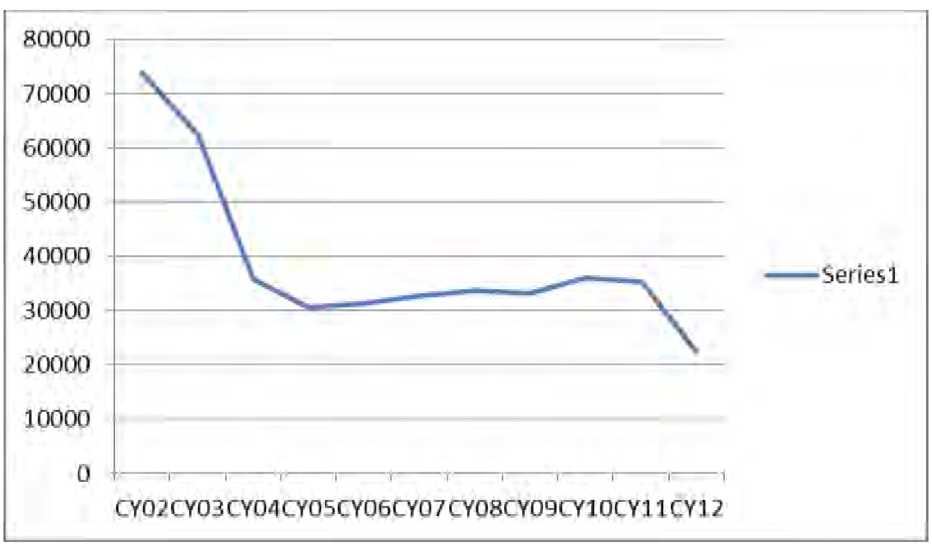


Figure I–1—Total Military Flights Over the Calendar Years 2002-2012

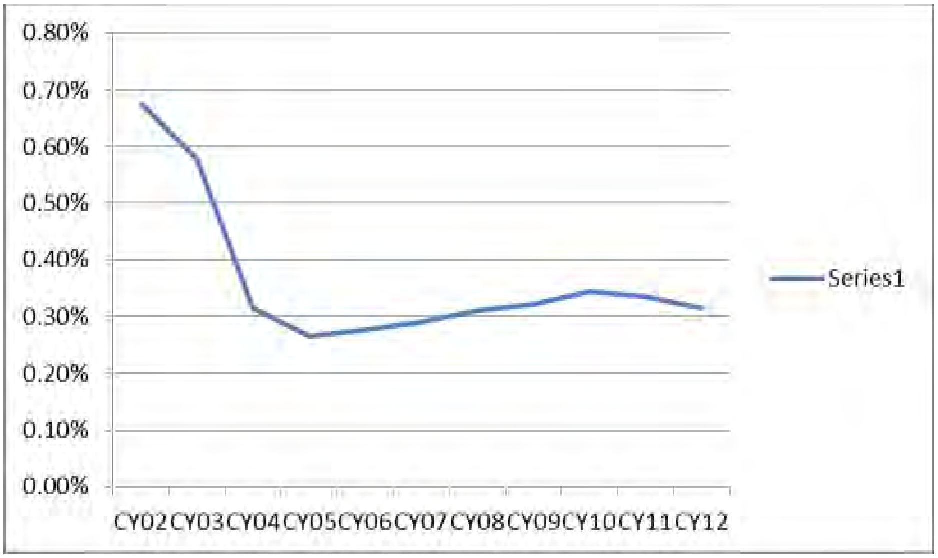


Figure I–2—Percentage of Military Flights Over the Calendar Years 2002-2012

Rank	Facility	IFR Itinerant							IFR Overflight							VFR Itinerant							VFR Overflight							Local				Tower Operations
		Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military	Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military	Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military	Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military	Civil	Military	Total	% Military	
1	ATL	497,917	125,585	3,566	115	627,183	0.57%	0.02%	194	42	16	1	253	6.32%	0.40%	0	344	1,572	173	2,089	75.25%	8.28%	0	274	390	61	725	53.79%	8.41%	0	0	0		630,250
2	JFK	237,217	33,622	2,399	176	273,414	0.88%	0.06%	298	43	131	11	483	27.12%	2.28%	3	373	3,090	92	3,558	86.85%	2.59%	0	249	11,489	264	12,002	95.73%	2.20%	0	0	0		289,457
3	LAS	232,310	21,297	23,838	668	278,113	8.57%	0.24%	102	319	1,335	199	1,955	68.29%	10.18%	8	71,127	5,976	356	77,467	7.71%	0.46%	0	4,419	5,992	104	10,515	56.99%	0.99%	0	0	0		368,050
4	PHL	168,163	121,663	7,693	113	297,632	2.58%	0.04%	177	296	59	9	541	10.91%	1.66%	1	276	1,816	165	2,258	80.43%	7.31%	0	1,936	1,455	448	3,839	37.90%	11.67%	0	0	0		304,270
5	LGA	180,008	68,231	2,617	157	251,013	1.04%	0.06%	166	84	256	25	531	48.21%	4.71%	0	95	1,775	55	1,925	92.21%	2.86%	0	629	48,097	446	49,172	97.81%	0.91%	0	0	0		302,641
6	SFO	213,459	59,462	7,347	376	280,644	2.62%	0.13%	1,381	357	90	7	1,835	4.90%	0.38%	10	569	1,481	1,864	3,924	37.74%	47.50%	0	79	4,385	293	4,757	92.18%	6.16%	0	0	0		291,160
7	LAX	324,140	71,718	11,169	425	407,452	2.74%	0.10%	987	278	811	39	2,115	38.35%	1.84%	296	23	1,163	1,358	2,840	40.95%	47.82%	7	134	40,544	1,136	41,821	96.95%	2.72%	0	0	0		454,228
8	EWR	194,624	84,885	3,137	69	282,715	1.11%	0.02%	156	368	726	29	1,279	56.76%	2.27%	6	176	3,456	235	3,873	89.23%	6.07%	3	648	57,163	428	58,242	98.15%	0.73%	0	0	0		346,109
9	CLT	233,053	122,790	11,862	995	368,700	3.22%	0.27%	170	82	88	4	344	25.58%	1.16%	1	256	3,753	130	4,140	90.65%	3.14%	0	599	2,172	21	2,792	77.79%	0.75%	0	0	0		375,976
10	IAD	117,114	83,136	26,881	413	227,544	11.81%	0.18%	112	134	300	36	582	51.55%	6.19%	77	17	1,425	87	1,606	88.73%	5.42%	0	36	4,522	633	5,191	87.11%	12.19%	0	0	0		234,923
11	IAH	193,185	146,830	7,167	45	347,227	2.06%	0.01%	490	401	247	19	1,157	21.35%	1.64%	167	363	939	112	1,581	59.39%	7.08%	1	1,128	2,421	297	3,847	62.93%	7.72%	0	0	0		353,812
12	BWI	144,116	27,590	8,546	496	180,748	4.73%	0.27%	165	45	287	12	509	56.39%	2.36%	16	73	1,699	156	1,944	87.40%	8.02%	0	14	9,278	312	9,604	96.61%	3.25%	194	0	194	0.00%	192,999
13	SEA	196,994	9,744	955	30	207,723	0.46%	0.01%	1,041	2,022	2,551	98	5,712	44.66%	1.72%	9	51	1,514	78	1,652	91.65%	4.72%	6	137	1,677	99	1,919	87.39%	5.16%	0	0	0		217,006
14	MDW	124,402	16,601	18,512	331	159,846	11.58%	0.21%	191	30	35	33	289	12.11%	11.42%	18	710	5,490	1,059	7,277	75.44%	14.55%	0	381	1,547	183	2,111	73.28%	8.67%	20	6	26	23.08%	169,549
15	PHX	239,987	44,653	9,046	1,356	295,042	3.07%	0.46%	637	91	43	20	791	5.44%	2.53%	17	5,853	5,440	503	11,813	46.05%	4.26%	8	9,327	7,812	1,652	18,799	41.56%	8.79%	138	6	144	4.17%	326,589
16	ORD	344,746	240,212	4,911	138	590,007	0.83%	0.02%	762	642	173	10	1,587	10.90%	0.63%	8	229	278	42	557	49.91%	7.54%	0	110	304	19	433	70.21%	4.39%	0	0	0		592,584
17	DTW	143,717	142,084	3,656	108	289,565	1.26%	0.04%	180	272	111	2	565	19.65%	0.35%	4	155	532	20	711	74.82%	2.81%	0	63	765	21	849	90.11%	2.47%	0	0	0		291,690
18	MSP	189,537	88,802	7,717	1,482	287,538	2.68%	0.52%	136	417	1,264	20	1,837	68.81%	1.09%	3	40	505	52	600	84.17%	8.67%	0	2,017	685	17	2,719	25.19%	0.63%	0	0	0		292,694
19	FLL	130,786	20,983	16,650	253	168,672	9.87%	0.15%	93	72	121	124	410	29.51%	30.24%	95	4,595	7,763	55	12,508	62.06%	0.44%	2	413	9,573	407	10,395	92.09%	3.92%	0	0	0		191,985
20	BOS	178,483	40,206	8,053	139	226,881	3.55%	0.06%	155	282	567	32	1,036	54.73%	3.09%	2	15,713	2,157	318	18,190	11.86%	1.75%	1	341	3,988	226	4,556	87.53%	4.96%	0	0	0		250,663
21	DEN	293,690	120,262	2,086	57	416,095	0.50%	0.01%	264	766	1,138	55	2,223	51.19%	2.47%	164	225	514	61	964	53.32%	6.33%	0	101	361	33	495	72.93%	6.67%	0	0	0		419,777
22	SAN	101,537	17,248	5,773	336	124,894	4.62%	0.27%	264	87	99	80	530	18.68%	15.09%	188	108	870	110	1,276	68.18%	8.62%	2	449	9,922	10,088	20,461	48.49%	49.30%	9	0	9	0.00%	147,170
23	MCO	193,086	8,307	9,179	301	210,873	4.35%	0.14%	1,540	147	147	5	1,839	7.99%	0.27%	16	259	2,055	63	2,393	85.88%	2.63%	2	116	358	25	501	71.46%	4.99%	0	0	0		215,606
24	DFW	294,793	134,338	3,107	95	432,333	0.72%	0.02%	1,069	371	503	18	1,961	25.65%	0.92%	9	449	733	42	1,233	59.45%	3.41%	0	868	1,722	140	2,730	63.08%	5.13%	0	0	0		438,257
25	DCA	126,965	61,205	2,435	396	191,001	1.27%	0.21%	218	110	550	256	1,134	48.50%	22.57%	7	3	1,855	819	2,684	69.11%	30.51%	0	50	22,529	11,605	34,184	65.91%	33.95%	0	0	0		229,003
26	TPA	98,994	12,784	9,924	457	122,159	8.12%	0.37%	65	31	117	39	252	46.43%	15.48%	0	561	5,491	74	6,126	89.63%	1.21%	0	1,816	2,569	307	4,692	54.75%	6.54%	338	0	338	0.00%	133,567
27	MEM	116,397	55,930	10,771	891	183,989	5.85%	0.48%	145	80	210	12	447	46.98%	2.68%	0	550	1,710	140	2,400	71.25%	5.83%	2	399	2,425	129	2,955	82.06%	4.37%	0	0	0		189,791
28	SLC	118,572	58,908	12,592	1,309	191,381	6.58%	0.68%	126	98	161	19	404	39.85%	4.70%	97	4,298	23,970	197	28,562	83.92%	0.69%	6	2,524	4,975	488	7,993	62.24%	6.11%	1,749	9	1,758	0.51%	230,098
29	PDX	99,645	21,405	7,319	2,839	131,208	5.58%	2.16%	200	135	735	41	1,111	66.16%	3.69%	5	5,803	7,309	185	13,302	54.95%	1.39%	2	407	18,651	100	19,160	97.34%	0.52%	2,120	0	2,120	0.00%	166,901
30	CLE	36,222	79,849	5,318	127	121,516	4.38%	0.10%	52	799	525	18	1,394	37.66%	1.29%	0	172	388	22	582	66.67%	3.78%	0	2,208	1,327	61	3,596	36.90%	1.70%	0	0	0		127,088
		IFR Itinerant Total		254,226	14693	8,173,108	3.11%	0.18%	IFR Overflight Total		13396	1273	35106	38.16%	3.63%	VFR Itinerant Total		96,719	8623	220,035	43.96%	3.92%	VFR Overflight Total		279098	30043	341055	81.83%	8.81%	Local Total	21	4589	0.46%	8,773,893

General Aviation (GA) and Military Flights at the Top 30 "Benefit" Airports - Calendar Year 2012
Tower Operations

Data Provided by the FAA's Air Traffic Activity Data System (ATADS)
https://aspm.faa.gov/opsnet/sys/Main.asp

Period of Report: 1/1/2012 - 8/31/2012

Created by: DoD NextGen Lead Service Office (LSO) (HQ AF/A3O-BAX), October 10, 2012

Data Summaries

		% General Aviation
Total Tower Operations	8,773,893	7.33%
Total General Aviation Flights	643,439	
		% Military
Total Tower Operations	8,773,893	0.62%
Total Military Flights	54653	

IFR Itinerant

Rank	Facility	Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military
1	ATL	497,917	125,585	3,566	115	627,183	0.57%	0.02%
2	ORD	344,746	240,212	4,911	138	590,007	0.83%	0.02%
3	LAX	324,140	71,718	11,169	425	407,452	2.74%	0.10%
4	DFW	294,793	134,338	3,107	95	432,333	0.72%	0.02%
5	DEN	293,690	120,262	2,086	57	416,095	0.50%	0.01%
6	CLT	233,053	122,790	11,862	995	368,700	3.22%	0.27%
7	LAS	232,310	21,297	23,838	668	278,113	8.57%	0.24%
8	IAH	193,185	146,830	7,167	45	347,227	2.06%	0.01%
9	EWR	194,624	84,885	3,137	69	282,715	1.11%	0.02%
10	PHX	239,987	44,653	9,046	1,356	295,042	3.07%	0.46%
11	PHL	168,163	121,663	7,693	113	297,632	2.58%	0.04%
12	LGA	180,008	68,231	2,617	157	251,013	1.04%	0.06%
13	MSP	189,537	88,802	7,717	1,482	287,538	2.68%	0.52%
14	DTW	143,717	142,084	3,656	108	289,565	1.26%	0.04%
15	SFO	213,459	59,462	7,347	376	280,644	2.62%	0.13%
16	JFK	237,217	33,622	2,399	176	273,414	0.88%	0.06%
17	MIA	213,643	37,136	9,982	587	261,348	3.82%	0.22%
18	BOS	178,483	40,206	8,053	139	226,881	3.55%	0.06%
19	IAD	117,114	83,136	26,881	413	227,544	11.81%	0.18%
20	SLC	118,572	58,908	12,592	1,309	191,381	6.58%	0.68%
		IFR Itinerant Total		168,826	8823	6,631,827	2.55%	0.13%

IFR Overflight

Rank	Facility	Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military
1	ATL	194	42	16	1	253	6.32%	0.40%
2	ORD	762	642	173	10	1,587	10.90%	0.63%
3	LAX	987	278	811	39	2,115	38.35%	1.84%
4	DFW	1,069	371	503	18	1,961	25.65%	0.92%
5	DEN	264	766	1,138	55	2,223	51.19%	2.47%
6	CLT	170	82	88	4	344	25.58%	1.16%
7	LAS	102	319	1,335	199	1,955	68.29%	10.18%
8	IAH	490	401	247	19	1,157	21.35%	1.64%
9	EWR	156	368	726	29	1,279	56.76%	2.27%
10	PHX	637	91	43	20	791	5.44%	2.53%
11	PHL	177	296	59	9	541	10.91%	1.66%
12	LGA	166	84	256	25	531	48.21%	4.71%
13	MSP	136	417	1,264	20	1,837	68.81%	1.09%
14	DTW	180	272	111	2	565	19.65%	0.35%
15	SFO	1,381	357	90	7	1,835	4.90%	0.38%
16	JFK	298	43	131	11	483	27.12%	2.28%
17	MIA	702	326	441	46	1,515	29.11%	3.04%
18	BOS	155	282	567	32	1,036	54.73%	3.09%
19	IAD	112	134	300	36	582	51.55%	6.19%
20	SLC	126	98	161	19	404	39.85%	4.70%
		IFR Overflight Total		8460	601	22994	36.79%	2.61%

VFR Itinerant

Rank	Facility	Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military
1	ATL	0	344	1,572	173	2,089	75.25%	8.28%
2	ORD	8	229	278	42	557	49.91%	7.54%
3	LAX	296	23	1,163	1,358	2,840	40.95%	47.82%
4	DFW	9	449	733	42	1,233	59.45%	3.41%
5	DEN	164	225	514	61	964	53.32%	6.33%
6	CLT	1	256	3,753	130	4,140	90.65%	3.14%
7	LAS	8	71,127	5,976	356	77,467	7.71%	0.46%
8	IAH	167	363	939	112	1,581	59.39%	7.08%
9	EWR	6	176	3,456	235	3,873	89.23%	6.07%
10	PHX	17	5,853	5,440	503	11,813	46.05%	4.26%
11	PHL	1	276	1,816	165	2,258	80.43%	7.31%
12	LGA	0	95	1,775	55	1,925	92.21%	2.86%
13	MSP	3	40	505	52	600	84.17%	8.67%
14	DTW	4	155	532	20	711	74.82%	2.81%
15	SFO	10	569	1,481	1,864	3,924	37.74%	47.50%
16	JFK	3	373	3,090	92	3,558	86.85%	2.59%
17	MIA	1,057	440	2,553	71	4,121	61.95%	1.72%
18	BOS	2	15,713	2,157	318	18,190	11.86%	1.75%
19	IAD	77	17	1,425	87	1,606	88.73%	5.42%
20	SLC	97	4,298	23,970	197	28,562	83.92%	0.69%
		VFR Itinerant Total		63,128	5933	172,012	36.70%	3.45%

VFR Overflight

Rank	Facility	Air Carrier	Air Taxi	General Aviation	Military	Total	% General Aviation	% Military
1	ATL	0	274	390	61	725	53.79%	8.41%
2	ORD	0	110	304	19	433	70.21%	4.39%
3	LAX	7	134	40,544	1,136	41,821	96.95%	2.72%
4	DFW	0	868	1,722	140	2,730	63.08%	5.13%
5	DEN	0	101	361	33	495	72.93%	6.67%
6	CLT	0	599	2,172	21	2,792	77.79%	0.75%
7	LAS	0	4,419	5,992	104	10,515	56.99%	0.99%
8	IAH	1	1,128	2,421	297	3,847	62.93%	7.72%
9	EWR	3	648	57,163	428	58,242	98.15%	0.73%
10	PHX	8	9,327	7,812	1,652	18,799	41.56%	8.79%
11	PHL	0	1,936	1,455	448	3,839	37.90%	11.67%
12	LGA	0	629	48,097	446	49,172	97.81%	0.91%
13	MSP	0	2,017	685	17	2,719	25.19%	0.63%
14	DTW	0	63	765	21	849	90.11%	2.47%
15	SFO	0	79	4,385	293	4,757	92.18%	6.16%
16	JFK	0	249	11,489	264	12,002	95.73%	2.20%
17	MIA	19	882	6,400	100	7,401	86.47%	1.35%
18	BOS	1	341	3,988	226	4,556	87.53%	4.96%
19	IAD	0	36	4,522	633	5,191	87.11%	12.19%
20	SLC	6	2,524	4,975	488	7,993	62.24%	6.11%
		VFR Overflight Total		205642	6827	238878	86.09%	2.86%

Local

Rank	Facility	Civil	Military	Total	% Military	Facility	Tower Operations
1	ATL	0	0	0		ATL	630,250
2	ORD	0	0	0		ORD	592,584
3	LAX	0	0	0		LAX	454,228
4	DFW	0	0	0		DFW	438,257
5	DEN	0	0	0		DEN	419,777
6	CLT	0	0	0		CLT	375,976
7	LAS	0	0	0		LAS	368,050
8	IAH	0	0	0		IAH	353,812
9	EWR	0	0	0		EWR	346,109
10	PHX	138	6	144	4.17%	PHX	326,589
11	PHL	0	0	0		PHL	304,270
12	LGA	0	0	0		LGA	302,641
13	MSP	0	0	0		MSP	292,694
14	DTW	0	0	0		DTW	291,690
15	SFO	0	0	0		SFO	291,160
16	JFK	0	0	0		JFK	289,457
17	MIA	0	0	0		MIA	274,385
18	BOS	0	0	0		BOS	250,663
19	IAD	0	0	0		IAD	234,923
20	SLC	1,749	9	1,758	0.51%	SLC	230,098
		Local Total	15	1902	0.79%		7,067,613

General Aviation (GA) and Military Flights at the 20 Busiest Airports - Calendar Year 2012
Tower Operations

Data Provided by the FAA's Air Traffic Activity Data System (ATADS)
https://aspm.faa.gov/opsnet/sys/M in.asp

Period of Report: 1/1/2012 - 8/31/2012

Created by: DoD NextGen Lead Service Office (LSO) (HQ AF/A3O-BAX), October 10, 2012

Data Summary

		% General Aviation
Total Tower Operations	7,067,613	6.31%
Total General Aviation	446,056	
		% Military
Total Tower Operations	7,067,613	0.31%
Total Military	22199	

Per Facility Summary

Rank	Facility	Tower Operations Total (Facility)	General Aviation Total (Facility)	Military Total (Facility)	% General Aviation (Facility)	% Military (Facility)	Rank	Facility	Tower Operations Total (Facility)	General Aviation Total (Facility)	Military Total (Facility)	% General Aviation (Facility)	% Military (Facility)
1	ATL	630,250	5,544	350	0.88%	0.06%	11	PHL	304,270	11,023	735	3.62%	0.24%
2	ORD	592,584	5,666	209	0.96%	0.04%	12	LGA	302,641	52,745	683	17.43%	0.23%
3	LAX	454,228	53,687	2,958	11.82%	0.65%	13	MSP	292,694	10,171	1571	3.47%	0.54%
4	DFW	438,257	6,065	295	1.38%	0.07%	14	DTW	291,690	5,064	151	1.74%	0.05%
5	DEN	419,777	4,099	206	0.98%	0.05%	15	SFO	291,160	13,303	2540	4.57%	0.87%
6	CLT	375,976	17,875	1150	4.75%	0.31%	16	JFK	289,457	17,109	543	5.91%	0.19%
7	LAS	368,050	37,141	1327	10.09%	0.36%	17	MIA	274,385	19,376	804	7.06%	0.29%
8	IAH	353,812	10,774	473	3.05%	0.13%	18	BOS	250,663	14,765	715	5.89%	0.29%
9	EWR	346,109	64,482	761	18.63%	0.22%	19	IAD	234,923	33,128	1169	14.10%	0.50%
10	PHX	326,589	22,341	3537	6.84%	1.08%	20	SLC	230,098	41,698	2022	18.12%	0.88%

APPENDIX J—UPDATED COST-BENEFIT ANALYSIS

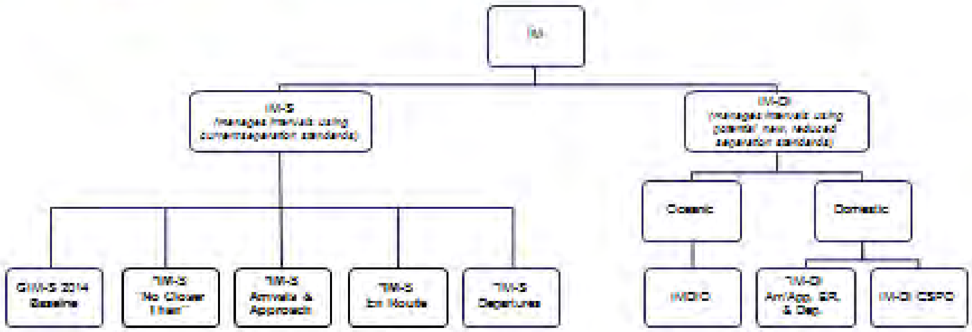
ADS-B In ARC Application Benefits October 2012 Results

October 3, 2012

Outline

- Applications
  - Hierarchy
  - Descriptions
- Data and Simulations
- Assumptions
- Results
- Equipage Dependence

IM Application Hierarchy



*Included in scope of FIM MOPS

IM Application Descriptions (1 of 2)

	Application	GIM Operational Overview	FIM Operational Overview	Organizational Interdependencies
Current Baseline	GIM-S 2014 Baseline	Extended metering, coupled scheduling, and speed advisories to en route ATC provide more consistent delivery of a/c into TRACON airspace	N/A	• Requires TBFM and ERAM to implement SBS requirements • Need to coordinate implementation of OPDs as follow through to achieve benefit
IM-S	IM-S "No Closer Than"	Provide support to FIM-S equipped a/c in arrival phase to manage a "no closer than" distance to preceding a/c, to give the controller a tool to achieve visual approach throughput to a runway when ceilings are too low to get visual approaches otherwise.	Upon receipt of ATC clearance, flight crew uses FIM avionics to manage a "no closer than" spacing from designated aircraft, until visual acquisition of the designated aircraft for a CAVS-based visual approach	• Requires Automation to implement SBS requirements
	IM-S Arrivals & Approach	Support to FIM-S equipped a/c in approach & arrival operations, including FIM-S pairs arriving from multiple corner posts, initiating FIM-S in Terminal, and support of FIM-S pairs when metering is not in effect. May also include support to FIM-S pairs during IM turn path stretching operations.	Upon receipt of ATC clearance, properly equipped a/c use avionics to maintain spacing from designated target a/c during approach & arrival operations	• Requires Automation to implement SBS requirements
	IM-S En Route	Add support to FIM-S equipped a/c during en route, with or without metering in effect, including support of FIM-S turn / path-stretching operations	Upon receipt of ATC clearance, properly equipped a/c use avionics to maintain spacing from designated target a/c during en route cruise operations, including MIT	• Requires Automation to implement SBS requirements • Would be aided by, but does not require, DataComm

IM Application Descriptions (2 of 2)

- Additional emerging applications beyond the scope of the 2013 JRC

	Application	GIM Operational Overview	FIM Operational Overview	Organizational Interdependencies
IMDI + IM-S Departures	IM-S Departures	Add support to FIM-S equipped a/c during departure operations	Upon receipt of ATC clearance, properly equipped a/c use avionics to maintain spacing from designated target a/c during departure operations	• Requires Terminal Sequencing & Spacing functionality
	IM-DI Arrivals & Approach, En Route, & Departures	Add support to FIM-DI equipped a/c during arrival & approach, en route, & departure operations to allow them to space more closely than current separation standards. Add ability to optimize the TBFM schedule based on FIM-DI equipage.	Upon receipt of ATC clearance, properly equipped a/c use avionics to maintain reduced spacing from designated target a/c	• Requires Terminal Sequencing & Spacing functionality
	IM-DIO	Add support to properly equipped a/c during oceanic operations	Upon receipt of ATC clearance, properly equipped a/c use avionics to maintain spacing from designated target a/c during oceanic operations	• Requires Automation to implement SBS requirements
	IM-DI CSPO	Add support to properly equipped a/c during CSPO operations	Upon receipt of ATC clearance, properly equipped a/c use avionics to maintain spacing from designated target a/c during CSPR operations	• Requires Terminal Sequencing & Spacing functionality • Requires ACAS-X

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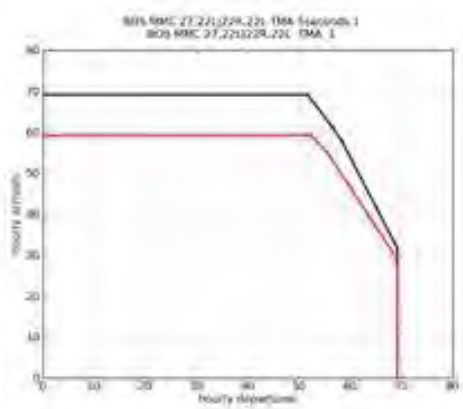
Data and Simulations



- Factors that impact throughput
  - Interarrival time (IAT) error
  - Meteorological Conditions
  - Closely Spaced Parallel Operations
- Capacity curves
  - New set of NextGen Baseline Pareto curves supplied by MITRE in May 2012
  - MITRE capacity group developed curves (VMC, MVMC, IMC) for IAT error at 5 sec, 8 sec, 10 sec for this effort (delivered in August 2012)
- Updates to NAS-wide model (SWAC)
  - NextGen System Wide Analysis Capability (SWAC) version 0.9.8
  - TFM/GDP module now operating so that more delay is pushed to ground
- Other planned programs that impact results
  - Time Based Flow Management (TBFM) -Terminal Sequencing and Spacing (TSS)
  - For this exercise we assumed TSS would be in place first since it will likely be in place before significant ADS-B In equipage

ADS-B In ARC Application Benefits October 2012 | Federal Aviation Administration | 6

Data and Simulations: NAS-wide model description

- **SWAC - System-Wide Analysis Capability**
  - Fast-time discrete-event simulation of entire NAS
  - Models all NAS flights and considers capacities for 110 airports
  - Models 12 representative days a year
  - Outputs include flight delays
  - Used by NextGen Systems Analysis Office for studies of multiple programs

- **Baseline and future airport throughput/capacities provided by MITRE capacity modeling group**
  - Throughputs include runway improvements and TBFM enhancements
  - Three major drivers of airport throughput we impact:
    - Delivery accuracy in terms of Standard Deviation of Inter-arrival Time
    - Impact of weather through extending use of Visual Approaches
    - Arrival rate at airports with Closely-spaced Parallel Runways

ADS-B In ARC Application Benefits October 2012 Federal Aviation Administration 7

Assumptions for IM simulations

1. **Baseline (GIM-S and CAVS)**
   IAT changes - Change IAT error from TMA baseline (16.5 sec) to 12 sec (this is already assumed in NextGen baseline curves) (not ADS-B In equipage dependent)
   Meteorological Condition Changes - Change to VMC capacity during MVMC down to 1000 ft ceiling but visibility needs to be in Visual range (ceiling in MVMC) all airports (ADS-B in equipage dependent)

2. **IM-S Arrivals and Approach (AA)**
   IAT changes
   a. IM-S without TBFM TSS – Change IAT error from 12 sec to 10 sec for all three weather conditions at TBFM airports only (FIM equipage dependent)
   b. TBFM TSS - Change IAT error from 12 sec to 10 sec for all three weather conditions at TBFM airports only (All aircraft)
   c. IM-S with TBFM TSS – Change IAT error from 10 sec to 8 sec for all three weather conditions at TBFM airports only (FIM equipage dependent)
   d. For this exercise we assumed TSS would be in place first since it will likely be in place before significant ADS-B In equipage
   Meteorological Condition Changes
   a. Change to VMC capacity during MVMC down to 1000 ft ceiling and 3 nmi visibility at TBFM airports

3. **IM-S No Closer Than (NCT)**– Change to VMC capacity during MVMC down to 1000 ft ceiling and 3 nmi visibility at non-TBFM airports

ADS-B In ARC Application Benefits October 2012 Federal Aviation Administration 8

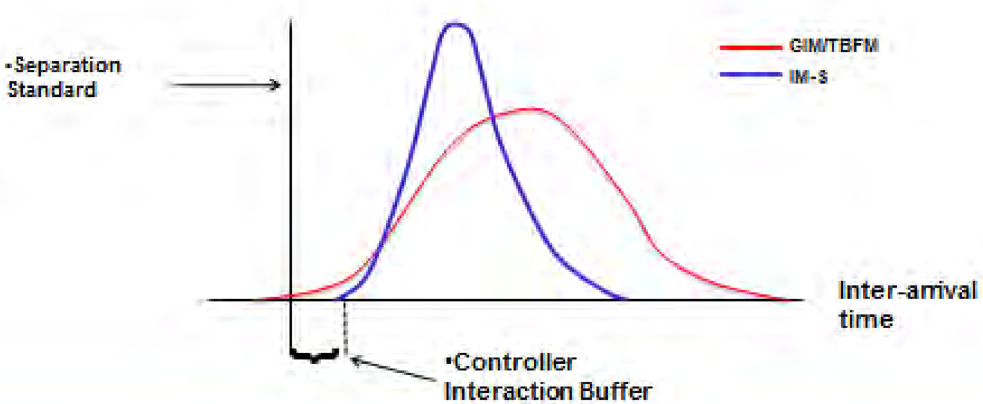
Assumptions for IM simulations (continued)

4. **IM-DI AA** – Change to MVMC capacity during IMC at TBFM airports (for non-CSPR arrivals)
5. **IM-DI CSPO** - Change to MVMC capacity during IMC at TBFM airports (for CSPR arrivals)
   a. ARC Phase 1 is for CSPR arrivals >2500 ft (and SOIA airports)
   b. ARC Phase 2 is for CSPR arrivals <2500 ft
6. **IM-DI with Wake** – Change to VMC capacity during MVMC and IMC at TBFM airports
7. **Reduction of IAT error to 5 sec** – No planned tool; just produced results for comparison

ADS-B In ARC Application Benefits October 2012 Federal Aviation Administration 9

Assumptions concerning increased spacing accuracy

- Increased spacing accuracy available through FIM results in increased delivery accuracy at runway leading to higher achievable arrival throughput



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Assumptions concerning MVMC with CAVS and IM-S

- Operational Differences
  - CAVS requires following aircraft to see lead aircraft on initiation (but can lose in a cloud layer on the way down); procedure also requires >1000 and 3 on final
  - IM-S AA/NCT can be initiated without seeing lead aircraft, but still requires >1000 and 3 on final
- Modeling difference
  - CAVS – Visibility needs to be in Visual range (ceiling in MVMC)
  - IM-S AA/NCT – Down to 1000 ft ceiling and 3 nmi visibility

Example: at BOS the VA cutoff is 2500ft and 3 mi

- ➢ Both CAVS and IM-S require >1000 and 3
- ➢ CAVS available when ceiling <2500 and vis>3
- ➢ IM-S available when ceiling <2500 and vis<3

Airport	Ceiling (ft)	Visibility (miles)	Airport	Ceiling (ft)	Visibility (miles)	Airport	Ceiling (ft)	Visibility (miles)
ABQ	3000	5	IAD	3000	7	PDX	3500	8
ANC	3000	5	IAH	4000	8	PHL	2300	4
ATL	3600	7	IND	2200	3	PHX	3300	7
AUS	3500	3	ISP	2500	5	PIT	1800	3
BDL	3000	7	JAX	2100	3	PSP	4000	3
BHM	2400	3	JFK	2000	4	PVD	2000	3
BNA	2600	3	LAS	5000	5	RDU	4000	5
BOS	2500	3	LAX	2500	3	RFD	1000	3
BUF	2300	3	LGA	3200	4	RSW	2100	3
BUR	3500	3	LGB	2100	3	SAN	2000	3
BWI	2500	5	MCI	2000	3	SAT	3000	5
CLE	2600	3	MCO	2500	3	SDF	3000	3
CLT	3600	5	MDW	1900	3	SEA	4000	3
CVG	2900	3	MEM	5000	5	SFO	3500	8
DAL	2400	3	MHT	2500	5	SJC	2500	5
DAY	2800	3	MIA	2000	5	SJU	2000	5
DCA	3000	4	MKE	2300	3	SLC	5300	3
DEN	2000	3	MSP	3500	8	SMF	2000	3
DFW	3500	5	MSY	2000	5	SNA	3000	5
DTW	3000	5	OAK	2500	8	STL	5000	5
EWR	3000	4	OGG	2000	3	SWF	1000	3
FLL	4000	5	OMA	2500	5	TEB	3500	5
GYY	1000	3	ONT	3000	3	TPA	2100	3
HNL	2500	3	ORD	1900	3	TUS	7500	3
HOU	2100	3	OXR	1000	3	VNY	1000	3
HPN	3500	5	PBI	2000	3			

Frequency of VMC, MCMC, IMC at TBFM airports

- Based on definition of categories from previous page and 30-year average of METARS from NCDC

	Percent of time in condition		
	VMC	MMC	IMC
ATL	73%	14%	13%
BOS	80%	7%	13%
BWI	81%	10%	9%
CLE	77%	11%	12%
CLT	76%	12%	12%
CVG	76%	13%	12%
DCA	82%	9%	9%
DEN	92%	3%	5%
DFW	82%	12%	6%
DTW	69%	19%	12%
EWR	77%	11%	12%
FLL	87%	12%	2%
HOU	81%	8%	12%
IAD	75%	14%	11%
IAH	56%	32%	12%
JFK	81%	7%	12%
LAS	98%	2%	0%
LAX	72%	12%	16%
LGA	76%	12%	12%
MCO	90%	4%	6%
MDW	82%	7%	11%
MEM	67%	22%	11%
MIA	95%	4%	2%
MKE	80%	8%	12%
MSP	72%	19%	8%
ORD	82%	7%	11%
PDX	70%	23%	7%
PHL	78%	9%	13%
PHX	99%	1%	0%
SAN	75%	16%	9%
SAT	71%	17%	12%
SEA	62%	27%	11%
SFO	64%	27%	9%
SLC	87%	8%	6%
STL	71%	20%	10%

Request to change MVMC definition

- In late August 2012 the ARC requested we change the definition for MVMC
  - Add 2000 feet to the current ceiling limit at each airport
  - Make the visibility limit 10 miles for all airports
- Activities needed to make this change
  - MITRE would need to produce new capacity curves for VMC and MVMC.
    - ➢ Current capacity curves are tuned based on what is measured during historical times when weather is in the proper range
    - ➢ Changing the range would require retuning the curves to meet the new definition
  - FAA NextGen Office might need to choose new model days
    - ➢ The 12 model days were chosen to best match the historical frequency of conditions
    - ➢ Changing the range of MVMC might modify the days that would be chosen
  - MCR would need to change definition of when to use MVMC and VMC curves inside the model
    - ➢ This is a relatively minor change in the model
- Difficulty in estimating impact on estimate
  - There are two competing factors that might modify the estimate and it is difficult to tell which would be dominant when changing the definition:
    - ➢ The frequency of MVMC would increase, consequently the CAVS/NCT benefit would increase
    - ➢ The baseline capacity during MVMC would increase, consequently the CAVS/NCT benefit would decrease

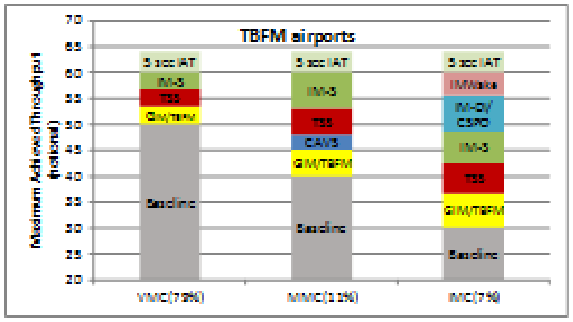
Assumptions concerning CSPO

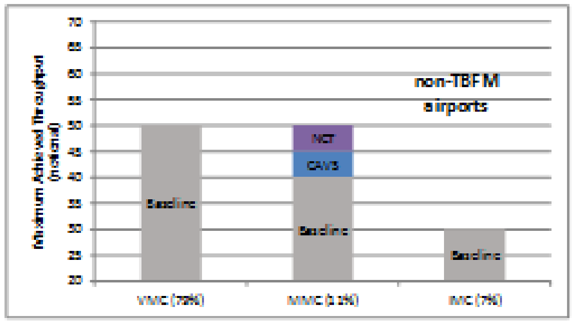
- Track data used to determine % of arrivals landing on dependent runways in 15 minute periods

	Percent of flights that arrive during different types of runway operations (during VMC)			
TSFM Airport	CSPR< 2500ft	CSPR> 2500ft and <4300ft	Independent	Data Source
ATL	3%	0%	97%	PDARS
BOS	26%	0%	74%	PDARS
BWI	0%	0%	100%	PDARS
CLE	43%	0%	57%	PDARS
CLT	0%	22%	78%	PDARS
CVG	0%	1%	99%	PDARS
DCA	0%	0%	100%	PDARS
DEN	0%	33%	67%	PDARS
DFW	13%	0%	87%	PDARS
DTW	7%	20%	73%	PDARS
EWR	11%	0%	89%	ASPM
FLL	0%	86%	14%	PDARS
HOU	26%	0%	74%	PDARS
IAD	0%	0%	100%	PDARS
IAH	0%	0%	100%	PDARS
JFK	0%	19%	81%	PDARS
LAS	23%	0%	77%	PDARS
LAX	15%	0%	85%	PDARS
LGA	0%	0%	100%	PDARS
MCO	20%	22%	58%	PDARS
MDW	30%	0%	70%	PDARS
MEM	5%	67%	28%	ASPM
MIA	3%	0%	97%	ASPM
MKE	0%	0%	100%	ASPM
MSP	0%	92%	8%	PDARS
ORD	0%	0%	100%	ASPM
PDX	0%	7%	93%	PDARS
PHL	41%	0%	59%	ASPM
PHX	12%	2%	86%	PDARS
SAN	0%	0%	100%	ASPM
SAT	25%	0%	75%	ASPM
SEA	41%	58%	1%	PDARS
SFO	83%	0%	17%	ASPM
SLC	0%	89%	11%	PDARS
STL	37%	0%	63%	PDARS

Throughput change - Summary

- The graphs to the right are NOTIONAL; the arrival-departure throughput curves differ dramatically by airport
- The ADS-B In applications modeled at an airport depend on whether FAA plans meter arrivals (TBFM/GIM) into that airport
- The implementation order impacts the benefit attributed to an application



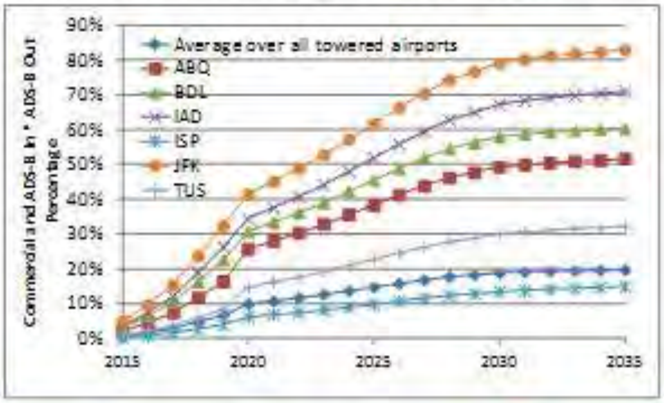


Equipage dependence

- The throughput for a particular application also depends on the equipage (specifically the ADS-B In equipage)
- Most of the applications exhibit an almost linear relationship between throughput and percent equipped
- Delay, in general, is not linear with changes to capacity
- The current results report the following
    1. Delay Savings benefits assuming 100% equipage
    2. Delay Savings assuming benefits are linear with equipage
    3. Delay Savings assuming benefits are proportional to the square of the equipage
- We are also developing equipage dependent results based on delay vs. capacity curves at each airport and scenario, but so far the results have been inconsistent. We do feel safe in saying the results will lie somewhere in between the linear and square cases for most airports.

Equipage dependence (continued)

- Percent of eligible aircraft different per airport
  - -Because the % of overall operations that are Air Carrier and Commuter differs by airport the throughput increase will also differ by airport for each of the scenarios.
  - -The y-axis below can be thought of as the Probability for any arrival pair that the following aircraft is Commercial and ADS-B In equipped and the leading aircraft is ADS-B Out equipped



ADS-B In ARC Application Benefits October 2012

Federal Aviation Administration

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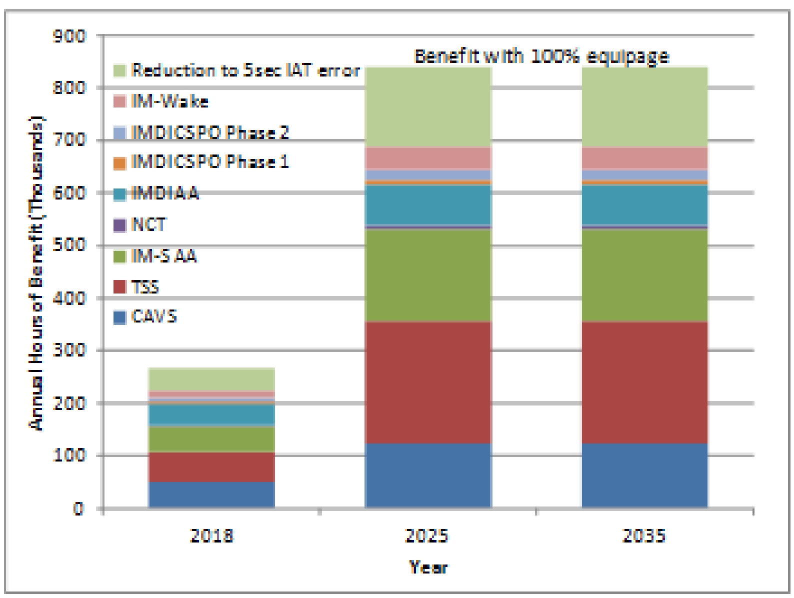
100% Equipage Results

- Assumes entire fleet 100% ADS-B In equipped
- In terms of total delay savings (Thousands of Hours)
- Benefits flatten out in 2025 because FAA Finance currently will not accept growth in baseline delay beyond this date because of uncertainty in airport infrastructure growth (new runways, secondary airports etc.)



ADS-B In ARC Application Benefits October 2012

Federal Aviation Administration

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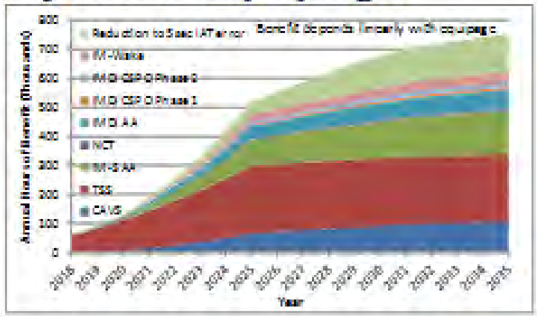
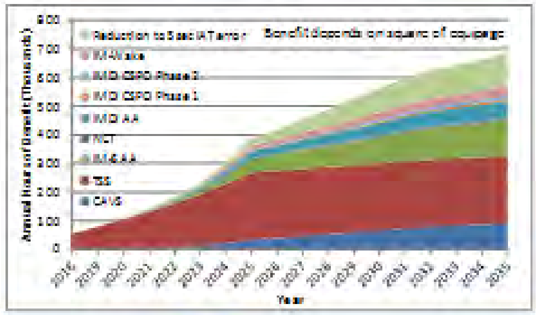
Results assuming projected equipage

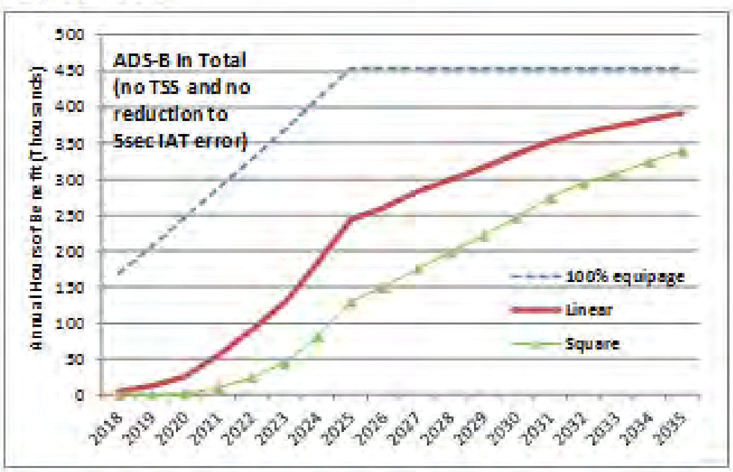
- Results shown for cases where benefit depends linearly and on square of equipage
- Potential TSS benefits are shown but these are not assumed to be ADS-B equipage dependent
- Assumes ADS-B In and ADS-B Out equipage curves used in the 2012 JRC (see slide 16 for more detail on applicable equipage)
- Benefits in terms of total delay savings (Thousands of Hours)
- Benefits flatten out in 2025 because FAA Finance currently will not accept growth in baseline delay beyond this date because of uncertainty in airport infrastructure growth (new runways, secondary airports etc.)





Comparison

- In terms of total delay savings (Thousands of Hours)
- TSS is not included because it is not equipage dependent
- Benefits flatten out in 2025 because FAA Finance currently will not accept growth in baseline delay beyond this date because of uncertainty in airport infrastructure growth (new runways, secondary airports etc.)



Results (Hours)

- Assuming linear (top) and square (bottom) with equipage (applied separately per site)
- In terms of total delay savings (Thousands of Hours)
- Table below shows percent of delay savings by phase of flight

	Percent of Delay savings by phase of flight		
	2018	2025	2018-2035
Air	38%	20%	22%
Taxi	25%	22%	22%
Gate	37%	58%	56%
Ground (Gate+Taxi)	62%	80%	78%

Application Benefits (Linear with equipage)

		Delay Savings (Thousands of Hours)		
	Application	2018	2025	2018-2035
Separate Applications	CAVS	1	65	1095
	TSS	56	235	3478
	IM-S AA*	1	90	1510
	NCT	0	4	71
	IMDI independent	1	42	709
	IMDI CSPO Phase 1	0	5	79
	IMDI CSPO Phase 2	0	10	167
	IM-Wake	0	23	395
	Reduction to 5 sec IAT error	1	45	1151
Application Combinations	CAVS, IM-S*, NCT	5	159	2674
	IMDI, CSPO, IM Wake	2	80	1351

Application Benefits (Square with equipage)

		Delay Savings (Thousands of Hours)		
	Application	2018	2025	2018-2035
Separate Applications	CAVS	0	34	741
	TSS	56	235	3478
	IM-S AA*	0	48	1050
	NCT	0	2	47
	IMDI independent	0	22	483
	IMDI CSPO Phase 1	0	3	54
	IMDI CSPO Phase 2	0	5	114
	IM-Wake	0	13	271
	Reduction to 5 sec IAT error	0	24	823
Application Combinations	CAVS, IM-S*, NCT	0	84	1818
	IMDI, CSPO, IM Wake	0	43	923

*Assumed IM-S AA incremental to TSS

Results (FY12 $M)

- Assuming linear (top) and square (bottom) with equipage (applied separately per site)
- In terms of total delay savings (FY12 $M)

Application Benefits (Linear with equipage)

		ADOC Savings (FY12 $M)			PVT Savings (FY12 $M)		
	Application	2018	2025	2018-2035	2018	2025	2018-2035
Separate Applications	CAVS	$5	$79	$1,567	$5	$169	$3,114
	TSS	$114	$549	$5,548	$129	$809	$9,615
	IM-S AA*	$5	$146	$2,472	$5	$235	$4,309
	NCT	$0	$4	$65	$0	$11	$201
	IMDI independent	$2	$49	$842	$5	$109	$2,019
	IMDI CSPO Phase 1	$0	$8	$134	$0	$12	$225
	IMDI CSPO Phase 2	$0	$12	$202	$1	$26	$477
	IM-Wake	$1	$46	$781	$1	$61	$1,127
	Reduction to 5 sec IAT error	$2	$101	$2,517	$5	$205	$3,775
Application Combinations	CAVS, IM-S*, NCT	$6	$229	$3,905	$7	$415	$7,625
	IMDI, CSPO, IM Wake	$3	$115	$1,960	$4	$206	$3,847

Application Benefits (Square with equipage)

		ADOC Savings (FY12 $M)			PVT Savings (FY12 $M)		
	Application	2018	2025	2018-2035	2018	2025	2018-2035
Separate Applications	CAVS	$0	$42	$920	$0	$89	$2,148
	TSS	$114	$549	$5,548	$129	$809	$9,615
	IM-S AA*	$0	$77	$1,680	$0	$124	$2,985
	NCT	$0	$2	$42	$0	$6	$136
	IMDI independent	$0	$26	$572	$0	$58	$1,400
	IMDI CSPO Phase 1	$0	$4	$91	$0	$7	$157
	IMDI CSPO Phase 2	$0	$6	$138	$0	$14	$332
	IM-Wake	$0	$25	$537	$0	$33	$786
	Reduction to 5 sec IAT error	$0	$90	$1,959	$0	$109	$2,610
Application Combinations	CAVS, IM-S*, NCT	$0	$121	$2,643	$0	$219	$5,269
	IMDI, CSPO, IM Wake	$0	$61	$1,338	$0	$111	$2,674

*Assumed IM-S AA incremental to TSS

Results (PV $M)

- Assuming linear (top) and square (bottom) with equipage (applied separately per site)
- In terms of total delay savings (PV $M) assuming 7% discount rate

Application Benefits (Linear with equipage)

	Application	ADOC Savings (PV $M) 2018	ADOC Savings (PV $M) 2025	ADOC Savings (PV $M) 2018-2035	PVT Savings (PV $M) 2018	PVT Savings (PV $M) 2025	PVT Savings (PV $M) 2018-2035
Separate Applications	CAVS	$2	$35	$436	$2	$70	$987
	TSS	$78	$145	$1,949	$88	$255	$5,385
	IM-S AA*	$2	$61	$781	$2	$98	$1,532
	NCT	$0	$1	$21	$0	$4	$84
	IMDI independent	$1	$20	$269	$2	$45	$650
	IMDI CSPO Phase 1	$0	$5	$45	$0	$5	$70
	IMDI CSPO Phase 2	$0	$5	$64	$0	$11	$148
	IM-Wake	$1	$19	$246	$1	$25	$349
	Reduction to 5 sec IAT error	$2	$67	$886	$2	$88	$1,167
Application Combinations	CAVS, IM-S*, NCT	$4	$95	$1,238	$5	$172	$2,585
	IMDI, CSPO, IM Wake	$2	$48	$622	$3	$88	$1,197

Application Benefits (Square with equipage)

	Application	ADOC Savings (PV $M) 2018	ADOC Savings (PV $M) 2025	ADOC Savings (PV $M) 2018-2035	PVT Savings (PV $M) 2018	PVT Savings (PV $M) 2025	PVT Savings (PV $M) 2018-2035
Separate Applications	CAVS	$0	$17	$272	$0	$57	$824
	TSS	$78	$145	$1,949	$88	$255	$5,385
	IM-S AA*	$0	$32	$495	$0	$52	$888
	NCT	$0	$1	$15	$0	$2	$40
	IMDI independent	$0	$11	$169	$0	$24	$407
	IMDI CSPO Phase 1	$0	$2	$27	$0	$3	$48
	IMDI CSPO Phase 2	$0	$3	$41	$0	$6	$98
	IM-Wake	$0	$10	$158	$0	$14	$228
	Reduction to 5 sec IAT error	$0	$37	$577	$0	$45	$757
Application Combinations	CAVS, IM-S*, NCT	$0	$50	$780	$0	$91	$1,330
	IMDI, CSPO, IM Wake	$0	$25	$395	$0	$46	$777

*Assumed IM-S AA incremental to TSS

Airport Results (Linear equipage)

- TBFM airports accrue the majority of the savings (96%)
- In terms of total delay savings (Hours)
- *NCT does not accrue at TBFM airports
- **ORD has a relatively small impact because of projected increase in capacity after redesign

TBFM Airport Delay Savings (Hours for Different Application Combinations) - Linear Equipage

Airport	CAVS, IM-S, NCT* Delay Savings	CAVS, IM-S, NCT* Percent	CAVS, IM-S, NCT* Rank	IMDI, CSPO, IM-Wake Delay Savings	IMDI, CSPO, IM-Wake Percent	IMDI, CSPO, IM-Wake Rank	Total Delay Savings	Total Percent	Total Rank
ATL	832,090	31.01%	1	492,105	36.44%	1	1,324,195	33.66%	1
BOS	11,665	0.43%	22	10,306	0.76%	16	21,971	0.56%	21
BWI	82,881	3.09%	8	67,092	4.97%	4	149,974	3.81%	7
CLE	11,303	0.42%	23	2,564	0.19%	31	13,867	0.35%	25
CLT	81,120	3.02%	9	65,649	4.86%	5	146,769	3.73%	8
CVG	5,373	0.20%	27	2,165	0.16%	32	7,538	0.19%	30
DCA	4,142	0.15%	29	10,868	0.80%	15	15,010	0.38%	24
DEN	13,064	0.49%	21	9,478	0.70%	18	22,542	0.57%	20
DFW	21,822	0.81%	16	5,146	0.38%	26	26,969	0.69%	19
DTW	16,068	0.60%	19	22,417	1.66%	12	38,485	0.98%	15
EWR	251,094	9.36%	2	113,085	8.37%	3	364,179	9.26%	2
FLL	5,600	0.21%	26	3,334	0.25%	30	8,934	0.23%	28
HOU	1,224	0.05%	33	1,899	0.14%	33	3,123	0.08%	35
IAD	63,988	2.38%	10	19,695	1.46%	14	83,683	2.13%	11
IAH	86,971	3.24%	7	46,570	3.45%	9	133,542	3.39%	9
JFK	192,656	7.18%	6	49,886	3.69%	8	242,542	6.16%	5
LAS	63,551	2.37%	11	8,536	0.63%	21	72,088	1.83%	12
LAX	195,150	7.27%	5	42,110	3.12%	10	237,260	6.03%	6
LGA	25,151	0.94%	14	28,865	2.14%	11	54,016	1.37%	14
MCO	8,844	0.33%	24	8,655	0.64%	20	17,499	0.44%	23
MDW	8,687	0.32%	25	4,395	0.33%	28	13,081	0.33%	26
MEM	21,528	0.80%	17	9,304	0.69%	19	30,832	0.78%	17
MIA	106	0.00%	34	6,040	0.45%	24	6,145	0.16%	33
MKE	3,323	0.12%	30	8,327	0.62%	22	11,650	0.30%	27
MSP	24,047	0.90%	15	63,918	4.73%	6	87,965	2.24%	10
ORD	18,594	0.69%	18	10,048	0.74%	17	28,642	0.73%	18
PDX	0	0.00%	35	6,798	0.50%	23	6,798	0.17%	32
PHL	228,506	8.52%	3	54,246	4.02%	7	282,753	7.19%	4
PHX	14,301	0.53%	20	4,647	0.34%	27	18,948	0.48%	22
SAN	32,729	1.22%	13	1,611	0.12%	34	34,340	0.87%	16
SAT	3,271	0.12%	31	4,324	0.32%	29	7,596	0.19%	29
SEA	43,072	1.61%	12	20,634	1.53%	13	63,706	1.62%	13
SFO	204,821	7.63%	4	139,672	10.34%	2	344,492	8.76%	3
SLC	5,308	0.20%	28	825	0.06%	35	6,133	0.16%	34
STL	1,903	0.07%	32	5,315	0.39%	25	7,218	0.18%	31

Airport Results (Square equipage)

- TBFM airports accrue the majority of the savings **(96%)**
- In terms of total delay savings (Hours)
- *NCT does not accrue at TBFM airports
- **ORD has a relatively small impact because of projected increase in capacity after redesign

TBFM Airport Delay Savings (Hours for Different Application Combinations) - Square Equipage

	CAVS, IM-S, NCT*			IMDI, CSPO, IM-Wake			Total		
Airport	Delay Savings	Percent	Rank	Delay Savings	Percent	Rank	Delay Savings	Percent	Rank
ATL	589,879	32.34%	1	347,205	37.61%	1	937,085	34.78%	1
BOS	6,888	0.38%	23	6,274	0.68%	18	13,162	0.49%	21
BWI	52,991	2.91%	9	42,789	4.64%	6	95,780	3.55%	8
CLE	7,483	0.41%	22	1,654	0.18%	31	9,138	0.34%	25
CLT	54,120	2.97%	8	43,515	4.71%	4	97,636	3.62%	7
CVG	3,721	0.20%	26	1,428	0.15%	32	5,149	0.19%	29
DCA	2,851	0.16%	29	7,460	0.81%	15	10,311	0.38%	24
DEN	9,323	0.51%	21	6,721	0.73%	17	16,044	0.60%	20
DFW	15,295	0.84%	16	3,626	0.39%	23	18,921	0.70%	19
DTW	11,195	0.61%	19	15,896	1.72%	12	27,091	1.01%	15
EWR	172,997	9.48%	2	77,116	8.35%	3	250,112	9.28%	2
FLL	3,303	0.18%	27	1,913	0.21%	29	5,216	0.19%	28
HOU	499	0.03%	33	785	0.09%	34	1,284	0.05%	35
IAD	38,768	2.13%	10	11,778	1.28%	14	50,547	1.88%	11
IAH	60,897	3.34%	7	32,682	3.54%	9	93,579	3.47%	9
JFK	135,981	7.46%	6	35,821	3.88%	8	171,802	6.38%	5
LAS	32,567	1.79%	11	4,243	0.46%	22	36,810	1.37%	13
LAX	135,996	7.46%	5	29,033	3.15%	10	165,029	6.12%	6
LGA	16,368	0.90%	14	19,928	2.16%	11	36,296	1.35%	14
MCO	6,074	0.33%	24	5,748	0.62%	20	11,823	0.44%	23
MDW	4,957	0.27%	25	2,529	0.27%	28	7,486	0.28%	26
MEM	14,074	0.77%	17	6,111	0.66%	19	20,185	0.75%	17
MIA	0	0.00%	34	4,101	0.44%	23	4,101	0.15%	31
MKE	2,004	0.11%	30	5,140	0.56%	21	7,143	0.27%	27
MSP	16,190	0.89%	15	43,359	4.69%	5	59,550	2.21%	10
ORD	13,029	0.71%	18	6,902	0.75%	16	19,930	0.74%	18
PDX	0	0.00%	35	3,926	0.43%	24	3,926	0.15%	32
PHL	157,799	8.65%	3	37,040	4.01%	7	194,839	7.23%	4
PHX	9,431	0.52%	20	3,194	0.35%	26	12,625	0.47%	22
SAN	21,727	1.19%	13	1,017	0.11%	33	22,744	0.84%	16
SAT	1,428	0.08%	31	1,906	0.21%	30	3,334	0.12%	34
SEA	30,315	1.66%	12	14,499	1.57%	13	44,814	1.66%	12
SFO	138,948	7.62%	4	94,158	10.20%	2	233,105	8.65%	3
SLC	3,087	0.17%	28	477	0.05%	33	3,564	0.13%	33
STL	1,109	0.06%	32	3,172	0.34%	27	4,281	0.16%	30

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Results per airport

- Non-TBFM airports only assume **4%** of total NAS CAVS, IM-S, NCT overall benefit
- Still some non-TBFM airports accrue significant savings from CAVS and NCT

Top 20 non-TBFM airports with CAVS, NCT Delay Savings (linear)		
Airport	Lifecycle Delay Savings (Hours)	Percent of total CAVS, NCT, IM-S benefit
IND	7,351	0.27%
OAK	5,647	0.21%
PIT	5,526	0.21%
MCI	5,084	0.19%
BNA	4,886	0.18%
TPA	4,836	0.18%
SMF	4,605	0.17%
SJC	4,283	0.16%
RDU	3,679	0.14%
BDL	3,420	0.13%
SNA	2,997	0.11%
MHT	2,946	0.11%
JAX	2,781	0.10%
RSW	2,735	0.10%
DAY	2,697	0.10%
SDF	2,545	0.09%
PVD	2,423	0.09%
DAL	2,391	0.09%
AUS	2,315	0.09%
ORF	2,309	0.09%

Top 20 non-TBFM airports with CAVS, NCT Delay Savings (square)		
Airport	Lifecycle Delay Savings (Hours)	Percent of total CAVS, NCT, IM-S benefit
IND	4,588	0.25%
MCI	3,373	0.18%
PIT	3,313	0.18%
SMF	3,028	0.17%
TPA	2,937	0.16%
OAK	2,929	0.16%
BNA	2,770	0.15%
SJC	2,469	0.14%
BDL	2,020	0.11%
RDU	1,925	0.11%
MHT	1,684	0.09%
RSW	1,672	0.09%
JAX	1,628	0.09%
SDF	1,556	0.09%
DAY	1,518	0.08%
PVD	1,330	0.07%
ORF	1,162	0.06%
DAL	1,105	0.06%
AUS	1,094	0.06%
ONT	1,071	0.06%

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Preliminary Economic Analysis Results

- Forward Fit costs ($479 PV$M)
  - Benefits exceed costs except for most conservative case if **no retrofit equipage** considered

Forward Fit Benefits (PV $M)	ADOC Only		ADOC & PVT	
	Low	High	Low	High
CAVS, IM-S AA*, NCT	$332.4	$787.9	$993.8	$2,298.7
IMDI, CSPO, IM Wake	$168.3	$395.9	$504.3	$1,161.8
Total	$500.7	$1,183.8	$1,498.1	$3,460.5

  - Benefits exceed costs for all cases if **retrofit equipage** considered (impacts low scenario where benefits assumed proportional to equipage squared)

Forward Fit Benefits (PV $M)	ADOC Only		ADOC & PVT	
	Low	High	Low	High
CAVS, IM-S AA*, NCT	$496.1	$787.9	$1,474.2	$2,298.7
IMDI, CSPO, IM Wake	$251.4	$395.9	$748.9	$1,161.8
Total	$747.5	$1,183.8	$2,223.1	$3,460.5

- Retrofit costs ($676 PV$M)
  - When applying ADOC only, benefits basically equal costs in the most aggressive case (all applications and benefits proportional to linear equipage)
  - When applying ADOC and PVT, benefits exceed costs for all cases (w/ forward fit equipage considered)

Retrofit Benefits (PV $M)	ADOC Only		ADOC & PVT	
	Low	High	Low	High
CAVS, IM-S AA*, NCT	$283.6	$450.4	$835.1	$1,302.2
IMDI, CSPO, IM Wake	$143.7	$226.2	$423.6	$657.2
Total	$427.3	$676.6	$1,258.7	$1,959.4

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Next Steps

- Need to determine phase-in of applications
  - Will differ by application
  - Might differ by airport if there is ground infrastructure dependence or a minimum equipage threshold to start service
- Still examining more sophisticated approaches for applying equipage dependence

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