U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

ORDER
1110.147

Effective Date:
July 15, 2007

SUBJ: ADS-B Aviation Rulemaking Committee

1. PURPOSE of THIS ORDER. This order establishes the Automatic Dependent Surveillance – Broadcast (ADS-B) Aviation Rulemaking Committee (ARC) according to the Administrator's authority under Title 49 of the United States Code (49 U.S.C.) section 106(p)(5).

2. AUDIENCE. This order is distributed to the director level in the Offices of Rulemaking; En Route and Oceanic Services; Chief Counsel; Flight Standards; Aviation Safety; Aircraft Certification Services; Terminal Services; and Aviation Policy and Plans. It is also distributed at the associate level in the Offices of Aviation Safety; the Air Traffic Organization; and Aviation Policy, Planning, and Environment.

3. WHERE CAN I FIND THIS ORDER
This order is available at
https://employees.faa.gov/tools_resources/orders_notices/

4. BACKGROUND

a. The Century of Aviation Reauthorization Act (Public Law 108-176) was enacted December 12, 2003. The law sets forth requirements and objectives for transforming the U.S. air transportation system to meet the demands of the 21st century. Section 709 requires the Secretary of Transportation to establish in the Federal Aviation Administration (FAA) a joint planning and development office to manage work related to the development of a next generation air transportation system (NextGen).

b. ADS-B has been identified as a cornerstone technology in the implementation of NextGen. ADS-B is a surveillance system that uses satellite technology, aircraft avionics, and a flexible ground infrastructure to transmit flight information between aircraft and air traffic control more accurately and quickly. Users who choose to equip with ADS-B receiver technology and a cockpit display could receive services that provide them with weather and traffic information and shared situational awareness with air traffic controllers. Within the FAA, the ADS-B project operates under the Air Traffic Organization, in the En Route and Oceanic Service Unit's Surveillance and Broadcast Services (SBS) program office.

c. In order to achieve the benefits of ADS-B, meet the increasing demands of air travel, enable the implementation of future applications, which could include possibly reducing aircraft separation standards, all aircraft in a given area must be equipped with ADS-B technology. While the FAA expects some level of voluntary equipage with ADS-B avionics, it is unlikely that voluntary equipage will reach 100 percent of the necessary population. The En Route and Oceanic Service Unit has initiated a rulemaking project that would facilitate ADS-B performance in the National Airspace System.

d. Industry and user groups have expressed a desire to be more involved in the FAA rulemaking process through the Air Traffic Management Advisory Committee (ATMAC). The FAA finds that a wide scope of input to would be beneficial to market and manage both the substantial benefits and significant costs of a nationwide ADS-B system.

4. OBJECTIVES AND SCOPE OF THE COMMITTEE. The ADS-B ARC will provide a forum for the U.S. aviation community to discuss and review an NPRM for ADS-B, formulate recommendations on presenting and structuring an ADS-B mandate, and consider additional actions that may be necessary to implement those recommendations. The ADS-B ARC will submit recommendations to the Administrator through the Chief Operating Officer, Air Traffic Organization. Specific taskings include the following:

a. While the NPRM is being finalized and leading up to its publication, the ARC will serve as a platform for developing a report on optimizing operational benefits of ADS-B prior to implementing a nationwide ADS-B airspace rule. Development of the report will not affect the release date of the NPRM.

b. After an NPRM has been published, the ARC will make specific recommendations to the FAA concerning the proposed requirements.

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5. COMMITTEE PROCEDURES.

a. The Chief Operating Officer, Air Traffic Organization, will issue additional taskings, including deliverable dates.

b. The committee provides advice and recommendations to the Chief Operating Officer, Air Traffic Organization. The committee acts solely in an advisory capacity.

c. The committee will discuss and present information, guidance, and recommendations that the members consider relevant to disposing of issues. Discussions will address the following:

1. Operational objectives, recommendations, and requirements.
2. Recommendations for rulemaking necessary to meet objectives (to be delivered based on a review of the NPRM).
3. Guidance material and the implementation processes.
4. Global harmonization issues and recommendations.

6. ORGANIZATION AND ADMINISTRATION.

a. The FAA will set up a committee with representatives from the various user groups, parts of the industry, and Government. The committee may set up specialized work groups that will include at least one committee member and invited subject matter experts from industry, the aviation community, and Government, as necessary.

b. The Chief Operating Officer, Air Traffic Organization, will have the sole discretion to invite members or organizations to serve as members of the committee. The FAA will provide participation and support from all affected FAA lines of business.

c. The Chief Operating Officer, Air Traffic Organization, will receive all committee recommendations and reports.

d. The Chief Operating Officer, Air Traffic Organization, is the sponsor of the committee and will select co-chairs from the membership of the committee. Also, the Chief Operating Officer, Air Traffic Organization, will select the FAA-designated representative to the committee. Once appointed, the co-chairs will:

1. Determine when a meeting is required.

2. Notify committee members of the time and place of each meeting.

3. Draft an agenda for each meeting and conduct the meeting.

e. A Record of Discussions of committee meetings will be kept.

f. Although a quorum is desirable at committee meetings, it is not required.

7. MEMBERSHIP.

a. The committee will consist of approximately 15 members, selected by the FAA, to represent National Airspace System users, stakeholders, industry, and the FAA.

b. Each member of the committee will represent an identified part of the aviation community and have the authority to speak for that part. Active participation and commitment by members will be essential for achieving the committee objectives and for continued membership on the committee. The committee may invite subject matter experts to support specialized work groups.

8. PUBLIC PARTICIPATION. The ADS-B ARC meetings are closed to the public. Persons who are not members of the committee but are interested in attending a meeting must request and receive approval in advance of the meeting from the co-chairs or the designated Federal representative.

9. AVAILABILITY OF RECORDS. Under the Freedom of Information Act, 5 U.S.C. § 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, 600 Independence Avenue, SW, Washington, DC 20591. Fees will be charged for the costs of furnishing information to the public according to the fee schedule in Title 49, Code of Federal Regulations, part 7.

11. PUBLIC INTEREST. Forming the ADS-B ARC is determined to be in the public interest to fulfill the performance of duties imposed on FAA by law.

12. EFFECTIVE DATE AND DURATION. This committee is effective as of July 15, 2007. The committee will remain in existence until July 15, 2009, unless sooner terminated or extended by the Administrator.

/s/
Marion C. Blakey
Administrator

October 3, 2007

Mr. Henry P. Krakowski
Chief Operating Officer
Air Traffic Organization
Federal Aviation Administration
800 Independence Avenue SW.
Washington, D.C. 20571

Dear Mr. Krakowski:

On behalf of the Automatic Dependent Surveillance–Broadcast (ADS–B) Aviation Rulemaking Committee (ARC), we are pleased to provide you with a copy of the ARC's report on optimizing the benefits of ADS–B before implementation of a nationwide rule. This report, written without knowledge of the Federal Aviation Administration's (FAA) notice of proposed rulemaking, was written to fulfill the ARC's first tasking.

This report explains the operational benefits of ADS–B and provides the FAA with 12 recommendations on how it could accelerate the delivery of these benefits through early equipage with ADS–B. To significantly accelerate early ADS–B equipage, the ARC believes the FAA will need to offer a combination of financial incentives and operational benefits. In addition, the ARC has confidence in the FAA's ability to deploy the ADS–B ground infrastructure; however, the ARC is concerned with the FAA's ability to approve operational procedures that would provide early operational benefits that can not be achieved with the existing national airspace surveillance infrastructure.

We trust this report will be helpful in your decisionmaking process. We and our fellow ARC members stand ready to assist the FAA in prioritizing implementation of the ARC's recommendations.

Sincerely,

Basil J. Barimo
Air Transport Association of America, Inc.
Co-Chair

Steve Brown
National Business Aviation Association, Inc.
Co-Chair

Enclosure

Optimizing the Benefits of Automatic Dependent Surveillance—Broadcast

REPORT FROM THE ADS–B AVIATION RULEMAKING COMMITTEE

October 3, 2007

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ACRONYM LIST

1090 ES	1090 MHz Extended Squitter
ABESS	Airline Based En Route Sequencing and Spacing
AC	Aircraft
ADS–B	Automatic Dependent Surveillance – Broadcast
ADS–R	Automatic Dependent Surveillance – Rebroadcast
ARC	Aviation Rulemaking Committee
ASDE	Airport Surface Detection Equipment
ASSA	Airport Surface Situational Awareness
ATC	Air Traffic Control
ATM	Air Traffic Management
ATMAC	Air Traffic Management Advisory Committee
ATO	Air Traffic Organization
ATS	Air Traffic Service
ATSP	Air Traffic Service Provider
CAVS	CDTI Assisted Visual Separation
CDA	Continuous Descent Approach
CDTI	Cockpit Display of Traffic Information
CFIT	Controlled Flight Into Terrain
CPR	Compact Position Reporting
EFB	Electronic Flight Bag
ELT	Emergency Locator Transmitter
EMOSIA	European Model for Strategic ATM Investment Analysis
ERAU	Embry-Riddle Aeronautical University
EUROCAE	European Organization for Civil Aviation Equipment
EVA	Enhanced Visual Approach
FAA	Federal Aviation Administration
FAROA	Final Approach Runway Occupancy Awareness
FIS–B	Flight Information Service – Broadcast
GBTs	Ground Based Terminals
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HPL	Horizontal Protection Limit
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IR&D	Independent Research and Development
ISD	In-Service Decision
ITP	In-Trail Procedure
JFK	John F. Kennedy International Airport
JPDO	Joint Planning and Development Office
MASPS	Minimum Aviation System Performance Standards
Mode S	Mode Select
MOPS	Minimum Operational Performance Standards
NACP	Navigation Accuracy Category for Position
NACV	Navigation Accuracy Category for Velocity

NAS	National Airspace System
NextGen	Next Generation Air Transportation System
NIC	Navigation Integrity Category
NM	Nautical Miles
NOTAM	Notices to Airmen
NPRM	Notice of Proposed Rulemaking
NPV	Net Present Value
NUC	Navigation Uncertainty Category
RNAV	Area Navigation
RNP	Required Navigation Performance
RPR	Rulemaking Project Record
RWY	Runway
SAR	Search and Rescue
SARP	ICAO Standard and Recommended Practice
SBS	Surveillance and Broadcast Services
SIL	System Implementation Level
SSR	Secondary Surveillance Radar
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Avoidance System
TIS-B	Traffic Information Service - Broadcast
TMA	Traffic Management Advisor
TSO	Technical Service Order
UAT	Universal Access Transceiver (978 MHz data link)
UND	University of North Dakota
VFR	Visual Flight Rules

EXECUTIVE SUMMARY

Automatic Dependent Surveillance–Broadcast (ADS–B) has been identified as a cornerstone technology in the implementation of the Next Generation Air Transportation System. ADS–B is a cooperative surveillance system that uses satellite technology, aircraft avionics, and a flexible ground infrastructure to more accurately and quickly transmit flight information between aircraft and air traffic control. To achieve the key benefits of ADS–B, meet the increasing demands of air travel, and enable the implementation of future applications, all aircraft in a given area will have to be equipped with ADS–B technology. While the Federal Aviation Administration (FAA) expects some level of voluntary equipage with ADS–B avionics, it is unlikely that 100 percent of the necessary population will equip without a mandate.

The FAA chartered the ADS–B Aviation Rulemaking Committee (ARC) to—

> provide a forum for the U.S. aviation community to discuss and review a notice of proposed rulemaking [(NPRM)] for ADS–B, formulate recommendations on presenting and structuring an ADS–B mandate, and consider additional actions that may be necessary to implement those recommendations.

Specifically, while the FAA is finalizing its NPRM, the ARC was tasked by the FAA to develop a report on optimizing the operational benefits of ADS–B before implementation of a nationwide ADS–B airspace rule. This report, written without any knowledge of the contents of the NPRM, is in response to that initial FAA tasking. To achieve a complete level of ADS–B avionics equipage, the ARC expects the NPRM will require ADS–B performance in certain classes of airspace. The ARC believes the benefits of ADS–B will accrue in proportion to the investment made into the system by the FAA, industry, and aviation community in general.

The ADS–B program is multidimensional and has the potential to offer a variety of benefits as the overall system matures. Although further work still lies ahead in global harmonization, one of the key strengths of ADS–B is that it is being adopted as a cost-effective, highly flexible surveillance tool in the global community. A program that offers a first tier of benefits to early adopters will recognize those users as “pioneers.” As the ADS–B system matures and more well-established performance standards find their way into the field, the system will access a broader set of benefits. These benefits will provide incentives to those that choose to update their systems to the recognized standards. And finally, to ensure the system matures to its intended cooperative surveillance environment, a mandate phase will recognize the long-term nature of the solutions.

The ARC expects that the standards for ADS–B avionics equipage will be defined in compliance with two internationally recognized equipment standards—the 1090 MHz extended squitter (1090 ES) frequency and the 978 MHz universal access transceiver (UAT) frequency. These dual links are intended to meet the specific needs of a wide variety of aircraft types and functions. The RTCA standards (DO–260A change 2 for

1090 ES and DO–282A change 1 for UAT) for these links vary somewhat from the standard in aircraft fitted in response to the Elementary and Enhanced Surveillance mandates in Europe. These early-equipped aircraft are expected to have access to limited benefits under the anticipated ADS–B mandate and will support early system-wide data gathering. The full suite of benefits will be made available to those aircraft capable of operating with the baseline performance standards. The ARC further believes the NPRM will specify requirements on the integrity, accuracy, and availability of aircraft position data transmitted in ADS–B messages. If these requirements necessitate augmentation and/or modification of existing navigation sources on aircraft, early implementation of ADS–B and the final rule itself could be affected because of cost-benefit issues.

As the overall ADS–B system matures, additional performance parameters likely will be defined to support ADS–B applications beyond the scope of the FAA's rulemaking. Equipage to these future standards is envisaged as voluntary and benefits-driven. These additional parameters will be captured in evolving standards consisting of, for example, DO–260B/C/D for the 1090 ES ADS–B datalink. While these standards have not been defined to date, they likely will enable higher performance applications and services that will further enhance the capacity, flexibility, and safety of the evolving airspace.

ADS–B consists of two functions: ADS–B Out and ADS–B In. ADS–B Out, defined as the capability necessary to transmit ADS–B messages in compliance with the expected ADS–B rule, is the core of the operational system. ADS–B Out provides the aircraft-derived data to support ground and air applications and services. Figure ES–1 illustrates the relationships between program phases, avionics standards, and benefits provided during operational phases of flight.

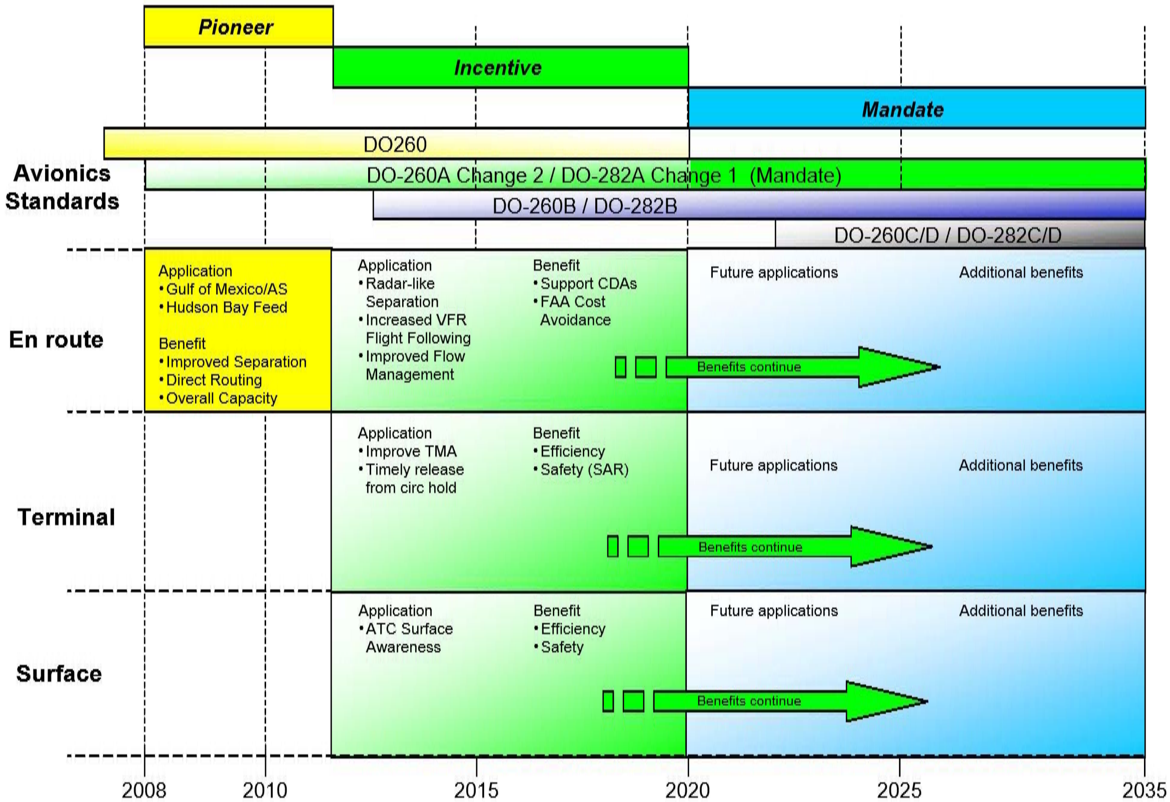


Figure ES–1—ADS–B Out Program Relationship

The ability to receive and display ADS–B messages and broadcast services (both from the ground and directly from other aircraft) is called ADS–B In. Additional airborne applications will be enabled for aircraft capable of receiving the ADS–B Out messages from surrounding aircraft and ground uplinked broadcast services that enable situational awareness, such as the Traffic Information Service–Broadcast and, on the UAT ADS–B datalink, the Flight Information Service–Broadcast (FIS–B). Further, to provide signals from aircraft operating on different datalinks and to transmit broadcast service information, it is necessary to have a rebroadcast function operating from the ground infrastructure called ADS–B Rebroadcast (ADS–R). A timely delivery of ADS–R signals will be necessary to enable advanced applications. Depending on the availability of additional processing and display tools, an expanded set of aircraft-to-aircraft applications and services can be offered. Figure ES–2 illustrates the complementary improvements and benefits possible once an aircraft is able to receive, process, and display the ADS–B and broadcast service information. The additional equipment necessary to support the ADS–B In functionality is outside the expected scope of the NPRM.

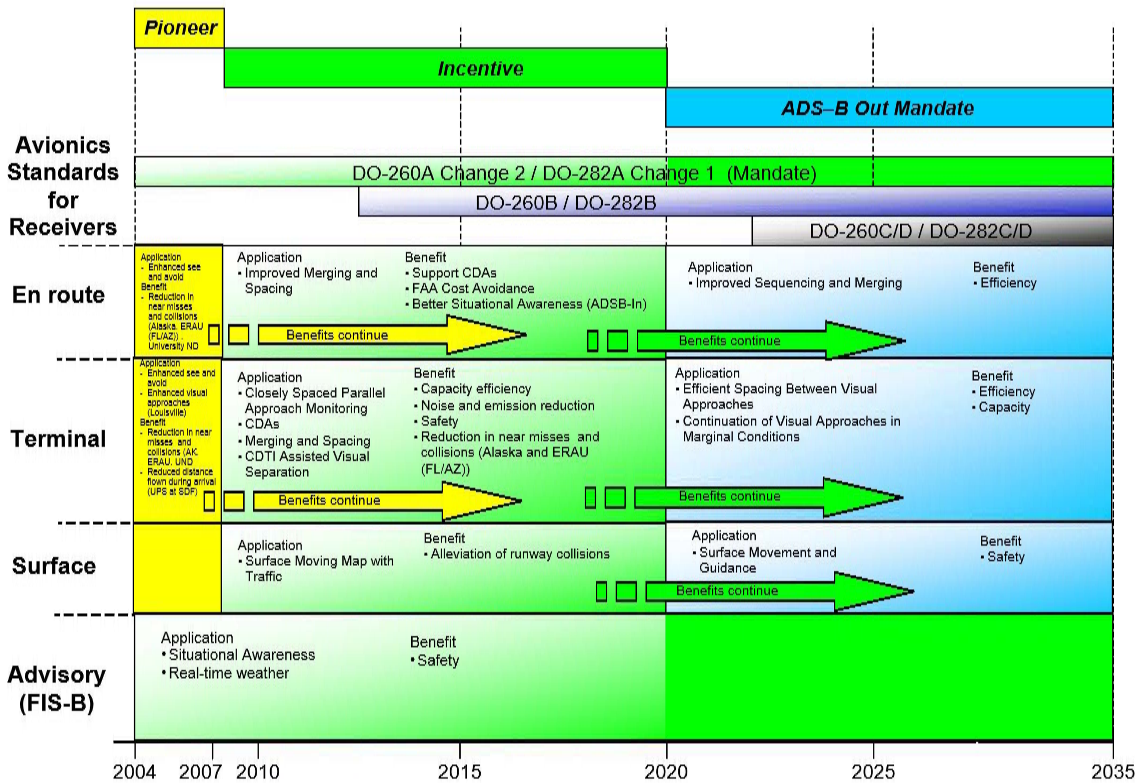


Figure ES–2—ADS–B In and FIS–B Program Relationships

This report discusses the incremental nature of airspace improvements and benefits as the ADS–B system matures, which has been illustrated by the preceding figures. To understand how users might maximize the value of different avionics suites over time, this report explains the benefits of surveillance and broadcast services chronologically and by level of equipage. The report also provides recommendations on how the Government might accelerate the realization of benefits through a mixture of financial incentives and operational benefits for early ADS–B equipage.

To transition to ADS–B as the new primary source of surveillance, all operators within certain airspace will have to equip with ADS–B avionics. Without a requirement for equipage in the nation's busiest airspace, the system cannot provide the benefits necessary to accommodate the current and future needs of the national airspace system (NAS). The aviation community recognizes the substantial benefit that can be gained by NAS users through the equipage of ADS–B avionics. This report explains the operational benefits of ADS–B and provides recommendations on how to accelerate the delivery of these benefits to NAS users through equipage with ADS–B before the expected compliance date. The ARC believes that some combination of financial incentives and operational benefits will be needed to significantly accelerate ADS–B equipage before the compliance date of the proposed rule. The ARC has confidence in the FAA's ability to deploy the ADS–B ground infrastructure. However, the ARC is concerned with the ability of the FAA to approve operational procedures that would provide early operational benefits that cannot be achieved with the exiting

NAS surveillance infrastructure. This report provides 12 recommendations. The key ARC recommendations are that the FAA—

1. **Collaborate with the aviation industry and aggressively develop an appropriate combination of financial incentives and accelerated operational benefits.**

2. **Accelerate and prioritize the identification of operations enabled by ADS–B, with approval of reduced separation standards for initial operations with a high level of user benefits by 2012.**

3. **Establish certification requirements for aircraft displays for ADS–B In applications by 2010.**

1.0 BACKGROUND

The U.S. air transportation system serves as a critical engine of economic growth and facilitates the safe and efficient movement of people and goods across the globe. As the demand for air traffic increases, new solutions must be developed to avoid an increase in costly air travel delays and the associated compromise of our ability as a nation to grow our economy. Congress tasked the Federal Aviation Administration (FAA) with creating the Next Generation Air Transportation System (NextGen) to accommodate the projected increase in demand for air traffic services. NextGen is designed to take advantage of the latest technologies, be flexible enough to accommodate new travel options, and be robust enough to handle a projected increase of up to three times the current level of operations. Recognizing the limits of a radar infrastructure, the FAA proposed a new surveillance system for the national airspace system (NAS). After 4 years of initial operational experience in Alaska, on September 9, 2005, the FAA selected Automatic Dependent Surveillance—Broadcast (ADS–B) as the preferred solution for meeting the future U.S. surveillance needs.

The improved accuracy and update rate of ADS–B in conjunction with other future NAS improvements will allow for an increase of capacity in the NAS. The additional information the system provides to both air traffic control (ATC) and flightcrews through cockpit displays will allow more efficient and safer flight. To achieve these benefits and to develop future applications based on the ADS–B infrastructure, all the aircraft in a given environment must be equipped with avionics that meet the stringent requirements for safe operation in dense U.S. airspace.

To develop, implement, and manage an ADS–B system, the FAA created the national Surveillance and Broadcast Services (SBS) Program Office within its Air Traffic Organization (ATO). The objective of the SBS Program Office is to develop a multi-segment, life cycle- managed, performance-based strategy that aligns with the NextGen vision and generates value for the NAS. Consistent with this goal and in conjunction with other agencies, the SBS Program Office is developing system requirements that meet the need for increased capacity, a comprehensive implementation plan, and a multifunctional backup strategy that can maintain surveillance in the event of a Global Positioning System (GPS) outage. The SBS program builds on the research, development, and safety work conducted by the Capstone Program Office operating ADS–B prototype technologies in Alaska and the Safe Flight 21 Office in the Continental United States.

The FAA intends to provide surveillance and broadcast services in all areas covered by radar today. To provide necessary ground infrastructure for these services, the FAA awarded a contract on August 30, 2007, to a team headed by ITT Corporation with options to extend over the lifecycle of the program. The ADS–B ground infrastructure acquisition has been structured as a multi-year, performance-based service contract under which the vendor will install, own, and maintain the equipment, and the FAA will purchase services in the same way it purchases telecommunications services today. The

FAA will define the services it requires and maintain ultimate control of the data that flows between the vendor's infrastructure, FAA facilities, and aircraft.

The initial scope of the SBS program includes two services (air-to-ground surveillance and traffic/flight information broadcast services) and support of five aircraft applications (enhanced visual acquisition, enhanced visual approaches[1], final approach and runway occupancy awareness, airport surface situational awareness, and conflict detection). The SBS program expects to support additional ADS–B applications in later phases of the program.

The FAA will manage the deployment of the above-listed services by segments. Each program segment has specific goals designed to provide a measured deployment of ADS–B. Figure 1 illustrates some of the key milestones the FAA must achieve to provide a NAS-wide ADS–B infrastructure.

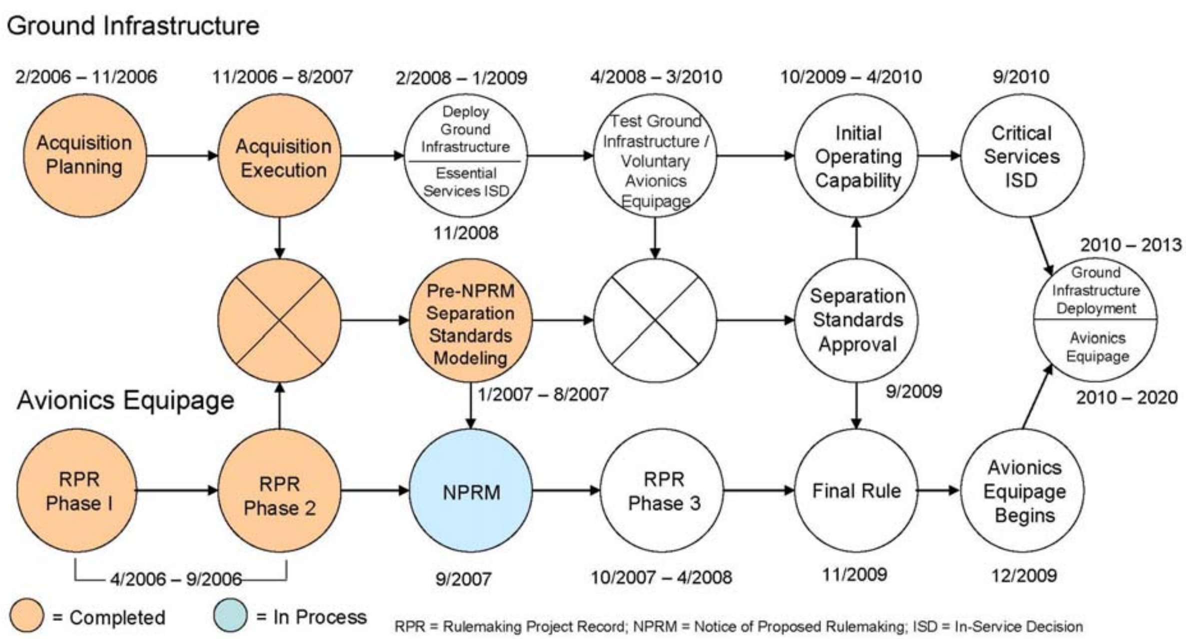


Figure 1—Segment 1 and 2 Milestones

The goal of segment 1 of the program is to prove the concepts of an end-to-end surveillance and broadcast services system. Segment 1 work already has begun and is scheduled to continue until September 2010. This effort includes the development of avionics standards for existing and future ADS–B avionics on both the 1090 ES and UAT datalinks. Development of a ground infrastructure specification, including both the development of ground stations and integration in ATC automation platforms is also part of segment 1. In addition, before a final rule can be issued and segment 2 of the program can commence, there must be approved ADS–B separation standards. Without this

[1] Merging and Spacing and Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS) are a part of the Enhanced Visual Approaches Application.

approval, aircraft cannot be separated from each other using ADS–B and the system would have limited benefit.

During segment 1 of the program, as discussed earlier, the SBS Program Office established a national contract with ITT Corporation to implement a ground infrastructure to support the surveillance and broadcast services applications. Segment 1 of the FAA's program also includes the issuance of a notice of proposed rulemaking (NPRM), which is intended to mandate ADS–B performance in aircraft, and the creation of an ADS–B Aviation Rulemaking Committee (ARC) (see the objective section of this report for further details on the ADS–B ARC). Segment 1 activities also include the completion of the technical analysis required to fully describe the end state broadcast services architecture.

Segment 2 of the program, currently scheduled to run from fiscal year 2009 through fiscal year 2014, includes the NAS-wide deployment of the ADS–B and broadcast services ground infrastructure. This effort includes the integration of the ADS–B system with existing surveillance systems and ATC automation platforms. Previous prototype equipment deployed along the U.S. east coast will be absorbed and expanded on with new equipment. Concurrent with this effort will be a proliferation of avionics equipage at operators who choose to equip in compliance with an expected ADS–B mandate for equipage (see expected rulemaking action section below) or earlier than the mandate requires. The ARC believes there are substantial benefits that could be accrued from early equipage in an optimal deployment of the ADS–B system. Also during segment 2, the FAA will develop future applications of the surveillance and broadcast services infrastructure based on an evaluation of those applications' values to NAS operators.

Expected Rulemaking Action

The ARC has not had any advance information concerning what the FAA will propose in its ADS–B NPRM. However, the ARC assumes that—

- The FAA's NPRM will establish the content and performance of the basic ADS–B Out message that will form the backbone for the evolving cooperative surveillance environment.
- The FAA will establish internationally recognized standards developed by RTCA as the baseline requirement for avionics equipage: DO–260A Change 2 (specifying the requirements for the 1090 MHz extended squitter (1090 ES) frequency) and DO–282A (specifying the requirements for the 978 MHz Universal Access Transceiver (UAT) frequency).
- While the FAA will mandate only ADS–B Out, it also will provide a set of services and applications that build from that core broadcast message to enable ground and limited air-to-air applications (ADS–B In).
- The FAA is establishing functional and performance equipment requirements for identified ADS–B In applications and services. In many cases, the ARC expects

that further applications and services will be defined by users who have specific operational requirements and who will apply for and seek approvals for those operations.

- ADS–B will enable many new and exciting opportunities for improved airspace operational efficiency, flexibility, and safety capabilities.

ADS–B System

ADS–B is an advanced system that uses a datalink to broadcast position and other information from aircraft to ground-based receivers and to other aircraft with receivers. This datalink enables a variety of capabilities on the aircraft and in ATC, as shown in figure 2 below.

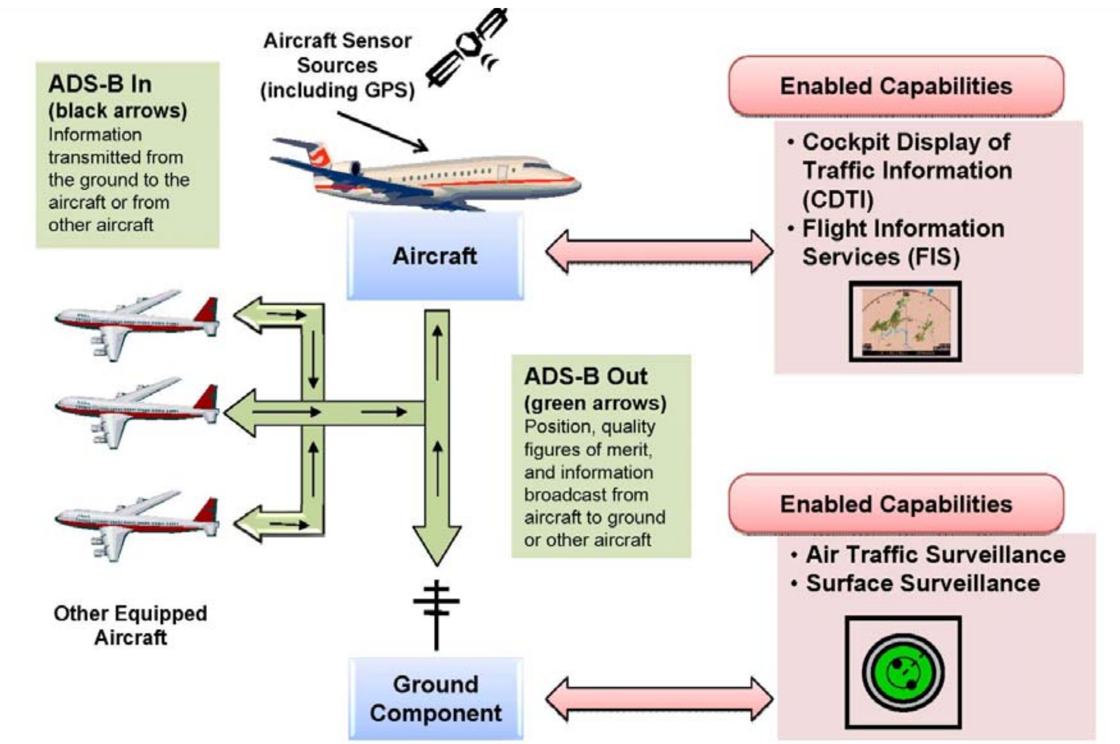


Figure 2—Overview of ADS–B System

The ADS–B system consists of two different functions: ADS– B Out and ADS–B In. The ability to transmit ADS–B messages is referred to as ADS–B Out. ADS–B Out allows for more accurate and timely surveillance as compared to existing primary and secondary radars but does not include the ability to receive, interpret, or display ADS–B signals. To derive the many benefits of the ADS–B system, including the ability for a flightcrew to have situational awareness of proximate traffic or to use other air-to-air applications, aircraft will need to be equipped with an avionics suite and display equipment. These capabilities are referred to as ADS–B In. Applications enabled by

ADS–B vary based on the characteristics of the particular ADS–B system implementation. However, they can generally be divided into capabilities on the aircraft and capabilities enabled on the ground.

Surveillance and broadcast services are expected to be provided by the FAA on two different frequencies, or broadcast links: the 1090 ES frequency and the UAT frequency. The 1090 ES link is more often employed by larger air transport category and air carrier aircraft, and the UAT link is generally used in general aviation aircraft. However, there are notable exceptions to these general guidelines, and providing an ADS–B receiver equipped to receive both links may provide additional value to operators. The ARC acknowledges that Flight Information Service–Broadcast (FIS–B) services cannot be provided on the 1090 ES link. Operators may want to consider examining the advantages of equipping with dual link receivers.

ADS–B Out

As shown in figure 3, using ADS–B Out, an aircraft periodically broadcasts its own sensor information through an onboard transceiver. The ADS–B signal can be received by other aircraft and by ground stations providing information to ATC and other aircraft. Included in this broadcast is the aircraft's flight identification, position (horizontal and vertical), velocity (horizontal and vertical), time, and various performance parameters. Depending on the source of the position information, there will be figures of merit for position precision and integrity. Standards for the information to be included in the ADS–B Out broadcast message are being developed incrementally so there are historical variants as well as projected enhancements. However, the ARC expects that the avionics and information necessary to perform ADS–B Out functions are going to be defined in the NPRM and will apply, subject only to the correction of any errors discovered through additional operational use, to the life cycle of the FAA's SBS program.

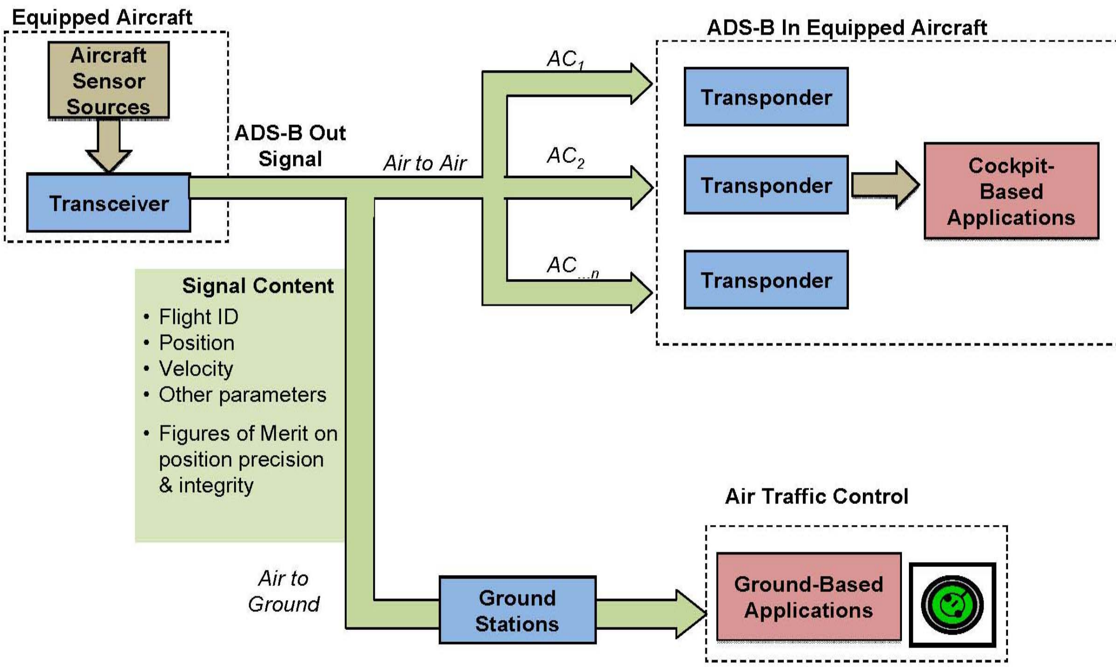


Figure 3—ADS–B Out Signal and Enabled Capabilities

ADS–B Out is automatic in the sense that no pilot or air traffic controller action is required for the information to be transmitted. It is dependent surveillance in the sense that the surveillance information depends on the navigation and broadcast capability of the source. As shown in figure 3, ADS–B Out is used by ATC for surveillance in a manner similar to the use of radar. The broadcast signal can also be received by other aircraft equipped with ADS–B In avionics (as discussed in the next section) to enable cockpit-based applications. Aircraft can be equipped with ADS–B Out without having ADS–B In capability.

ADS–B In

The ability to receive ADS–B signals from the ground and other aircraft, process those signals, and display traffic and information to flightcrews is referred to as ADS–B In, as illustrated in figure 4.

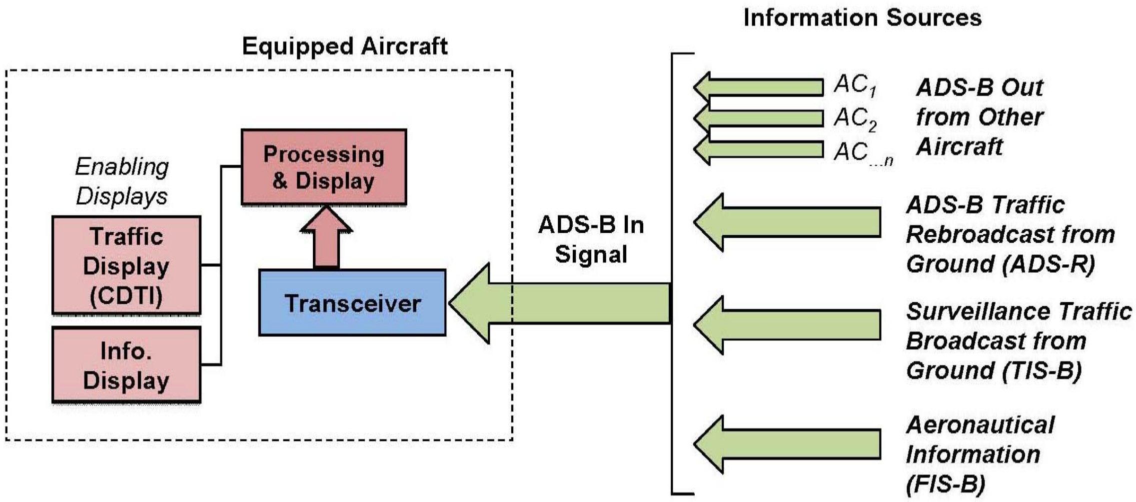


Figure 4—ADS–B in Signal Sources and Enabled Capabilities

As shown in figure 4, an ADS–B In-equipped aircraft can receive information from multiple sources. Achieving benefits from ADS–B In requires onboard processing of the ADS–B signal and integration with aircraft avionics. Processing of the ADS–B signal may be done in terms of a decision logic platform to generate warnings or may be presented on a variety of display platforms. ADS–B In complements ADS–B Out by providing pilots and aircraft navigation systems with advanced positioning information on other aircraft operating nearby. At the most basic level, ADS–B In enhances the flightcrew's situational awareness of other aircraft operating within their proximity with a high degree of precision. The full potential of ADS–B In would allow flightcrews to have situational awareness of the airspace around their aircraft and, independent of ground based systems, plot the most efficient flight path to their destination. All the while, ADS–B In-equipped aircraft would be avoiding other traffic, monitoring for collision potential, and deconflicting flight paths between aircraft.

ADS–B In will require the certification of new cockpit displays and consideration of pilot human factors as well as potential changes to operational procedures both in the cockpit and on the ground. Additionally, the FAA will need to make decisions about electronic flight bags (EFB) for pilots. ADS–B In will be a major element of the future surveillance technology mix in accordance with the International Civil Aviation Organization (ICAO) Global Air Navigation Plan. The FAA has not established performance standards for supplemental, essential, and critical services and applications for ADS–B In and the subsystems needed to support those expanded operations.

Automatic Dependent Surveillance – Rebroadcast (ADS–R)

To take advantage of all ADS–B In applications, flightcrews must have situational awareness that includes both aircraft that are not equipped with ADS–B and aircraft that are equipped with ADS–B but are transmitting on a different frequency. The ARC expects that air carrier and business aviation aircraft will mostly equip with 1090 ES, while general aviation aircraft will equip with UAT. Interoperability between the links would be provided by a service referred to as ADS–R through the ADS–B ground infrastructure.

ADS–R provides an optimized rebroadcast capability for presenting the UAT information to 1090 ES users and the 1090 ES information to UAT users, thereby filling in the total surveillance picture for presentation or processing onboard an aircraft. ADS–R is seen as a potentially critical function as it is intended to support most future ADS–B In functions in the United States. However, ADS–R currently has not been globally adopted. The ADS–R function would not be necessary for any aircraft equipped to receive both 1090 ES and UAT signals.

Traffic Information Service – Broadcast (TIS–B)

ADS–B is a cooperative surveillance environment that requires all users to participate to maximize operational benefits. During the transition period, when only some users have been able to equip with ADS–B, other systems will be necessary to provide the best available information to those seeking the total surveillance picture onboard an aircraft. The TIS–B service uses secondary surveillance radars and multilateration systems coupled with other sources to provide proximate traffic situational awareness, including position reports from aircraft not equipped with ADS–B. However, additional ground processing is necessary to create that information (including a measure of the accuracy and integrity of those messages), and source data may not be equivalent to ADS–B information provided by a participating aircraft. Therefore, the TIS–B signal is planned to be used only as an essential advisory service and not to be employed to separate or maneuver aircraft. The ARC expects that TIS–B will be phased out when all airspace users become cooperative participants in the ADS–B-served airspace via direct air-to-air ADS–B and ADS–R. See figure 5 for a prototype multifunctional aircraft cockpit display that shows both aircraft position reports derived directly from other ADS–B-equipped aircraft and from the TIS–B service (for those aircraft not equipped with ADS–B Out).

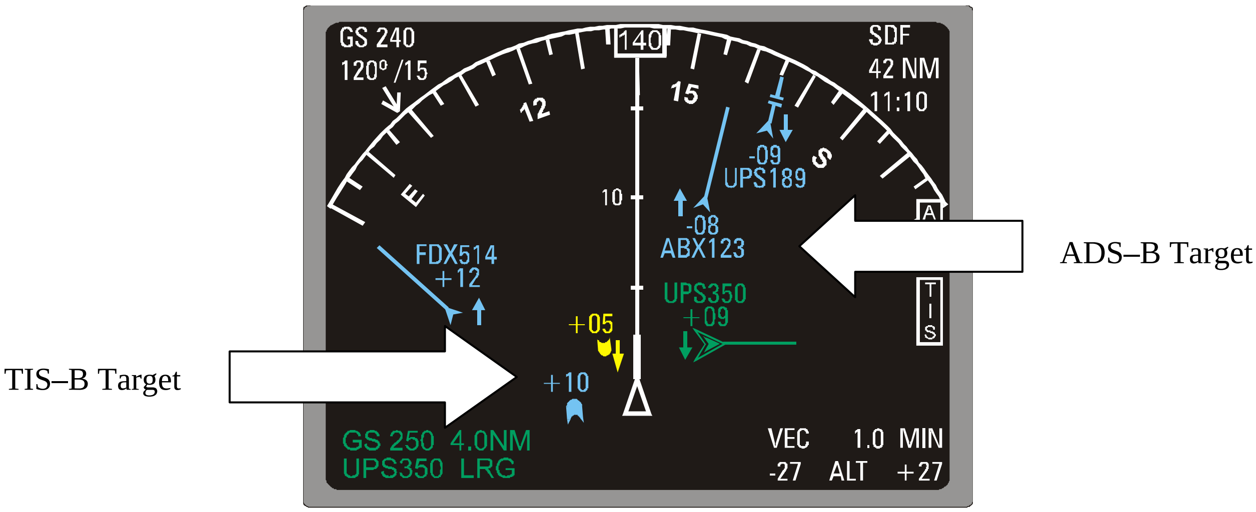


Figure 5—Prototype Traffic Display

Flight Information Service—Broadcast (FIS–B)

The FIS–B service is carried on the UAT channel and provides additional supplementary flight information. The FIS–B services are intended to provide enhanced weather services, textual and graphic weather and terrain information, Notices to Airmen (NOTAM), Temporary Flight Restrictions, and other flight information for processing and display in a single piece of avionics. For the general aviation user, this provides a single platform that will enhance safety through a broader suite of situational awareness services. See figure 6 for a prototype FIS–B aircraft cockpit display.

Figure 6—Prototype FIS–B Display

There has also been some interest expressed by the air transport community in using the FIS–B service to increase the real-time availability of weather data in the cockpit on 1090 ES-equipped aircraft — this would require the aircraft to be equipped with a UAT In capability.

ADS–B and Global Harmonization

ADS–B offers global aviation regulators the opportunity to create an integrated single sky for aircraft flying to international destinations. Through focused global harmonization efforts, aircraft could be enabled to fly the most fuel efficient routes between the world's airports. However, to fully leverage these benefits, U.S. and international regulators will need to agree to compatible equipment standards, interoperability rules, and comparable flight procedures for ADS–B technology. Done properly, this could result in seamless control of air traffic, which would be a technological leap over today's global patchwork of services and control facilities. With many nations on the verge of making critical ADS–B decisions, it is vitally important that all efforts be unified and coordinated.

The FAA, Joint Planning and Development Office (JPDO), ICAO, EUROCONTROL, the European Organization for Civil Aviation Equipment (EUROCAE), Airservices Australia, Japan Civil Aviation Authority, NAV CANADA, and RTCA are fostering the necessary international cooperation required for ADS–B interoperability through their support of the activities of joint standards workgroups. Additionally, several nations have traded key ADS–B subject matter experts to foster greater dialog and exchange concepts and new ideas for ADS–B planning. Such initiatives are defining for international stakeholders the issues related to aircraft equipment standards and air traffic management procedures.

Australia, Canada, and the European Union currently are using ADS–B operationally or demonstrating potential uses of ADS–B. China, Fiji, Hong Kong, India, Indonesia, Japan, Mongolia, New Zealand, Singapore, and Thailand are planning their own trials as well. The United States provided the first operational implementation of ADS–B through its Capstone program in Alaska in 2001 and has conducted ADS–B operational evaluations in the Ohio River Valley.

Australia currently uses ADS–B to provide radar-like separations in non-radar airspace at en route altitudes over much of the Australian continent. Australia will have 22 ADS–B ground stations commissioned by the end of 2007. Combined with the deployment of 6 stations in 2008 and 20 planned additional sites, Australia is on pace to have ADS–B coverage for its entire continental upper airspace. Australia has provided 383 aircraft with ADS–B service approval and has 80 additional aircraft pending approval. Australia has issued a final rule mandating ADS–B equipage in its continental upper airspace with a compliance date of June 2012.

By November 20, 2008, Canada's first ADS–B implementation will provide coverage over 250,000 square nautical miles of Hudson Bay. NAV CANADA projects that ADS–B equipped customers will save $200 million over 15 years. The next phases of the project will deploy ADS–B in the non-radar areas over Northern British Columbia, the Northwest Territories, and Nunavut.

EUROCONTROL's CASCADE is preparing a number of ADS–B Out and In applications for implementation in 2008 and 2011. CASCADE already has organized 11 airlines and 351 aircraft around activities to pioneer standardization, flight trials, and implementation activities, and expects to increase those numbers in Phase Two, which is already underway, to 20 airlines and 450 aircraft. Most likely the first ADS–B applications will be for ADS–B Out in non-radar environments around some secondary airports or between oil rigs and for ADS–B In in–trail procedures over the Atlantic Ocean. Implementation most likely will be voluntary using existing DO–260 certified avionics. An implementing rule is being prepared for ADS–B Out, which is expected to be published in April 2008. This rule is expected to mandate ADS–B Out equipage with DO–260A "change X" around 2015. No rule is expected to mandate ADS–B In.

In the United States, the FAA has been collaborating closely with the user community in developing and maturing ADS–B concepts. Capstone, a joint industry and FAA Alaskan Region effort, was initiated to improve aviation safety and efficiency by putting new technology avionics equipment into aircraft and providing the supporting ground infrastructure. The Capstone program equipped aircraft used by commercial operators in an accident prone area of Alaska with a Government-furnished global positioning system-based avionics package. In addition to the avionics suites, Capstone deployed equipment for improved weather observation, ADS–B ground stations, and flight information services. The FAA conducted a long-term operational evaluations in Alaska to get preliminary assessments of the costs, benefits, operational safety and security, and architectural requirements for ADS–B. The demonstration areas of the program were in a non-radar environment where most of the air carrier operations had been limited to visual flight rules operating conditions. In January 2001, the air traffic controllers in Anchorage, Alaska, were the first in the world to use ADS–B to provide instrument flight rules air traffic control services to Capstone-equipped aircraft in this non-radar demonstration area. Those services continue today. RTCA developed initial avionics standards for the system and refined the avionics standards (to the current level) in 2004 based on feedback from the Capstone operational experiences. As of 2005, Capstone has reduced the accident rate in that part of Alaska by 49 percent.

On December 22, 2006, the FAA announced that it would integrate the Alaska Capstone project into the national ADS–B program. ADS–B systems and services will continue to be deployed throughout Alaska as part of the nationwide rollout of ADS–B.

In the Ohio River Valley of the United States, the FAA has been working very closely with the Cargo Airline Association, and several other industry groups, to demonstrate and refine ADS–B concepts and applications. The initial activities included three operational demonstrations held from 1999 to 2001. Many applications were demonstrated using aircraft ranging from large transport category aircraft to small general aviation aircraft. Many of the aircraft were equipped with early ADS–B displays. Surface, air-to-air, air-to-ground, and ground-to-air applications were demonstrated. This was the foundational work that ultimately has led to the certification of the initial ADS–B applications and the ground breaking UPS applications of ADS–B being pursued today.

2.0 OBJECTIVE

Through the Air Traffic Management Advisory Committee (ATMAC), industry and user groups have expressed a desire to be more involved in the FAA's ADS–B rulemaking process. The FAA agreed that a wide scope of input would be beneficial to market and manage both the substantial benefits and significant costs of a nationwide ADS–B system. Therefore, on July 15, 2007, the FAA chartered the ADS–B ARC to—

> provide a forum for the U.S. aviation community to discuss and review a notice of proposed rulemaking [(NPRM)] for ADS–B, formulate recommendations on presenting and structuring an ADS–B mandate, and consider additional actions that may be necessary to implement those recommendations.

The ADS–B ARC will submit recommendations to the Administrator through the Chief Operating Officer, Air Traffic Organization.

Specifically, the ARC was given the following two tasks:

Task 1: While the NPRM is being finalized and leading up to its publication, the ARC will serve as a platform for developing a report on optimizing the operational benefits of ADS–B before the implementation of a nationwide ADS–B airspace rule.

Task 2: After publication of the NPRM, the ARC will make specific recommendations to the FAA concerning the proposed requirements based on the comments submitted to the NPRM docket.

This report, completed under task 1, will explain the operational benefits of ADS–B and provide recommendations to the FAA on how to optimize these benefits to NAS users through the equipage of ADS–B before the proposed compliance date.

3.0 OPERATIONAL BENEFITS

Section 3.1 Obtaining Early Operational Benefits from ADS–B with Existing Aircraft Equipage that Will Not Be Compliant with the Technical Standards of the Proposed ADS–B Rule

Introduction

As detailed in appendix C, over 5,000 transport category aircraft are equipped with ADS–B avionics for the 1090 ES. The ADS–B avionics of these aircraft, which were implemented but not certified to the requirements of the initial 1090 ES ADS–B standard (RTCA DO–260) most likely will not be compliant with the proposed ADS–B rule, which is expected to be based on a later version of the 1090 ES ADS–B standards, RTCA DO–260A Change 3. See appendix C for more information on the versions of DO–260.

Figure 7 below represents a sample of reports on ADS–B equipage collected by the FAA. It cannot be established whether the aircraft listed as being ADS–B-equipped have ADS–B installations that are compliant with any particular ADS–B data link standard. What figure 7 demonstrates is a level of interest in ADS–B equipage and an early movement by aircraft suppliers to provide an ADS–B capability.

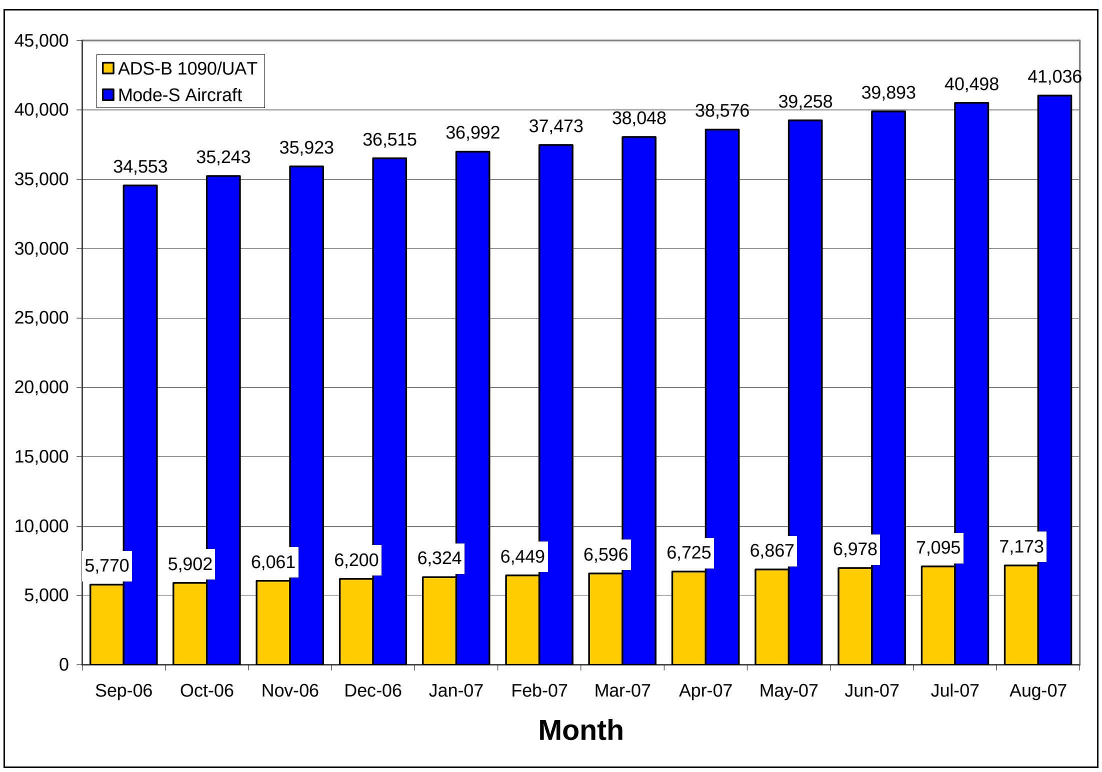


Figure 7—Report on Aircraft Equipage (Graphic of Active Mode S and ADS–B Aircraft/Vehicles — All Sites)

As of September 2007, Australia offers aircraft that demonstrate sufficient compliance with DO–260 ADS–B-based surveillance services with 5 nautical miles (radar-like) separation in the upper airspace. These aircraft also are candidates to participate in the ADS–B-based EUROCONTROL CASCADE Pioneer Program. Additionally, Canada is planning to offer operational benefits to such aircraft over Hudson Bay.

To provide early ADS–B benefits and, from realization of those benefits, incentivize early equipage with avionics compliant with the NPRM, this report recommends that the FAA and the aviation community pursue opportunities for aircraft with existing DO–260-based avionics to receive operational benefits from ADS–B. These operational benefits would be limited in scope and less than those for aircraft equipped with ADS–B avionics compliant with the proposed rule, and would only be obtained before the compliance date for the proposed rule. Nonetheless, these benefits would provide an initial step toward the benefits of ADS–B with existing avionics, provide additional early credibility to the U.S. ADS–B implementation program, and incentivize equipage with DO–260A Change 3 avionics to obtain much broader benefits than those actually realized with DO–260.

ADS–B Out Benefits

Sharing ADS–B information with third parties could be an early commercially valuable application. If an ADS–B position reports database could be compiled on operations for a particular fleet of aircraft, that monitoring would provide a valuable analysis tool for optimizing fleet management practices. The use of ADS–B analysis at flight schools already has been demonstrated and should continue as flightcrews transition to an ADS–B surveillance environment.

DO–260 1090 ES Avionics

Many transport category aircraft have been delivered with DO–260-capable Mode S transponders or have been upgraded to DO–260-capable transponders for a number of reasons, primarily to satisfy European elementary and enhanced surveillance requirements. Typically, these transponders will broadcast ADS–B if they have a position input. In some installations, the position input only was available to the ADS–B-capable transponder from the flight management system, not from the global positioning system (GPS) source. Consequently, the messages broadcast are not useable for any of the identified ADS–B applications because the accuracy and quality parameters are insufficient. In addition, the various Mode S transponder manufacturers interpreted 1090 ES requirements differently, resulting in inconsistent parameters being broadcast.

After Australia levied firm requirements for DO–260-based 1090 ES avionics, all problem Mode S transponders with DO–260-based 1090 ES now have service bulletins that correct the inconsistencies. However, there is no process, except for those aircraft transiting Australian airspace and for the emerging CASCADE Pioneer Program in Europe, that requires the service bulletins to be installed or for operators to correct any wiring problems between aircraft sources of ADS–B data and the ADS–B avionics of those aircraft. In addition to ground automation requirements discussed later, there will have to be a process to ensure all DO–260-based Mode S transponders with ADS–B capability are broadcasting properly calculated performance measures, because there is no way for ground systems to know.

For all the applications in appendix B that are noted to be realizable with DO–260-based avionics, the fusion of surveillance sources in the ATC automation system is assumed. A primary reason that fusion is needed is the lack of the 4096 code as a message parameter in the DO–260 ADS–B message set (resolved with DO–260A). The current terminal and en route surveillance/automation systems in the United States have no way of associating an aircraft with a flight plan except by use of a 4096 code. To use DO–260 ADS–B avionics, a method would have to be established to associate a DO–260 ADS–B message with a flight plan. This could be done in the fusion process. Such a fusion approach alone, however, could limit the identified ADS–B benefits to a radar environment. Almost all of the interim potential ADS–B benefits for DO–260 1090 ES ADS–B equipage that have been identified are in the radar environment, with the exception of the Gulf of Mexico (see the discussion below). It may be possible to associate an aircraft with its flight plan in the radar environment and carry that association when the aircraft enters the non-radar airspace of the Gulf of Mexico.

To realize the benefits noted as achievable in appendix B by DO–260-based ADS–B-equipped aircraft, the following two key conditions must be met:

- The FAA must develop a process to ensure (1) all DO–260-based equipment properly calculate performance parameters and (2) the equipment is properly integrated (for example, correctly wired to appropriate aircraft data sources) into the aircraft to ensure sufficient compliance with DO–260.

- The FAA must develop a method to associate a flight plan with ADS–B messages from a DO–260-equipped aircraft.

The FAA needs to examine the timing and expense of meeting these conditions to assess the viability of providing operational benefits to DO–260-equipped aircraft.

The ARC notes that a further consideration for operators is the cost of any DO–260-compliance service bulletin (such cost being highly specific to the particular DO–260-based Mode S transponder manufacturer and the aircraft integration of that transponder) versus the cost of a DO–260A Change 3 service bulletin and the associated time and processes involved before DO–260 is chosen as an interim solution to achieve limited ADS–B benefits until the mandate date (as opposed to a direct upgrade to DO–260A Change 3 to obtain larger benefits).

An Opportunity for Initial ADS–B Benefits with DO–260-based Avionics: ADS–B in the Gulf of Mexico

The oceanic operations in the Gulf of Mexico region have increased from 61,000 operations in 1996 to 100,000 operations in 2005. It is estimated that traffic will reach 119,000 operations in 2007. Traffic management initiatives are routinely used to manage the high traffic volume in this constrained airspace. Because of limited availability of radar coverage, the north-south traffic has to be cleared via non-radar routings (15 minutes in-trail unless compatible speeds, then 10 minutes in-trail). The communication between flightcrews and air traffic controllers is limited and at times is unreliable.

The ARC finds that the initial benefits of ADS–B implementation in the Gulf of Mexico would be more north-south routings and, with DO–260 equipment, the separation between aircraft might be reduced to 10 nautical miles or less. As aircraft become equipped with DO–260A Change 3 equipment, it will be possible to reduce the separation to 5 nautical miles or maybe even 3 nautical miles between aircraft, thus providing additional capacity. The ability to provide radar-type separation also will enable aircraft to use area navigation (RNAV) routes that increase fuel efficiency and allow more direct routings. The ARC notes that these routes should be available when initial ADS–B procedures are be implemented in 2010.

If ATC facilities south of the Gulf of Mexico equip with ADS–B, there will be an increased handoff capability at all altitudes. This also will enable enhanced automated flight plan information exchange between the United States and Mexico.

ADS–B will provide the ability to improve service to the helicopters flying to the oil platforms in the Gulf of Mexico by providing ATC surveillance at low altitudes well beyond the current radar coverage. This will allow the helicopter operators to receive instrument flight rules (IFR) ATC services, thus providing them with improved operations during IFR conditions and improving overall safety. The helicopter operators may also benefit from improved fleet tracking as well as weather in the cockpit (FIS–B) services.

There are several issues that will affect the implementation of ADS–B in the Gulf of Mexico. ADS–B-aircraft equipage will play a very important role as some users may not see enough benefit to equip their fleet before any mandate. Separation between mixed equipped aircraft may result in the need for exclusionary altitudes for non-equipped aircraft. (The mixed equipage issue between DO–260 and DO–260A will end in 2020 when DO–260 is phased out.)

There also may be a need to track the installation of DO–260-based ADS–B equipment to specific aircraft registration, as discussed in the section on DO–260 section above. Additionally, a solution will need to be implemented to associate a DO–260-equipped aircraft in non-radar airspace with a flight plan, as also discussed in the section above.

ADS–B implementation in the Gulf of Mexico will result in more aircraft that may require more air traffic sectors and additional controllers.

There are known benefits of ADS–B installation in the Gulf of Mexico, and this report recommends that the potential provision of partial ADS–B benefits to DO–260-equipped aircraft be aggressively studied and, if feasible, implemented.

One potential use of the DO–260 standard avionics is a reduction in separation in non-radar areas such as the Gulf of Mexico. While the DO–260 standard is not likely to be certified for aircraft separation at the same level as the DO–260A standard, some incremental benefits could be accrued by certifying DO–260 avionics for a separation standard that would still improve capacity in the non-radar area of the Gulf of Mexico.

Currently, air traffic controllers use forms of procedural separation at both high and low altitudes in the Gulf of Mexico. These procedures dictate that aircraft must be kept far apart to maintain a high level of safety; at high altitudes the standard separation is 15 minutes, which is equivalent to approximately 120 nautical miles (see figure 8 below).

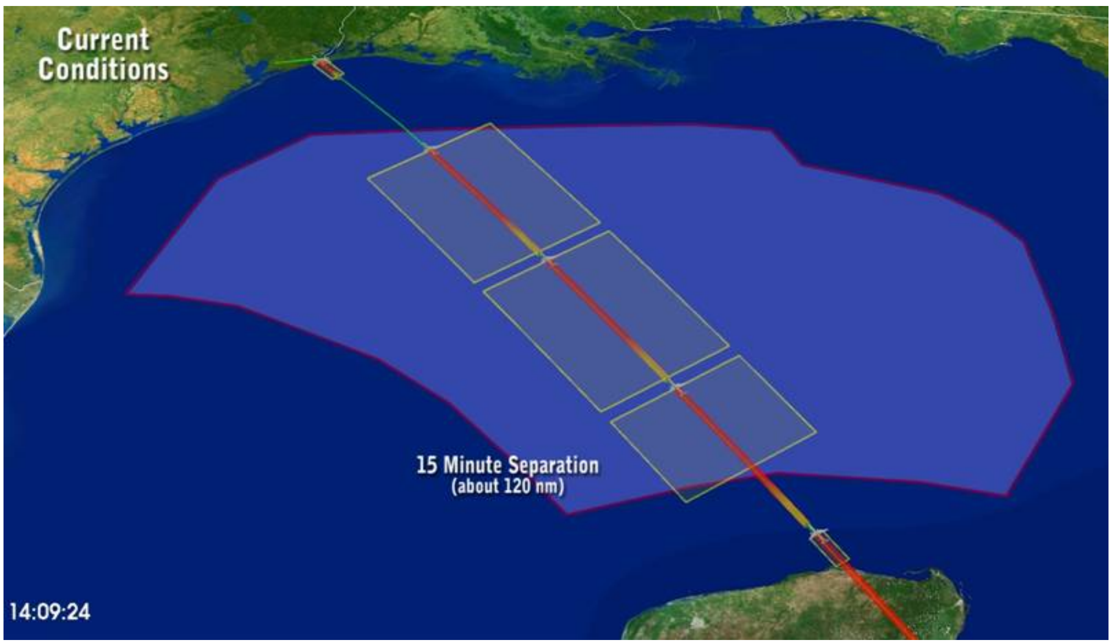


Figure 8—Current Procedural Separation in the Gulf of Mexico

If ATC were supplied with some form of surveillance, aircraft could fly closer together without compromising safety. ADS–B In capability would not necessarily be required to achieve a reduction in separation standards, as the responsibility of separating aircraft would still lie with the air traffic controllers. Figure 9 gives a national depiction of how a transition to surveillance-based ATC procedures could increase the efficiency and capacity of non-radar airspace like that in the Gulf of Mexico.

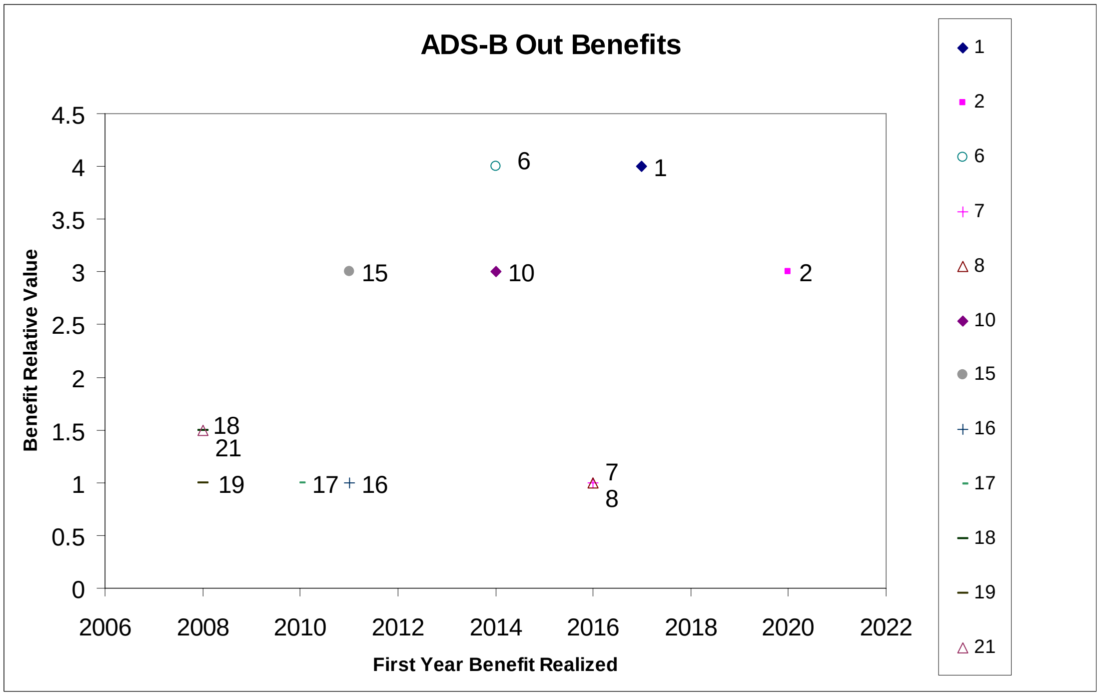
Figure 9—Possible Enabling of Radar-Like Separation Using ADS–B

International coordination still would be necessary to ensure optimal use of north-south routes, but U.S. ATC could take advantage of east-west routes to provide a more direct routing between major transport hubs. This benefit could probably not be achieved in an environment with aircraft not equipped with DO–260A avionics. If the FAA were to establish a preferential routing system based on level of equipage, it would incentivize early equipage with ADS–B-compliant avionics and allow a protected environment for those who equip to derive maximum benefits from their avionics suite.

Section 3.2 Obtaining Operational Benefits from ADS–B Out in Compliance with the Expected Mandate (DO–260A Out and DO–282A Out)

ADS–B Out Benefits

ADS–B test bed areas such as Alaska and Louisville International Airport already have made use of procedures and routes that have been made available by ADS–B. Some of these benefits might be transferred to the NAS as the nationwide level of equipage increases. Table 1 describes the relative value and anticipated benefit accrual dates for ADS–B Out benefits.



Legend	Benefit
1	Improve en route conflict probe.
2	Improve traffic management advisor.
6	More efficient merging and spacing because of increased surveillance (quantified in SBS Program business model. Benefit first realized in 2014 for NAS (includes 2008 for UPS)).
7	ATC surface management.
8	ATC surface safety.
10	Surveillance cost avoidance.
15	Radar-like IFR separation (en route/oceanic).
16	Optimal routing (Gulf).
17	Access to lower routes (Alaska only).
18	Increased VFR flight following (Alaska only).
19	Improved search and rescue (Alaska only).
21	Gate-to-gate company flight tracking (Alaska only).

Table 1—Benefit Accrual for ADS–B Out Benefits[2]

The ADS–B Out performance requirement expected to be mandated by the FAA provides substantial performance improvements compared to most existing surveillance systems. The benefits that accrue from the improved accuracy and update rate of the ADS–B system can result in a wider array of service availability for individual operators in addition to providing the national airspace capacity necessary to meet increasing demand for air travel.

[2] Benefit relative value key in present value measured in millions of dollars: 1 = <$100M; 2 = $100M to $300M; 3 = $300M to $500M, 4 = >$500M.

Because ADS–B ground units are smaller and easier to deploy than a conventional radar system, it likely will become cost effective to expand the existing air traffic surveillance coverage in the NAS. Radar-like services, such as aircraft separation, already have been provided in the State of Alaska, where placement of primary radar systems was impractical. The FAA should investigate a similar expansion of services into non-radar airspace in the NAS as a whole.

Because ADS–B transmits a signal directly from the aircraft, ADS–B Out also provides some safety benefits in terms of an additional tool for search and rescue. The FAA should evaluate whether ADS–B can be used as a replacement for existing safety requirements, such as the emergency locator transmitter (ELT).

Many high value flight procedures that are unavailable or rarely used today because of he technological constraints of radar could be enabled with ADS–B Out. For example, ADS–B Out coupled with a tool imbedded in ATC automation systems could allow for existing separation standards to be employed without the need for air traffic controllers to include extra separation to compensate for radar inaccuracies. Successful integration of ADS–B into existing automation systems could also enable improved ATC-based merging and spacing procedures and surface situational awareness for controllers that does not exist at many airports today.

ATC-Based Merging and Spacing Benefit Example

ATC-based merging and spacing is enabled by the ADS–B Out improved update rate and accuracy at range from a receiver over primary radar. Air traffic controllers will be able to issue speed and heading directions farther out from the airport runway, decreasing the need for large adjustments in heading and speed, which increase noise and decrease potential efficiency of operations and fuel savings.

This benefit can be accrued through modification of air traffic control automation systems to employ Airline Based En Route Sequencing and Spacing tool, enabling ATC-based merging and spacing operations in medium density airspace. High-density merging and spacing operations could be enabled using ADS–B In technology and additional NextGen systems (see section 3.4).

Some of the benefits that may be derived from the ATC-based merging and spacing applications include a reduction in high speed/high altitude vectoring, communication, workload, fuel burn, noise, time and distance flown. Figure 10 below provides a notional example of merging and spacing approximate distances at Louisville International Airport.

Figure 10—Notional Depiction of Merging and Spacing

Current DO–282A Equipage

Table 2 shows figures for aircraft currently equipped with DO–282A standard compliant avionics in specific areas. A broader sense of the level of equipage could be inferred from figure 7 in section 3.1 of this report.

Table 2—Aircraft Equipped with DO–282A Standard Compliant Avionics

Region	No. of Airplanes Equipped
Alaska	375
North Carolina	25
Washington DC Region	20
Embry Riddle (Arizona and Florida)	78
University of North Dakota	62

Further Separation Reduction with DO–260A-compliant Avionics

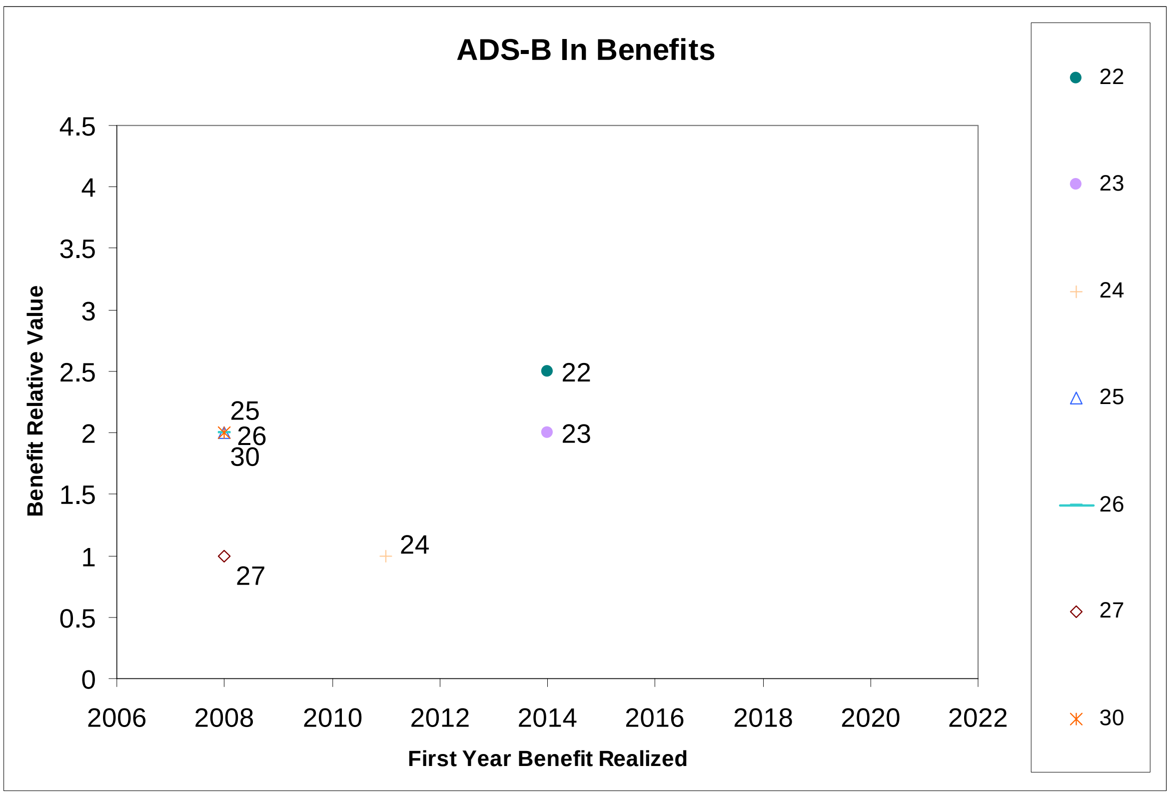
As discussed in section 3.1 of this report, aircraft separation could be reduced in the Gulf of Mexico because of the new surveillance capability supplied by ADS–B. The additional avionics and system level integrity parameters provided by DO–260A compliant avionics should allow for a smaller margin of error around the position reports from an aircraft and therefore more closely spaced aircraft at the target level of safety. Figures 8 and 9 in section 3.1 of this report illustrate the notional effects of improving upon existing procedural separation methods.

The FAA is pursuing separation standards for ADS–B mandate compliant avionics that are equivalent to the en route and terminal standards that exist with radar today. Once those standards are complete, a reduction in separation standards might be possible and should be pursued in the Gulf of Mexico and elsewhere in the NAS. Once the separation standards work has been completed, aircraft could be separated at 5 nautical miles in much the same way as they are handled in most en route airspace today.

Section 3.3 Available and Potential Benefits of ADS–B In

ADS–B In Benefits

The relative value of some of the ADS–B applications, including an estimate of when benefits should begin accrual under the current FAA program plan, is displayed in table 3 below.



Legend	Benefit[3]
22	More efficient spacing during visual approaches (quantified in SBS Program business model. Benefit first realized in 2014 for NAS (includes 2009 for UPS)).
23	Continuation of visual approach in marginal conditions (quantified in SBS Program business model. Benefit first realized in 2014 for NAS (includes 2009 for UPS)).
24	Increased surface safety.
25	Fewer aircraft-to-aircraft conflicts.
26	Fewer weather-related accidents.

[3] All values derived from potential ADS–B In and Out benefits, SBS scope, and existing technical standard orders.

Legend	Benefit[3]
27	More efficient route in adverse weather.
30	Fewer CFIT accidents (increased equipage).

Table 3—ADS–B In Benefits Accrual[4]

See appendix B for benefits and applications associated with DO–260A ADS–B In early equipage. These FAA-funded applications are not the only ones identified as being of value to users.

ADS–B In Applications

ADS–B In capability would enable a display of the TIS–B and FIS–B services and a platform for other situational awareness applications. These applications provide benefits to operators who choose to equip with DO–282A- or DO–260A-compliant ADS–B In capability in addition to the expected mandate of ADS–B Out. NAS users should be able to begin accruing these benefits as soon as they equip with ADS–B In, regardless of the equipage level of other aircraft. Brief descriptions of the applications are included below.

Airport Surface Situational Awareness

The objective of this application is to reduce the potential for deviations, errors, and collisions through an increase in flightcrew situational awareness while operating an aircraft on the airport movement area. Flightcrews will use a cockpit display to increase awareness of other traffic positions on the airport movement area. Additionally, the display could be used to determine the position of ground vehicles, for example, snow plows, emergency vehicles, tugs, follow-me vehicles, and airport maintenance vehicles.

Final Approach and Runway Occupancy Awareness

The objective of this application is to reduce the likelihood of flightcrew errors associated with runway occupancy and to improve the capability of the flightcrew to detect ATC errors. The application involves the use of a cockpit display that depicts the runway environment and displays traffic from the surface up to approximately 1,000 feet above ground level on final approach and will be used by the flightcrew to help determine runway occupancy. Figure 11 below depicts a prototype display of this function.

[4] Benefit relative value key in present value measured in millions of dollars: 1 = <$100M; 2 = $100M to $300M; 3 = $300M to $500M, 4 = >$500M

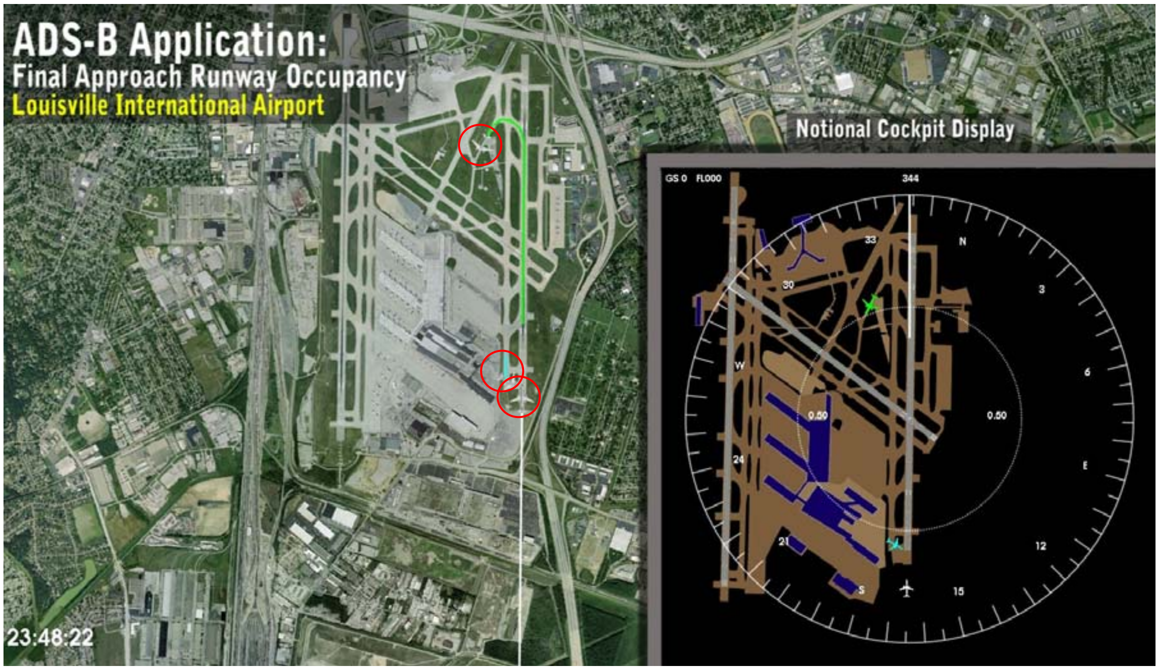


Figure 11—Prototype display of Runway Occupancy

Enhanced Visual Acquisition

The objective of this application is to provide the flightcrew with enhanced traffic situational awareness in controlled and uncontrolled airspace and airports. The application uses a cockpit display to enhance out-of-the-window visual acquisition of air traffic. Flightcrews will refer to the display during the instrument scan to supplement visual observations. The display can be used t either o initially detect an aircraft or to receive further information on an aircraft that has been reported by ATC. The application provides the flightcrew with the relative range, altitude, and bearing of other aircraft.

Enhanced Visual Approach

This application is intended to enhance successive approaches for aircraft cleared to maintain visual separation from another aircraft on the approach. The goal is to maintain visual approach procedure operation arrival rates even during periods of reduced visibility or obstructions to vision (for example, haze, fog, and sunlight). To achieve this objective, flightcrews will be supported by a cockpit display of nearby traffic. This will provide continually updated identity and position information to assist the flightcrew with achieving and maintaining visual contact with relevant traffic. Additional information such as range and speed will be provided to assist flightcrews in monitoring their distance from the preceding aircraft. The display may also be used to monitor aircraft on approach to parallel runways. A prototype of this display function is shown in figure 12.

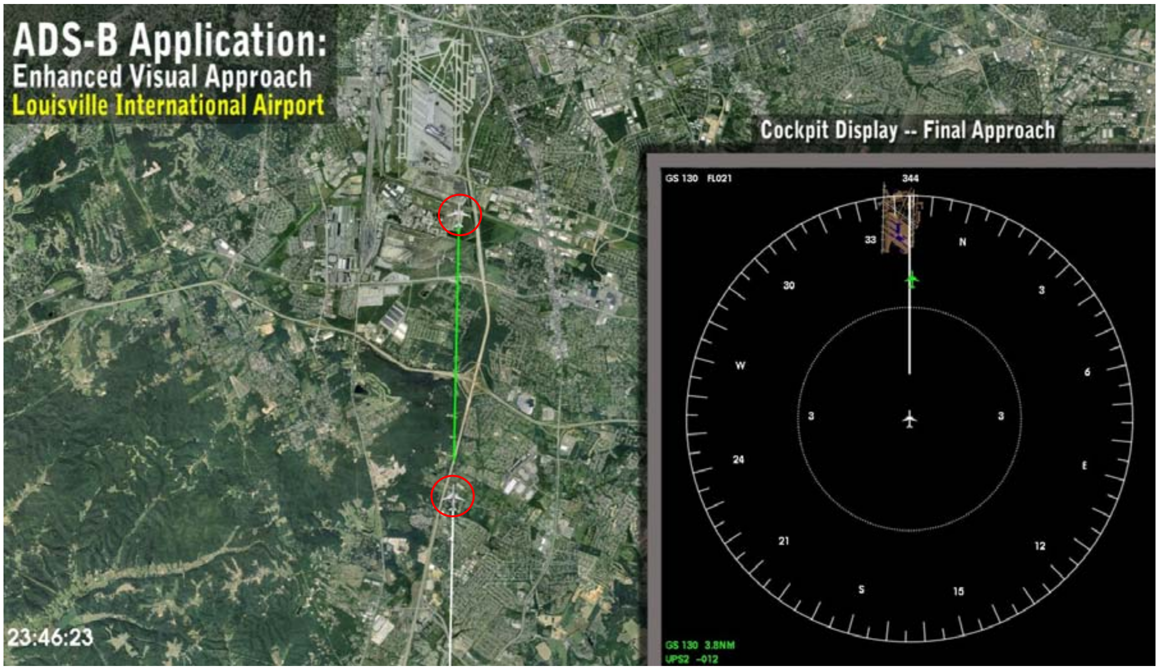


Figure 12—Prototype Display of Enhanced Visual Approach Application

Conflict Detection

The objective of the application is to provide alerting and relevant traffic information to help the flightcrew identify conflicts with other aircraft based on current flight status and intentions. Aircraft equipped with a cockpit display have the capability to display aircraft location. More than simply displaying traffic, the application will alert flightcrews to developing conflicts. Also, the long surveillance range afforded by ADS–B will enable alerts to be issued in time to solve the conflict with minimum disruption to the flight path.

> **NOTE: The conflict detection application is intended by the FAA to be an advisory ADS–B-enabled capability for properly equipped aircraft and is not intended as a traffic collision avoidance system replacement.**

In addition to the above-described applications (enhanced visual acquisition and conflict detection), the FAA will provide the data necessary to enhance see-and-avoid capability for aircraft that are not broadcasting an ADS–B message via TIS–B service available above 6,000 feet NAS-wide and even lower in the vicinity of the service broadcast points.

CDTI Assisted Visual Separation (CAVS)

ADS–B In technology could also enable the continuation of visual approaches in circumstances that would dictate their termination today. Termination of a visual approach because of an aircraft losing visual contact of another aircraft because of factors other than IFR conditions is a relatively frequent occurrence that entails additional delays, fuel burn, and arrival inefficiency. The FAA is researching and developing CAVS to enable the continuation of visual approaches through the use of a cockpit display.

During a CAVS procedure (see figure 13), an air traffic controller would provide a traffic advisory at the time a flightcrew could get an initial out-the-window acquisition of an aircraft arriving ahead of them and correlate the position of the aircraft with a cockpit display of traffic information (CDTI). If the flightcrew were granted a clearance for visual separation and the air traffic controller were aware of their ADS–B In level of equipage, the flightcrew could be given clearance to maintain a visual separation even if the aircraft they are following is lost in glare, city lights, or other types of view obstructions. Once the lead aircraft is lost out-the-window, the CDTI would be used to maintain separation until landing. The types of environments where a CAVS can be made available would need to be fully defined to make use of this application.

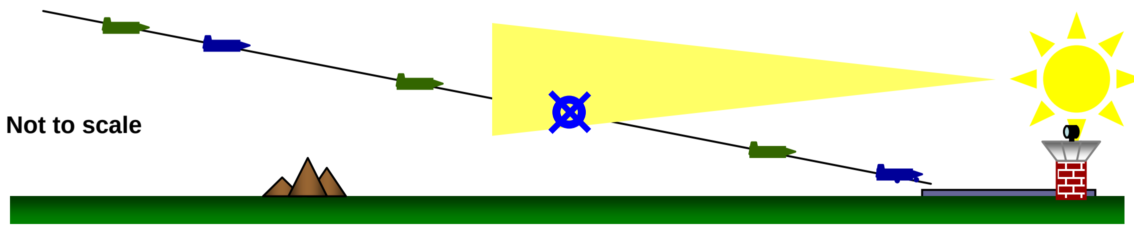


Figure 13—Notional Depiction of CAVS

Aircraft-Based Merging and Spacing

Aircraft-based merging and spacing in high-density airspace is enabled by the ADS–B In functionality and builds on the earlier-described ATC-based merging and spacing. In this application, the air traffic service provider supplies an aircraft with direction on which aircraft to follow, and time interval space behind that aircraft. This information is loaded into aircraft systems, with flightcrew awareness and approval, and the flightcrew would use onboard speed advisories from en route through CDA to landing.

In-trail Procedures

Another application that may provide increased value to operators traveling in en route airspace is the development of in-trail procedures during flight that would enable aircraft to adjust their altitude to pass each other even when there is no radar surveillance available. In today’s environment, an air traffic controller separates aircraft based on information derived from equipment onboard an aircraft and relayed to them by a flightcrew. See figure 14 below.

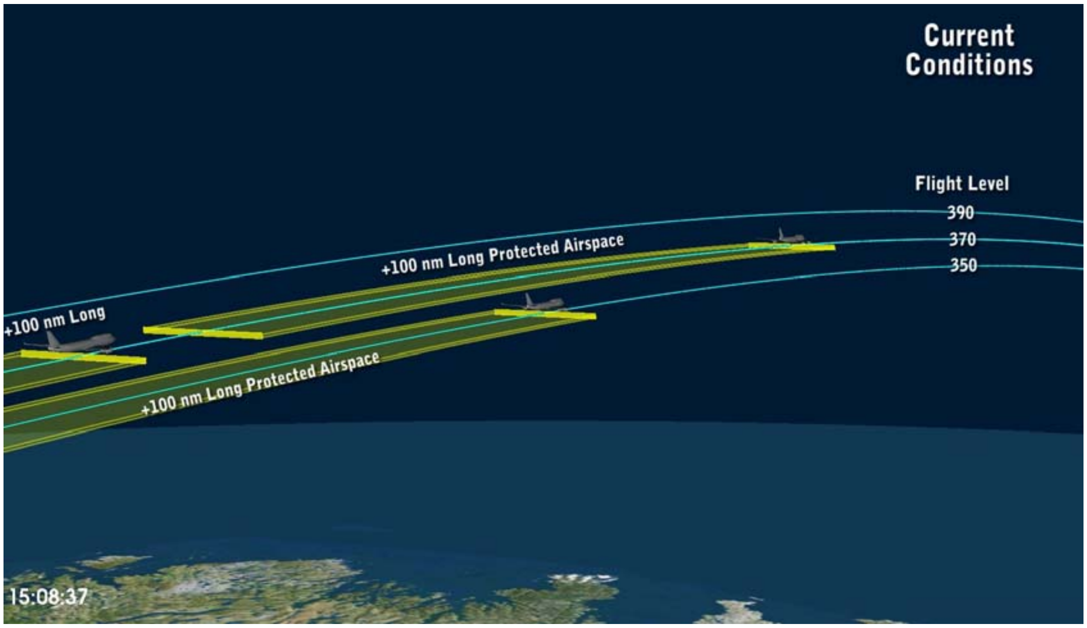


Figure 14—Current Oceanic Non-Radar Procedure

Aircraft equipped with ADS–B In functionality will receive ADS–B data from surrounding aircraft, and use a cockpit display and software that provide data that qualify the aircraft to arrange an in-trail passing procedure with ATC. See figure 15 below. The flightcrew would request, and the air traffic controller may approve, a flight level change based on information derived in the cockpit and the air traffic controller's awareness of the traffic picture. No direct airborne monitoring from ATC during the adjustment would be required. The air traffic controller would retain responsibility for separation, but safety would be maintained based on the information provided by ADS–B. The procedural separation provided today in non-radar en route airspace does not provide ATC with sufficient information on aircraft position to allow this type of procedure to occur. Increased availability of in-trail procedures would provide increased efficiency and safety (for example, fuel savings and avoiding turbulent flight levels).

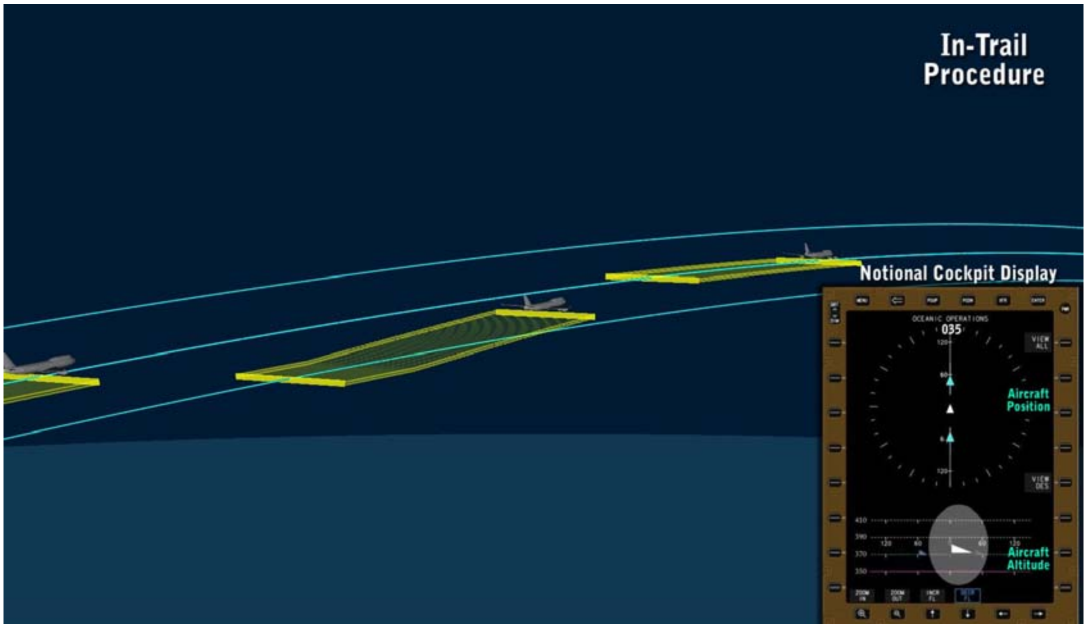


Figure 15—ADS–B Enabled In-Trail Procedure

Other ADS–B In Applications

ADS–B In capability on an aircraft coupled with a display function sets a platform for the development of a wide array of services that could be developed by the Government or by industry to provide flight services directly to the cockpit.

FIS–B Applications

The FIS–B is enabled by UAT data link and is not related to DO–260 or DO–260A standards. The primary objective of FIS–B is to provide flightcrews with improved access to weather information and aeronautical data. The data will be provided in-flight directly to the cockpit to enhance flightcrew situational awareness. The focus in the FIS–B application is improved access to standard text weather products (for example, Metrological Aviation Report, Terminal Aerodrome Forecasts, Significant Meteorological Advisory, and Pilot (weather) Reports), as well as standard graphical products (for example, next generation weather radar depictions).

While the FAA is focused on providing elementary weather products in the near future, it is envisioned that the program will evolve to provide flightcrew with enhanced weather and aeronautical data. As a result, the flightcrew will have better information on such hazards as icing, turbulence, and volcanic ash. Based on this information, flightcrew will have the ability to make better in-flight decisions, including better strategies for avoidance of areas of hazardous weather and, thereby, reduce the frequency of weather-related accidents.

In addition to safety considerations, the efficiency of flight operations also can be increased with improved access to weather information. Next generation weather radar graphics will offer the opportunity to make earlier decisions for deviations around some convective weather hazards, and provide a better characterization of all convective weather hazards.

Better and timely access to weather information via FIS–B also reduces the risk of operator deviations and landing at an alternate airport because of unknown or uncertain weather conditions at the intended destination airport. This leads to the benefit of reduction in unnecessary cancellations and diversions during marginal weather conditions.

Controlled-flight-into-terrain (CFIT) accidents are defined as those in which the flightcrew inadvertently allows the aircraft to strike terrain, a water surface, or an obstacle, even though the aircraft is under his or her full control. In almost all cases, these accidents are attributable, to some extent, to the flightcrew's lack of awareness of the aircraft's altitude relative to proximate terrain and obstacles. CFIT accidents usually occur during flight conditions in which the flightcrew cannot visually ascertain terrain or obstacle clearance (for example, visual obscuration from fog, clouds, or precipitation; nighttime with unlighted terrain features; and poor contrast in the landscape because of snow and glassy water surfaces).

A basic objective of the FAA is to provide flightcrew who are operating aircraft not included under the Terrain Awareness and Warning System (TAWS) mandate (aircraft with fewer than six passenger seats, which account for over 90 percent of aircraft in the continental United States) with a safe and cost-effective means to be aware of the aircraft's altitude with respect to the surrounding terrain. The focus is on the display of the navigation situation and terrain information. The equipment also provides an alerting function that monitors terrain clearance and issues an appropriate warning to the flightcrew if inadequate terrain clearance is anticipated. The latter is an enhancement over TAWS that provides incremental benefits for aircraft already equipped with TAWS.

Another FIS–B service that offers a user benefit is the uplink and appropriate display of NOTAM information. Critical information such as temporary flight restrictions and runway closures are provided to users via NOTAMs. Timely NOTAM information that is easily accessible to users is expected to reduce aviation accidents and incidents.

DO–282 Equipage

The improved surveillance capability of the ADS–B system may provide an increase in the type and availability of high-efficiency operations in the NAS. However, those aggregate benefits are not expected to accrue at levels that would be of substantial value to an individual user until a high level of equipage has been achieved. However, there will be a variety of services available immediately to users to who choose to equip with ADS–B In technology. In areas where multiple aircraft have been equipped with ADS–B In, there may also exist a potential to employ advanced air-to-air applications (see section 3.4). Those air-to-air applications will be available to ADS–B In users regardless of what link they are transmitting on. The broadcast services of TIS–B and FIS–B are only available on the UAT datalink. Since 2003, aircraft equipped with UAT have benefited from receiving traffic, weather, terrain, and flight information data.

Equipage Sensitivity Analysis

The value of the above applications to different user groups has been estimated by the FAA. The sensitivity analysis the FAA conducted in support of this report revealed that the rate of equipage contributed to the net present value (NPV) of ADS–B equipage differently for different user groups. Figures 16 and 17 illustrate the NPV effect of early equipage of both ADS–B Out and In (respectively) on air transportation aircraft. The FAA concluded that accelerating ADS–B Out equipage improves business case results by increasing benefits associated with ATC efficiencies, merging and spacing, and the Gulf of Mexico. However, accelerating and increasing ADS–B In equipage for this same population did not improve the business case because equipage requires additional high-priced retrofit installations that do not outweigh the benefits of the initial advisory applications being deployed by the FAA.

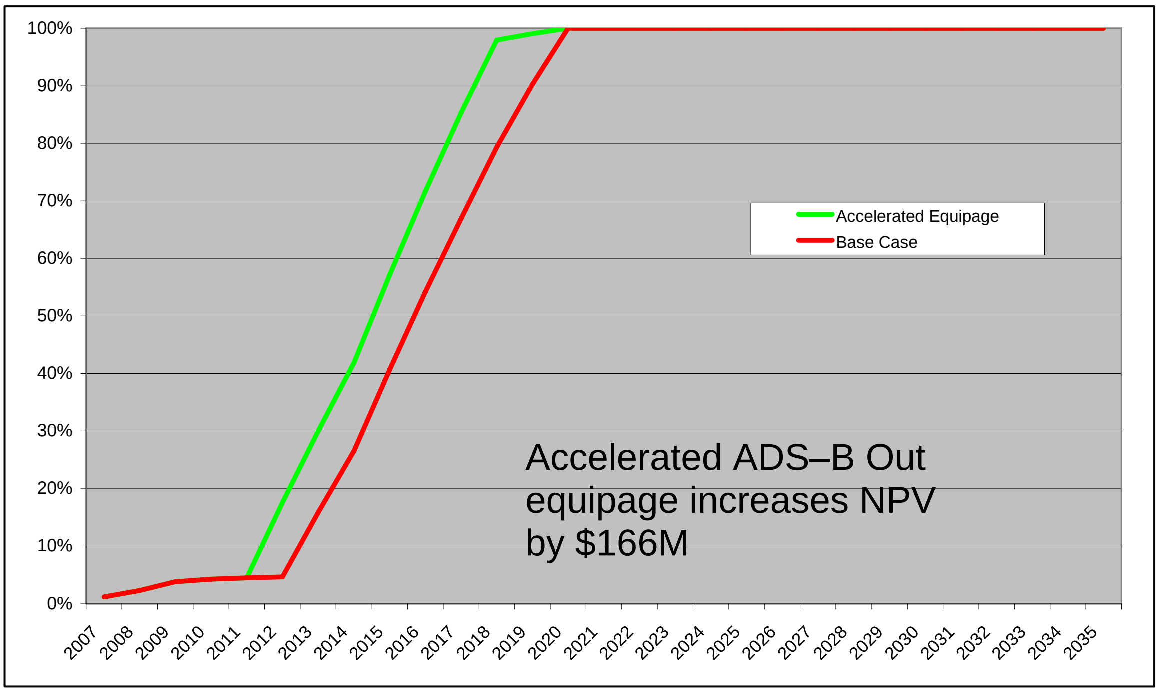


Figure 16—ADS–B Out Air Transport Equipage Sensitivity Analysis

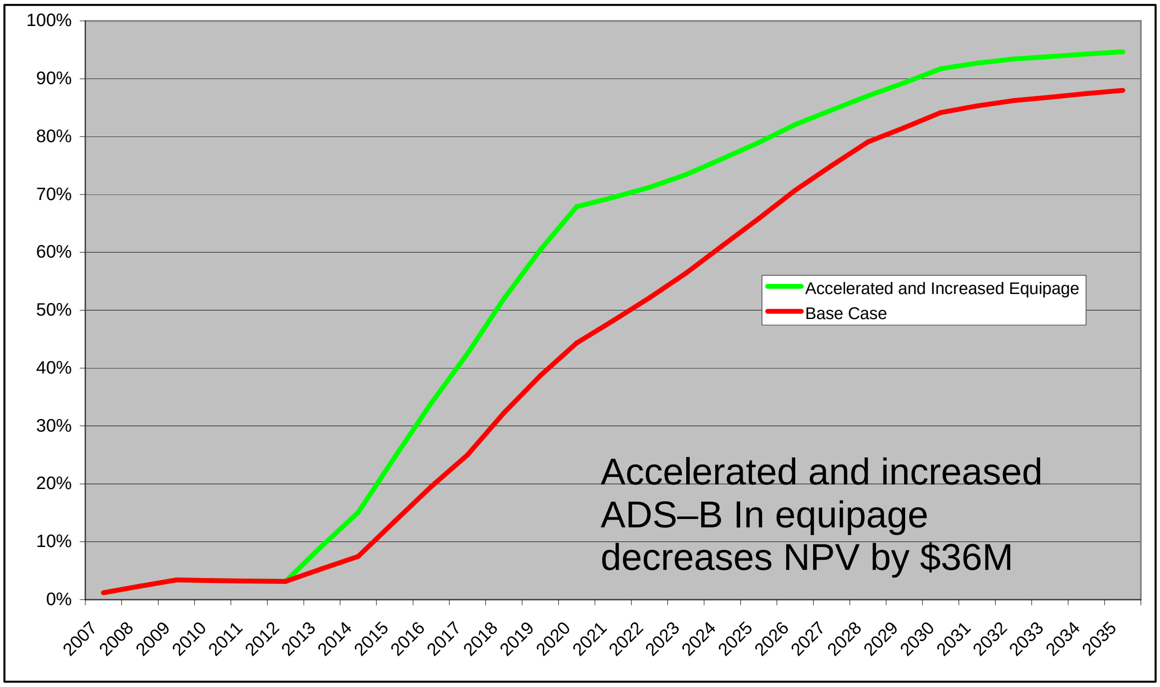


Figure 17—ADS–B In Air Transport Equipage Sensitivity Analysis

General aviation and air taxi aircraft tended to derive more benefit from early equipage of ADS–B In the FAA analysis. The earlier general aviation users equipped, the higher the total value of the ADS–B In equipage. Figures 18 and 19 illustrate that for this aircraft population, accelerating and increasing ADS–B Out and In equipage improves the business case by increasing benefits associated with FIS–B and TIS–B services and initial advisory applications.

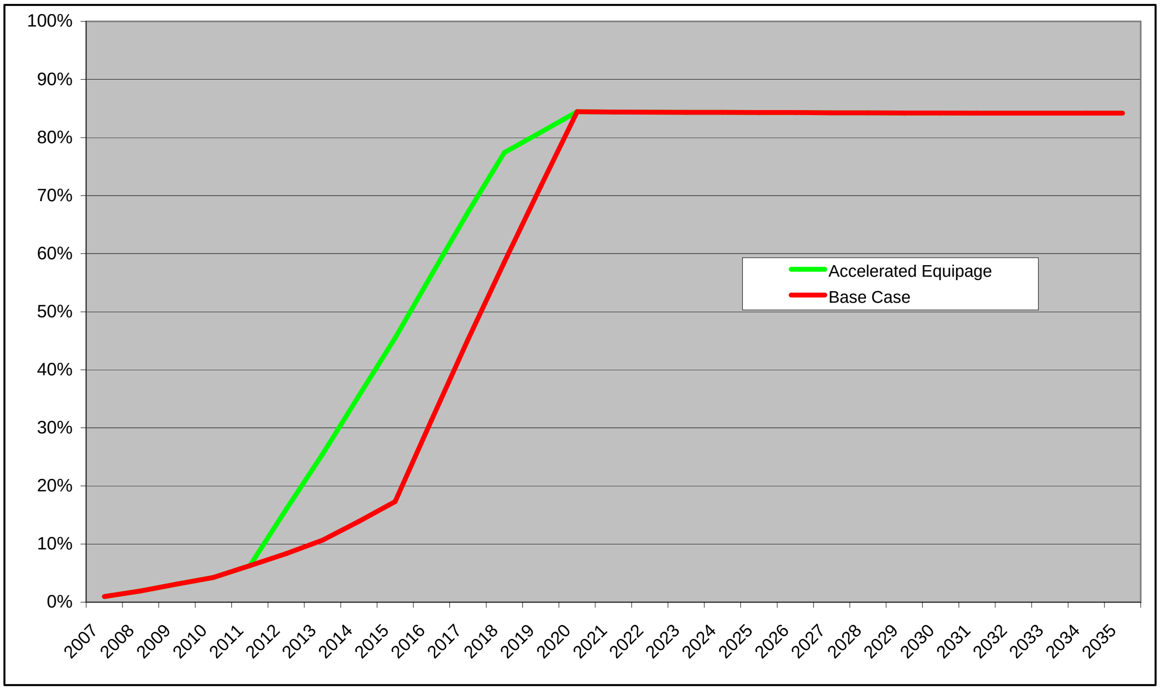


Figure 18—ADS–B Out Sensitivity Analysis Equipage for General Aviation and Air Taxi Aircraft

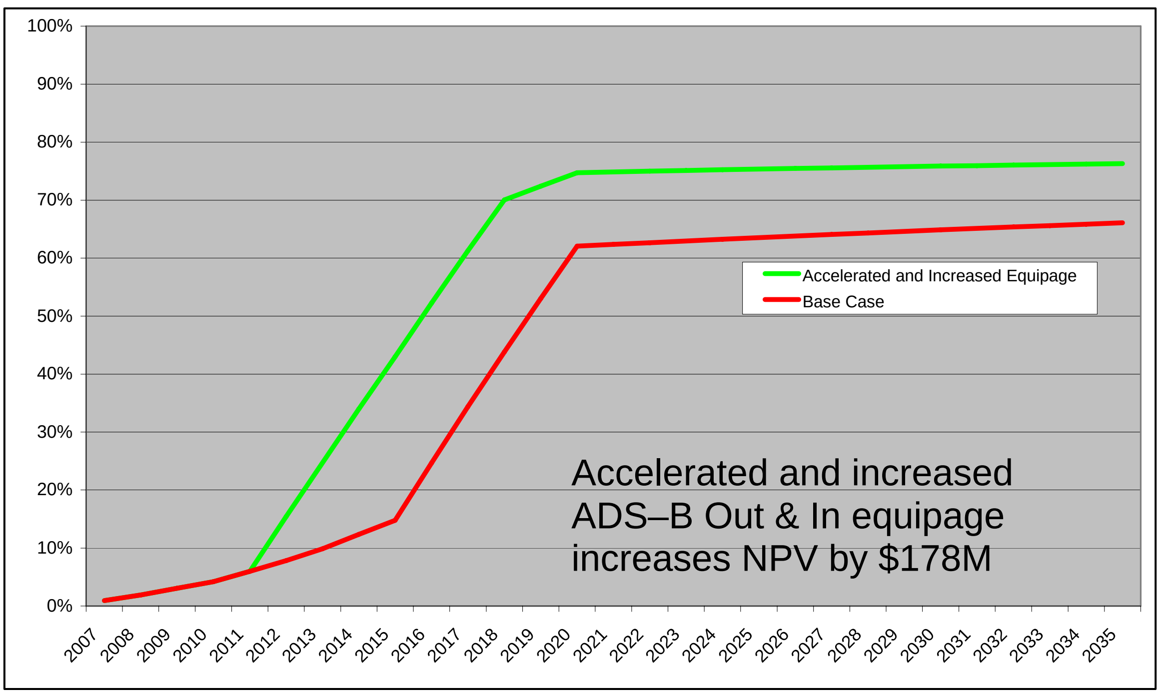


Figure 19—ADS–B In Sensitivity Analysis Equipage for General Aviation and Air Taxi Aircraft

ADS–B In Early Equipage Issues

There are a number of issues that must be addressed by the FAA and NAS users and suppliers before the benefits of ADS–B In equipage can achieve a high level of certainty. Regarding the display function, the FAA has yet to certify many specific display packages for various functions and applications. Without a clear understanding of what equipage will be suitable for performing specific operations, it will be difficult for users to commit to equipage.

Another significant cost associated with ADS–B equipage is the cost of retrofitting aircraft that do not currently have ADS–B mandate compliant avionics. The additional costs involved in retrofit may not be practical for some aircraft, especially those that would be taken out of service before the compliance date of the proposed rule. The ARC recommends that the FAA commission a project to address the complex certification requirements of ADS–B In avionics and develop ways to decrease the costs and uncertainty around ADS–B In reception and display equipment.

Certification of one or several electronic flight bags (EFBs) may mitigate the uncertainty around avionics. However, it is incumbent upon industry to apply for certification of this equipment for certain functions. Certification of new types of equipment for even existing operations—not including future capabilities such as possible reduction of separation standards—traditionally has been a lengthy process, often entailing years of effort. Training flightcrews to use new equipment, applications, and procedures also may delay the accrual of benefits until the proposed rule compliance date if not managed effectively. If these processes cannot be accelerated, it could hinder a decision to equip early with ADS–B avionics despite existing benefits.

The air transportation industry will have to weigh the progress of ADS–B certification and application acceleration projects, in addition to a normal assessment of costs and benefits. Significant and quantifiable benefits likely will be required to justify the early equipage of aircraft fleets, especially those fleets that may be retired before the proposed compliance date.

Section 3.4 Future Applications

This section describes future applications of ADS–B that have been conceptualized but are still either speculative or being researched. These applications are expected to require ADS–B capabilities or information beyond that described in RTCA DO–260A Change 3 or RTCA DO–282A Change 1.

Each application is described briefly, along with the general benefit mechanism and recipients.

ADS–B Out

An advanced application area for ADS–B Out is for improved flight path conformance monitoring. The two expected application domains for improved flight path conformance monitoring in the NAS are—

- National and Homeland security applications, and
- Air traffic management (ATM) applications.

The above application domains would use aircraft flight path intent information (for example, next waypoint) and possibly autopilot state, via the aircraft ADS–B message, to significantly improve flight path monitoring. Benefits of the security applications could include fewer false alerts and perhaps aircraft operations closer to sensitive areas. Benefits for the ATM applications could include improved conflict detection or blunder protection algorithm performance, and would probably allow reduced separations standards for a given target level of safety.

ADS–B In

There are a variety of advanced applications for ADS–B In and these applications are expected to provide the largest user benefits. Therefore, absent any future regulatory actions by aviation regulators, these applications likely will motivate equipage, and future revisions of ADS–B standards, to the extent this may be needed.

Advanced Surface Operations

The advanced surface operations applications, including high-speed runway turnoff guidance and low visibility taxi capability, would increase airport throughput in low visibility conditions that are equivalent to visual conditions. High-speed runway turnoff guidance uses a primary field-of-view display in low visibility to provide surface traffic awareness from ADS–B In to ensure the high-speed turnoff is cleared of traffic. This capability would improve runway occupancy times in visual conditions and allow interarrival aircraft spacing reductions. The low visibility taxi application would require an airport surface map and surface traffic awareness via ADS–B In, probably with taxi clearance displayed. This application may be able to rely on aircraft “avoidance” of surface traffic (or “coordination” with same) to reduce air traffic service provider workload and improve safety. These capabilities would build on applications/capabilities described in previous sections.

Advanced Terminal Applications

Advanced extended terminal operations applications, including airborne merging and spacing and use of aircraft intent information, are aimed at providing airport throughput in low visibility conditions equivalent to visual conditions, as well as improved operations in visual conditions via reduced spacings at the target level of safety. Airborne merging and spacing uses intent information from aircraft being followed or merged-behind (both route and along-path planned airspeeds schedule). Improved surveillance along with aircraft/ATC automation allows aircraft to perform continuous descent arrivals from top-of-descent to near the final approach fix while maintaining precise interarrival times at the runway threshold. This is an extension of earlier-described airborne merging and spacing applications. The use of aircraft intent information allows even more closely spaced terminal area routes than described in earlier sections. This includes departures and arrivals using RNP capabilities, and parallel approaches down to 700 feet centerline separation. This is an extension of earlier-described applications.

Advanced En Route and Cruise

The advanced en route/cruise applications including in-trail passing, aircraft RNP capabilities, delegated separation, and aircraft-based separation management, are aimed at providing increased airspace throughput at the target level of safety.

In-trail passing and/or merging into or leaving in-trail flows is an extension of the earlier-described in-trail climb procedure. This is envisioned to be most useful in an air traffic service provider-established route or aircraft flow, where aircraft are responsible for maintaining assigned spacing from other aircraft during passing or merging maneuvers within the route or flow. The expected benefits are improved air traffic service provider /airspace capacity, improved fuel efficiency for operators, reductions in air traffic service provider workload, and potential reductions in separation standards at the target level of safety.

Aircraft RNP capabilities, combined with ADS–B In surveillance and on-board spacing or "conflict detection" algorithms, should allow reduced longitudinal and lateral separations in oceanic airspace. The expected benefits are improved airspace capacity and improved fuel efficiency for operators.

Delegated separation (to aircraft) is a broad category of operations referring to any separation tasks delegated by the air traffic service provider to suitably equipped aircraft (delegation can range from one to several aircraft). Such aircraft would need onboard conflict detection automation and some conflict resolution capability. The expected benefits are improved air traffic service provider /airspace capacity and/or reductions in air traffic service provider workload.

Using aircraft-based separation management (self-separation), aircraft are fully responsible for maintaining separation from other aircraft in accordance with rules and approved separation standards, probably in segregated airspace, but under the assumption that traffic flow management functions are performed by the air traffic service provider, a flight operations center, or both via some collaborative process. The expected benefits are routings closer to operator preference, reductions in air traffic service provider workload, and less reliance by operators on air traffic service provider services.

FIS–B Applications

The advanced application of FIS–B is to transmit dynamic airspace changes to aircraft operating in the NAS. This application is an envisioned expansion of "Reduction in Accidents and Incidents Due to Improvements in Aeronautical Data (NOTAMs)" in appendix B. Dynamic airspace notifications can be applied to special use airspace or temporary flight restrictions (or similar restricted airspace), benefiting all users because restricted airspace is only applied when needed. Such notifications can also be applied to flexible class B openings/closings based on airport operating configurations, benefiting lesser-equipped aircraft that wish to transit this airspace.

4.0 INCENTIVES FOR EQUIPAGE

Introduction

The aviation community makes its equipage decisions based on a thorough financial evaluation. Therefore, any incentives for ADS–B equipage must involve a financial cost-benefit evaluation. The ARC conducted a brainstorming session and identified a number of incentives, some with direct financial impact and others without, that could be used to encourage voluntary equipage. The ARC did not conduct any extensive analysis on any of the options, including the legality. In addition, not all ARC members agree that all incentives listed are viable options.

The ARC believes that operational benefits are not enough to encourage voluntary equipage, and some financial incentives would be necessary to encourage early equipage. The Government, and to some extent state and local authorities, can affect that cost-benefit evaluation through direct financial incentives or the creation of operational benefits that reduce costs and positively affect an operator's bottom line. However, the decisions to equip are different in the general aviation and air carrier communities, and general aviation operators may elect to invest in new equipment regardless of the cost-benefit analysis.

Financial Incentives

The following are some mechanisms by which the ARC believes the Federal Government can fund or partially fund ADS–B avionics equipment, some of which are described further. The Government can—

- Pay for the certification, purchase, and installation of the equipment.
- Provide a grant for the equipment.
- Provide an investment tax credit.
- Provide adjustments to the existing aviation excise tax rate.
- Encourage market competition through research and development tax credits specifically targeted at ADS–B avionics development.
- Reduce landing/overflight fees for ADS–B-equipped aircraft.
- Reduce or waive registration fees.
- Provide a fuel tax break for equipped aircraft.
- Provide interest-free loans for equipage that are paid back when benefits are accrued.

Government-purchased equipment

The Alaska Capstone program relied on Government-purchased avionics equipment as the starting point for operators to equip with ADS–B avionics. This provided a base of airplanes with installed equipment where quantifiable benefits were identified by the FAA. The benefits of equipage, including safety, provided an encouragement for additional operators to invest in ADS–B avionics.

Investment tax credits

Investment tax credits have been introduced by Congress to encourage investment in certain property or equipment. This option would require Congress to authorize an investment tax provision specifically for ADS–B avionics. This investment tax provision would involve a basic cost to the Government and would provide an opportunity for a company to offset taxes on profits through the investment tax credit.

Aviation taxes

Aviation taxes make up the bulk of the money the aviation community pays for the FAA's aviation infrastructure. Congress would have the option of creating an incentive for equipping with ADS–B by lowering the effective excise tax rate (either fuel or other mechanisms) for operators who elect to equip.

Research and development tax credits

All avionics development involves significant investments by the equipment manufacturer and installer in research, development, engineering, and certification costs. The Government has the option of creating research and development tax credits targeted at the development of ADS–B avionics. Currently, there is a research and development tax credit in place, and several research and development tax credits have existed since introduced in 1981. A targeted research and development tax credit for ADS–B avionics could provide further incentive for companies to develop avionics.

Other Incentives

The following are some operational incentives by which the ARC believes the Federal Government can encourage equipage. The Government can—

- Identify the benefits and savings with existing equipment (DO–260) and use this information to promote further investment.
- Accelerate development of procedures and an intended set of functions.
- Provide preferred access to additional capacity and efficiencies enabled by ADS–B equipage.
- Accelerate identification of high-value operations enabled by ADS–B that would support reduced separation standards.
- Remove equipment (for example, transponders, ELTs (couple with search and rescue)) and reduce/eliminate recurring inspections.

- Increase program confidence using memorandums of understandings for joint investments and schedule stability.
- Provide local incentives/engagement (for example, deicing stations, sell data to airports, broaden existing pilot program and commitment to leverage State and local investment to supplement what's being done at the Federal level).
- Use equipment to see vehicles on the runway to reduce runway incursion events and consider extending coverage areas beyond the baseline.
- Facilitate more practical and low-cost displays.

5.0 RECOMMENDATIONS

Consistent with the objective of this report, the ARC has attempted to identify incentives to accelerate ADS–B equipage before the compliance date of the proposed nationwide ADS–B airspace rule. These incentives generally fall into two categories: financial incentives and operational benefits. The financial incentives identified take a number of forms, varying from tax breaks to equipment grants and subsidies. The operational benefits may be characterized as the enablement, through ADS–B equipage, of operations that cannot be performed with the existing NAS surveillance infrastructure and procedures.

The ARC believes some combination of financial incentives and operational benefits will be needed to significantly accelerate ADS–B equipage before the compliance date of the proposed rule. The ARC notes that such a combination has been employed since 2001 to achieve the present level of ADS–B equipage in the NAS.

The ARC has confidence in the FAA's ability to deploy the ADS–B ground infrastructure. However, the ARC is concerned with the ability of the FAA to approve operational procedures that would provide early operational benefits that cannot be achieved with the exiting NAS surveillance infrastructure.

The ARC presents its recommendations to the FAA below. The ARC's first three recommendations have been identified as being particularly critical to achieving early ADS–B equipage. The ARC will work with the FAA to prioritize implementation of its recommendations.

The ARC recommends that the FAA—

1. **Collaborate with the aviation industry and aggressively develop an appropriate combination of financial incentives and accelerated operational benefits.**

   The FAA should complete a legal and financial review of the financial incentives listed in this report and evaluate whether financial incentives for ADS–B equipage could be provided. The Government should carefully evaluate the timing of any financially based incentive to determine when it would have the most positive impact. The ARC expects that the next FAA reauthorization will be in 2012, which would provide an opportunity to include specific financial incentives. Each of the financial incentives listed in this report would involve a direct cost to the Government that would have to be offset in the existing pay-and-go situation.

2. **Accelerate and prioritize the identification of operations enabled by ADS–B, with approval of reduced separation standards for initial operations with a high level of user benefits by 2012.**

   To determine which applications should be given the most resources and attention, the FAA and the aviation community will have to identify the level of demand for given operations. Specifically, the aviation community should, in an operationally driven manner, investigate which operations to focus on when prioritizing the certification of operations employing reduced separation standards. The FAA must, as it has indicated it will, approve ADS–B-based separation standards equivalent to those used today with radar before the ADS–B final rule is issued. Given that certification of reduced separation standards is expected to be a lengthy process, one way to accelerate ADS–B equipage is to start certifying immediately those operations where reduced separation standards are of the most value to NAS users. Such operations are not currently within the funded scope of the SBS program. Approval of initial high-value operations by 2012 is needed to coincide with the deployment of high-value zones in the national ADS–B ground infrastructure.

3. **Establish certification requirements for aircraft displays for ADS–B In applications by 2010.**

   No mandate is planned for the equipage of ADS–B In equipment; however, the services provided by ADS–B In capability are very useful to flightcrews and necessary to enable future air-to-air applications. Those services will be acquired by users based solely on a cost-benefit analysis. The FAA should create a dedicated group to resolve the display requirements, including human factors considerations. If the FAA can better define its requirements for ADS–B In to perform a wide variety of high-value operations and lower the cost of those systems, a higher level of ADS–B In equipage becomes likely.

4. **Extend the coverage of the ADS–B ground infrastructure to include high-value non-radar areas beyond those currently identified.**

   The benefits of ADS–B in terminal surface and en route environments where radar exists today provides substantial value. The FAA should establish a forum to determine which areas outside that baseline would provide the greatest benefits to NAS operators. Surveillance and broadcast services in areas where no coverage exists today provide the most relative value and safety increases to the existing surveillance infrastructure. The FAA should have a mechanism to evaluate how the SBS program's scope might be expanded to accrue benefits in non-radar areas.

5. **In the Gulf of Mexico area—**

    - **Deploy an ADS–B infrastructure south of the Gulf of Mexico to facilitate ADS–B traffic feeds.**

    - **Apply radar-like separation standards in the Gulf of Mexico for DO–260-equipped aircraft.**

6. **Establish a mechanism to verify that existing DO–260 installations are capable of being used to achieve early operational benefits.**

    As of September 2007, over 5,000 aircraft are capable of transmitting 1090 ES ADS–B messages. Almost all of these aircraft transmit ADS–B messages that generally follow the requirements of RTCA DO–260. However, none of these DO–260 implementations have been TSO-certified to the requirements of DO–260. Initial RTCA DO–260A TSO certifications are in process or are complete for at least two avionics manufacturers.

    Several years of actual use of ADS–B in Alaska by ATC led to a number of changes to ADS–B avionics being requested by the U.S. operational community. Most of these changes were implemented in DO–242A, and all of them were implemented in DO–260A. Two of the most important of these ATC-requested changes were the transmission in ADS–B messages of the Mode 3/A code ("4096 code") assigned to the aircraft by ATC and the ability for a controller to use ADS–B to "IDENT" an aircraft that had declared an emergency. The inclusion of the Mode 3/A code in ADS–B messages was seen as being particularly important operationally with regard to aircraft identification/handoff and flight plan registration.

7. **Collaborate with the aviation industry to determine by 2010 which non-ADS–B avionics can be replaced by ADS–B equipage.**

    Operators would have an increased incentive to equip if ADS–B avionics could provide relief from other requirements. ADS–B message elements and requirements share a significant overlap with existing equipage on the aircraft, including several types of transponders and the ELT system.

8. **Provide preferred access to additional capacity and efficiencies enabled by ADS–B equipage.**

    The Gulf of Mexico has been identified as one area where the establishment of preferential routes could provide substantial benefits. The FAA should investigate what other routes, including routes in existing surveillance areas, could be employed to maximum benefits.

9. **Leverage the benefits of ADS–B information to incentivize equipage by establishing agreements with specific operators.**

The FAA should be able to provide ADS–B flight monitoring information or accelerated deployment of ADS–B and broadcast services at air transport hubs in exchange for an agreement to equip. By tailoring equipage to the needs of the earliest operators through formal agreements, the confidence in the ADS–B schedule accrual of benefits could increase.

10. **Continue to establish agreements with local and State governments to leverage the benefits of ADS–B.**

    By operating on a local level with specific airports, as well as local and State governments, the FAA could continue to provide targeted benefits without the constraints of national deployment.

11. **Evaluate the extension of coverage of ADS–B in airport non-movement areas.**

12. **Develop an economic decision tool for aircraft owners and operators to evaluate the direct benefits and costs involved in equipping with ADS–B.**

    The ARC believes the FAA should develop a tool for operators to assess the benefits of both early equipage and when full equipage is required by the mandate. This tool would allow an operator to evaluate early equipage in the context of existing equipage. Assuming operators have a long lead time to equip their aircraft, they would be able to examine various equipage strategies. This approach could be tailored to an operator's specific environment and needs, taking local constraints into account. Typically, in a mandate situation, the only additional cost for early equipage is the cost of money.

    The decision tool would be similar in form and function to the European Model for Strategic ATM Investment Analysis (EMOSIA). The EMOSIA is generic to cover any change in the air traffic management (ATM) environment. The ADS–B tool would be specific to ADS–B equipage, but should still provide targeted input to an array of stakeholders and use a full scope of possible cost and benefits to arrive at a net present value of different levels of ADS–B equipage.

Appendix A—ARC Members

Mr. Doug Arbuckle, Joint Planning and Development Office

Mr. Basil Barimo, *Co-Chair,* Air Transport Association of America, Inc.

Mr. Steve Brown, *Co-Chair,* National Business Aviation Association, Inc.

Mr. Jim Byrum, Cessna Aircraft Company

Mr. Vincent Capezzuto, *Designated Federal Official*, FAA, En Route and Oceanic Services

Ms. Sarah Dalton, Alaska Airlines

Mr. Jerry Davis, Airbus

Mr. Bruce DeCleene, FAA, Aircraft Certification Service

Mr. Jim Duke, Air Line Pilots Association

Mr. Ken Dunlap, International Air Transport Association

Mr. Scott Foose, Regional Airline Association

Mr. R. John Hansman, Massachusetts Institute of Technology

Mr. Rick Heinrich, Rockwell Collins

Mr. Jens Hennig, General Aviation Manufacturers Association

Mr. Bob Hilb, United Parcel Service

Mr. Randy Kenagy, Aircraft Owners and Pilots Association

Mr. George Ligler, Project Management Enterprises, Inc.

Mr. John McGraw, FAA, Flight Standards Service

Mr. Jeff Mittelman, MITRE/CAASD

Mr. William Richards, Boeing

Mr. Sam Seery, Garmin

Mr. Allan Storm, Department of Defense

Mr. Dale Wright, National Air Traffic Controllers Association

Appendix B—Benefits Associated with ADS–B In Early Equipage

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
ADS–B Out Surveillance Benefits in Radar Airspace							
ATC Efficiencies	Improve En Route Conflict Probe (1)	URET becomes an R-side tool per OEP; improved surveillance allows reduction in alert parameters from 8nm to 7nm, reducing alerts and providing more efficient maneuvers	Efficiency (User Benefit)	Y 2017 based on URET migration to R-side	4	N/A	Sec. 3.2 (Sec 3.1 w/ fusion)
ATC Efficiencies	Improve Traffic Management Advisor (2)	Improved surveillance increases the accuracy of meter fix projections enhancing the benefits of TMA	Efficiency (User Benefit)	Y 2020 based on conservative assumption; possible for earlier mixed equipage benefits	3	N/A	Sec. 3.2 (Sec 3.1 w/ fusion)
ATC Efficiencies	More efficient release from circular holding (3)	Improved surveillance aids in reducing unnecessary gaps between aircraft as they are released from holding patterns	Efficiency (User Benefit)	N	Not fully quantified but expected to be in group 1 or 2	N/A	Sec. 3.2 (Sec 3.1 w/ fusion)

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
	Enable RNAV procedures where current surveillance doesn't support (4)	Approaches to adjacent airports can be separated using RNAV procedures if the paths are separated by at least 4,300 ft. It is feasible to do with today's radar but it is not being done. Examples include JFK RWY 13L and LGA RWY 4.	Efficiency (User Benefit)	N	Not fully quantified but expected to be in group 2 or 3 at a minimum	N/A	Sec. 3.2 (Sec 3.1 w/ fusion)
	Enhanced surveillance fusion (5)	Contributes to benefits above; need further definition for additional benefits			Contributes to benefits above	N/A	Sec 3.1
	More efficient ATC-based merging and spacing due to improved surveillance (6)	Improved surveillance along with ATC automation allows CDAs in higher density environments than can be accomplished today	Efficiency (User Benefit)	Y 2009 UPS only; NAS-wide 2014 based on SBS implementation schedule	4	N/A	Sec 3.2
	ATC Surface Management (7)	Upgrading remaining ASDE–3 sites to include target IDs enhances ATC situational awareness	Efficiency (User Benefit)	Y (ASDE-3 Sites Only) 2016 based on SBS implementation schedule	1	N/A	Sec 3.1

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
ATC Safety	ATC Surface Safety (8)	Upgrading remaining ASDE–3 sites to include target IDs enhances ATC situational awareness	Safety (User Benefit)	Y (ASDE-3 Sites Only) 2016 based on SBS implementation schedule	1	N/A	Sec 3.1
	Improved Search and Rescue (9)	Updating flight plans to indicate ADS–B equipage would enhance SAR	Safety (User Benefit)	N	Not fully quantified but expected to be in group 1 or 2	N/A	Sec 3.2
Surveillance Replacement	Surveillance Cost Avoidance (10)	Implementation of ADS–B allows for the reduction of SSRs by approx 50% as well as surface movement radar	Cost Avoidance (FAA Benefit)	Y 2014 based on when investments in radar would be made if ADS–B was not pursued	3	N/A	Sec. 3.2 (Sec 3.1 w/ fusion)
	Mode-S Transponder Certification Cost Savings (11)	Download of ADS–B message sets and registers may reduce requirements and costs of biennial transponder certification	Cost Savings (User Benefit)	N	Not fully quantified but expected to be in group 1 or 2	N/A	Sec 3.1

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
Operator Tools	Gate to Gate Company Flight Tracking (12)	Distribution of surveillance data via service provider would enable application (surface coverage at ASDE airports)	Efficiency/Safety (User Benefit)	N	???	N/A	Sec 3.1
	Surface Management Systems (13)	Distribution of surveillance data via service provider would enable decision support tools at AOCs (surface coverage at ASDE airports)	Efficiency (User Benefit)	N	??? (potential to be in group 3 or above)	N/A	Sec 3.1
Enable ADS–B In	Better utilization of ADS–B In (14)	Increased situational awareness for users who equip with ADS–B In thus increasing their benefits	Efficiency/Safety (User Benefit)	Y (embedded in estimates)	??? (embedded in ADS–B In estimates)	Supports other users with ADS–B In	Sec 3.1
ADS–B Out Surveillance Benefits in Non-Radar Airspace (but within ADS–B service area)							
ATC Services	Radar-Like IFR Separation (en route/oceanic) (15)	Surveillance in non-radar airspace allows for reduced separation	Capacity (User Benefit)	Y (Gulf Only) 2011 based on SBS implementation schedule	3	N/A	Sec. 3.2 (Sec 3.1 w/ fusion)

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
	Optimal Routing (16)	Surveillance in non-radar airspace allows for an increase in direct routes	Efficiency (User Benefit)	Y (Gulf Only) 2011 based on SBS implementation schedule	1	N/A	Sec. 3.2 (Sec 3.1 w/ fusion)
	Access to Lower Routes (17)	Surveillance in non-radar airspace supports utilization of additional lower routes	Capacity (User Benefit)	Y (AK Only) 2010 based on SBS implementation schedule	1	N/A	Sec. 3.2
	Increased VFR Flight Following (18)	Surveillance in non-radar airspace increases ATC situational awareness	Safety (User Benefit)	Y (AK Only) 2008 based on existing activities in AK and SBS implementation schedule	Not quantified separately 1 to 2	N/A	Sec. 3.1
	Improved Search and Rescue (19)	Surveillance in non-radar airspace increases ATC situational awareness	Safety (User Benefit)	Y (AK Only) 2008 based on existing activities in AK and SBS implementation schedule	1	N/A	Sec. 3.2

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
	Reduce unnecessary intercepts of friendly aircraft (20)	Surveillance in non-radar airspace increases ATC situational awareness	Security (Government Benefit)	N	1	N/A	Sec. 3.1
Operator Tools	Gate to Gate Company Flight Tracking (21)	Distribution of surveillance data via service provider would enable application	Safety/Efficiency (User Benefit)	Y (AK Only) 2008 based on existing activities in AK and SBS implementation schedule	Not quantified separately 1 to 2	N/A	Sec. 3.1
ADS–B In Applications							
Visual Approaches	More Efficient Spacing During Visual Approaches (22)	Enhanced Visual Approach (EVA) application	Efficiency (User Benefit)	Y 2014 based on SBS implementation schedule and assumed equipage curves	2/3	CDTI/E VA	Sec. 3.3

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
Pilot Situational Awareness	Continuation of Visual Approaches in Marginal Conditions (23)	CDTI Assisted Visual Separation (CAVS) application	Capacity (User Benefit)	Y UPS only 2009; NAS-wide 2014 based on SBS implementation schedule and assumed equipage curves	2	CDTI/CAVS	Sec. 3.3
	Increased Surface Safety (24)	Airport Surface Situational Awareness (ASSA) and Final Approach Runway Occupancy Awareness (FAROA) applications	Safety (User Benefit)	Y 2011 based on assumed equipage curves	1	CDTI/ASSA/FAROA	Sec. 3.3
	Fewer Aircraft-to-Aircraft Conflicts	Cockpit display of traffic information enhances pilot situational awareness	Safety (User Benefit)	Y 2008 based on SBS implementation schedule and assumed equipage curves	2	TIS–B	Sec. 3.3

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
	More efficient merging and spacing due to improved surveillance	Improved surveillance along with ATC automation allows CDAs in higher density environments than can be accomplished today	Efficiency and Capacity (User Benefit)	Y 2009 UPS only; NAS-wide 2014 based on SBS implementation schedule	4	N/A	Sec 3.3 and 3.4
Broadcast Services (TIS–B and FIS–B)							
TIS–B	Fewer Aircraft-to-Aircraft Conflicts (25)	Cockpit display of traffic information enhances pilot situational awareness	Safety (User Benefit)	Y 2008 based on SBS implementation schedule and assumed equipage curves	2	TIS–B	Sec. 3.3
FIS–B	Fewer Weather Related Accidents (26)	Display of weather information enhances pilot situational awareness, reducing encounters with hazardous weather	Safety (User Benefit)	Y 2008 based on SBS implementation schedule and assumed equipage curves	2	FIS–B	Sec. 3.3

	Benefit Elements (Number corresponding to graphics)	Key Assumptions	Benefit Category	Quantified in FAA SBS Program Business Model	Relative Value Benefits thru FY35 1: Less than $100M PV; 2: $100M to $300M PV; 3: $300M to $500M PV; 4: $500M+ PV	ADS–B In	Cross Ref. to Report Section
	More Efficient Routes in Adverse Weather (27)	Display of weather information enhances pilot situational awareness, resulting in more efficient deviations around hazardous weather	Efficiency (User Benefit)	Y 2008 based on SBS implementation schedule and assumed equipage curves	1	FIS–B	Sec. 3.3
	Reduction in Unnecessary Cancellations and Diversions During Marginal Weather Conditions (28)	Display of weather information enhances pilot situational awareness, resulting in improved go/no-go decisions	Efficiency (User Benefit)	N	Not fully quantified but expected to be in group 1	FIS–B	Sec. 3.3
	Reduction in Accidents and Incidents Due to Improvements in Aeronautical Data (NOTAMs) (29)	Display of NOTAMs enhances pilot situational awareness	Safety (User Benefit)	N	Not fully quantified but expected to be in group 1	FIS–B	Sec. 3.3
Enabling Benefits	Fewer CFIT Accidents (increased equipage) (30)	ADS–B In equipage for Broadcast Services will increase number of users with moving map displays and terrain awareness capabilities	Safety (User Benefit)	Y 2008 based on assumed equipage curves	2	Moving map display	Sec. 3.3

Appendix C—Standards for Avionics for the 1090 MHz Extended Squitter (1090 ES): Status, Surveillance System Impacts, and ATS Provider Implementations August 2007

Introduction

RTCA and EUROCAE published in September 2000 RTCA DO–260/ED-102, Minimum Operational Performance Standards (MOPS) for ADS–B avionics supporting the transmission/reception of ADS–B messages using 1090 ES. The 1090 ES has been generally agreed to be the basis for international interoperability of ADS–B implementations for at least the next several decades.

After (1) several years of initial use of ADS–B OUT in Alaska with an ADS–B message set equivalent to that in DO–260; and (2) further development of ADS–B IN application requirements, RTCA published RTCA DO–260A in 2003 and has since published two changes to that document.

This paper summarizes and motivates key differences between DO–260 and DO–260A Change 2, reviews current implementations of 1090 ES on aircraft and their certification status, and discusses how 1090 ES standards are being invoked in ADS–B implementations around the world.

RTCA DO–260 and RTCA DO–260A Change 2

RTCA DO–260 was developed, jointly with EUROCAE, in 1998 to 2000 as the 1090 ES implementation of the ADS–B Minimum Aviation System Performance Standards (MASPS), RTCA DO–242 (February 1998). When DO–260 was published in 2000, RTCA, EUROCAE, and ICAO standards for 1090 ES were harmonized.

Two major developments shaped the introduction of an updated ADS–B MASPS (DO–242A) and, subsequently, an updated 1090 ES MOPS (DO–260A).

First, the U.S. began using ADS–B OUT in Alaska in 2001 and gained operational experience with ADS–B. That the UAT ADS–B datalink (as opposed to 1090 ES) was used in Alaska is unimportant to this discussion, since the messages to be transmitted to ATC by both 1090 ES and UAT in this time frame were similarly compliant with the ADS–B MASPS. Several years of actual use of ADS–B by ATC led to a number of changes to ADS–B avionics being requested by the U.S. operational community. Most of these changes were implemented in DO–242A and all of them were implemented in DO–260A. Two of the most important of these ATC-requested changes were the transmission in ADS–B messages of the Mode 3/A Code (“4096 code”) assigned to the aircraft by ATC and the ability for a controller to use ADS–B to “IDENT” an aircraft that had declared an emergency. The inclusion of the Mode 3/A code in ADS–B messages was seen as being particularly important operationally with regard to aircraft identification/handoff and flight plan registration.

Second, further developments in ADS–B In application requirements led to several important changes to DO–260. First, enhanced reception techniques were developed to improve the air-to-air range of the 1090 ES subsystem. Further, additional ADS–B message parameters providing information on the quality of the transmitted position and velocity data were codified. Finally, a number of additional flags were added to 1090 ES ADS–B messages, further information was included in ADS–B messages to support applications on the airport surface, support was provided for the receipt of Traffic Information Service-Broadcast (TIS–B) messages, and corrections were made to several DO–260 algorithms.

The ADS–B data quality parameters added in DO–260A resulted in the single Navigation Uncertainty Category (NUC) parameter of DO–260 being superseded in DO–260A by five ADS–B information quality parameters, including Navigation Integrity Category for Position (NIC), Navigation Accuracy Category for Position (NACP), and Navigation Accuracy Category for Velocity (NACV). The differentiation of position integrity (e.g., GNSS Horizontal Protection Limit or Containment Radius from an RNP-certified Flight Management System) and 95 percent accuracy indicators has been found particularly important for airport surface applications of ADS–B as well as for operational approval of a number of ADS–B OUT applications. RTCA DO–260 initially permitted its NUC parameter to be calculated using as a source either an integrity parameter or a 95 percent accuracy indicator: Change 1 to DO–260 requires that an integrity parameter be used as the source for NUC.

The development of DO–260A was done by RTCA without a joint-document agreement with EUROCAE. After the publication of DO–260A in 2003, ICAO standards for 1090 ES were updated to permit either DO–260 or DO–260A implementations for transmission of ADS–B messages. ICAO standards for 1090 ES receivers require the improvements developed in DO–260A. Changes 1 and 2 to RTCA DO–260A were subsequently developed in light of further experience with 1090 ES (particularly in Australia), the need to support ADS–B Rebroadcast, and to clarify and harmonize terminology with other ADS–B standards. These changes have been harmonized as appropriate with ICAO. Table C–1 provides a more detailed comparison between DO–260 and DO–260A Change 2.

A Change 3 to DO–260A is currently in development by RTCA, with the primary purpose of ensuring, at the request of the European operational community, that the Mode 3/A code is transmitted in ADS–B messages on a worldwide basis. (Change 2 localizes transmission of the Mode 3/A code to the United States.)

Current 1090 ES Avionics and their Certification

As of September 2007, over 5000 aircraft are capable of transmitting 1090 ES ADS–B messages. Almost all of these aircraft transmit ADS–B messages that generally follow the requirements of RTCA DO–260. None of these DO–260 implementations have been TSO-certified to the requirements of DO–260. Initial RTCA DO–260A TSO certifications are in process or are complete for at least two avionics manufacturers.

Current DO–260-based implementations were generally done in the context of implementing 1090 ES in a Mode S transponder that was in the process of being upgraded to comply with European requirements for Elementary/Enhanced Surveillance. Certification of these implementations was completed in accordance with the TSO for Mode S transponders, which does not levy the requirements of DO–260 for 1090 ES functionality. Moreover, these implementations were generally complete before the FAA issued TSO C–166 to form a certification basis for 1090 ES avionics compliant with DO–260.

The FAA received no applicants for certification of DO–260 compliant avionics under TSO C–166 before the issuance of TSO C–166A in December 2006 for the certification of 1090 ES avionics to the requirements of DO–260A Change 2. The ability to certify DO–260 implementations has been withdrawn by the FAA in light of the anticipated use of DO–260A Change 2 in U.S. ADS–B rulemaking.

ATS Provider Implementations of 1090 ES-based ADS–B

From discussions within the ATMAC ADS–B Work Group and with the EUROCONTROL CASCADE Program Office, the United States and Europe plan to use DO–260A as the baseline for ADS–B rulemaking. The European operational community has documented several concerns with DO–260 implementations. These concerns have been addressed in DO–260A Change 2, with the exception of broadcasting the Mode 3/A code outside of the United States, which is the primary motivation for the upcoming Change 3 to DO–260A, as discussed above. Additionally, Europe is also implementing a Pioneer Program to obtain near-term benefit and operational experience using existing 1090 ES ADS–B avionics—this program will accept participants transmitting 1090 ES in general conformance with DO–260.

Australia's ADS–B implementation supports either DO–260 or DO–260A (with the provision that the NUC for DO–260 equipped aircraft be computed based upon an integrity parameter such as a GNSS Horizontal Protection Limit). Australia's ATC automation system does not require the transmission of the Mode 3/A code in ADS–B messages but rather relies upon alternative mechanisms for flight plan registration and aircraft identification/handoff. These alternative mechanisms will be recognized in an Appendix to upcoming RTCA/EUROCAE standards for the use of ADS–B for ATC surveillance in areas of radar coverage. These standards will specify the transmission of the Mode 3/A code in ADS–B messages as a means of mitigating a number of potential operational hazards. Canada is implementing ADS–B over the Hudson Bay and plans to support DO–260 and DO–260A implementations of 1090 ES.

The Australia ADS–B and EUROCONTROL Pioneer Programs have instituted checking of the ADS–B installations of DO–260-based participating aircraft to ensure sufficient compliance with the requirements of DO–260. Australia's checking is expected to cease once recent rulemaking which mandates the use of GNSS Horizontal Protection Limit in calculating the DO–260 NUC ADS–B message parameter has been in effect for a suitable period of time.

Table C–1. Comparison of DO–260 and DO–260A Change 2

Output Capabilities	Receiving	
	DO–260	**DO–260A Change 2**
ADS–B MASPS Version	DO-242	DO-242A
Technical Standard Order (TSO)	TSO-C166	TSO-C166a
Position, Velocity, Identification Messages	YES	YES
Emergency/Priority Status Messages	YES	YES
MOPS Version Number	Not identified	YES
NUC ADS–B Quality Parameter	Installation ambiguity: Corrected in Change 1 to require use of HPL	
NIC, NIC_{BARO},NAC_P, NAC_V, and System Implementation Level (SIL) SIL ADS–B Message Quality Parameters	NO	YES
Enhanced Reception Techniques	NO	YES: Only applies to Receivers
Air/Ground Determination/Validation	Errors, unless updates in TSO-C166 or DO–260 Change 1 are followed	YES
Transmission of Mode 3/A ("4096") Code in ADS–B Message Set	Optional in DO–260 Change 1	YES-Required
ADS–B Rebroadcast	NO	YES: Only applies to receivers
Reasonableness Tests on Compact Position Reporting (CPR) of Latitude and Longitude	NO	YES: Only applies to receivers
TCAS Availability Flag	NO	YES
TCAS RA Active Flag	NO	YES
CDTI Availability Indicator	NO	YES
ARV Report Capability Flag	NO	YES
Target State Capability Flag	NO	YES
Trajectory Change Capability Flag	NO	YES
IDENT Active Flag	NO	YES
Receiving ATC Services Flag	NO	YES
A/V Length/Width Code	NO	YES

Appendix D—Standards for Avionics for the Universal Access Transceiver (UAT): Status, Surveillance System Impacts, and ATS Provider Implementation September 2007

Introduction

The UAT concept was developed in the mid-1990's at the MITRE Corporation under Independent Research and Development (IR&D) funding. The technology was designed to support ADS–B and broadcast uplink services such as Flight Information Service-Broadcast and Traffic Information Service-Broadcast. Initially used operationally in a "pre-MOPS" form in Alaska in 2001, UAT avionics have been standardized by both RTCA and ICAO. UAT is expected, in accordance with the July 2002 FAA ADS–B Link Decision, to be one of two ADS–B datalinks implemented in the United States, particularly for general aviation aircraft.

This paper summarizes UAT standards, reviews current implementations of UAT on aircraft and their certification status, and discusses current and planned UAT implementation.

UAT Standards

UAT prototype development at the MITRE Corporation was followed by the development of "pre-MOPS" UAT avionics and ground stations for initial operational use in the FAA Capstone Program in Alaska, beginning in 2001. The "pre-MOPS" units provided an ADS–B message set in general compliance with that specified in the initial ADS–B Minimum Aviation System Performance Standards (MASPS), RTCA DO–242, February 1998. Additionally, "pre-MOPS" UAT avionics provided for uplink of situational awareness information from UAT Ground Broadcast Terminals (GBTs) procured and installed by the FAA.

Initial deployment of the "pre-MOPS" UAT units was planned to be followed by a retrofit of UAT avionics and GBTs to be in compliance with/consistent with an eventual UAT Minimum Operational Performance Standard (MOPS), to be finalized after several years of operational experience with ADS–B had been achieved.

Three major developments shaped the development of UAT standards in 2001 through 2004.

First, as discussed above, the United States began using ADS–B OUT in Alaska in 2001 and gained operational experience with ADS–B. Several years of actual use of ADS–B by ATC led to a number of changes to ADS–B avionics being requested by the U.S. operational community. The changes recommended by ATC before mid-2002 were implemented in an updated ADS–B MASPS, RTCA DO–242A (June 2002) and the initial DO–242A-compliant UAT MOPS, RTCA DO–282 (August 2002). All of the remaining ATC-recommended changes were implemented in DO–282A (July 2004). Two of the most important of these ATC-requested changes were the transmission in ADS–B messages of the Mode 3/A Code (“4096 code”) assigned to the aircraft by ATC and the ability for a controller to use ADS–B to “IDENT” an aircraft that had declared an emergency. The inclusion of the Mode 3/A code in ADS–B messages was seen as being particularly important operationally with regard to aircraft identification/handoff and flight plan registration.

Second, further developments in ADS–B IN application requirements led to several important changes to DO–242 and were reflected in DO–242A and DO–282. Additional ADS–B message parameters providing information on the quality of the transmitted position and velocity data were codified. Further information was included in ADS–B messages to support applications on the airport surface, and several new status flags were added to the ADS–B message set.

Third, the UAT system went through ICAO standardization. Several changes resulting from UAT SARPs and ICAO Manual development were reflected in DO–282A. UAT SARPs have been approved for incorporation into Annex 10 with an effective date of November 2007. The UAT frequency of 978 MHz has achieved worldwide spectrum approvals for ADS–B transmissions from aircraft, and radio regulation changes to confirm spectrum approval for UAT uplinks on a worldwide basis are in process and are supported by ICAO.

Change 1 to DO–282A was issued in December 2006 to clarify the definitions of several ADS–B message quality parameters, harmonizing those definitions across all pertinent RTCA ADS–B standards.

Current UAT Avionics and their Certification

As of September 2007, over 700 aircraft are capable of transmitting UAT ADS–B messages. Approximately 550 of these aircraft operate in the United States. All of these aircraft have TSO-certified UAT avionics to a certification baseline of TSO C–154 (November 2002) plus “Capstone extensions” which effectively provide compliance with TSO C-154A (June 2005). TSO C–154B has been subsequently issued by the FAA in December 2006 to reflect the approval of Change 1 to DO—282A and to provide a certification baseline for an optional diplexer which permits UAT avionics to share Mode A/C/S transponder antennas.

Presently there is one manufacturer of certified UAT avionics. All fielded UAT avionics can readily be updated to compliance with TSO C–154B via a field service bulletin with no hardware changes.

ATS Provider Implementation of UAT

The FAA continues to provide UAT-based ADS–B separation services in major portions of Alaska. A number of additional UAT GBTs are operating as of September 2007 elsewhere in the United States, providing uplink services. The FAA intends to implement nationwide UAT coverage in the 2013 time frame.

Two hundred sets of UAT avionics have been contracted for by the Civil Aviation Flight University of China. Five UAT GBTs have been installed, with two additional GBTs planned. The Civil Aviation Authority of China is reported to be evaluating UAT for broader deployment as part of a new low altitude surveillance architecture.

Federal Register

Friday,
May 28, 2010

Part III

Department of Transportation

Federal Aviation Administration

14 CFR Part 91

Automatic Dependent Surveillance—Broadcast (ADS–B) Out Performance Requirements To Support Air Traffic Control (ATC) Service; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 91

[Docket No. FAA–2007–29305; Amdt. No. 91–314]

RIN 2120–AI92

Automatic Dependent Surveillance—Broadcast (ADS–B) Out Performance Requirements To Support Air Traffic Control (ATC) Service

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This final rule amends FAA regulations by adding equipage requirements and performance standards for Automatic Dependent Surveillance—Broadcast (ADS–B) Out avionics on aircraft operating in Classes A, B, and C airspace, as well as certain other specified classes of airspace within the U.S. National Airspace System (NAS). ADS–B Out broadcasts information about an aircraft through an onboard transmitter to a ground receiver. Use of ADS–B Out will move air traffic control from a radar-based system to a satellite-derived aircraft location system. This action facilitates the use of ADS–B for aircraft surveillance by FAA and Department of Defense (DOD) air traffic controllers to safely and efficiently accommodate aircraft operations and the expected increase in demand for air transportation. This rule also provides aircraft operators with a platform for additional flight applications and services.

DATES: This final rule is effective on August 11, 2010. The compliance date for this final rule is January 1, 2020. Affected parties, however, do not have to comply with the information collection requirement in § 91.225 until the FAA publishes in the **Federal Register** the control number assigned by the Office of Management and Budget (OMB) for this information collection requirement. Publication of the control number notifies the public that OMB has approved this information collection requirement under the Paperwork Reduction Act of 1995. The incorporation by reference of certain publications listed in the rule is approved by the Director of the Federal Register as of August 11, 2010.

FOR FURTHER INFORMATION CONTACT: For technical questions concerning this final rule, contact Vincent Capezzuto, Surveillance and Broadcast Services, AJE–6, Air Traffic Organization, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591; telephone (202) 385–8637; e-mail *vincent.capezzuto@faa.gov*.

For legal questions concerning this final rule, contact Lorelei Peter, Office of the Chief Counsel, AGC–220, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591; telephone 202–267–3134; e-mail *lorelei.peter@faa.gov*.

SUPPLEMENTARY INFORMATION:

Authority for This Rulemaking

The FAA's authority to issue rules on aviation safety is found in Title 49 of the United States Code (49 U.S.C.). Subtitle I, Section 106, describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in Subtitle VII, Part A, Subpart I, Section 40103, Sovereignty and use of airspace, and Subpart III, Section 44701, General requirements. Under section 40103, the FAA is charged with prescribing regulations on the flight of aircraft (including regulations on safe altitudes) for navigating, protecting, and identifying aircraft, and the efficient use of the navigable airspace. Under section 44701, the FAA is charged with promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce.

This regulation is within the scope of sections 40103 and 44701 because it prescribes aircraft performance requirements to meet advanced surveillance needs to accommodate increases in NAS operations. As more aircraft operate within the U.S. airspace, improved surveillance performance is necessary to continue to balance the growth in air transportation with the agency's mandate for a safe and efficient air transportation system.

Guide to Terms and Acronyms Frequently Used in This Document

ACI–NA—Airports Council International-North America
ACSS—Aviation Communication and Surveillance Systems
ADIZ—Air Defense Identification Zone
ADS–B—Automatic Dependent Surveillance-Broadcast
ADS–C—Automatic Dependent Surveillance-Contract
ADS–R—Automatic Dependent Surveillance-Rebroadcast
AGL—Above Ground Level
AIA—Aerospace Industries Association of America
ALPA—Air Line Pilots Association, International
AOPA—Aircraft Owners and Pilots Association
ARC—Aviation Rulemaking Committee
ASA—Aircraft Surveillance Applications
ASAS—Aircraft Surveillance Applications System
ASDE–X—Airport Surface Detection Equipment, Model X
ASSA—Airport Surface Situational Awareness
ATC—Air Traffic Control
CAA—Cargo Airline Association
CDTI—Cockpit Display of Traffic Information
CNS—Communication, Navigation, and Surveillance
EAA—Experimental Aircraft Association
ELT—Emergency Locator Transmitter
ES—Extended Squitter
EUROCAE—European Organisation for Civil Aviation Equipment
EUROCONTROL—European Organisation for the Safety of Air Navigation
FAROA—Final Approach Runway Occupancy Awareness
FedEx—Federal Express
FIS–B—Flight Information Service–Broadcast
FL—Flight Level
GA—General Aviation
GAMA—General Aviation Manufacturers Association
GNSS—Global Navigation Satellite System
GPS—Global Positioning System
HAI—Helicopter Association International
IATA—International Air Transport Association
ICAO—International Civil Aviation Organization
MHz—Megahertz
MOPS—Minimum Operational Performance Standards
MSL—Mean Sea Level
NAC_P—Navigation Accuracy Category For Position
NAC_V—Navigation Accuracy Category for Velocity
NAS—National Airspace System
NBAA—National Business Aviation Association
NextGen—Next Generation Air Transportation System
NIC—Navigation Integrity Category
NM—Nautical Mile
NPRM—Notice of Proposed Rulemaking
NTSB—National Transportation Safety Board
OPD—Optimized Profile Descent
OMB—Office of Management and Budget
RAA—Regional Airline Association
RAIM—Receiver Autonomous Integrity Monitoring
RFA—Regulatory Flexibility Act
RNP—Required Navigation Performance
SANDIA—Sandia National Laboratories
SARPs—Standards and Recommended Practices
SCAP—Security Certification and Accreditation Procedures
SDA—System Design Assurance
SIL—Source Integrity Level
SSR—Secondary Surveillance Radar
TCAS—Traffic Alert and Collision and Avoidance System
TIS–B—Traffic Information Service-Broadcast
TMA—Traffic Management Advisor

TSO—Technical Standard Order
UAT—Universal Access Transceiver
UPS—United Parcel Service
URET—User Request Evaluation Tool
VFR—Visual Flight Rules
WAAS—Wide Area Augmentation System

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I. Background

While there is currently a drop in air travel due to a general economic downturn, delay and congestion continue to build in the nation's busiest airports and the surrounding airspace. The FAA must not only address current congestion, but also be poised to handle future demand that will surely return as the nation's economy improves. The FAA has been developing the Next Generation Air Transportation System (NextGen) for the purpose of changing the way the National Airspace System (NAS) operates. NextGen will allow the NAS to expand to meet future demand and support the economic viability of the system. In addition, NextGen will improve safety and support environmental initiatives such as reducing congestion, noise, emissions and fuel consumption through increased energy efficiency. for more information on NextGen, go to *http://www.faa.gov/about/initiatives/nextgen/*.

As part of NextGen development, the FAA has determined that it is essential to move from ground-based surveillance and navigation to more dynamic and accurate airborne-based systems and procedures if the agency is to enhance capacity, reduce delay, and improve environmental performance. Automatic Dependent Surveillance–Broadcast (ADS–B) equipment is an advanced surveillance technology that combines an aircraft's positioning source, aircraft avionics, and a ground infrastructure to create an accurate surveillance interface between aircraft and ATC. It is a key component of NextGen that will move air traffic control (ATC) from a radar-based system to a satellite-derived aircraft location system. ADS–B is a performance-based surveillance technology that is more precise than radar. ADS–B is expected to provide air traffic controllers and pilots with more accurate information to help keep aircraft safely separated in the sky and on runways. The technology combines a positioning capability, aircraft avionics, and ground infrastructure to enable more accurate transmission of information from aircraft to ATC.

ADS–B consists of two different services: ADS–B Out and ADS–B In. ADS–B Out, which is the subject of this rulemaking, periodically broadcasts information about each aircraft, such as identification, current position, altitude, and velocity, through an onboard transmitter. ADS–B Out provides air traffic controllers with real-time position information that is, in most cases, more accurate than the information available with current radar-based systems. With more accurate information, ATC will be able to position and separate aircraft with improved precision and timing.

ADS–B In refers to an appropriately equipped aircraft's ability to receive and display another aircraft's ADS–B Out information as well as the ADS–B In services provided by ground systems, including Automatic Dependent Surveillance–Rebroadcast (ADS–R),[1] Traffic Information Service–Broadcast (TIS–B),[2] and, if so equipped, Flight Information Service–Broadcast (FIS–B).[3] When displayed in the cockpit, this information greatly improves the pilot's situational awareness in aircraft not equipped with a traffic alert and collision avoidance system (TCAS)/airborne collision avoidance system (ACAS). Benefits from universal equipage for ADS–B In currently are not substantiated, and standards for ADS–B In air-to-air applications are still in their infancy. Thus it is premature to require operators to equip with ADS–B In at this time. This rule, however, imposes certain requirements that will support some ADS–B In applications.

As noted in the preamble of the Notice of Proposed Rulemaking (NPRM) associated with this rule, published in the **Federal Register** on October 5, 2007 (72 FR 56947), Congress enacted the "Century of Aviation Reauthorization Act" in 2003. That Act mandated that the Secretary of Transportation establish a Joint Planning and Development Office (JPDO) to manage NextGen-related work, including coordinating the development and use of new technologies for aircraft in the air traffic control system. Since 2006, Congress has appropriated over $500 million to the FAA for implementing ADS–B and developing air-to-air capabilities. The FAA remains committed to implementing NextGen and adopts this final rule, with some modifications, as discussed in further detail below.

A. Notice of Proposed Rulemaking

The FAA published the NPRM for ADS–B Out in the **Federal Register** on October 5, 2007 (72 FR 56947). The comment period for the NPRM was scheduled to close on January 3, 2008. In response to several commenters, the FAA subsequently extended the comment period to March 3, 2008 (72 FR 64966, Nov. 19, 2007). The FAA received approximately 190 comments to the docket on the NPRM. Commenters included air carriers, manufacturers, associations, Government agencies, and individuals.

B. ADS–B Aviation Rulemaking Committee

As part of the rulemaking effort, the FAA chartered an aviation rulemaking committee (ARC) on July 15, 2007, to provide a forum for the U.S. aviation community to make recommendations on presenting and structuring an ADS–B Out mandate, and to consider additional actions that may be necessary to implement its recommendations. The ADS–B ARC submitted its first report, "Optimizing the Benefits of Automatic Dependent Surveillance–Broadcast,"[4] on October 3, 2007.

The FAA also tasked the ARC to make specific recommendations concerning the proposed rule based on the comments submitted to the docket. The ARC submitted its second report, "Recommendations on Federal Aviation Administration Notice No. 7–15, Automatic Dependent Surveillance-Broadcast (ADS–B) Out Performance Requirements to Support Air Traffic Control (ATC) Service; Notice of Proposed Rulemaking,"[5] to the FAA on September 26, 2008.

To give the public an opportunity to comment on the recommendations received from the ARC, the FAA published a notice in the **Federal Register** on October 2, 2008 (73 FR 57270), reopening the comment period of the ADS–B Out NPRM docket for an additional 30 days. The purpose of reopening the comment period was to receive public comments on the ARC recommendations only. This comment period closed November 3, 2008, with the FAA receiving approximately 50 comments to the ARC's recommendations. Commenters included air carriers, manufacturers, associations, and individuals.

C. Summary of the Final Rule

This final rule will add equipage requirements and performance standards for ADS–B Out avionics. ADS–B Out broadcasts information about an aircraft through an onboard transmitter to a ground receiver. Use of ADS–B Out will move air traffic control from a radar-based system to a satellite-derived aircraft location system. As discussed more fully in the sections of this preamble describing equipage requirements and performance standards, operators will have two options for equipage under this rule—the 1090 megahertz (MHz) extended squitter[6] (ES) broadcast link or the Universal Access Transceiver (UAT) broadcast link.[7] Generally, this equipment will be required for aircraft operating in Classes A, B, and C airspace, certain Class E airspace, and other specified airspace. See section C.1. "Airspace" below for additional details.

The NPRM proposed performance requirements for ADS–B Out to be used for ATC surveillance. In addition, several aspects of the proposal would be necessary for future ADS–B In applications. The comments to the NPRM and the ARC recommendations raised significant concerns about the operational needs and costs of the proposed performance requirements, as well as the proposed antenna diversity requirement.

The FAA specifically proposed higher ADS–B Out and antenna diversity requirements than what is needed for ATC surveillance to enable certain ADS–B In applications. As discussed in further detail in this document, the FAA has reconsidered these elements in view of the comments and has changed the implementation plan for ADS–B.

The FAA has concluded that this rule will require only the performance requirements necessary for ADS–B Out. While certain requirements adopted in this rule will support some ADS–B In applications, the agency is not adopting

[1] ADS–R collects traffic information from each broadcast link and rebroadcasts it to ADS–B In-equipped operators on the other broadcast link. This is further explained in section B.2., Automatic Dependent Surveillance-Rebroadcast.

[2] TIS–B uses primary and secondary surveillance radars and multilateration systems to provide proximate traffic situational awareness, including position reports from aircraft not equipped with ADS–B. TIS–B data may not provide as much information as could be received directly from an aircraft's ADS–B Out broadcast, because of the required data processing. The TIS–B signal is an advisory service that is not designed for aircraft surveillance or separation, and cannot be used for either purpose.

[3] With FIS–B, aircraft equipped with 978 megahertz (MHz) Universal Access Transceiver (UAT) ADS–B In avionics can receive weather information, notices to airmen, temporary flight restrictions, and other relevant flight information, at no additional cost.

[4] A copy of this report is available from the Web site *http://www.regulations.gov.* To find the report, enter FAA–2007–29305–0009.1 in the search field.

[5] A copy of this report is available from the Web site *http://www.regulations.gov.* To find the report, enter FAA–2007–29305–0221.1 in the search field

[6] An extended squitter is a long message that Mode S Transponders transmit automatically, without needing to be interrogated by radar, to announce the own-ship aircraft's presence to nearby ADS–B equipped aircraft or ground based Air Traffic Control.

[7] The 1090 MHz ES broadcast link uses the 1090 MHz frequency. The UAT broadcast link uses the 978 MHz frequency.

the higher performance standards that would enable all of the initial ADS–B In applications. The agency is mindful, and operators are advised, that in accepting the commenters' and the ARC's positions regarding antenna diversity and position source accuracy, compliance with this rule alone may not enable operators to take full advantage of certain ADS–B In applications. Operators may voluntarily choose equipment that meets the higher performance standards in order to enable the use of these applications.

The following table provides an overview of the costs and benefits of this final rule.

SUMMARY OF COSTS AND BENEFITS

3% Discount Rate:	
Low Costs	$2.74
High Benefits	5.03
Net Benefits-High Benefit/ Low Cost	2.29
High Costs	5.47
Low Benefits	3.98
Net Benefits-Low Benefits/ High Costs	(1.49)
7% Discount Rate:	
Low Costs	2.15
High Benefits	2.74
Net Benefits-High Benefit/ Low Cost	0.59
High Costs	4.11
Low Benefits	2.09
Net Benefits-Low Benefits/ High Costs	(2.02)

1. Airspace

This final rule prescribes ADS–B Out performance requirements for all aircraft operating in Class A, B, and C airspace within the NAS; above the ceiling and within the lateral boundaries of a Class B or Class C airspace area up to 10,000 feet mean sea level (MSL); and Class E airspace areas at or above 10,000 feet MSL over the 48 contiguous United States and the District of Columbia, excluding the airspace at and below 2,500 feet above the surface.

The rule also requires that aircraft meet these performance requirements in the airspace within 30 nautical miles (NM) of certain identified airports [8] that are among the nation's busiest (based on annual passenger enplanements, annual airport operations count, and operational complexity) from the surface up to 10,000 feet MSL. In addition, the rule requires that aircraft meet ADS–B Out performance requirements to operate in Class E airspace over the Gulf of Mexico at and above 3,000 feet MSL within 12 NM of the coastline of the United States.

2. Datalink Requirements

ADS–B requires a broadcast link for aircraft surveillance and to support ADS–B In applications. Operators have two options for equipage under this rule— the 1090 MHz ES broadcast link or the UAT broadcast link. The 1090 MHz ES broadcast link is the internationally agreed upon link for ADS–B and is intended to support ADS–B In applications used by air carriers and other high-performance aircraft. The 1090 MHz ES broadcast link does not support FIS–B (weather and related flight information) because the bandwidth limitations of this link cannot transmit the large message structures required by FIS–B. The UAT broadcast link supports ADS–B In applications [9] and FIS–B, which are important for the general aviation (GA) community.

This final rule requires aircraft flying at and above 18,000 feet MSL (flight level (FL) 180) (Class A airspace) to have ADS–B Out performance capabilities using the 1090 MHz ES broadcast link. This rule also specifies that aircraft flying in the designated airspace below 18,000 feet MSL may use either the 1090 MHz ES or UAT broadcast link.

3. System Performance Requirements

When activated, ADS–B Out continuously transmits aircraft information through the 1090 MHz ES or UAT broadcast link. The accuracy and integrity of the position information transmitted by ADS–B avionics are represented by the navigation accuracy category for position (NAC_P), the navigation accuracy category for velocity (NAC_V), the navigation integrity category (NIC), the system design assurance (SDA), and the source integrity level (SIL).

In the proposed rule, the FAA referenced the accuracy and integrity requirements to the appropriate NAC_P, NAC_V, NIC, and SIL values defined in Technical Standard Order (TSO)–C166a [10] (for operators using the 1090 MHz ES broadcast link), and TSO–C154b [11] (for operators using the UAT broadcast link) as the baseline requirements for ADS–B Out equipment. TSO–C166a adopted the standards in RTCA, Inc.[12] (RTCA) DO–260A.[13] TSO–C154b adopted the standards in RTCA DO–282A.[14]

After the NPRM was published, the ADS–B ARC issued numerous recommendations in response to public comments on the TSOs referenced in the proposal. Based on the ARC recommendations and broad industry input, RTCA revised DO–260A to become DO–260B [15] and revised DO–282A to become DO–282B.[16] The new RTCA revisions include: (1) An allowance for transmitting a NIC of 7 on the surface, (2) procedures for correctly setting the NAC_V, (3) clarifying the latency requirements, (4) removing the vertical component of NAC_P, NAC_V, NIC, and SIL, (5) revising the definition of SIL to correspond to the definition in the FAA NPRM, (6) clarifying the definition of SIL by dividing it into SIL and SDA message elements, (7) creating a medium power single antenna class, and (8) redefining the bit for the "ADS–B In capability installed" message element.[17] DO–260B and DO–282B are more mature standards and fully support domestic and international ADS–B air traffic control surveillance. The updated standards do not increase performance requirements.

The FAA updated the TSOs in accordance with these new RTCA standards. In addition, the FAA has

[8] These airports are listed in appendix D to part 91.

[9] These applications include enhanced visual acquisition, conflict detection, enhanced visual approach, Airport Surface Situational Awareness (ASSA), and Final Approach Runway Occupancy Awareness (FAROA).

[10] Extended Squitter Automatic Dependent Surveillance–Broadcast (ADS–B) and Traffic Information Service—Broadcast (TIS–B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz).

[11] Universal Access Transceiver (UAT) Automatic Dependent Surveillance—Broadcast (ADS–B) Equipment Operating on the Frequency of 978 MHz.

[12] RTCA, Inc. is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many FAA TSOs. For more information, *see http://www.rtca.org.*

[13] Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance—Broadcast (ADS–B) and Traffic Information Services—Broadcast (TIS–B).

[14] Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance—Broadcast.

[15] Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance–Broadcast (ADS–B) and Traffic Information Services–Broadcast (TIS–B).

[16] Minimum Operational Performance Standards for Universal Access Transceiver Automatic Dependent Surveillance–Broadcast.

[17] A number of these items address issues with the current TSOs.

decided that it is necessary to require the new standards contained in TSO–C166b [18] (1090 MHz ES) and TSO–C154c [19] (UAT) as the minimum performance standards in this final rule.[20] The updated standards incorporate multiple changes that address public comments and the ARC's recommendations on the proposal. On September 11, 2009, the FAA announced in the **Federal Register** the availability of draft TSO–C166b and TSO–C154c for comment (74 FR 46831). The FAA issued final versions of the above TSOs on December 2, 2009. The FAA also added additional language in §§ 91.225 and 91.227 stating that equipment with an approved deviation under § 21.618 also meet the requirements of the rule.

In addition, this final rule specifies the performance requirements for accuracy and integrity (NAC_P, NAC_V, and NIC) in meters and nautical miles rather than referencing the numerical values used in DO–260B, DO–282B, or the NPRM. This change translates the values but does not alter the actual performance requirements. The FAA wants to avoid any misinterpretations of the performance requirements for this rule, if in the future, RTCA revises NAC_P, NAC_V, and NIC.

Table 1 summarizes the NAC_P, NAC_V, NIC, and SIL values proposed in the NPRM and their equivalent measurements, as noted in DO–260A and DO–282A. Table 2 summarizes NAC_P, NAC_V, NIC, SDA, and SIL values as defined in DO–260B and DO–282B. These two tables contain only the values applicable to the NPRM and the final rule. See DO–260B paragraph 2.2.3 or DO–282B paragraph 2.2.4 for complete information on all values.

Table 1. NAC_P, NAC_V, NIC, and SIL values as defined in DO–260A and DO–282A

	Value	Equivalent Measure as defined in DO–260A and DO–282A
NAC_P	5	Horizontal position accuracy < 926 meters (0.5 NM)
	8	Horizontal position accuracy < 92.6 meters (0.05 NM)
	9	Horizontal position accuracy < 30 meters; Vertical position accuracy < 45 meters
NAC_V	1	Horizontal velocity accuracy < 10 meters per second, Vertical velocity accuracy < 50 feet per second
NIC	7	Containment radius <0.2 NM
SIL	2	Per flight hour or per sample probability of exceeding the NIC containment radius $\leq 1x10^{-5}$ AND Per flight hour probability of failure causing false or misleading information being transmitted from the aircraft $\leq 1x10^{-5}$
	3	Per flight hour or per sample probability of exceeding the NIC containment radius $\leq 1x10^{-7}$ AND Per flight hour probability of failure causing false or misleading information being transmitted from the aircraft $\leq 1x10^{-7}$

[18] Extended Squitter Automatic Dependent Surveillance–Broadcast (ADS–B) and Traffic Information Service–Broadcast (TIS–B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz).

[19] Universal Access Transceiver (UAT) Automatic Dependent Surveillance–Broadcast (ADS–B) Equipment Operating on the Frequency of 978 MHz.

[20] Operators with equipment installed that meets a later version of TSO–C166b or TSO–C154c, as applicable, are in compliance with this rule.

Table 2. NAC_P, NAC_V, NIC, SDA, and SIL values as defined in DO–260B and DO–282B

	Value	Equivalent Measure as defined in DO–260B and DO–282B
NAC_P	5	Horizontal position accuracy < 926 meters (0.5 NM)
	8	Horizontal position accuracy < 92.6 meters (0.05 NM)
	9	Horizontal position accuracy < 30 meters
NAC_V	1	Horizontal velocity accuracy < 10 meters per second
NIC	7	Containment radius < 0.2 NM
SDA	2	Per flight hour probability of an avionics system failure causing false or misleading information to be transmitted from the aircraft ≤ $1x10^{-5}$
	3	Per flight hour probability of an avionics system failure causing false or misleading information to be transmitted from the aircraft ≤ $1x10^{-7}$
SIL	2	Per flight hour or per sample probability of exceeding the horizontal NIC containment radius ≤ $1x10^{-5}$
	3	Per flight hour or per sample probability of exceeding the horizontal NIC containment radius ≤ $1x10^{-7}$

In this final rule, the NAC_P must be less than 0.05 NM. The NAC_V and NIC values are adopted as proposed. The NAC_V must be less than 10 meters per second. The NIC must be less than 0.2 NM. The SIL parameter from the NPRM has been divided into two separate parameters and is discussed in detail later in this document.[21] In this final rule, the SDA parameter must be less than or equal to $1x10^{-5}$ per hour, which is equivalent to an SDA of 2, and the SIL parameter must be less than or equal to $1x10^{-7}$ per hour or per sample, which is equivalent to a SIL of 3. Global navigation satellite system (GNSS) systems[22] will set their SILs based on a $1x10^{-7}$ per-hour probability. Operators must meet these performance requirements to operate in the airspace where ADS–B is required. Any ADS–B position source that meets the specified performance standards is acceptable and complies with the requirements in the final rule.

4. Antenna Diversity and Transmit Power Requirements

The aircraft antenna is a major contributor to ADS–B system link performance and an important part of the overall ADS–B Out system. In the NPRM, the FAA proposed an antenna diversity requirement that would support ADS–B In applications, such as Airport Surface Situational Awareness (ASSA) and Final Approach Runway Occupancy Awareness (FAROA).

The FAA has reconsidered the need for antenna diversity in view of the comments submitted. The agency has determined that a single bottom-mounted antenna is the minimum requirement for ATC surveillance. Furthermore, the analysis of ASSA and FAROA does not conclude that antenna diversity is required for these applications. As discussed later, the FAA decision to require a NAC_P less than 0.05 NM signifies that certain ADS–B In applications, including ASSA and FAROA, will not be fully supported.

If future analysis indicates that antenna diversity is required for ASSA and FAROA, a higher NAC_P than that required in this rule also would be necessary to support these applications. The FAA does not adopt antenna diversity as a requirement for ADS–B Out under this rule because it is not required to support ATC surveillance. Operators must note that this rule does not remove or modify any existing antenna diversity requirements for transponders or TCAS/ACAS.

Aircraft must transmit signals at a certain level of power to ensure ground stations and ADS–B In-equipped aircraft and vehicles can receive the transmitted signals. As proposed, the final rule requires UAT systems to broadcast at a 16-watt minimum-transmit power, and 1090 MHz ES systems to broadcast at a 125-watt minimum-transmit power.

5. Latency of the ADS–B Out Message Elements

When using an ADS–B system, aircraft receive information from a position source and process it with onboard avionics. The aircraft's ADS–B system then transmits position and other information to the ground stations through antenna(s) using either the UAT or 1090 MHz ES broadcast link. Generally, latency is the time lag between the time that position measurements are taken to determine the aircraft's position, and the time that the position information is transmitted by the aircraft's ADS–B transmitter. The latency requirements in this final rule, although different from the proposal, represent a more appropriate way to address latency. The proposal created ambiguities that are addressed in these modifications and are supported by the commenters. Under this rule, total

[21] In the NPRM, SIL was defined as surveillance integrity level and represented the maximum probability of exceeding the NIC containment radius and a maximum probability of a failure causing false or misleading data to be transmitted. In this final rule, SIL is referred to as source integrity level and defines the probability of exceeding the NIC containment radius; SDA represents the probability of transmitting false or misleading position information.

[22] Global navigation satellite system (GNSS) is a generic term for a satellite navigation system, such as the Global Positioning System (GPS), that provides autonomous worldwide geo-spatial positioning and may include local or regional augmentations.

latency cannot exceed 2.0 seconds. Within those 2.0 seconds, uncompensated latency cannot exceed 0.6 seconds. Total and uncompensated latency are explained in further detail in section II F. "Performance Requirements—Total And Uncompensated Latency."

6. Conforming Amendments and Editorial Changes

Section 91.225 requires ADS–B Out for operations in Class A, B, and C airspace. In the NPRM, the FAA inadvertently left out the proposed conforming amendments to §§ 91.130, 91.131, and 91.135, which address Class A, B, and C airspace. This rule amends these sections to include the ADS–B Out performance requirements for the appropriate airspace.

In addition, the regulatory text for § 91.225 has been reorganized from the proposed rule language. The restructuring of the text should make this section clearer and more reader-friendly.

Lastly, the proposed regulatory text has been moved from Appendix H to new § 91.227.

All substantive changes to this rule are fully discussed in Section II, Discussion of the Final Rule.

D. Differences Between the Proposed Rule and the Final Rule

Table 3 summarizes the substantive changes between the proposed rule and this final rule. Editorial changes and clarifications are explained elsewhere in this preamble.

TABLE 3.— SUBSTANTIVE DIFFERENCES BETWEEN THE PROPOSED RULE AND THE FINAL RULE

Issue area	The NPRM—	The final rule—
Technical Standard Order	Proposed performance standards as defined in TSO–C166a (1090 MHz ES) or TSO–C154b (UAT).	Requires performance standards as defined in TSO–C166b (1090 MHz ES) or TSO–C154c (UAT).
Airspace	Proposed requiring all aircraft above FL 240 to transmit on the 1090 MHz ES broadcast link.	Requires all aircraft in Class A airspace (FL 180 and above) to transmit on the 1090 MHz ES broadcast link.
	Proposed ADS–B performance standards for operations in all Class E airspace at and above 10,000 feet MSL.	Requires ADS–B performance standards for operations in Class E airspace at and above 10,000 feet MSL, excluding the airspace at and below 2,500 feet AGL.
NAC_P	Proposed a $NAC_P \geq 9$, which provides navigation accuracy < 30 meters.	Requires NAC_P < 0.05 NM. ($NAC_P \geq 8$)
NIC	Proposed changes in NIC be broadcast within 10 seconds.	Requires changes in NIC be broadcast within 12 seconds.
SIL	Proposed a SIL of 2 or 3	Requires an SDA of 2. Requires a SIL of 3.
Antenna Diversity	Proposed antenna diversity in all airspace specified in the rule.	Does not require antenna diversity.
Total Latency	Proposed latency in the position source < 0.5 seconds and latency in the ADS–B source < 1 second.	Requires uncompensated latency ≤ 0.6 seconds and maximum total latency ≤ 2.0 seconds.
Message Elements	Proposed a broadcast message element for "receiving ATC services".	Does not require a broadcast message element for "receiving ATC services."
An ability to turn off ADS–B Out.	Proposed that the pilot be able to turn off ADS–B transmissions if directed by ATC.	Does not require the pilot be able to disable or turn off ADS–B transmissions.

E. Separation Standards Working Group

The FAA established an internal Surveillance and Broadcast Systems Separation Standards Working group (SSWG) to develop methodologies and define metrics as appropriate that evaluate the end-to-end performance of ADS–B and wide area multilateration surveillance systems. These evaluations include investigating the integration of these technologies in conjunction with legacy surveillance technologies, that is, separation between target positions that are derived from ADS–B, radar, and wide area multilateration on ATC displays.

This SSWG was tasked to perform: (1) Analyses of performance using system models and simulations, including the identification of key performance drivers and the development of test scenarios; (2) preliminary evaluations with prototype system components to enable verification and validation of the models and as early evidence of system performance; and (3) analyses of test results, operational testing and dedicated separation standards flight tests for each key-site with fully functional end-to-end systems. Also included is a test period for each system where performance data is collected on aircraft operating in the surveillance service volume.

The SSWG analyses and evaluations are the basis for most of the performance requirements specified in this rule.[23]

II. Discussion of the Final Rule

Below is a more detailed discussion of the final rule relative to the comments received on the proposal:

A. Airspace

1. 2,500 Feet Above Ground Level Exclusion in Class E Airspace

The NPRM proposed that aircraft meet ADS–B Out performance requirements to operate in Class E airspace at and above 10,000 feet MSL over the 48 contiguous states and the District of Columbia.

Several commenters, including the DOD and the Experimental Aircraft Association (EAA), stated that the proposed ceiling of 10,000 feet MSL for aircraft without ADS–B would be a major hardship and safety issue for aircraft operators flying in mountainous terrain. Commenters and the ARC suggested that the final rule exclude Class E airspace at and below 2,500 feet above ground level (AGL), similar to the exclusion in § 91.215, ATC Transponder and Altitude Reporting Equipment and Use.

The FAA recognizes the benefit of excluding this airspace in the rule, particularly for visual flight rules (VFR) pilots flying in mountainous areas. This modification addresses airspace that is not affected by the agency's efforts to maximize NAS efficiency and capacity. Excluding this airspace from the rule minimizes any unnecessary financial and operational burdens being placed on aircraft operators who fly in mountainous areas that encroach on

[23] The SSWG findings are available from the Web site *http://www.regulations.gov*. The docket number for this rulemaking is FAA –2007–29305.

Class E airspace at and above 10,000 feet MSL, but choose not to equip for the ADS–B Out performance standards in this rule. Consequently, the final rule does not require ADS–B performance standards for operations 2,500 feet AGL and below in Class E airspace at and above 10,000 feet MSL.

2. Airspace for Which ADS–B Is Required

The NPRM proposed requiring ADS–B performance standards for operations in most classes of airspace where operators currently are required to carry a transponder.

Numerous commenters recommended that the FAA limit ADS–B performance requirements to aircraft operating in Class A airspace only, or Class A and B airspace only. Several commenters questioned the proposed ADS–B performance requirements in Class E airspace above 10,000 feet MSL. Many of these commenters made varying requests to the FAA concerning the proposed altitude for which ADS–B Out would be required, including 12,000 feet MSL, 15,000 feet MSL, FL 180, and FL 250. The United States Parachute Association noted that skydiving operations are typically conducted above 10,000 feet MSL and sometimes conducted in Class A, B, and C airspace.

ADS–B cannot be used for ATC surveillance if all aircraft are not appropriately equipped. Moreover, it is unreasonable to set up a regulatory framework and performance standards that are based on using two primary systems for surveillance; nor is it feasible to fund and maintain two such systems. The airspace requirements specified in this rule for ADS–B Out meet ATC surveillance needs.

Class B and C airspace have the highest volume of air carrier and GA traffic. They also experience the most complex transitions of aircraft from the en route environment to the terminal area. With the intricate nature of the airspace, current regulations dictate more stringent operational requirements to operate within Class B and C airspace areas.

In addition, ATC must have surveillance data for all aircraft operating in these areas to ensure appropriate situational awareness and to maximize the use of the NAS. ADS–B Out will enhance surveillance in controlled airspace areas where secondary surveillance radar (SSR) currently exists.

One commenter stated that the FAA should expand the airspace in which ADS–B is required and specifically recommended including Air Defense Identification Zones (ADIZ) [24] and Offshore Control Area Extensions.

This rule applies to aircraft operating within U.S. airspace, which extends 12 NM from the U.S. coast. (The airspace also includes the Washington, DC, Special Flight Rules Area (SFRA), referred to as an "ADIZ" prior to 2009.) Most of the airspace in the ADIZ falls outside the 12 NM boundaries.

3. Requests for Deviations From ADS–B Out Requirements

This rule requires operators to broadcast ADS–B Out information when operating in specified airspace. If an aircraft is not capable of meeting the performance requirements, the operator may request a deviation from the ATC facility responsible for that airspace. However, as noted in the NPRM, ATC authorizations may contain conditions necessary to provide the appropriate level of safety for all operators in the airspace. ATC may not be able to grant authorizations in all cases for a variety of reasons, including workload, runway configurations, air traffic flows, and weather conditions.

B. Dual-Link Strategy

The NPRM proposed a dual-link strategy for ADS–B Out broadcasts. Under the proposal, aircraft operating above FL 240 would be required to use the 1090 MHz ES broadcast link. Aircraft operating below FL 240 and in airspace where ADS–B Out performance requirements were proposed could use either the 1090 MHz ES or UAT broadcast link.

Many commenters suggested that a single-link system would reduce operational complexity. The commenters noted that the installation and maintenance costs of a dual-link system exceed those of a single-link system. Some of the commenters proposed a single-link solution but disagreed over which link should be chosen. Commenters supporting a single-link UAT system noted that 1090 MHz ES does not support FIS–B and is at risk for frequency congestion in a future air traffic management environment. Commenters supporting a single-link 1090 MHz ES system explained that UAT is not internationally interoperable and opposed a system that requires international operators to equip with both links.

Boeing noted that most of the NAS system delays are associated with arrivals and departures. Therefore, Boeing recommended that the airborne surveillance functions should provide benefits at all altitudes and on the ground. Ultimately, Boeing commented that a single 1090 MHz ES broadcast link would advance future ADS–B In applications at low altitudes.

In mandating ADS–B, the FAA is mindful that some members of the international air transport community and the GA community have already purchased ADS–B Out equipment, which use either the 1090 MHz ES or UAT broadcast link. The FAA finds that a dual-link system is necessary for the United States to meet the operational needs of all NAS operators. Moreover, if the FAA were to require one segment of the aviation community to equip to meet the needs of another segment of the community, this would present additional costs for some operators to equip.

1. Altitude To Require the 1090 MHz ES Datalink

Under the proposal, aircraft operating above FL 240 would be required to use the 1090 MHz ES broadcast link. Operators using only the UAT broadcast link would be limited to operations below FL 240.

The Air Line Pilots Association, International (ALPA) recommended that the FAA require operators to use 1090 MHz ES above 18,000 feet MSL to be consistent with the Class A airspace lower boundary (rather than introduce a new subclassification of established airspace). In addition, several GA commenters requested limiting ADS–B performance requirements to only Class A airspace. The EAA and some individuals stated that UAT would work just as well as 1090 MHz ES above FL 240 and that aircraft should be permitted to use exclusively UAT for operations above FL 240.

The final rule specifies FL 180 (the lower boundary of Class A airspace) as the ceiling for operating an aircraft equipped only with UAT. Using 1090 MHz ES at or above FL 180 provides a clear operational boundary for controllers and pilots, and does not create conditions of mixed equipage for existing or future applications. The FAA recognizes that this modification will affect certain operators that want to operate above FL 180 and equip only with UAT. However, the agency concludes that requiring 1090 MHz ES performance standards for operations in all of Class A airspace is not only reasonable for surveillance, but also establishes a baseline for ADS–B In.

The requirement to broadcast 1090 MHz ES at and above FL 180 does not

[24] An Air Defense Identification Zone (ADIZ) is an area of airspace over land or water in which the ready identification, location, and control of civil aircraft is required in the interest of national security.

preclude UAT reception of FIS–B services up to FL 240 for aircraft with a dual-link reception capability.

2. Automatic Dependent Surveillance-Rebroadcast (ADS–R)

Under a dual-link strategy, the FAA will use ADS–R to allow ADS–B In-equipped aircraft using one type of broadcast link to receive messages about aircraft transmitting on the other broadcast link.

Various commenters, including the Air Transport Association of America, Inc. (ATA), Airservices Australia, the Australia Civil Aviation Safety Authority, the Aircraft Owners and Pilots Association (AOPA), Boeing, British Airways, and the International Air Transport Association (IATA), expressed concern about a dual-link system. Some of these commenters asserted that the need for ADS–R introduces additional system-wide latency into the ADS–B system and poses a single point of failure for the degradation or loss of surveillance data. In their view, this could limit potential separation and efficiency improvements and affect the air-to-air surveillance element of future ADS–B In applications. In addition, some commenters expressed concern about the additional risk of faults or failures that could result from translating, merging, and rebroadcasting data from the 1090 and 978 MHz frequencies.

Some commenters, including Boeing, contended that ADS–R may not have sufficient growth capability to support future ADS–B In air-to-air applications. Such applications include merging and spacing, self separation, or using ADS–B data to supplement or replace TCAS because of potential of latency or loop delays. Rockwell-Collins stated that ADS–R should be able to support many ADS–B In air-to-air applications, including closely spaced parallel approaches and enhanced visual approach. It recommended developing ADS–R to support more demanding aircraft surveillance applications (ASA).[25]

Several commenters, including AOPA, asserted that the dual-link system presents a safety hazard because aircraft equipped with different links cannot "see" each other on ADS–B In displays in areas without ADS–R coverage. The commenters suggested providing ADS–R at all public airports where a mix of both systems will be encountered.

The FAA is deploying ADS–R in all areas where ADS–B ATC surveillance exists.[26] ADS–R collects traffic information broadcast on the 978 MHz UAT broadcast link and rebroadcasts the information to 1090 MHz ES users. Similarly, ADS–R collects traffic information provided on the 1090 MHz ES broadcast link and rebroadcasts the information to UAT users. ADS–R permits aircraft equipped with either 1090 MHz ES or UAT to take advantage of ADS–B In applications.

The FAA disagrees with the comments suggesting that ADS–R introduces safety issues because of the added latencies attributed to ADS–R processing. ATC automation systems do not require or use ADS–R to provide surveillance. The added latency in the rebroadcast of the original ADS–B message are measurably small and do not degrade the reported NAC_P, NAC_V, and NIC values. The ARC agreed in its report that the latency in ADS–R processing does not degrade the reporting of the position quality parameters.[27] Latency attributed to ADS–R does not compromise the safety of the initial ADS–B In applications.

The intended functions of ADS–B, as identified in the NPRM, are not compromised by the latency introduced with rebroadcasting the messages. However, future ADS–B In applications necessarily may be limited becauseof the latency associated with ADS–R.[28] The FAA has a strong interest in providing the option for operators to equip with UAT, so they may benefit from FIS–B service. In making the decision to use a dual-link strategy, the FAA acknowledged and weighed the fact that potential benefits of future applications may not be fully realized based on this decision. In situations where an airport is not within the planned ADS–B coverage area, the airport will not have ADS–R coverage. Consequently, an aircraft with ADS–B In will not have the benefit of ADS–R, and ADS–B In will not provide awareness of aircraft that are broadcasting on a different broadcast link.

If an aircraft leaves the ADS–B coverage area, there will be an indication to the pilot that the aircraft is no longer within range of ADS–R service. In this case, the pilot needs to maintain separation in the same manner done today, which is relying on visual scanning and directions from ATC. The FAA will ensure that the dual-link strategy does not impact safety as future applications are developed.

3. 1090 MHz Frequency Congestion

Boeing, Federal Express (FedEx), and IATA suggested that the FAA assess future 1090 MHz frequency congestion. The ARC supported the dual-link strategy, but recommended that the FAA study the necessary mitigations of 1090 MHz frequency congestion. The ARC specifically recommended that these mitigations ensure 1090 MHz ES is interoperable with ACAS and SSR, while providing sufficient air-to-air range to support NextGen ADS–B In applications.

Congestion on the 1090 MHz frequency is a risk shared by TCAS/ACAS and SSR systems using the Mode S transponder. The FAA conducted a study to assess 1090 MHz frequency congestion in the future air traffic environment.[29] The FAA is analyzing alternatives and will enact the necessary mitigations to reduce the 1090 MHz frequency congestion risk for ADS–B, TCAS, and SSR, while enabling ranges appropriate for many ADS–B In applications through 2035.

C. Performance Requirements—System

While some commenters supported the proposed performance requirements, numerous organizations and individuals commented that the performance requirements generally were too stringent, unnecessary, and would entail an undue economic burden on operators.

1. Performance Requirements Tailored to Operator, Airspace, or Procedure

The NPRM proposed specific performance requirements for ADS–B Out. Several commenters, including the Aerospace Industries Association of America (AIA), Boeing, the DOD, EAA, Honeywell, Lockheed Martin, and the ARC, asked the FAA to tailor the ADS–B performance requirements based on specific application requirements or airspace.

Lockheed Martin and the DOD noted that some military aircraft may not meet the proposed equipage requirements and would need accommodations to operate in ADS–B Out-designated airspace. One commenter was concerned that the DOD was exempt from the proposed requirements.

[25] ASA comprises a number of flight-deck-based aircraft surveillance and separation assurance capabilities that may directly provide flight crews with surveillance information and alerts.

[26] The service coverage volume for ADS–B In applications is explained in greater detail at *http://www.adsb.gov*.

[27] *ADS–B ARC Task II Report to the FAA* Appendix N, ADS–R Latency and Reliability Expectations (September 26, 2008), available on the Web site, *http:///www.regulations.gov,* FAA–2007–29305–0221.1.

[28] To date, the requirements for using ADS–B for advanced iterations of merging and spacing, and self separation have yet to be defined.

[29] A copy of this report is available from the Web site *http://www.regulations.gov*. The docket number for this rulemaking is FAA–2007–29305.

The FAA has determined that it is not operationally feasible to assign different performance requirements dependent on the nature of the operation. It would not be effective to require both pilots and controllers to verify specific performance parameters before any given operation or change of airspace. Therefore, the FAA is specifying minimum performance requirements for all ADS–B Out-equipped aircraft to operate in certain designated airspace.

No special allowance is made in this rule to relieve the military from the same performance requirements as the civilian aviation community. The FAA recognizes that the DOD and other Federal agencies are NAS users, and need access to all areas of the NAS today and in the future. This rule provides procedures for an aircraft that does not meet the ADS–B Out performance requirements, *i.e.,* to obtain an ATC authorized deviation to operate in the airspace for which ADS–B is required. The FAA will collaborate with the appropriate U.S. Government departments or agencies (including but not limited to DOD, and the Department of Homeland Security) to develop Memorandums of Agreement to accommodate their National defense mission requirements while supporting the needs of all other NAS users.

2. Navigation Accuracy Category for Position (NAC_P)

The NPRM proposed requiring a NAC_P greater than or equal to 9. This is equivalent to horizontal position accuracy of less than 30 meters and vertical position accuracy of less than 45 meters. A NAC_P of less than 30 meters horizontal would support ATC surveillance, ASSA, FAROA, and other future ADS–B In applications.

Airbus, ATA, Aviation Communication and Surveillance Systems (ACSS), Boeing, Rockwell-Collins, United Airlines, and United Parcel Service (UPS) questioned the necessity of a NAC_P greater than or equal to 9. The ARC recommended that the FAA institute NAC_P requirements based on domains of airspace defined by different types of operations, with minimum NAC_P values ranging from 5 through 9.[30] The ARC also recommended that when a NAC_P greater than or equal to 9 is necessary, operators should only be required to equip with a position source that could meet a NAC_P greater than or equal to 9 for 95 percent of an hour and meet a NAC_P greater than or equal to 8 for 99.9 percent of an hour.

Boeing commented that there is no need for vertical accuracy because neither ATC nor any of the initial ADS–B In applications require it. The ARC recommended that the FAA not apply the vertical position accuracy requirement associated with a NAC_P of 9 for surface operations. The ARC also recommended that the FAA modify the definition of a NAC_P of 9 in DO–260A and DO–282A. This modification would remove the vertical accuracy requirement if the aircraft is on the surface.

The FAA reviewed these comments and the necessary requirements for the ADS–B Out and ADS–B In applications that are contemplated today. A NAC_P of less than 0.05 NM is required for ATC surveillance. A NAC_P of less than 30 meters is required only for ASSA and FAROA. Because surface surveillance benefits enabled by ADS–B will only be fully available where Airport Surface Detection Equipment, Model X (ASDE–X) systems,[31] and ADS–R and TIS–B are in use, the FAA has reconsidered the universal requirement of a NAC_P of less than 30 meters.

While the higher NAC_P would support a limited number of ADS–B In applications, it could also increase costs [32] to all operators required to meet the ADS–B performance standards. Therefore, this final rule reduces the position accuracy reporting requirement and adopts a NAC_P of less than 0.05 NM. This NAC_P requirement applies to all aircraft operating in the airspace identified in this rule.

In addition, the FAA considered the comments regarding the vertical accuracy component of NAC_P. As there are no ATC separation services requirements for vertical accuracy or integrity, the FAA has removed the vertical accuracy and integrity requirement from NAC_P, NAC_V, NIC, and SIL in TSO–C154c and TSO–C166b.

3. Navigation Accuracy Category for Velocity (NAC_V)

The NPRM proposed requiring a NAC_V greater than or equal to 1, which is equivalent to velocity accuracy of less than 10 meters per second.

The European Organisation for the Safety of Air Navigation (EUROCONTROL) commented that a NAC_V of 1 is not sufficient for ATC services or advanced ADS–B In applications. The ARC recommended that NAC_V should not be required.

Different air navigation service providers may need different performance requirements depending on the airspace in which they implement ADS–B separation services. The FAA reviewed this requirement and concludes that a NAC_V is required for separation services in the United States. The agency modeled and calculated the NAC_V requirements for aircraft separation, using assumptions unique to the U.S. environment. Based on this analysis, the FAA determined that a horizontal velocity accuracy of less than 10 meters per second, as proposed in the NPRM, is required for ATC surveillance within the NAS.[33] Therefore, this requirement is adopted as proposed.

4. Navigation Integrity Category (NIC)

The NPRM proposed requiring a NIC greater than or equal to 7, which provides navigation integrity of less than 0.2 NM. Boeing questioned the necessity of this requirement. The ARC recommended that the FAA adopt NIC requirements based on airspace, with minimum NIC values ranging from 0 to 7.

The FAA reviewed this requirement and determined that a NIC of less than 0.2 NM is necessary for ATC separation services, particularly in the approach environment. Similar to the NAC_P, it is not practical to assign different NIC values based on types of airspace. Therefore, this rule requires a NIC of less than 0.2 NM.

5. Surveillance Integrity Level

The FAA's proposal for surveillance integrity level stated that the surveillance integrity level is based on both the design assurance level of the ADS–B Out avionics and the position source. Several commenters, including Rockwell-Collins, pointed out that the proposed definition was inconsistent with the surveillance integrity level definition provided in DO–260A. Commenters stated that DO–260A Change 2 defined surveillance integrity level as including only the position source. The ARC recommended that the FAA use the definition of surveillance integrity level found in RTCA DO–

[30] *ADS–B ARC Task II Report to the FAA 6* (September 26, 2008), available on the Web site, *http://www.regulations.gov,* FAA–2007–29305–0221.1.

[31] ASDE–X is a traffic management system for the airport surface that provides seamless coverage and aircraft identification to air traffic controllers. The system uses a combination of surface movement radar and transponder multilateration sensors to display aircraft position.

[32] *ADS–B ARC Report to the FAA* Appendix P, Programmatic Decision Analysis (September 26, 2008), available at *http://www.regulations.gov,* FAA–2007–29305–0221.1.

[33] A copy of the Separation Standards Working Group report is available from the Web site *http://www.regulations.gov.* The docket number for this rulemaking is FAA–2007–29305.

289,[34] which also limited the design assurance to the position source.

The FAA asserts that the design assurance of the ADS–B system needs to represent the complete system, and not a single piece of that system, to provide air traffic separation services. The FAA agrees that the inconsistency between the proposed rule and the RTCA standard is unworkable; however, RTCA has updated the design assurance requirements in DO–260B and DO–282B to include the entire ADS–B avionics system, rather than just the position source. The ADS–B system includes ADS–B transmission equipment, ADS–B processing equipment, position source, and any other equipment that processes the position data transmitted by the ADS–B system. The DO–260B change is consistent with the rule.

6. Source Integrity Level (SIL) and System Design Assurance (SDA)

In DO–260A (TSO–C166a) and DO–282A (TSO–C154b), SIL was defined as surveillance integrity level and represented two separate components: (1) The maximum probability of exceeding the NIC containment radius and (2) a maximum probability of a failure causing false or misleading data to be transmitted. DO–260B (TSO–C166b) and DO–282B (TSO–C154c) separate these two components into two distinct parameters. SIL is now referred to as source integrity level and defines the maximum probability of exceeding the NIC containment radius; SDA now defines the maximum probability of a failure causing false or misleading data to be transmitted.

The FAA proposed a SIL value of 2 or 3. A SIL of 2, as stated in TSO–C166a and TSO–C154b, represented: (1) A maximum probability of exceeding the NIC containment radius of $1x10^{-5}$ per hour or per sample; and (2) a maximum probability of a failure causing false or misleading data to be transmitted of $1x10^{-5}$ per hour.

A SIL of 3 represented: (1) A maximum probability of exceeding the NIC containment radius of $1x10^{-7}$ per hour or per sample and (2) a maximum probability of a failure causing false or misleading data to be transmitted of $1x10^{-7}$ per hour.

The FAA proposed these two values for SIL because its separation standards modeling determined that the probability of exceeding the NIC containment radius must be less than $1x10^{-7}$ per hour or per sample and the probability of a failure causing false or misleading data must be less than $1x10^{-5}$ per hour. The FAA's TSOs and the corresponding RTCA documents did not allow for this combination.

Therefore, in developing and issuing the NPRM, the FAA assumed that most operators, in upgrading their equipment for ADS–B, would equip with a global positioning system (GPS)[35] that would provide a NIC containment radius of $1x10^{-7}$ per hour (a SIL of 3). However, to require the associated maximum probability of failure causing false or misleading data to be transmitted at $1x10^{-7}$ per hour was not only unreasonable but also unnecessary. Therefore, the FAA proposed that a SIL of 2 was also acceptable.

With the separate SIL and SDA values available under DO–260B and DO–282B, the rule requires a maximum probability of exceeding the NIC containment radius of $1x10^{-7}$ per hour or per sample (which equates to a SIL of 3), and a maximum probability of $1x10^{-5}$ per hour of a failure causing false or misleading data to be transmitted (which equates to an SDA of 2).

Changing the proposed probability of exceeding the NIC containment radius from $1x10^{-5}$ per hour or per sample to $1x10^{-7}$ per hour or per sample should not impact NAS users. This is because currently available ADS–B Out systems using GNSS will provide an integrity metric based on $1x10^{-7}$ per hour.

7. Secondary Position Sources

The General Aviation Manufacturers Association (GAMA), IATA, and Rockwell-Collins commented that the final rule should specify separate performance requirements for secondary position sources in the event that their primary position source is unavailable.

The FAA disagrees that a separate set of requirements is necessary for secondary position sources because the rule does not require a secondary source. The NAC_P, NAC_V, NIC, SDA and SIL requirements in this rule apply regardless of the position source in use.

D. Performance Requirements—Antenna Diversity

The NPRM proposed that aircraft meet optimum system performance by equipping with both a top and a bottom antenna to support ADS–B In applications.

Several commenters, including AOPA, did not support this aspect of the proposal because antenna diversity significantly increases the cost of ADS–B. AOPA also noted that historical TCAS and transponder use does not indicate that dual antennas are necessary.

Airservices Australia and the Australia Civil Aviation Safety Authority noted that Australia is not requiring antenna diversity for GA aircraft. The ARC recommended allowing non-diversity antenna installations for VFR aircraft flying through Class B and C airspace and below 15,000 feet MSL (1090 MHz ES) or below 18,000 feet MSL (UAT), but not landing at a primary airport. The ARC also recommended that the FAA undertake further studies to assess and validate the need for antenna diversity in low-altitude airspace.

The FAA proposed dual antennas to support ADS–B Out and ADS–B In air-to-air applications. For ATC surveillance, only a single bottom-mounted antenna is necessary. The commenters and the ARC identified this element of the proposal as requiring significant costs for the GA operators.[36]

The FAA has reconsidered its initial strategy for launching the ADS–B requirements and is adopting the performance standards necessary for ATC surveillance. Therefore, this rule does not require antenna diversity for ADS–B to operate in any airspace. This change does not alter or affect antenna diversity requirements for other aircraft systems, such as transponders or TCAS II.

Operators should be aware that a dual antenna installation could provide additional benefits that are not included in the scope of this rule. Airport surface situational awareness or alerting applications may be compromised by a single-antenna installation. Operators who equip with a single antenna may not be able to accrue all available benefits from some or all future ADS–B In applications.

While requirements for these applications have not yet been fully defined, modeling performed by both the ARC and the FAA has indicated that a single antenna may not be able to perform adequately for surface applications. If the FAA, for example, issues a future mandate requiring surface performance capability, operators of single-antenna-equipped aircraft may need to upgrade the avionics installed on their aircraft.

Operators should also be aware that single-antenna installations are not as capable as dual-antenna installations of receiving ADS–B messages in an

[34] Minimum Aviation System Performance Standards (MASPS) for Aircraft Surveillance Applications (ASA).

[35] GPS is a U.S. satellite-based radio navigation system that provides a global-positioning service.

[36] *ADS–B ARC Task II Report to the FAA* Appendix T, Antenna Diversity Comments on Cost, (September 26, 2008), available at *http://www.regulations.gov,* FAA–2007–29305–0221.1.

environment with a highly congested spectrum. Because of increasing congestion on the 1090 MHz frequency over time, single-antenna installations of ADS–B may not be able to achieve the same range for ADS–B In applications as aircraft with two antennas.

This limitation on the upper bound of ADS–B In application range for single-antenna installations does not impact any of the application benefits cited in this rule. The FAA is actively pursuing strategies to mitigate spectrum congestion concerns of the 1090 MHz frequency. However, operators employing the 1090 MHz ES broadcast link should be aware that future air-to-air applications that require longer range reception may require dual antennas or a UAT system.

E. Performance Requirements—Transmit Power

The NPRM proposed that aircraft equipped with UAT would have a minimum 16-watt transmit power performance and aircraft equipped with 1090 MHz ES would have a minimum 125-watt transmit power performance. Some commenters, particularly AOPA, argued that the proposal was not warranted and imposed unnecessary expense. The ARC commented that using the existing power level without antenna diversity may provide the performance needed to make broader use of non-diversity antenna installations.

The FAA has determined that reducing the transmit power requirement would significantly impact the ground infrastructure. The FAA will rely on a series of approximately 800 ground stations to provide ATC separation services throughout the United States. The ground stations will be placed 150 to 200 miles apart and will require the minimum aircraft output power specified in the rule to ensure coverage. Lowering the aircraft output power requirements, as suggested by the commenters, would require the FAA to expand and redesign the ADS–B ground infrastructure. Consequently, the power levels remain unchanged in the final rule.

F. Performance Requirements—Total and Uncompensated Latency

In the NPRM, the FAA proposed to define latency as the time information enters the aircraft through the aircraft antenna(s) until the time it is transmitted from the aircraft. The FAA further proposed that the navigation sensor should process information received by the aircraft's antenna(s) and forward this information to the ADS–B broadcast link avionics in less than 0.5 seconds. The processed information then would be transmitted in the ADS–B message from the ADS–B Out broadcast link avionics in less than 1.0 second from the time it was received from the navigation sensor.

Several commenters, including Airbus, Boeing, EUROCONTROL, GAMA, and Honeywell, commented that the latency requirements are not well defined, are too stringent, and are not consistent with other standards.[37] United Airlines and UPS recommended that the FAA specify the accuracy of position information at the time of transmission. Boeing and Honeywell recommended that the FAA specify latency, based on the time of applicability of the position source.

The ARC stated that the FAA should: (1) Specify latency requirements at the aircraft level, not the equipment level; (2) specify the maximum uncompensated latency to minimize or eliminate installation wiring changes of existing ADS–B Out implementations, while meeting ATC surveillance requirements; (3) specify total latency and uncompensated latency; and (4) reference latency to the time of applicability of the position provided by the position sensor, rather than the time of measurement.

The FAA adopts three of the four ARC recommendations. First, the FAA agrees that latency must be defined at the aircraft level and not the equipment level. Second, the latency requirements are set at the maximum value that will allow ATC surveillance. Although the latency requirements will drive wiring changes in some aircraft, the requirements will minimize the number of aircraft affected to the maximum extent possible. Third, the FAA has defined the latency requirements as total latency and uncompensated latency. The FAA does not agree with the fourth recommendation to measure latency at the time of applicability. To do so would place latency requirements only on part of the overall system and specifically exclude the position source latency. Since the entire system's latency, including the position source, must be limited to ensure accuracy of the transmitted position the rule requires latency to be measured from the position source time of measurement and not the time of applicability.

This rule specifies two separate latency requirements: Total latency and uncompensated latency. Total latency is defined as the time between when measurements are taken to determine the aircraft's geometric position (latitude, longitude, and geometric altitude) and when the ADS–B transmitter broadcasts the aircraft's position. Under this rule, the total latency cannot exceed 2.0 seconds. Latency is compensated to account for the movement of the aircraft while the unit is processing the position information. The avionics usually compensate latency based on velocity but may also compensate based on acceleration.

Uncompensated latency is defined as the time the avionics does not compensate for latency. Under this rule, within the 2.0 second total latency allocation, a maximum of 0.6 seconds may be uncompensated latency. The avionics must compensate for any latency above 0.6 seconds up to the maximum of 2.0 seconds by extrapolating the position to the time of transmission.

Aircraft velocity, as well as position accuracy and integrity metrics (NAC_P, NAC_V, NIC, SDA, and SIL), must be transmitted with their associated position measurement, but are not required to be compensated.

G. Performance Requirements—Time To Indicate Accuracy and Integrity Changes

The NPRM proposed that changes in NIC and NAC_P must be broadcast within 10 seconds. This proposed requirement would bind the latency of the NIC and NAC_P, however this requirement would also bind the maximum amount of time an integrity fault can exist without an indication, as an integrity fault is indicated by changing the NIC and NAC_P to zero.

The ARC, GAMA, and Rockwell-Collins commented that 10.0 seconds is not enough time to indicate a change in the NIC. They specifically noted that GNSS position sources use the entire 10-second allocation, which does not allow time for the ADS–B equipment to actually transmit the change. Rockwell-Collins, GAMA, and the ARC recommended instead that changes in NIC and SIL be broadcast within 12.1 seconds.

Position sources typically provide an accuracy and integrity metric with each position that is output. To allow GNSS-based position sources time to detect and eliminate possible satellite faults, GNSS systems allow the integrity metric associated with a position to actually lag behind the output of the position. TSO–C145/146 and TSO–C196 GNSS systems have up to 8.0 seconds to alert to an

[37] The commenters specifically referenced the RTCA Airborne Surveillance Applications Minimum Aviation System Performance Standards and DO–303 Safety "Safety, Performance and Inoperability Requirements Document of the ADS–B Non-Radar-Airspace (NRA) Application."

integrity fault. TSO–C129 systems do not have an overarching integrity fault time-to-alert requirement, but they do have navigation mode specific integrity fault time-to-alert requirements. Specifically, TSO–C129 systems must indicate an integrity fault within 10 seconds in terminal and approach modes.

The requirement to indicate a change in NIC applies to the time between when a fault-free NIC is transmitted with a faulted position and when the NIC is updated to indicate the fault. Thus, the clock to indicate the change in NIC does not start at the onset of the fault, but rather at the broadcast of the faulted position from the ADS–B system. Thus, the total time to update the NIC is based on the cumulative effect of—(1) the position source fault detection and exclusion time, and (2) the worst-case asynchronous transmission difference between when the fault-free NIC with faulted position is transmitted and when the faulted NIC is transmitted.

The FAA reviewed the separation standards work to determine if a 12.0 second delay in the broadcast of an integrity fault would impact separation standards. The FAA found that no existing terminal and en route surveillance standards would be impacted with a 12.0 second delay, and thus the rule requires that changes in NIC be broadcast within 12.0 seconds.

The ARC, GAMA, and Rockwell-Collins also commented that changes in NAC_P, NAC_V, and SIL should be broadcast within 3.1 seconds versus 10.0 seconds. The FAA determined that there is no basis to tighten the requirement. Therefore, the 10.0 second requirement applies to indicating changes in NAC_P, NAC_V, SDA, and SIL.

H. Performance Requirements—Availability

The FAA did not propose any availability [38] requirements for this rule. The proposed rule generated multiple comments concerning statements in the preamble regarding availability and whether the FAA should require operators to accomplish a preflight determination of GNSS availability. Other commenters focused on a perceived requirement for operators to equip with avionics that had a system availability equivalent to Wide Area Augmentation System (WAAS) [39].

1. Preflight Determination of Availability

The proposal preamble explained that operators must verify ADS–B Out availability before flight as part of their pre-flight responsibilities. This is similar to the requirement for preflight determination of availability for certain Required Navigation Performance (RNP) [40] operations.

ATA argued that the process to determine availability could be time consuming for operators and that the FAA should provide further justification. Boeing stated that the NPRM did not include an availability requirement; therefore, the FAA should correct its statement in the NPRM preamble advising operators to make this part of their preflight actions.

The ARC recommended that the FAA provide preflight prediction systems that assess the ability of typical positioning sources to meet the position accuracy and integrity requirements.

This rule requires operators to meet the adopted minimum position accuracy and integrity performance requirements to operate in the airspace described in the rule. To facilitate compliance with the rule and assist pilots for the flight planning, the FAA will provide a preflight availability prediction service by 2013. Therefore, prior to departure, operators should verify that the predicted performance requirements will be met for the duration of the flight. This service will determine whether GNSS equipment is capable of meeting § 91.227 position accuracy and integrity requirements for operating in the airspace defined in this rule. Operators may also use their own preflight availability prediction tools, provided the predictions correspond to the performance of their equipment. The FAA advises operators to consult manufacturers' information on specific avionics and prediction services.

2. System Availability

Numerous commenters, including the DOD, contended that the proposal required WAAS (or implied that the positioning service used by the aircraft have an availability equivalent to WAAS.)

As stated in the NPRM, operators may equip with any position source. Although WAAS is not required, at this time it is the only positioning service that provides the equivalent availability to radar (99.9 percent availability). The FAA expects that future position sources such as GNSS using the L5 GPS signal, GPS using Galileo signals, and GPS tightly integrated with inertial navigation systems will also provide 99.9 percent availability. Operators who equip with other position sources, such as non-augmented GPS, may experience outages that limit their access to the airspace defined in this rule.

If an aircraft's avionics meet the requirements of this rule but unexpected GPS degradations during flight inhibit the position source from providing adequate accuracy (within 0.05 NM) and integrity (within 0.2 NM), ATC will be alerted via the aircraft's broadcasted data and services will be provided to that aircraft using the backup strategy. An aircraft that is not equipped to meet the requirements of this rule will not have access to the airspace for which ADS–B is required. The FAA notes that preflight availability verification eliminates any need for the system to meet a specified availability requirement upon installation.

I. Performance Requirements—Continuity

The FAA did not propose a continuity [41] requirement in the NPRM. Several commenters, including Airbus, GAMA, Rockwell-Collins, and the ARC, suggested that the FAA add a continuity requirement. These commenters argued that such a requirement would ensure that an aircraft could continue providing the ADS–B information throughout a flight.

Aircraft are to meet the performance requirements for the duration of the operation, not just a portion of the flight. The FAA's preflight availability prediction service will help pilots ensure that the aircraft can continue transmitting ADS–B information throughout their planned flight, based on expected operations. Unexpected

[38] RTCA DO–229, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment, defines the availability of a navigation system as the ability of the system to provide the required function and performance at the initiation of the intended operation. Availability is an indication of the ability of the system to provide usable service with the specified coverage area. Signal availability is the percentage of time that navigational signals transmitted from external sources are available for use. Availability is a function of both the physical characteristics of the environment and the technical capabilities of the transmitter facilities.

[39] WAAS is a U.S. wide-coverage augmentation system to GPS that calculates integrity and correction data on the ground and uses geostationary satellites to broadcast the data to GPS/SBAS (Satellite-Based Augmentation System (non-U.S.)) users.

[40] Required Navigation Performance (RNP) is a statement of the total aircraft navigation performance necessary for operation within a defined airspace.

[41] DO–229 defines the continuity of the system as the ability of the total system (comprising all elements necessary to maintain aircraft position within the defined airspace) to perform its function without interruption during the intended operation. More specifically, continuity is the probability that the specified system performance will be maintained for the duration of a phase of operation (presuming that the system was available at the beginning of that phase of operation), and predicted to exist throughout the operation.

failures will be accommodated, as described in the discussion on availability; therefore, there is no need for a separate continuity requirement.

J. Performance Requirements—Traffic Information Service—Broadcast Integrity (TIS–B)

The NPRM did not propose any changes to the standards for TIS–B. Boeing stated that the FAA's plans to implement TIS–B with a SIL of 0 would severely limit its utility for ADS–B In applications. Boeing recommended that the FAA change TIS–B to provide a SIL of 2 or greater, to be consistent with the SIL proposed for ADS–B Out. Honeywell commented that a TIS–B integrity level should be established for value-added, near-term applications. The ARC did not specifically comment on the TIS–B SIL, but did recommend that the FAA include a discussion of the FIS–B and TIS–B benefits in the preamble to the ADS–B Out final rule.

The TIS–B system is expected to support four of the five initial ADS–B In applications. The FAA acknowledges that future ADS–B In applications may require improved representation of the position integrity metrics. With the SIL and SDA changes incorporated in DO–260B and DO–282B and possible changes to future versions of DO–317, the FAA plans, outside of this rulemaking effort, to evaluate the usefulness of the broadcast of integrity parameters from TIS–B.

K. Broadcast Message Elements

1. NAC_P/NAC_V/NIC/SDA/SIL

The NPRM did not specifically propose NAC_P, NAC_V, NIC, or SIL as broadcast message elements in section 4 of appendix H to part 91, Minimum Broadcast Message Element Set for ADS–B Out. These requirements were specified in section 3 of appendix H to part 91, ADS–B Out Performance Requirements for NIC, NAC, and SIL.

Honeywell noted that NAC_P, NAC_V, NIC, and SIL are required message elements in DO–260A.

To resolve any questions, the FAA has repeated the indications for these elements in § 91.227(d)(16) through (19). In addition, and consistent with TSO–C166b and TSO–C154c, SIL and SDA are listed as separate values.

2. Receiving ATC Services

The NPRM proposed requiring the message element "Receiving ATC Services." Several commenters, including ACSS, Airbus, Boeing, EUROCONTROL, United Airlines, and UPS, commented that this message element is unnecessary and poorly defined. UPS and United Airlines suggested that the FAA use the ground automation system to accomplish the function of this message element. Some commenters also contended that this message element could require an additional user interface, which is not available on current equipment.

The ARC recommended that the FAA clarify the definition of this message element and explain how it can be implemented without pilot entry. The ARC also requested that the FAA research whether both "Receiving ATC Services" and "Mode 3/A Code" are necessary.

The FAA concludes that "Receiving ATC Services" is not necessary for ATC surveillance because this information can be directly inferred from the Mode 3/A code. Furthermore, this message element could increase costs for an additional user interface. Therefore, this rule does not include "Receiving ATC Services" as a required broadcast message element.

3. Length and Width of the Aircraft

The NPRM proposed requiring a message element to broadcast the length and width of the aircraft.

Airbus and EUROCONTROL commented that length and width information is not necessary for surveillance or airborne ADS–B Out applications. Airbus and an individual commenter noted that length and width information should be quantified relative to the aircraft position reference point or to a known offset.

GAMA and Rockwell-Collins noted that the TSOs allow some aircraft to continuously transmit "in-air" because these aircraft do not have a means to determine their air/ground status. Rockwell-Collins commented that the rule should require all aircraft to assess their air/ground status and broadcast the appropriate set of messages for that status. The ARC recommended that the FAA address this issue in the preamble to the final rule.

The FAA notes that TSO–C154c and TSO–C166b allow the operator to determine whether to transmit the aircraft's latitude and longitude referenced to the GPS antenna location or the ADS–B position reference point. The ADS–B position reference point is the center of a box, based on the aircraft length and width. With the position offset to the ADS–B reference point, the ADS–B is able to report the position of the edges of the aircraft. This rule does not require operators to apply the position offset because ATC surveillance does not require a position offset.

The FAA concludes that the requirement to transmit aircraft length and width is necessary because this message element will be used as an input for ASDE–X systems and allows the FAA to decommission ASDE–3 radars [42] that interface with ASDE–X, as well as the surface movement radar systems that are at certain ASDE–X sites without ASDE–3. The length-width code will be preset when ADS–B equipment, meeting the standards in TSO–C154c or TSO–C166b, is installed in the aircraft.

ADS–B equipment transmits an airborne position message when the aircraft is airborne, and a surface position message when the aircraft is on the ground. Aircraft automatically determine airborne or ground status and transmit the appropriate message. For aircraft that are unable to determine their air-ground status automatically, the RTCA standards and TSOs allow the aircraft to continuously transmit the airborne position message. However, the length width code is a required message element in this rule, and is only transmitted in the surface position message. Thus, to comply with the rule, the aircraft must automatically determine its air-ground status and transmit the surface position message which includes the length width code when on the ground.

4. Indication of the Aircraft's Barometric Pressure Altitude

The NPRM proposed a broadcast message that would report the aircraft's barometric pressure altitude. Several commenters, including the ARC, GAMA, Rockwell-Collins, Sandia National Laboratories (SANDIA), and UPS, identified an inconsistency regarding the barometric altitude message element between the proposed rule's preamble and regulatory text.

The FAA agrees that the NPRM preamble was not completely clear and should have better reflected the proposed regulatory text. The proposed regulatory text stated that the pressure altitude reported for ADS–B Out and Mode C/S transponder is derived from the same source for aircraft equipped with both a transponder and ADS–B Out. The FAA confirms that the barometric altitude reported from the aircraft's transponder and ADS–B Out must be derived from the same source.

In addition, the FAA is striking the January 1, 2020 compliance date from proposed § 91.217(b). If an operator chooses to use ADS–B before January 1,

[42] ASDE–3 is an airport radar that shows to tower controllers the location of aircraft on the surface.

2020, the operator must meet the provisions of that section.

5. Indication of the Aircraft's Velocity

The NPRM proposed a message element that would provide ATC with information about the aircraft's velocity and direction. However, the NPRM preamble mistakenly referred to velocity as airspeed. Several commenters, including Airbus, the ARC, Rockwell-Collins, SANDIA, and UPS, recommended that the message element reflect velocity instead of airspeed. Rockwell-Collins noted that velocity could be derived from other sources, including an inertial navigation system. ACSS, United Airlines, and UPS recommended that the FAA require the velocity source for ADS–B transmissions to be the most accurate velocity source on the aircraft. The ARC recommended that the issue of velocity source be referred to RTCA.

This message element will provide ATC with the aircraft's velocity, as well as a clearly stated direction and description of the rate at which an aircraft changes its position. The velocity must be transmitted with a NAC_V of less than 10 meters per second. Any velocity source that meets these requirements will comply with this rule. The FAA referred the question on velocity source to RTCA for further review, as the ARC recommended. RTCA determined that the velocity source must be the same source that provides the aircraft's position, and included this requirement in DO–260B and DO–282B.

6. Indication If Traffic Alert and Collision Avoidance System II or Airborne Collision Avoidance System Is Installed and Operating in a Mode That May Generate Resolution Advisory Alerts

The NPRM proposed requiring a message element that would (1) identify to ATC whether the aircraft is equipped with TCAS II or ACAS and (2) identify whether the equipment is operating in a mode that could generate resolution advisory alerts. Airbus asked for more information on why this message element is required. EUROCONTROL commented that this message element should be internationally harmonized before the FAA adopts this requirement. UPS asked whether this message should be indicated if the TCAS II is operated in the traffic advisory mode. The ARC sought to retain this message element, but asked the FAA to clarify its intended use in the final rule.

The TCAS installed and operating in a mode that can generate a resolution advisory message will be used by the FAA to monitor in-service performance to address NAS inefficiencies and take appropriate corrective actions. This information may also be used to support future ADS–B In applications. This message element was harmonized with the international community in the development of DO–260B and ED–102A.[43]

7. For Aircraft With an Operable Traffic Alert and Collision Avoidance System II or Airborne Collision Avoidance System, Indication If a Resolution Advisory Is in Progress

The NPRM proposed a message element to indicate that a resolution advisory is in progress. EUROCONTROL recommended that the FAA internationally harmonize this message element before adopting the requirement. Airbus noted that this element may be achieved with DO–260A.

Similar to the discussion in II.K.6. above, the message that a TCAS resolution advisory is in progress will be used by the FAA to monitor in-service performance to address NAS inefficiencies and take appropriate corrective actions. This information may also be used to support future ADS–B In applications. This message element was harmonized with the international community in the development of DO–260B and ED–102A.

8. Indication of the Mode 3/A Transponder Code Specified by ATC (Requires Flightcrew Entry)

The NPRM proposed a message element to transmit the aircraft's assigned Mode 3/A transponder code.

Several commenters, including ACSS, Boeing, SANDIA, and UPS, argued that this message element should not be necessary with ADS–B surveillance, and suggested deleting the requirement. GAMA expressed concern that different codes in the Mode 3/A transponder and the ADS–B could result in an indication of a traffic conflict. GAMA specifically recommended a one code entry or revising the automation to resolve conflicting information. Airbus and the ARC supported this message element requirement and the ARC requested more information on its intended use.

The FAA has determined that the same ATC-assigned Mode 3/A code must be transmitted by both the transponder and the ADS–B Out message. If the code transmitted by ADS–B differs from the Mode 3/A code transmitted by the transponder, it could result in duplicative codes or inaccurate reporting of aircraft position. If the aircraft's avionics are not capable of allowing a single point of entry for the transponder and ADS–B Out Mode 3/A code, the pilot must ensure that conflicting codes are not transmitted to ATC.

ATC uses the Mode 3/A code to identify aircraft that are under surveillance and possibly under ATC direction. This identifier is necessary to issue directions to specific aircraft about nearby air traffic. The Mode 3/A code and the International Civil Aviation Organization (ICAO) 24-bit address are duplicative for some functions. This duplication is necessary because many current ATC automation systems are not yet capable of using the ICAO 24-bit address. Therefore, the FAA retains this message element in the rule.

9. Indication of the Aircraft's Call Sign That Is Submitted on the Flight Plan, or the Aircraft's Registration Number (Aircraft Call Sign Requires Flightcrew Entry)

The NPRM proposed a requirement for this message element to indicate either the aircraft's call sign (as submitted on its flight plan), or the aircraft's registration number. An individual commenter disagreed with the required broadcast message element for aircraft identity and noted that it uses unnecessary bandwidth.

This message element correlates flight plan information with the data that ATC views on the radar display, and facilitates ATC communication with the aircraft. This message element also will support certain ADS–B In applications such as enhanced visual approach.

In the final rule, the regulatory text is amended to provide that an operator does not need to populate the call sign/aircraft registration field for a UAT equipped aircraft if he or she has not filed a flight plan, is not requesting ATC services, and is using a UAT self-assigned temporary 24-bit address. Although the FAA does not prohibit the anonymity feature, operators using the anonymity feature will not be eligible to receive ATC services, may not be able to benefit from enhanced ADS–B search and rescue capabilities, and may impact ADS–B In situational awareness benefits.

10. Indication If the Flightcrew Has Identified an Emergency, Radio Communication Failure, or Unlawful Interference (Requires Flightcrew Entry)

The NPRM proposed this message element to alert ATC that an aircraft is experiencing emergency conditions. Airbus asked the FAA to clarify which emergency/priority codes are required.

[43] EUROCAE MOPS for 1090 MHz Automatic Dependent Surveillance-Broadcast (ADS–B).

The ARC recommended that the FAA explain in the final rule the emergency status requirement and describe how it will be used.

This message element alerts ATC that the aircraft is experiencing emergency conditions and indicates the type of emergency. Both TSO–C154c and TSO–C166b identify six unique emergency codes. All emergency codes may be transmitted. Under this rule, only emergency, radio communication failure, and unlawful interference are required. This information will alert ATC to potential danger to the aircraft so it can take appropriate action. Message elements for minimum fuel, downed aircraft, and medical emergency are not required by this rule.[44] ADS–B equipment may automatically set these required emergency conditions based on the Mode 3/A code.

11. Indication of the Aircraft's "IDENT" to ATC (Requires Flightcrew Entry)

The NPRM proposed this message element to help controllers quickly identify a specific aircraft. United Airlines and UPS commented that they believe controllers use the "IDENT" function to attain aircraft identification information. They noted that future identification systems should include aircraft information; therefore, they believed this element is not necessary. FreeFlight commented that "IDENT" should be retained. The ARC recommended that the FAA clarify how the "IDENT" requirement will be used.

The "IDENT" function is used regularly in current ATC operations to help controllers quickly identify a specific aircraft. The "IDENT" feature also allows ATC to quickly identify aircraft that have entered incorrect flight identification or Mode 3/A codes. The FAA is adopting this message element in this rule.

12. Indication of the Emitter Category

The NPRM proposed requiring a message element for an aircraft's emitter category.

EUROCONTROL questioned the business case behind this requirement. UPS asked that the FAA better define the emitter categorizations in the final rule.

This message element is necessary for ATC separation services and wake turbulence separation requirements. TSO–C166b and TSO–C154c provide a list and description of the different emitter categories. Emitter category is set during installation of the ADS–B avionics in the aircraft and will not change over time.

13. Indication Whether an ADS–B In Capability Is Installed

The NPRM proposed this message element to indicate to ATC whether a cockpit display of traffic information (CDTI)[45] is installed and operational. Several commenters, including Boeing, EUROCONTROL, and SANDIA, commented that this message element was poorly defined, difficult and expensive to implement, and of little value to ADS–B In applications and ATC surveillance. UPS asked whether a message is required when a CDTI is installed but not operating. The ARC recommended that the FAA clarify the use of this data element.

RTCA updated the definition of this message element in DO–260B and DO–282B. The FAA adopted these updates in TSO–C166b and TSO–C154c. This message element now indicates which aircraft are capable of receiving ADS–B In services and therefore require TIS–B and ADS–R transmissions from the ground. Under the new definition, this message element now indicates whether an ADS–B In capability is installed in the aircraft, but does not require a report of operational status.

14. Indication of the Aircraft's Geometric Altitude

The NPRM proposed a message element indicating the aircraft's geometric altitude.

Several commenters, including Airbus, Boeing, Dassault, the European Business Aviation Association (EBAA), EUROCONTROL, Honeywell, and Rockwell-Collins, commented on the proposed requirement. Most of the commenters questioned this message element and stated that neither ATC surveillance nor ADS–B In require geometric altitude. Dassault, EBAA, EUROCONTROL, and Honeywell supported this message element. The ARC recommended that the FAA justify the need for this message element.

Geometric altitude is the height of the aircraft above the World Geodetic System 84 ellipsoid, which is a scientific approximation of the earth's surface. This message element will be used within the ADS–B ground system to confirm accuracy and identify discrepancies between geometric altitude and barometric altitude. Additionally, the FAA will integrate this comparison function into a continuing airworthiness monitoring function.

L. Ability To Turn Off ADS–B Out Transmissions

The NPRM proposed requiring a pilot to turn off ADS–B equipment if directed by ATC, for example, if the ADS–B unit was broadcasting erroneous information.

The ARC, Boeing, United Airlines, and UPS recommended eliminating the requirement to turn off ADS–B Out transmissions. A few commenters, including British Airways, were concerned that being able to turn off ADS–B Out, while keeping the transponder on, could require additional design changes and increase costs because most existing equipment is not capable of operating in this manner. Boeing stated that eliminating erroneous ADS–B transmissions could be accomplished by turning the transponder off or having a capability within the ground system to allow the controller to manually remove selected targets. Rockwell-Collins recommended that the FAA require the ADS–B equipment to detect failures and disable ADS–B Out transmissions of erroneous data.

The FAA modified the ground automation system to be able to exclude incorrect ADS–B data. With this enhancement to the automation, the aircraft does not need to have a capability for a pilot to disable ADS–B transmissions. Therefore, the final rule does not require the pilot to be able to turn off ADS–B Out transmissions.

M. Existing Equipment Requirements

1. Transponder Requirement

The NPRM specified that the proposal for ADS–B equipage would not alter existing transponder regulations.

Several organizations and individuals, including AOPA, opposed adding ADS–B Out performance requirements without removing the transponder requirement. ATA and Boeing requested that the FAA make a commitment to remove transponders. Several organizations and individuals further commented that the FAA should pursue an ADS–B based collision-avoidance system and reconsider the backup strategy, which is based on secondary surveillance systems. ALPA supported the FAA's plan to retain transponders.

The ARC made multiple recommendations associated with

[44] Mode A codes 7700, 7600, and 7500 currently are reserved for these emergencies. See Annex 10 to the Convention on International Civil Aviation Aeronautical Telecommunications, Volume 4, Surveillance and Collision Avoidance Systems, 4th Edition, July 2007.

[45] CDTI is a generic display that provides a flight crew with traffic surveillance information about other aircraft, surface vehicles, and obstacles, including their identification, position, and other message set parameters. CDTI information would commonly be displayed on a Multifunction Display (MFD).

transponder removal: (1) The ADS–B implementation strategy should include the removal of transponders from low-altitude aircraft without an ACAS; (2) the FAA should commit to a strategy for achieving transponder removal from low-altitude domestic aircraft; and (3) the FAA should study whether ACAS can be modified to use ADS–B as the primary surveillance data for collision avoidance, as well as what ACAS upgrades are required to support NextGen.

Removing the transponder requirement would involve substantial changes to the ADS–B backup strategy and TCAS II/ACAS, which are outside the scope of this rulemaking. Transponders will still be required when the backup surveillance strategy using SSR is necessary and to interact with TCAS- and ACAS-equipped aircraft. Separate from this rulemaking, the FAA may consider (in coordination with the appropriate surveillance and NextGen planning organizations), whether transponders could eventually be removed and, if so, what steps are necessary to accomplish this.

2. Emergency Locator Transmitter Requirement

The NPRM did not propose any changes to the emergency locator transmitter (ELT) [46] requirements.

Several commenters, including ATA and the National Business Aviation Association (NBAA), argued that ADS–B should be used instead of an ELT, and that ELT requirements could be included in this rule. AOPA also recommended a long-term strategy to include ELT removal, and stated that ADS–B could enhance current search-and-rescue procedures to increase the number of successful rescues.

The ARC recommended that the FAA explore whether an ADS–B tracking service also could be used for search and rescue to aid in crash locating. The ARC also recommended that the FAA conduct a study considering an ADS–B-based search-and-rescue solution that would enable removal of 121.5 MHz ELTs for certain domestic operations.

The FAA has determined that the ADS–B system currently cannot replace the ELT function. The ADS–B system is not required to be crashworthy and, thus, may not be operable or able to transmit following an aircraft accident. Additionally, current search-and-rescue technology is not compatible with ADS–B operations because ELTs broadcast on 121.5 or 406 MHz (not 1090 or 978 MHz). The FAA recognizes the value of a ground application that could allow for timely and accurate flight tracking of downed aircraft and is evaluating this capability separate from this rulemaking.

The FAA considered the ARC recommendation to evaluate the feasibility of replacing the ELT with the ADS–B system. However, the FAA has determined that ADS–B is not a feasible replacement for the ELT, as discussed above; therefore, the FAA does not plan to undertake such a study at this time.

N. Program Implementation

1. Timeline

The FAA proposed that all aircraft operating in the airspace areas specified in the rule meet the performance requirements by January 1, 2020.

The majority of commenters recommended various options for the implementation of ADS–B, including the discontinuation of secondary and/or primary radar systems once ADS–B is operational NAS-wide. Some commenters, including AIA and AOPA, requested that the FAA provide certain basic levels of ADS–B service for several years before the ADS–B compliance date.

Several commenters, including ALPA and the National Transportation Safety Board (NTSB), suggested that the compliance date or service provision of ADS–B occur sooner than 2020, to obtain benefits more quickly. United Airlines recommended a 2015 compliance date for operations above FL 240. The Cargo Airline Association (CAA) recommended lower performance requirements for a 2015 compliance date. Several commenters, including the Aircraft Electronics Association, FedEx, and the National Air Carriers Association, suggested extending or adding flexibility to the 2020 compliance date.

Numerous commenters, including ATA, Boeing, IATA, and Rockwell-Collins, suggested a two-phased implementation strategy. The first phase would use existing equipment, avionics standards, and capabilities, which would allow industry and the FAA to demonstrate, validate, and evaluate ADS–B applications. After operational experience in the first phase was sufficient to generate the appropriate standards, the second phase would establish a mandate for ADS–B Out performance standards. Some commenters suggested that the second phase be a combined ADS–B In and ADS–B Out rule.

The ARC endorsed the proposed 2020 compliance date, but recommended that the FAA allow operators to use existing equipage to accrue early benefits. Specifically, the ARC recommended that the FAA: (1) Take advantage of existing 1090 MHz ES-equipped aircraft and allow their operation in the Gulf of Mexico for non-radar airspace and (2) transition to a fully functional ADS–B Out capability enabled by DO–260B,[47] to allow access to the additional applications and services for ADS–B In. The ARC also recommended that the FAA adopt the European Aviation Safety Agency (EASA) Acceptable Means of Compliance 20–24 (permitting the use of early DO–260 avionics for separation) in non-radar airspace, with appropriate measures to ensure ADS–B integrity.

After reviewing all the comments, the FAA finds that a 2020 compliance date remains appropriate because NAS users need time to equip to the requirements of the rule. Most air carriers can use regularly scheduled maintenance to install or upgrade their equipment. The FAA also expects that this timeframe will provide sufficient operational experience to make ADS–B the primary source for surveillance in 2020.

FIS–B and TIS–B services are already available in several areas of the country for ADS–B In-equipped aircraft and will continue as an integral part of the implementation of the ADS–B ground infrastructure. NAS-wide ground infrastructure implementation is scheduled to be complete in 2013, which would provide operators with at least 7 years of operational experience with these services before the ADS–B compliance date of 2020.

The FAA examined whether it is operationally feasible and economically beneficial to use DO–260 avionics in radar and non-radar airspace before 2020. From an operational perspective, the FAA found that the existing DO–260 equipment does not meet the surveillance needs for ATC in the United States for various reasons: (1) DO–260 avionics do not independently report the accuracy and integrity metrics; (2) DO–260 avionics allow the integrity metric to be populated with accuracy information during integrity outages, which is unacceptable for aircraft separation services; (3) DO–260 avionics do not include a message element for Mode 3/A code, which is necessary for aircraft surveillance; and (4) the majority of existing DO–260 installations were accomplished on a noninterference basis under the transponder approval guidelines. (This certification verifies that the equipment

[46] An ELT is an electronic battery-operated transmitter developed as a means of locating downed aircraft.

[47] The ARC recommended DO–260A Change 3, which is DO–260B.

is safe onboard the aircraft, but does not issue any approval that would permit its use for ADS–B operations.)

Therefore, the FAA concluded that without upgrades to the equipment, the use of DO–260 avionics will not meet the surveillance needs in the NAS. Furthermore, without appropriate integrity monitoring, DO–260 avionics cannot be used for separation of aircraft. Its utility would be limited to potentially reducing separation in non-radar areas, or increasing efficiency in radar airspace through more timely updates of information.

Further analysis addressed whether existing DO–260 avionics could be beneficial to provide separation services in the Gulf of Mexico, or to provide efficiency benefits through improved performance of User Request Evaluation Tool (URET)[48] and Traffic Management Advisor (TMA).

To use DO–260 avionics in the Gulf of Mexico, the FAA estimated it would incur approximately $4 million in costs to upgrade the automation; would need to provide additional ground stations and receiver autonomous integrity monitoring (RAIM) predictions; would need to develop procedures; and would need to address aircraft certification issues.[49] Comparatively, the FAA concluded that benefits from this action would only recover approximately 70 percent of the costs.

The costs associated with using existing DO–260 avionics relative to improved performance of URET and TMA were estimated at $31 million and the estimated benefit in performance was $72 million. While this analysis indicated that the benefits of improved URET and TMA performance outweigh the costs of accommodating DO–260 equipped aircraft,[50] the FAA found that it raised some policy concerns.

First, the FAA does not expect to have the full NAS-wide ADS–B infrastructure completed for this effort until 2013. As the ADS–B rule would go into effect in 2020, any benefits accrued through the use of DO–260 avionics would only be available for approximately 7 years. Operators would be required to make a second investment in avionics to comply with the rule in 2020.

Second, a collection of broadcast samples indicated that there is a wide variety of equipage among current DO–260 users. Although approximately 7,500 aircraft in the United States transmit some ADS–B data that would conform to DO–260, only about 1,500 aircraft transmit enough data to be useful for 5 NM separation in the Gulf of Mexico and input into ATC decision support tools (URET and TMA).[51] Many DO–260 operators would require some upgrade costs to bring their existing systems into compliance with a unified standard; these would be in addition to the costs incurred for taking aircraft out of service for certification. Although the user costs were not thoroughly assessed by the ARC, the FAA estimated the costs at $15,000 per aircraft.[52]

Given the above, the FAA could not justify the proliferation of avionics for the short-term that would not be compliant with the final rule in 2020. Therefore, the agency concluded that the public interest was not best served by using DO–260 avionics for ADS–B applications in radar and non-radar airspace before 2020.

2. Financial and Operational Incentives

Numerous commenters, including AIA, the ARC, and NBAA, recommended a variety of financial and operational incentives to make ADS–B more cost-beneficial for the end user. Some commenters specifically recommended that the FAA offer additional incentives for operators who adopt early. NBAA recommended accelerated operational benefits to encourage early installation of ADS–B equipment. Several commenters stated that without operational incentives, aircraft operators with legacy equipment will delay upgrades until the mandated compliance date.

AOPA and the Helicopter Association International (HAI) recommended several operational improvements and safety enhancements for ADS–B, including: (1) Flight following and radar services at lower altitudes, (2) terminal ATC services at GA airports, (3) automatic instrument flight plan closure, (4) instrument flight rules (IFR) low altitude direct routing, (5) enhanced flight service information, and (6) improved real time weather. HAI also recommended that the FAA install ground stations near hospitals and trauma centers to maximize benefits for the emergency medical services community and encourage ADS–B equipage.

ATA, CAA, the National Air Transportation Association, NBAA, and UPS recommended specific operational incentives for early equipage, including: (1) Implementing ADS–B in under-used areas of the NAS, (2) providing preferential access to congested airspace, (3) deploying the necessary ADS–B infrastructure for traffic crossing the Gulf of Mexico, and (4) providing services for on-demand operators at small community airports.

Some commenters, including AOPA, HAI, and CAA, recommended financial incentives or tax credits for ADS–B equipage.

The following activities are scheduled to be complete by 2013:

- Ground infrastructure coverage needed for the mandated airspace,[53]
- ADS–B interface to automation systems,
- Guidelines for equipment certification,
- Operations Specifications approval,
- Approval to use ADS–B to meet established separation standards,
- ATC operational procedures for non-radar airspace that has ADS–B coverage, and
- FAA controller training and procedures.

The ADS–B program is currently funded and designed to provide services in parts of Alaska, the Gulf of Mexico, and areas in the NAS where radar coverage currently exists. Additionally, actual ADS–B coverage may exceed the defined radar coverage at lower altitudes in some areas. The FAA cannot assess, however, the extent of this coverage or its potential use for the ADS–B service until the ADS–B implementation is complete in 2013.

The FAA acknowledges that the ADS–B system could be improved by expanding the surveillance coverage of ADS–B to non-radar airspace. The improved accuracy and update rate afforded by ADS–B provides the ability to improve future NAS operations. As the number of projected flight operations continues to increase, efficiency improvements to the NAS are critical to addressing new demands. Therefore, the FAA will continue to explore opportunities to use the ADS–B infrastructure to provide additional coverage in non-radar areas. The FAA also notes that ADS–B implementation will not affect flight following services in effect today.

[48] URET is an air traffic control tool that assists controllers with timely detection and resolution of predicted air traffic problems.

[49] A copy of the DO–260 Business Case Analysis is available from the Web site *http://www.regulations.gov*. The docket number for this rulemaking is FAA–2007–29305.

[50] The analysis concluded that it was not cost-beneficial to use DO–260 avionics in the Gulf of Mexico prior to 2020.

[51] A copy of the Honeywell Technology Solutions Inc. DO–260 study is available from the Web site *http://www.regulations.gov*. The docket number for this rulemaking is FAA–2007–29305.

[52] The DO–260 Business Case Analysis assumed the cost of $15,000 to upgrade an aircraft equipped with DO–260 only. The cost does not include all costs to meet the rule. The cost was used for the DO–260 Business Case Analysis and not used in the Regulatory Impact Analysis.

[53] The planned ADS–B service coverage is explained in greater detail at *http://www.adsb.gov/*.

The FAA is actively pursuing agreements with airlines, avionics manufacturers, airports, and other NAS users to encourage early equipage of ADS–B. These agreements incorporate a variety of items, including: (1) The possibility of developing preferred routes and cost sharing for avionics in testing new applications, and (2) early equipage and experience with advanced ADS–B applications that are not available to non-equipped aircraft.

The FAA currently has several agreements with airlines and state entities specifying that the FAA may enable benefits in exchange for early ADS–B equipage. Additionally, the FAA, HAI, and oil platform owners have an agreement for the Gulf of Mexico by which the FAA is providing communication, navigation, and surveillance for ADS–B-equipped helicopter operators.

The FAA and UPS have an agreement for testing and developing merging and spacing, CDTI/Multi Function Display Assisted Visual Separation (CAVS), and surface situational awareness applications in an environment that provides measurable benefits. Additionally, the FAA is working with Honeywell and ACSS to accelerate ASSA, FAROA, and surface indication and alerting applications.

The FAA is working with US Airways to develop a work plan for implementing ADS–B/NextGen technologies and procedures in parts of the East Coast as a prelude to national implementation. In addition, the FAA has an agreement with United Airlines to expedite oceanic in-trail procedures development. The FAA is also working with NetJets on several NextGen initiatives for performance-based navigation, communication, and surveillance applications.

The FAA has established an ADS–B compatible Wide Area Multilateration system in the mountainous areas of Colorado pursuant to an agreement with the Colorado Department of Transportation. The FAA continues to examine different areas of the country to determine opportunities for surveillance service expansion and is continuing to work with various state aviation offices.

In addition, the FAA continues to examine opportunities to provide ADS–B services in areas that would benefit from increased surveillance. The FAA does not currently have a list of airports that are targets for ADS–B expansion. However, the FAA has started to identify areas that would benefit most from ADS–B services. The FAA encourages cities, states, airports, and private interests (such as hospitals and trauma centers) to help determine surveillance needs and opportunities.

ADS–B can provide surveillance at lower altitudes than radar. Moreover, ADS–B infrastructure is more easily deployed than most radar in remote and hard-to-reach areas. The flexibility associated with implementing ADS–B can facilitate service by helicopters to certain communities. Deployment of ADS–B systems on medical, police, or tourist helicopters could provide a level of asset tracking and search-and-rescue capability that would be difficult to replicate with existing surveillance systems. The FAA has already developed agreements with HAI to support operations in the Gulf of Mexico. The FAA is open to implementing similar agreements as opportunities for ADS–B service expansion present themselves.

While this rule does not mandate ADS–B equipage in all airspace classifications, the FAA is analyzing whether ADS–B services can be expanded to provide improved safety and capacity enhancements for low altitude flight operations and airports underlying non-mandated airspace. The FAA will work with users to identify new candidate airports for these services. This activity will continue throughout the initial implementation period and post 2013 when the nationwide ADS–B infrastructure is expected to be available NAS-wide.

The extent to which ADS–B can contribute to operations in special use airspace is still being studied; however, the FAA is committed to examining any proposals for the use of ADS–B outside of the scope of implementation described in this rule.

3. Decommissioning Traffic Information Service–Broadcast (TIS–B)

In the NPRM preamble, the FAA noted that once all aircraft are equipped with ADS–B Out, ADS–R will provide the complete traffic picture and the FAA will decommission TIS–B.

A few commenters, including the DOD, questioned the assumption that all aircraft would be equipped for ADS–B Out. Rockwell-Collins recommended retaining TIS–B after the ADS–B mandate takes effect, because it provides a critical support for ADS–B airborne applications.

The original purpose of TIS–B was to provide proximate traffic information to ADS–B In-equipped aircraft about targets that were not equipped with ADS–B. When this rule takes effect in 2020 aircraft operating in the airspace subject to this rule must be equipped with ADS–B, thus theoretically eliminating the need for the TIS–B service. However, the FAA realizes that TIS–B may still have value after 2020 as a backup traffic service for ADS–B In aircraft during GNSS outages or when an individual target's ADS–B system is inoperative. Thus, the FAA, outside of this rulemaking effort, will evaluate the benefits of continuing TIS–B past the 2020 rule compliance date.

O. Safety

Several commenters, including AOPA, the ARC, and Boeing, suggested that the FAA expand the ADS–B service volume and ensure that TIS–B, FIS–B, and ADS–R are included in the ADS–B expanded coverage area.

Some commenters believed that reducing primary radars would reduce safety. These commenters noted that primary radar is important to track aircraft without ADS–B. They also recommended that the FAA continue requiring transport category aircraft to equip with Mode S transponders and TCAS II as an independent collision avoidance system. Some commenters argued that the complexity of the ADS–B system poses a collision risk.

Other commenters noted that ADS–B In cockpit displays can be confusing and distracting, which may cause a pilot to lose situational awareness. They added that the FAA should evaluate the CDTI to understand the additional monitoring responsibility and workload placed on the flightcrew. One individual contended that ADS–B will increase a pilot's dependence on cockpit equipment and reduce the pilot's tendency to look outside the aircraft. Another individual commenter asked for data to prove that ADS–B will not be susceptible to own-ship ghosting or target duplication. ("Own-ship ghosting" is a term that is used to describe a traffic display showing one's own aircraft as an actual target. Ensuring targets that are transmitting ADS–B are not also transmitted as TIS–B targets helps reduce the chances of seeing one's own aircraft as a target on the display.)

The final rule does not eliminate the requirement for transponders, TCAS, or primary radars. The FAA notes that any aircraft required to have TCAS II or ACAS, or that voluntarily has TCAS II or ACAS installed, must also be equipped with a Mode S transponder. This generally includes all aircraft operated under 14 CFR parts 121, 125, and 129, and certain aircraft operated under 14 CFR part 135.

Mode S transponders transmit both aircraft altitude and aircraft identification information. Both Mode A/C transponders and Mode S transponders require interrogation to provide information. ADS–B In Conflict

Detection does not replace the functions of TCAS II or ACAS; however, future versions of hybrid surveillance systems may use passive ADS–B messages to reduce unnecessary interrogations and, thus, reduce 1090 MHz spectrum congestion.

As stated in the NPRM, the FAA is maintaining its current network of primary radars. However, the FAA expects to reduce a large percentage of its secondary radars as a result of this rule. Both primary surveillance radar and SSR will continue to be used for surveillance during the transition period of ADS–B avionics equipage.

The benefits of certain ADS–B In applications cannot be fully realized in areas where there is no ADS–B coverage; however, the lack of ADS–B surveillance or ADS–R does not present a safety risk. When an aircraft is outside of the ADS–B coverage area, the ADS–R/TIS–B system will inform the pilot that the traffic picture is not complete. In all areas, regardless of ADS–B coverage, pilots will use the same procedures they have today to maintain safe separation of aircraft. TIS–B and FIS–B services are advisory and cannot be used to maneuver an aircraft without ATC clearance. The FAA will investigate ADS–B service expansion as part of the ADS–B NAS-wide implementation.

With regard to the comment regarding own-ship ghosting, the ADS–B system minimizes the chance of target duplication because it will not transmit TIS–B data on a target that is broadcasting ADS–B. This is because ADS–R is designed to relay information about aircraft transmitting on a different broadcast link, and TIS–B is designed to relay information only about aircraft not broadcasting ADS–B messages.

This rulemaking only mandates ADS–B Out, which does not involve any requirements for a cockpit display. Before any mandate of ADS–B In, the FAA will conduct extensive safety analysis and training. The current ADS–B Out rule does not eliminate or reduce the requirement under § 91.113 for pilots to see and avoid other aircraft.

P. Efficiency

In the NPRM preamble, the FAA stated that ADS–B will enhance ATC surveillance, which will increase airspace efficiency and capacity to meet the predicted demand for ATC services.

Several commenters, including the Airports Council International—North America (ACI–NA), Boeing, and FedEx, commented on the anticipated efficiency improvements stated in the NPRM. Some commenters contended that the proposed rule did not prove that a decrease in en route separation of aircraft will decrease delays or increase airspace capacity. Two commenters argued that the FAA has not demonstrated that system choke points can handle the increased capacity if en route separation is reduced.

Other commenters, including the National Air Traffic Controllers Association, argued that reducing separation will not mitigate commercial traffic delays caused by an inadequate number of runways, weather, hub-and-spoke operations, or airline scheduling practices. Era Corporation recommended that the FAA improve the infrastructure at small airports to relieve congestion. Boeing stated that ADS–B alone will not lead to the advances required by NextGen.

The FAA has consistently stated that ADS–B will not produce a complete NextGen air traffic management solution, but rather will set the initial steps to achieving a NextGen solution. The airport infrastructure is a crucial component of the NAS. Efficiency and capacity of the NAS can be positively affected by improving the efficiency of individual flights and improving the quality of input to air traffic controllers. ADS–B can help maximize the use of existing airport infrastructure. The ability to transmit ADS–B Out messages can increase the efficiency of the NAS in radar airspace by providing accurate updates at a faster rate than many existing surveillance systems. This increased update rate permits ATC to merge and sequence aircraft more effectively into existing airport choke points, which should mitigate, rather than increase, congestion and delay. This rule's regulatory evaluation does not include any benefits that are dependent on, or attributable to, other NextGen systems outside the scope of this rulemaking.

The FAA expects that ADS–B Out will enable the establishment of more direct routes outside airspace subject to this rule, which would use less fuel, emit less carbon dioxide and nitrogen oxide, and increase NAS efficiency. The FAA is currently developing specific ADS–B routes for certain areas that have the potential for significant benefits (airspace off the shore of the east coast and over the Gulf of Mexico). The FAA expects that other opportunities for routes enabled by ADS–B will emerge as the ground infrastructure is implemented NAS-wide.

1. Improved Position Reporting

According to operational evaluations,[54] ADS–B provides improved accuracy over radar in most air traffic scenarios. While some terminal radars can provide increased accuracy the closer the aircraft is to the receiver, ADS–B provides consistent position accuracy regardless of the aircraft's range from a receiver. ADS–B also provides more timely information updates than conventional radar. Unlike radar, the accuracy and integrity of ADS–B Out is uniform and consistent throughout the service areas. Therefore, ATC's ability to accurately identify and locate aircraft that are further away from the air traffic control facilities will be better than radar.

ADS–B does not scan an environment in the same way as radar; therefore, ADS–B does not provide unnecessary returns based on weather or other obstructions, which can impede the effectiveness of primary radars.

ADS–B provides consistent, frequently updated position reporting and additional aircraft information for ATC decision-support tools, which increases ATC confidence in aircraft position. This will allow ATC to apply existing separation standards more exactly and without the need for ATC to correct for possible radar inaccuracies. The regulatory evaluation provides more discussion on the benefits of improved surveillance information.

2. Optimized Profile Descents (OPDs)

The FAA plans to use the information broadcast by ADS–B to better sequence aircraft approaching the terminal area with the development of a Merging and Spacing application. This ground-based system sends precise suggested speed instructions to en route aircraft. These exact-speed instructions should allow aircraft to arrive at extended terminal area merge points at times that are much more precise than currently feasible.

As part of the Merging and Spacing application, the FAA is developing both a ground tool and aircraft requirements that can be used to optimize aircraft spacing. In addition to other airspace efficiencies, this tool will enable a fuel-saving procedure called Optimized Profile Descent (OPD), previously referred to as Continuous Descent Arrivals (CDAs).

OPDs are a type of terminal arrival procedure, specifically designed to keep an aircraft at, or near idle power during

[54] Surveillance and Broadcast Services Systems Engineering Separation Standards Working Group, Final Report on Operational Evaluation of 5 NM ADS–B to Radar Separation Services in Alaska, November 30, 2006.

the entire arrival until the final approach fix.[55] These procedures increase flight efficiencies while reducing noise, fuel consumption, and emissions. OPDs eliminate step-down altitudes and the associated inefficient power adjustments. OPDs depend on minimal aircraft vectoring to maintain the arrival pattern. Therefore, aircraft must be accurately metered with ADS–B-enabled spacing and sequencing tools prior to and during descent and approach.

Below a certain level of demand, controllers can authorize OPDs using current onboard equipment and procedures. As the terminal demand increases, it becomes progressively more difficult for controllers to allow OPDs because of interference with other traffic flows in the airspace. As demand approaches capacity, the tradeoff between total airport throughput (and delays) and individual flight profile efficiency (that is, OPDs) would most likely prohibit OPDs for very high traffic density situations. This situation will be aggravated over time as air traffic resumes growth and terminal airspace constraints increase.

Many airports start to exhibit significant delays when demand reaches approximately 70 percent of capacity. The proposed FAA spacing tool, using more accurate ADS–B position information, would enable OPDs in medium-density terminal airspace when the demand approaches the point where delays would be encountered. The FAA believes that ADS–B Out can expand use of OPDs into medium levels of traffic density (40 percent to 70 percent), which may not be possible without ADS–B Out. Accomplishing OPDs at this level of traffic density would have important environmental and energy benefits with no increase in congestion or delay.

3. Reduced Aircraft Separation

In non-radar airspace, ADS–B Out allows ATC to apply radar-like separation standards in areas where ATC currently applies non-radar, procedural separation. In some cases, routes laterally separated without radar by as much as 90 NM are now separated with ADS–B at only 20 NM. Longitudinal separation of typically 10 minutes (80 NM) can be reduced to 5 NM.

Boeing commented that the accuracy and integrity values proposed in the NPRM will not support reduced en route separation standards. ADS–B position accuracy supports current surveillance standards. Experience with the mature system may allow reductions at a future time. The FAA plans to expand 3 NM separation to locations in the NAS that currently only permit 5 NM separation. Currently, the FAA is modeling several scenarios to determine if ADS–B can support 3 NM en route separation based on a target level of safety. The FAA will not move forward with reduced separation until all safety and operational analyses have been completed and ADS–B has been certified to perform this service.

4. Expanded Surveillance Coverage

In the future, there may also be an opportunity for ATC to use ADS–B Out data for surveillance in areas of the NAS below the floor or outside the lateral coverage of existing radar surveillance. The FAA does not yet know where in the NAS this extra coverage might be available. This information will likely not be available until ADS–B surveillance has already been implemented in a service area. As the FAA identifies areas with additional coverage, the FAA will investigate how this additional coverage could be used.

Q. ADS–B In

Many commenters, including ACSS, ALPA, CAA, Lockheed Martin, the NTSB, and UPS, commented that the majority of the ADS–B benefits will be derived from ADS–B In. Numerous commenters asserted that ADS–B Out alone would not be cost-beneficial or provide them with any added benefits compared to their operations today. Some commenters noted that ADS–B In, however, would provide necessary services to the cockpit. Many of these commenters asserted that ADS–B In should be mandated as well. However, AOPA specifically recommended that ADS–B In be voluntary because it is cost-prohibitive for most GA owners. British Airways also questioned the business case for ADS–B In.

Many commenters, including the DOD, ACI–NA, and AIA, pointed out that the capabilities and functions of ADS–B Out alone will not provide the full range of benefits available from ADS–B. To improve the overall system, they recommended developing standards for ADS–B Out in unison with standards for ADS–B In. GAMA and IATA recommended that the FAA work to define the requirements for ADS–B In to encourage ADS–B equipage. ATA specifically asked the FAA to define ADS–B In standards by 2010. IATA noted that many operators will delay upgrades until there is a single, defined ADS–B package with avionics and procedures to support NextGen and the Single European Sky Air Traffic Management (ATM) Research Program.

The ARC recommended that the FAA, in partnership with industry, define a strategy for ADS–B In by 2012 and ensure that the strategy is compatible with ADS–B Out avionics. The ARC also recommended that the FAA describe how to proceed with ADS–B In beyond the voluntary equipage concept discussed in the NPRM.

A few commenters, including NBAA, praised the benefits of ADS–B and recommended that the FAA resolve ADS–B In display requirements, including human factors. The NTSB stated that ADS–B would significantly improve situational awareness for pilots, especially during ground operations. GAMA recommended that the FAA not limit display options in the final rule.

The FAA fully recognizes that ADS–B In and other future air-to-air applications are functions that could provide substantial benefits to aircraft operators and the NAS. While additional benefits can be accrued using ADS–B In functions, requirements for an ADS–B In system are not sufficiently defined to implement them at this time.

ADS–B Out is necessary to establish an air transportation infrastructure that is consistent with the NextGen plan and will change the way the NAS operates. Further, the economic evaluation of the ADS–B Out proposal found the system to be cost-beneficial if ADS–B Out avionics costs are at the low end of the estimated cost range and if the benefits are at the high end of the estimated benefits range.

Given the value of ADS–B In services to individual operators and the benefits to future NAS operations, the requirements adopted for ADS–B Out also support certain ADS–B In applications.[56] The FAA has modified several aspects of the proposed rule to minimize the cost impact to operators of the requirements driven by ADS–B In. The requirements in this final rule also establish a stable infrastructure for current and future applications of ADS–B In.

The FAA concurs with the ARC's recommendation to define a strategy for ADS–B In equipage by 2012 and is working with industry to develop a strategy for future ADS–B In applications. By 2012, the requirements and benefits of ADS–B In applications should be well enough defined for the

[55] The final approach fix identifies the beginning of the final approach segment, and is the fix from which the final instrument flight rule (IFR) approach to an airport is executed.

[56] These applications include Enhanced visual acquisition, conflict detection, and enhanced visual approach.

FAA to specify a set of performance requirements that would be tied to a well-defined bundle of applications.

Furthermore, RTCA has completed the DO–317, Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications System (ASAS),[57] and the FAA is currently developing a TSO to utilize this RTCA standard.

R. ADS–B in Applications

Multiple commenters, including SANDIA, asked for more information about potential ADS–B In applications. This information is provided below.

1. Surface Situational Awareness With Indications and Alerting

This application is being designed to provide information regarding potential traffic conflicts on or near the airport surface to the flightcrew. The ADS–B In cockpit display would indicate the relevant runway occupancy status. Depending on the severity of the conflict, the system would alert the flight crew with visual and/or audible alerts.

2. In-Trail Procedures

This application is being designed to facilitate aircraft conducting oceanic in-trail flight level changes using a reduced separation standard. This application should improve the use of oceanic airspace, increase efficiency, reduce fuel consumption, and increase safety by helping flightcrews avoid turbulent flight levels. With this application, ATC will continue to provide procedural non-radar separation services. However, the FAA is exploring whether controllers would be able to allow flight level changes where aircraft are separated by only 15 NM during climb or descent, instead of 100 NM in use today.

3. Interval Management

This application is intended to improve current merging and spacing capabilities to ensure more consistent aircraft spacing, and potentially increase airspace capacity. With this application, controllers would issue a different set of instructions to pilots, for example, to maintain a given time or distance from the preceding aircraft. The flight crews will then use ADS–B In information to adjust their airspeeds or flight paths to maintain the instructed separation.

4. Airport Surface Situational Awareness and Final Approach Runway Occupancy Awareness

ASSA and FAROA increase situational awareness of potential airport ground conflicts at several of the nation's busiest airports. However, the reduced NAC_P requirement in this rule, while sufficient for ADS–B Out, is not sufficient for all aircraft to use in ASSA and FAROA.

S. International Harmonization

Several commenters stated that the ADS–B program technical standards and requirements in the NPRM may be exclusive of, and not harmonized with, ICAO and international efforts under way in Europe, Australia, and Canada. Several individual commenters and AOPA questioned the interoperability of UAT in international airspace, including Canada and Mexico. They also questioned the applicability of UAT through ICAO Standards and Recommended Practices (SARPs). The ARC recommended that the FAA advocate national policies that explicitly allow for the use of non-U.S. positioning sources (for example, Galileo) as part of the infrastructure to meet aviation performance requirements.

The FAA fully supports the need for international regulators to focus on a global interoperability of ADS–B through the continuing development of standards for equipment, applications, flight procedures, and operating rules. The RTCA standards for DO–260B and DO–282B (referenced in TSO–C166b and TSO–C154c) were developed with close international cooperation. The FAA supports the RTCA/European Organization for Civil Aviation Equipment (EUROCAE) Requirements Focus Group, which is internationally coordinating ADS–B In. Additionally, the FAA actively meets with EUROCONTROL, the Australian Civil Aviation Safety Authority, and Transport Canada to internationally coordinate ADS–B regulation.

The FAA has structured the ADS–B Out program on performance requirements and not a specific navigation or positioning source. The FAA is proposing harmonized requirements for aircraft separation to ICAO, with the support of Australia, Canada, and EUROCONTROL. The United States is working with other GNSS providers to ensure system interoperability, improve performance, and reduce costs for integrated receiver equipment. This rule does not prohibit the use of international GNSS; any navigation source that meets the requirements complies with this rule.

The performance standards for the UAT were developed by RTCA through international cooperation and coordination. The standards were published in DO–282B, (MOPS for UAT ADS–B). Additionally, DO–282B was developed in accordance with Annex 10 to the convention of international civil aviation. As such, individual states are allowed to invoke these standards as their own requirements.

T. Backup ATC Surveillance

In the NPRM, the FAA described an ADS–B backup strategy that included a reduced network of SSRs to support high-density terminal airspace, all en route airspace above 18,000 feet MSL, and medium-density terminal airspace above certain altitudes. In the proposal, the FAA noted that it intends to retain all primary surveillance radar as a means to mitigate single-aircraft avionics failures.

Several aviation associations, air carriers, pilots, and various other organizations commented on the proposed backup strategy. The commenters suggested several potential alternatives including Automatic Dependent Surveillance—Contract (ADS–C), long range navigation (LORAN), enhanced long range navigation (eLORAN), fusion, and multilateration.

Some commenters, including UPS and United Airlines, recommended that the FAA develop a backup system that not only backs up surveillance, but also works in a fusion process to increase the accuracy, integrity, and availability of the primary surveillance system. Boeing recommended that during RAIM outages, ADS–B could broadcast position data derived from a flight management system or an inertial navigation system. Other commenters questioned whether there was a robust and fully independent airborne- or ground-based backup timing system in the event of GPS timing signal loss. The DOD contended that the backup must be able to support planned GPS electronic testing and solar flare activity.

Several commenters opposed having one interdependent service for both navigation and surveillance. They believed that this combination of navigation and surveillance could be detrimental when a pilot experiences a GPS outage while operating in instrument meteorological conditions. The ARC recommended that the FAA, in coordination with other Government agencies, develop an integrated communication navigation and

[57] ASAS provides the platform for the processing and display of ADS–B In applications.

surveillance (CNS) strategy to address GNSS interference and outages.

Various entities also questioned the procedures that would be in place for aircraft operating with a NAC_P value of less than 9. One individual asked how the system will accommodate aircraft without ADS–B, if an entire broadcast link is inoperable.

The FAA will provide ATC separation services for aircraft meeting the minimum ADS–B-required performance parameters (NAC_P, NAC_V, NIC, SDA, and SIL) for airspace subject to this rule. If, during flight, an individual aircraft does not meet the minimum ADS–B-required performance parameters, then ATC may provide separation services using the backup (for example, radar where available and procedural separation elsewhere). This transition will be seamless because secondary surveillance data will be one of several surveillance sources fused into the display used by ATC.

The ADS–B ground automation combines or "fuses" all available surveillance information from ADS–B with primary surveillance radar and SSR. This provides a complete or "fused" picture of all the traffic operating in a given area. Multi-sensor fusion allows the automation to combine data from various sensors, and use the most accurate measurements. In most cases, a Kalman Filter Tracker optimizes the accuracy of track estimates from multiple sensors. In addition to improved aircraft position accuracy, data fusion uses all the updates from multiple sensors, which increases the overall update rate. The FAA currently uses practical trackers for data fusion with the Common-Automated Radar Terminal System and the Standard Terminal Automation Replacement System.

If the ADS–B ground infrastructure or a particular broadcast link is out of service, or a sufficient number of aircraft cannot meet the minimum required performance for a given airspace and controller workload is adversely impacted, ATC will use the backup system to provide ATC separation services for all aircraft in that airspace. Transition to the backup strategy will not impact the ability of ATC to provide separation services to the operator.

The FAA completed the Surveillance/Positioning Backup Strategy Alternatives Analysis [58] on January 8, 2007. This study included a comprehensive analysis of various strategies for mitigating the impact of the loss of GPS on ADS–B surveillance. The analysis identified a reduced network of SSRs as the recommended backup for ADS–B. This strategy retains all existing en route SSRs (150) and approximately 50 percent of SSRs in high-density terminal areas (40).

The FAA assessed numerous technologies as part of this analysis, including: Multilateration; eLORAN; distance measuring equipment (DME); DME/inertial reference units; satellite-based augmentation systems; ground-based augmentation systems; and various combinations and implementations of these technologies. The FAA determined the backup strategy based on the most effective tradeoff between performance, schedule, and cost factors among airborne and ground segments of the NAS architecture.

This backup strategy will support continued use of the separation standards in effect today. However, for select areas experiencing degraded surveillance coverage during an outage, ATC may increase aircraft separation as operationally required.[59] The FAA concludes that these operational capabilities are sufficient, given that loss of required position information is expected to be a rare event.

In meeting the performance standards adopted by this rule, an aircraft's navigation and surveillance functions may be dependent on the same position source. Using GNSS technology for ADS–B provides for improved performance (i.e., increased update rate, increased accuracy at long range, and cleaner surveillance picture to ATC) over other surveillance systems and allows for a more flexible ground infrastructure.

The risks posed by this dependency have been accepted because the navigation and surveillance functions have independent backup systems. In evaluating the options, the FAA specifically considered the scenario in which the satellite positioning source failed. As a result, the FAA determined that an effective backup system could not also be satellite-based. The FAA further determined that these backup capabilities ensure sufficient navigation and surveillance capabilities during a positioning source outage and maintain appropriate levels of safety.

U. Privacy

The NPRM proposed requiring a message element to transmit the aircraft's assigned 24-bit ICAO address.

Many commenters, including AOPA and Rockwell-Collins, strongly argued against ADS–B Out broadcasts of identifiable data, including aircraft tail number and operator name. These commenters argued that the information could be used to continuously watch all aircraft and ultimately could be used by the FAA for enforcement or assessing user fees. Certain commenters argued in favor of retaining the anonymous mode for VFR operations because aircraft identification is only required for ATC purposes.

Commenters suggested several alternatives: (1) Use UAT's privacy message function (which allows the pilot to select "VFR" mode) to have the UAT system randomly select a 24-bit ICAO address; (2) require manufacturers to design ADS–B systems that archive data onboard, and advise pilots to archive the data so there is an independent data source that corroborates government data; and (3) design a system host configuration protocol to assign transponder codes through a unique address when the UAT or 1090 MHz ES is turned on. They contended that this would allow a network to eliminate system duplicity and guarantee anonymity to the pilot of the aircraft (therefore, the 24-bit Mode S identifiers would no longer be needed).

The ARC made three recommendations regarding privacy: (1) The FAA should treat the 24-bit ICAO code assignments as information covered under privacy laws, so they are available only to authorized personnel or released by the holder; (2) the FAA should use the anonymity feature of UAT and develop an equivalent anonymity feature for 1090 MHz ES that would apply to VFR operations not using ATC services; and (3) the FAA should accommodate assignment of the 24-bit ICAO codes so that they do not easily correlate to an aircraft tail number and they permit aircraft call signs to be something other than the aircraft registration number when receiving ATC services.

The FAA reviewed all the comments regarding privacy and notes that most of the commenters specifically addressed VFR operations. The FAA notes that there is no right to privacy when operating in the NAS. The FAA specifically designates airspace for which the identification of aircraft is necessary, so that the agency can effectively separate aircraft. The transponder rule specifies that an

[58] It is important to recognize that this is a performance-based rule and does not require GNSS. For the purpose of the backup strategy evaluation the FAA assumed that users would equip with a GNSS as their position source.

[59] The standard for reverting to backup surveillance is also discussed in H.2, System Availability.

aircraft operating in airspace designated in § 91.215 must have ATC transponder equipment installed that meets the performance requirements of TSO–C74b, TSO–C74c, or TSO–C112.

Many GA aircraft are equipped with Mode C, which has the capability to squawk 1200 and meets the requirements of § 91.215, without specifically identifying the aircraft. Most of these commenters are seeking similar treatment under ADS–B so that ATC can track the aircraft without specifically identifying the aircraft.

TSO–C154c includes a feature to temporarily and randomly assign a 24-bit address for UAT-equipped aircraft. This rule does not prohibit the use of this feature. UAT-equipped aircraft conducting VFR operations that have not filed a flight plan and are not requesting ATC services may use this feature. Although the FAA does not prohibit the anonymity feature, operators using the anonymity feature will not be eligible to receive ATC services and will not be able to benefit from enhanced ADS–B search and rescue capabilities. TSO–C166b does not include a feature to accommodate anonymous 24-bit addresses. Should safety or efficiency of the NAS so require, the FAA could initiate rulemaking to prohibit an operator from using the anonymity feature. Additionally, if the FAA, in coordination with the Department of Homeland Security (DHS), determines that the anonymity feature is an unacceptable risk to security, the FAA could initiate rulemaking to prohibit an operator from using the anonymity feature.

This rule does not implement any type of user fee. Subsequent agency rulemaking would be necessary to establish such fees. Furthermore, this rule does not affect the process for the FAA assigning the 24-bit ICAO codes.

The FAA has not determined that archiving data onboard the aircraft is necessary for ATC surveillance. However, this rule does not preclude manufacturers from designing equipment with this function.

V. Security

Various commenters, including the DOD, commented on the security aspects of the ADS–B system. They contended that, as ADS–B will broadcast the location and identity of users, malicious parties could monitor transmissions from the aircraft and ATC to obtain information to target and harm the aircraft. Another commenter stated that the ADS–B information could be used by an unmanned aircraft to target passenger aircraft. Some commenters alleged that security safeguards are needed for ADS–B to protect aircraft from terrorist attacks.

Other commenters argued that an aircraft's ADS–B transmissions or GPS position/timing signals could be subject to inadvertent or intentional interruption or loss of the GPS timing signal. Several commenters recommended a planned oversight feature (for example, requiring ADS–B ground receivers to be licensed) to ensure that only authorized personnel access the data collected, and that the data is only accessed for authorized purposes. The DOD recommended that the FAA work with DHS and the DOD to determine ADS–B risks and appropriate countermeasures.

The FAA conducted several analyses on the security aspects of ADS–B. These analyses include the information system for collecting data, transmitting and storing data, as well as risk assessments on the vulnerability of ADS–B broadcast messages. All FAA information, including ADS–B transmissions received by the FAA, that is collected, processed, transmitted, stored, or disseminated in its general support systems and applications is subject to certification and accreditation, under National Institutes of Standards and Technology (NIST) information technology standards. It is a continuing process that protects the confidentiality, integrity, and availability of the information.

The FAA's Security Certification and Accreditation Procedures (SCAP) were developed in accordance with Federal law, including: (1) The Federal Information Security Management Act of 2002, (2) OMB Circular A–130 (Management of Federal Information Resources), (3) Federal Information Processing Standards 199, and (4) NIST Special Publications (SP) 800–37 (Guide for the Security Certification and Accreditation of Federal Information Systems), NIST SP 800–53 (Recommended Security Controls for Federal Information Systems), and NIST SP 800–53A (Guide for Assessing the Security Controls in Federal Information Systems).

The FAA completed the SCAP for the ADS–B system originally in September 2008. The FAA completed a new SCAP in October 2009 as a result of changes made to the ADS–B system. This process ensures that ADS–B does not introduce new security weaknesses. It also ensures that the hardware and software composing the ADS–B system meets rigid and well-documented standards for infrastructure security. ADS–B meets all qualifications and mandates of this process. As part of the SCAP, the system is tested annually for security compliance, and every 3 years the system goes through an entirely new SCAP. In addition, the FAA specifically assessed the vulnerability risk of ADS–B broadcast messages being used to target air carrier aircraft. This assessment contains Sensitive Security Information that is controlled under 49 CFR parts 1 and 1520, and its content is otherwise protected from public disclosure. While the agency cannot comment on the data in this study, it can confirm, for the purpose of responding to the comments in this rulemaking proceeding, that using ADS–B data does not subject an aircraft to any increased risk compared to the risk that is experienced today. As part of this process, the FAA forwarded the assessment to its interagency partners, including the DOD, the Transportation Security Administration, the Federal Bureau of Investigation, the United States Secret Service, and other appropriate agencies for review. These entities evaluated the modeling approach, analysis, and risk outcome. They did not identify any reason to invalidate the analysis which determined that ADS–B data does not increase an aircraft's vulnerability. The FAA commits to annual updates of this assessment to monitor any changes in the underlying assumptions in the risk analysis, and to monitor new threat information that becomes available.

The FAA concludes that ADS–B transmissions would be no more susceptible to spoofing (that is, intentionally broadcasting a false target) or intentional jamming than that experienced with SSR transmissions (Mode A, C, and S) today. Spoofing of false targets and intentional jamming very rarely occur with the surveillance systems in place today.

The ADS–B transmission signals from aircraft will be fused with surveillance data from both primary and secondary radars before it is displayed for ATC. The controllers, therefore, are receiving and viewing a composite of aircraft data from multiple surveillance systems. The FAA does not expect spoofing and jamming to occur during the transition to using this fused data for surveillance. This is because the automation will reveal the discrepancy between a spoofed or jammed ADS–B target and the target reported by radar and SSR position reports. Fusion also provides for a smooth transition to backup surveillance if an ADS–B system is experiencing interference. Furthermore, encryption of any ADS–B data would unnecessarily limit its use internationally.

The FAA also concludes that additional certification and accreditation of ground equipment will not be necessary because of the strict SCAP provision certifying that crucial information and equipment are not available to unauthorized individuals.

The FAA finds no basis at this point that ADS–B Out provides any greater security risks to air navigation systems to the United States. The FAA continues to meet regularly with DOD and DHS representatives regarding the use of ADS–B information and national security issues.

W. Alternatives To ADS–B

The NPRM compared: (1) Radar as it exists today, (2) multilateration, and (3) ADS–B. In the NPRM, the FAA's alternatives analysis found radar to be the most cost-effective solution; however, radar would neither be effective in supporting air traffic growth over time nor provide the necessary technical capabilities to support the NextGen concept of operations.

Several commenters indicated that the existing radar system is sufficient for operations. Some commenters suggested expanding the radar infrastructure or implementing an alternative reporting system using commercial off-the-shelf technologies that have a means to encode and transmit GPS position data.

Other commenters believed that multilateration could provide similar benefits to ADS–B at a potentially lower cost. Boeing requested that the FAA provide an analysis explaining its conclusion that multilateration would not provide the same level of benefits as ADS–B. ATA specifically stated that they do not believe multilateration is a viable alternative; however, it can provide highly accurate position reports for surface ADS–B In applications. Several commenters objected to the prohibitive cost of upgrading the avionics with ADS–B because there are commercial products currently available that provide real time weather and traffic information.

The agency has determined that the improved accuracy and update rate afforded by ADS–B is a critical segment of the NextGen infrastructure and capabilities that offer the opportunity to make the system more efficient. Specifically, enhanced surveillance data via ADS–B will improve the performance of ATC decision-support tools (URET and TMA) which rely on surveillance data to make predictions. The end result will be fewer, more efficient reroutes to avoid potential conflicts, as well as improved metering into the terminal area. This will allow increased and more efficient use of OPDs, which have lower energy and emissions profiles. Unlike radar and multilateration, ADS–B provides more detailed flight information (for example, update rate, velocity, and heading) that supports ground-based merging and spacing tools. These tools use this information to determine optimal tracks for ATC arrival planning.

FIS–B and TIS–B provide the uplink of weather and traffic information to the cockpit. Equipping with the necessary ADS–B In avionics (receiver and display components) is voluntary for operators and is not required by the ADS–B rule. The FAA analyzed alternative sources for weather and traffic information. Individually, these alternative sources may be less costly than the ADS–B solution. However, the FAA's analysis showed that the bundling of surveillance, weather, and traffic information is cost-effective for users who have not already invested in alternative capabilities. The FAA compared the costs and benefits of ADS–B, multilateration, and radar, as well as the cost savings for bundling services. A report ("Exhibit 300, Attachment 2, Business Case Analysis Report for Future Surveillance, JRC Phase 2a") is available in the docket for this rulemaking.

In sum, none of the alternatives offers the range of capabilities nor supports the NextGen concept of operations as well as ADS–B.

X. ADS–B Equipment Scheduled Maintenance

The NPRM did not propose any additional continuing airworthiness requirements associated with the installation of ADS–B avionics equipment. A few commenters questioned the FAA's plan for continued airworthiness inspections for ADS–B equipment.

This final rule does not add any continuing airworthiness inspection requirements. Transponder-based ADS–B systems will still be required to meet the requirements of § 91.413. However, ADS–B systems, without a transponder, do not have any new inspection requirements. The FAA will use the ground automation system to continuously monitor ADS–B functionality, which accomplishes the purposes of a recurrent inspection.

Y. Specific Design Parameters

In the NPRM, the FAA proposed performance standards for ADS–B Out, but did not specify any specific design parameters.

Several commenters, including the EAA, and the United States Parachute Association, recommended specific design parameters for ADS–B avionics, including size, weight, and power consumption.

The FAA again notes that this is a performance-based rule and does not mandate a particular system or design specifications (including size, weight, or power consumption). A performance-based rule provides industry with the opportunity to use innovative approaches in designing ADS–B avionics to meet the needs of their customers.

Z. Economic Issues

The FAA updated the cost and benefit estimates in the final regulatory impact analysis for this rule. For a summary of the final regulatory impact analysis, see Section III. The full final regulatory impact analysis may be found in the docket for this rulemaking. The following section discusses comments the FAA received on the proposal's regulatory evaluation. Where appropriate, the discussion includes information on the updated costs and benefits for this final rule.

1. ADS–B Out Equipage Cost

The FAA estimated that costs for the proposed rule would be between $2.3 billion and $8.5 billion. The FAA also considered that industry would start to incur equipage costs in 2012, ranging from $1.27 billion to $7.46 billion. In the final rule, the FAA estimates total costs to range from $3.3 billion to $7.0 billion, and industry equipage costs to range from $2.5 billion to $6.2 billion.

Several commenters, including ATA, Boeing, British Airways, Delta Airlines, EAA, Honeywell, NBAA, and the Regional Airline Association (RAA), questioned specific cost estimates in the proposal's economic analysis or asked for more information about the cost and benefit estimates. Most of the commenters believed that equipage costs for ADS–B Out would exceed the estimates provided in the proposal.

Several commenters, including AOPA, EAA, Embraer, and the United States Parachute Association, stated that the cost to equip with ADS–B Out was too high. Commenters pointed out that, given the value of most GA aircraft, the cost of equipage could represent a significant percentage of, or possibly exceed, the current value of the aircraft. Some commenters noted that costs of this magnitude could make recreational or business flying cost-prohibitive. Some commenters, including FedEx, noted that equipage costs will be significantly higher for aircraft not currently equipped with a certified GPS/WAAS position source.

For the proposed rule, the FAA contacted manufacturers, industry associations, and ADS–B Out suppliers to estimate ADS–B equipage and maintenance costs by aircraft model. The proposal included industry estimates for the cost of installation, maintenance, additional weight, and the addition of ADS–B Out equipment to meet the performance mandate. The proposal's regulatory impact analysis also assumed that all active airframes in service would be retrofitted by 2020.

The FAA expects that the increased demand for the ADS–B Out equipment required by this performance-based rule will result in a more competitive market, such that the prices may decrease in the coming years for certain aircraft groups. The FAA also anticipates that any investment in ADS–B Out equipage will increase the residual value of that aircraft and will allow easier access to the regulated airspace.

The FAA agrees that equipping aircraft with ADS–B Out will cost more for those aircraft that are not equipped with a position source capable of providing the necessary accuracy and integrity. To capture this cost in the proposal, the FAA requested that industry categorize large category turbojet airplanes by classic, neo-classic, modern, and new production classes, as well as the existing level of airplane equipage for each class. However, due to the confidentiality of cost data, the regulatory evaluation does not present ADS–B-supplier level data details. The FAA fully acknowledges that the general aviation community will incur significant costs from this rule. However, this must be balanced against the foundation this capability provides in moving toward the NextGen infrastructure and benefits from its overall usage.

2. FAA Cost Savings With ADS–B Out Compared to Radar

The FAA considered the following three systems for future NAS surveillance: (1) Radar, (2) multilateration, and (3) ADS–B. The FAA explained in the proposal that radar was the lowest cost option. Based on forecasts at the time of the NPRM, the FAA did not expect that radar could accommodate the projected increase in traffic.

Several commenters, including EAA and RAA, stated that the ADS–B program would result in a cost savings to the FAA because it would have less radar to maintain, operate, and replace. Most of the commenters claimed that the ADS–B program would shift costs from the FAA to aircraft operators.

The ADS–B program is not expected to result in a cost savings to the FAA from 2009 through 2035. As ADS–B becomes operational, the FAA plans to decommission some SSR. While this will reduce the operational costs of maintaining radar, the FAA will incur additional costs for ADS–B ground stations. This results in a net increase in cost for the FAA.

3. Business Case for ADS–B Out and In

In the NPRM, the FAA estimated that the total costs of ADS–B Out and In (excluding avionics for ADS–B In), relative to the radar baseline, would range from $2.8 billion to $9.0 billion. The FAA further estimated that ADS–B Out and In would yield $13.8 billion in total benefits.

The FAA concluded that ADS–B Out and In would be cost beneficial at a present value of 7 percent, if: The avionics costs for ADS–B Out are low ($670 million at a 7 percent present value) and the avionics costs for ADS–B In do not exceed $1.85 billion at a 7 percent present value.

As stated in the NPRM, ADS–B Out and In would be cost beneficial at a 3 percent present value if: (1) The avionics costs for ADS–B Out are low ($950 million at a 3 percent present value) and the avionics costs for ADS–B In do not exceed $5.3 billion at a 3 percent present value or (2) the avionics costs for ADS–B Out are high ($5.35 billion at a 3 percent present value) and the avionics costs for ADS–B In do not exceed $870 million.

Boeing asked for further clarification of scenarios in which ADS–B may not be cost beneficial. Specifically, Boeing referred to the 3 percent present value estimate in the NPRM with high avionics costs. Boeing noted that it does not believe ADS–B In avionics costs will be less than ADS–B Out avionics costs. Boeing also asked for the cost beneficial values of ADS–B Out and In at a 7 percent present value if avionics costs are high.

Boeing suggested that the FAA conduct a thorough cost-benefit analysis for the ADS–B program, including accurate cost estimates for ADS–B In. Boeing further recommended that if the FAA cannot determine the costs associated with ADS–B In, the FAA should not include these costs and benefits in the economic analysis.

Boeing also questioned why the FAA estimated the benefits for ADS–B Out and In at $13.9 billion in the proposal, while the FAA estimated the ADS–B Out and In benefits at $18.5 billion in the "Surveillance and Broadcast Services Benefits Basis of Estimates"[60] (SBS BOE) report.

The FAA agrees with Boeing that if the costs of ADS–B Out avionics are at the high end of our estimates and if ADS–B In avionics are more expensive than ADS–B Out avionics, then the costs estimated for ADS–B Out and In will exceed the quantified benefits, given the assumptions in the economic evaluation. The FAA also notes that at a 7 percent present value with the assumptions in the economic evaluation (i.e., if industry costs for ADS–B Out avionics are at the high end of the range), then ADS–B Out and In will not be cost-beneficial. The FAA does not agree that the estimates in the regulatory impact analysis need to be consistent with the estimates in the SBS BOE report. The economic analysis quantifies the potential benefits that the FAA expects to result from adoption of the rule. The economic analysis does not include benefits that could be realized without the rule.

Specifically, the regulatory impact analysis did not include benefits from ADS–B in Alaska or for low altitude operations in the Gulf of Mexico because these benefits would occur without the rule. The regulatory evaluation also did not include benefits related to controlled flight into terrain because terrain avoidance warning systems currently provide these benefits. Other benefits that the FAA did not consider in the proposal, but are in the SBS BOE, include: An estimate of the reduction in FAA subscription charges because of value added services and a reduction in costs to obtain weather information.

In addition, the regulatory impact analysis did not specifically include a benefit for radar system replacement cost avoidance. Rather, the FAA compared the total cost of continuing full radar surveillance (the baseline) to the cost of providing surveillance with ADS–B. This included the costs of gradually discontinuing some radar and continuing some radar as a backup. The lower costs of radar (what is referred to as "surveillance cost avoidance" in the SBS BOE) were captured in the cost comparison of radar under the baseline and radar under the ADS–B Out scenario (the rule).

The draft regulatory impact analysis released with the NPRM included a cost-benefit analysis of ADS–B Out alone, as well as for the scenarios for ADS–B Out and In. For the final rule,

[60] This report was published in August 2007. A copy of this report is available from the Web site *http://www.regulations.gov.* To find the report, enter FAA–2007–29305–0013.1 in the search box.

the FAA also queried industry for equipage costs for ADS–B Out and In. Although the FAA initially attempted to capture the benefits for ADS–B In, upon further consideration the agency has determined that the performance requirements are not sufficiently developed to conduct a meaningful analysis. The FAA has not included ADS–B In costs and benefits in the final regulatory impact analysis.

4. Improved En Route Conflict Probe Benefit Performance

In the NPRM, the FAA estimated the benefit for en route conflict probe at $3.3 billion.[61] To calculate this savings, the FAA estimated the reduction in ATC vectors resulting from improved en route conflict probe. Then, the FAA attributed this time savings to direct aircraft operating costs and the passenger value of time.

Several commenters questioned the improved en route conflict probe benefit estimates. The commenters noted that the amount of time saved per passenger was low, compared to other delays in the overall travel environment (for example, late arrivals at the airport and waiting for baggage). They recommended that the FAA delete the passenger value of time from its benefit estimate.

The FAA does not agree that the passenger value of time should be removed from its benefit estimate and therefore includes it in the final regulatory impact analysis. There has been significant discussion about whether small increments of time should be valued at lower rates than larger increments. The present state of theoretical and empirical knowledge does not appear to support valuing small increments of time less than larger ones.[62]

5. Capacity Enhancements, Airspace Efficiency, and Fuel Saving Benefits

In the NPRM, the FAA estimated that between 2017 and 2035, ADS–B would allow for more efficient handling of potential en route conflicts. In the NPRM, the FAA estimated this would save 410 million gallons of fuel and eliminate 4 million metric tons of carbon dioxide emissions. The FAA also noted in the initial regulatory impact analysis that, during this same time period, continuous descent approaches (now referred to as OPDs), would allow for a 10 billion pound fuel savings and a 14 million ton reduction in carbon dioxide emissions. Furthermore, the FAA noted that optimal routing over the Gulf of Mexico would eliminate 300,000 metric tons of carbon dioxide emissions between 2012 and 2035. In the final regulatory impact analysis, the FAA estimated a net reduction in carbon dioxide emissions attributable to the rule and calculated a monetary value to this net reduction. See the full regulatory impact analysis for details.

A few commenters, including RAA, questioned the cost savings associated with more efficient flights using ADS–B. Some of these commenters also asked the FAA to remove the discussion on reduced carbon dioxide emissions because the efficiency and fuel saving claims have not been validated.

RAA noted that the FAA has considerable experience justifying rules that enhance safety, but suggested that the FAA is not experienced in justifying rules based on increased airspace capacity and fuel savings. RAA asked the FAA to validate whether the reduced vertical separation minimum (RVSM) program reduced fuel consumption, as estimated in the RVSM regulatory evaluation. RAA also noted that the benefit analysis should quantify the benefits that ADS–B would provide over current descent procedures enabled without ADS–B.

GAMA and an individual commenter noted the environmental impact of airspace modernization. GAMA encouraged the FAA to provide additional details and quantify the benefit from fuel savings that the FAA expects ADS–B surveillance will provide.

In the proposal's benefit analysis, the FAA quantified the benefits that ADS–B alone will provide over current, recognized OPD procedures. The agency agrees that the efficiency benefits are, in part, conceptual, and with new technologies, conceptual efficiency benefits analysis is the only option. While outside the scope of this rulemaking, as noted by a commenter, the RVSM program offers an example of how airspace redesign and new technological capabilities can result in significant efficiency and operational (fuel savings) gains.

6. Deriving Benefits From Capstone Implementation in Alaska

In the NPRM, the FAA explained that ADS–B has been demonstrated and used in Alaska for terrain and traffic awareness, and that it had a noticeable effect on safety. Several commenters argued that Capstone is an insufficient basis to assume benefits from ADS–B equipage. The commenters noted that Capstone is a strong component of the justification for the system; they added that a major component of Capstone is the addition of terrain information and warnings. Commenters also noted that the flight environment in southeast Alaska is unlike any in the lower 48 states.

The FAA understands that the conditions in Alaska do not translate to the continental United States. While the regulatory impact analysis does not include any benefits from Capstone, the rulemaking action does highlight the potential benefits derived from more accurate and timely positioning information from ADS–B.

7. Regional Airline Benefits

In the NPRM, the FAA quantified the benefits as shown in Table 4.

TABLE 4—ESTIMATED BENEFITS INCLUDED IN THE NPRM REGULATORY EVALUATION

Benefit area	Benefit 2007 M$	Discounted at 3%	Discounted at 7%
Total Benefits	$9,948.5	$5,484.3	$2,657.7
Gulf of Mexico:			
High Altitude Operations	2,067.2	1,104.4	509.9
More Efficient En Route Separation Delay Savings	1,810.6	946.1	421.3
Additional Flights Accommodated Optimal and More Direct Routing	256.6	158.4	88.6
Improved En Route Conflict Probe Performance	3,258.1	1,774.0	840.1
More Efficient Metering Based on Improved TMA Accuracy	1,746.6	944.9	441.1
Increased Ability to Perform Continuous Descent Approaches	2,876.7	1,661.0	866.6

[61] This translates to $840 million at a 7 percent present value or $1.8 billion at a 3 percent present value.

[62] Economic Values For FAA Investment and Regulatory Decisions, A Guide, Final Report Revised Oct. 3, 2007, GRA Incorporated.

RAA expressed concern that regional operators do not have equal access to large airports; therefore, they will not achieve the same benefits as larger air carriers. RAA specifically noted that the FAA has not committed to a measurable reduction in aircraft-to-aircraft separation standards. They believed that without reduced separation standards, the benefits would be localized and would not apply to regional airlines. RAA also noted that regional aircraft typically do not carry life rafts and, therefore, they cannot conduct extended over-water operations. As a result, they will not benefit from more efficient aircraft separation over the Gulf of Mexico.

The FAA agrees that regional operators who cannot operate over the Gulf of Mexico will not attain this separation benefit. However, the FAA did not estimate benefits specifically for regional carriers. The agency expects regional airlines to benefit from ADS–B Out even without reduced aircraft-to-aircraft separation standards. This is because other benefits, including improved en route conflict probe performance, apply to all aircraft in Class A airspace, including regional airlines.

8. General Aviation: High Equipage Costs With Little Benefit

In the proposal, the FAA estimated that the total cost to equip GA aircraft from 2012 through 2035 would range from $1.2 billion to about $4.5 billion with a mid-point average of nearly $2.9 billion.[63] Although the FAA did not specifically estimate GA benefits in the NPRM, the agency now estimates that GA could receive up to $200 million in ADS–B Out benefits.

Numerous commenters, including AOPA and EAA, expressed concern that the proposed rule would require GA operators to add costly equipment to their aircraft, while providing these operators with few benefits. GAMA noted that many of the benefits for GA operators exist with ADS–B In. Several of the commenters noted that GA aircraft do not substantially contribute to delays or congestion in the NAS. They further stated that if ADS–B lessens traffic delays, it will benefit the airlines rather than the GA community. AOPA recommended that the FAA work with key stakeholders to identify a strategy that either removes low-altitude airspace users from the proposal or greatly improves the benefits for them.

The FAA considered three options to resolve the GA cost benefit comments. First, the FAA considered modifying performance requirements to reduce equipage costs. Second, the FAA evaluated options to provide additional benefits to GA operators. Third, the FAA explored tailoring the rule such that fewer GA operators would be affected.

For the first option, the FAA determined that opportunities do exist for reducing the equipage costs for GA operators. In the rule, the FAA bases the performance requirements solely on ATC separation services; whereas in the proposal, the performance requirements were based on ATC separation services and five initial ADS–B In applications. This change eliminated the need for ADS–B antenna diversity because the ATC separation services can operate effectively without it and the ADS–B Out benefits can be achieved. Multiple commenters and the ARC felt that removing antenna diversity would help make the rule cheaper to implement for light general aviation operators.

For the second option, using comments received by the GA community, the FAA has identified opportunities to provide additional benefits to GA operators by expanding ADS–B services throughout the NAS to areas not currently serviced. Thus, outside of this rulemaking effort, the FAA intends to explore the costs and benefits for the following ADS–B enabled service expansions:

(a) Expanding low altitude surveillance coverage, both in areas receiving increased collateral coverage from the initial ADS–B ground station infrastructure and in areas that could benefit from additional ground station coverage.

(b) Providing radar-like terminal ATC services at airports not currently served.

(c) Providing an automated mechanism for the closure of IFR flight plans based on the new technologies ability to detect an aircraft's arrival at its destination airport.

(d) Making enhancements to current search and rescue technology and procedures that will assist rescue personnel in determining the last known location of aircraft that are reported missing.

(e) Providing Flight Service Stations (FSSs) with ADS–B positional display information and assisting in the development of automation systems that will allow for more tailored in flight service functions.

For the third option, the FAA looked at tailoring the ADS–B airspace such that the number of general aviation aircraft needing to equip would be minimized. Specifically the FAA considered limiting the rule to only Class A and B airspace. Although ADS–B surveillance is not as critical to the NexGen goals in lower density airspace, such as Class E airspace above 10,000 feet and Class C airspace, ADS–B equipage for all aircraft in these areas is essential to gaining the overall stated ADS–B benefits, realizing savings associated with radar decommissioning,[64] the expansion of potential future benefits discussed above, and moving towards the NextGen concept of operations. Thus, the airspace subject to this rule remains unchanged.

AA. Revisions To Other Regulations

Several commenters, including ACI–NA, ACSS, ATA, United Airlines, and UPS, recommended changes to other regulations. Specifically, they recommended that the FAA update subpart F of 14 CFR part 25 to include ADS–B requirements. ACI–NA recommended that the FAA amend 14 CFR part 139 to require airport surface vehicles to equip with ADS–B to prevent runway incursions. Airbus recommended that the FAA update advisory circular (AC) 120–86, Aircraft Surveillance Systems and Applications.

This rule only amends the operating regulations in part 91. At this point, the FAA has not identified any ADS–B Out requirements for parts 23, 25, 27, and 29. The FAA will issue the appropriate aircraft installation and operational guidance material consistent with the requirements of this rule upon issuance or shortly thereafter. The FAA is discussing with airports and the Federal Communications Commission whether ADS–B would benefit airport ground vehicles.

III. Regulatory Notices and Analyses

A. Paperwork Reduction Act

As required by the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), the FAA submitted a copy of the new (or amended) information collection requirement(s) in this final rule to the Office of Management and Budget (OMB) for its review. OMB assigned the number 2120–0728 in advance, but has not yet approved the collection. Affected parties do not have to comply with the information collection requirements until the FAA publishes in the **Federal Register** notice of the approval of the control number

[63] The FAA also calculated this midpoint to be $2.1 billion at a 3 percent present value or $1.5 billion at a 7 percent present value.

[64] The costs of radar will be about $1 billion less with ADS–B Out, although the total ground costs of ADS–B Out with the cost to sustain and decommission select radar will exceed the cost of continuing radar without implementing ADS–B.

assigned by OMB for these information requirements. Approval of the control number notifies the public that OMB has approved these information collection requirements under the Paperwork Reduction Act of 1995.

The FAA received comments on the proposed performance requirements for ADS–B Out aircraft equipment. Those comments are discussed in section II, Discussion of the Final Rule, elsewhere in this preamble. However, the agency received no comments specifically on the burden associated with collecting aircraft transmissions from the ADS–B Out equipment required by this rule.

A description of the annual burden is shown below.

Use: This final rule will support the information needs of the FAA by requiring avionics equipment that continuously transmits aircraft information to be received by the FAA, via automation, for use in providing air traffic surveillance services.

Respondents: The average number of aircraft that will be equipped annually for the first 3 years—577. The number of aircraft (general aviation, regional, and majors) that will be equipped by 2035: 247,317.

Frequency: ADS–B equipment will continuously transmit aircraft information in "real time" to FAA ground receivers. The information is collected electronically, without input by a human operator. Old information is overwritten on a continuous basis.

Annual Burden Estimate: Base-case start-up cost for an ADS–B Out-compliant transponder: $4,371.09 million (in 2009 dollars).

An agency may not collect or sponsor the collection of information, nor may it impose an information collection requirement unless it displays a currently valid OMB control number.

B. International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to conform to ICAO SARPs to the maximum extent practicable. ATA, British Airways, and EUROCONTROL recommended that the FAA harmonize this rule with the appropriate ICAO SARPs. Considering that the long-term global capabilities of ADS–B are not yet fully defined, ICAO SARPs will continue to evolve to reflect developing ADS–B applications. In addition, current ICAO SARPs for the 1090 MHz ES and UAT ADS–B links will be updated to reflect harmonized changes to both RTCA and EUROCAE minimum performance standards, as appropriate, for ADS–B Out operations. The FAA has reviewed the existing ICAO requirements[65] as related to ADS–B Out operations and has identified no differences with these regulations. The FAA also will continue to work with the international community to ensure harmonization.

C. Regulatory Impact Analysis, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 (Pub. L. 96–354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Pub. L. 96–39) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation with a base year of 1995). This portion of the preamble summarizes the FAA's analysis of the economic impacts of this final rule. The FAA suggests that readers seeking greater detail read the full regulatory impact analysis, a copy of which has been placed in the docket for this rulemaking.

In conducting these analyses, the FAA has determined that this final rule: (1) Has benefits that justify its costs; (2) is an economically "significant regulatory action" as defined in section 3(f) of Executive Order 12866; (3) is "significant" as defined in DOT's Regulatory Policies and Procedures; (4) will have a significant economic impact on a substantial number of small entities; (5) will not create unnecessary obstacles to the foreign commerce of the United States; and (6) will impose an unfunded mandate on the private sector but not on state, local, or tribal governments. These analyses are summarized below.

Regulatory Impact Analysis

The FAA reviewed the following three alternatives for surveillance and found Alternative 2 (the rule) to be the preferred alternative:

1. *Baseline radar*—Maintain the current radar based surveillance system and replace radar facilities when they wear out;
2. *ADS–B*—Aircraft operators equip to meet performance requirements required by the rule and the FAA provides surveillance services based on downlinked aircraft information.
3. *Multilateration*—The FAA provides surveillance using multilateration.

Key Assumptions

- All costs and benefits are denominated in 2009 dollars.
- The final rule will be published in 2010 and have a compliance date of 2020.
- Present value rates are 3% and 7%.
- Period of analysis: 2009–2035.

Benefits of the Final Rule

The benefits of the final rule include the dollar value of savings in fuel, time, net reduction in CO_2 emissions, and the consumer surplus associated with the additional flights accommodated because of the rule. The estimated quantified benefits of the rule range from $6.8 billion ($2.1 billion at 7% present value) to $8.5 billion ($2.7 billion at 7% present value).

Costs of the Final Rule

The estimated incremental costs of the final rule range from a low of $3.3 billion ($2.2 billion at 7% present value) to a high of $7.0 billion ($4.1 billion at 7% present value). These include costs to the government, as well as to the aviation industry and other users of the NAS, to deploy ADS–B, and are incremental to maintaining surveillance via current technology (radar). The aviation industry would begin incurring costs for avionics equipage in 2012 and would incur total costs ranging from $2.5 billion ($1.4 billion at 7% present value) to $6.2 billion ($3.3 billion at 7% present value) with an estimated

[65] ICAO references: Procedures for Air Navigation Services—Air Traffic Management, Doc 4444, Amendment 4, (24/11/05) Procedures for Air Navigation Services—Air Traffic Management; Doc 9694, ICAO Manual of Air Traffic Services Data Link Applications; Annex 2, Rules of the Air; Annex 4, Aeronautical Charts; Annex 6 Part II, Operation of Aircraft; Annex 11, Air Traffic Services; Annex 15, Aeronautical Information Services; Doc 9689, Manual for Determination of Separation Minima; Circular 311, SASP Circular—ADS–B Comparative Assessment; Circular 278, National Plan for CNS/ATM Systems Guidance Material; Annex 10 Vol. IV, Amendment 82, Aeronautical Telecommunications; Doc 9871, Technical Provisions for Mode S Services and Extended Squitter.

midpoint of $4.4 billion ($2.3 billion at 7% present value) from 2012 to 2035.

Regulatory Flexibility Determination and Analysis

Introduction and Purpose of this Analysis

The Regulatory Flexibility Act of 1980 (Pub. L. 96–354) (RFA) establishes "as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration." The RFA covers a wide range of small entities, including small businesses, not-for-profit organizations, and small governmental jurisdictions.

Agencies must perform a review to determine whether a rule will have a significant economic impact on a substantial number of small entities. If the agency determines that the rule will have such an impact, the agency must prepare a regulatory flexibility analysis as described in the RFA. Section 603 of the RFA requires agencies to prepare and make available for public comment a final regulatory flexibility analysis (FRFA) describing the impact of final rules on small entities. As the FAA Administrator, I certify that this rule will have a significant economic impact on a substantial number of small entities. The purpose of this analysis is to provide the reasoning underlying this FAA determination.

Section 603(b) of the RFA specifies the content of a FRFA.

Each FRFA must contain:

- A description of the reasons why action by the agency is being considered;
- A succinct statement of the objectives of, and legal basis for, the final rule;
- A description and an estimate of the number of small entities to which the rule will apply;
- A description of the projected reporting, record keeping and other compliance requirements of the final rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;
- An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap, or conflict with the final rule;
- A description of any significant alternatives to the final rule which accomplish the stated objectives of applicable statutes and minimize any significant economic impact of the final rule on small entities.
- A summary of significant issues raised by public comments in response to the initial regulatory flexibility analysis and how the agency resolved those comments.

Reasons Why the Final Rule is Being Promulgated

Public Law 108–176, referred to as "The Century of Aviation Reauthorization Act," was enacted December 12, 2003 (Pub. L. 108–176). This law set forth requirements and objectives for transforming the air transportation system to progress further into the 21st century. Section 709 of this statute required the Secretary of Transportation to establish in the FAA a Joint Planning and Development Office (JPDO) to manage work related to NextGen. Among its statutorily defined responsibilities, the JPDO coordinates the development and use of new technologies to ensure that, when available, they may be used to the fullest potential in aircraft and in the air traffic control system.

The FAA, the National Aeronautics and Space Administration (NASA), and the Departments of Commerce, Defense, and Homeland Security have launched an effort to align their resources to develop and further NextGen. The goals of NextGen, as stated in section 709, that are addressed by this final rule include: (1) Improving the level of safety, security, efficiency, quality, and affordability of the NAS and aviation services; (2) Taking advantage of data from emerging ground- and space-based communications, navigation, and surveillance technologies; (3) Being scalable to accommodate and encourage substantial growth in domestic and international transportation and anticipate and accommodate continuing technology upgrades and advances; and (4) Accommodating a wide range of aircraft operations, including airlines, air taxis, helicopters, GA, and unmanned aerial vehicles.

The JPDO was also charged to create and carry out an integrated plan for NextGen. The NextGen Integrated Plan, transmitted to Congress on December 12, 2004, ensures that the NextGen system meets the air transportation safety, security, mobility, efficiency and capacity needs beyond those currently included in the FAA's Operational Evolution Plan (OEP).

As described in the NextGen Integrated Plan, the current approach to air transportation (*i.e.,* ground based radars tracking congested flyways and passing information among the control centers for the duration of flights) is becoming operationally obsolete. The current system is increasingly inefficient, and despite decreases in air traffic, still subject to significant delays. Resumption of growth will only aggravate congestion and delays, given the capabilities of the present system. The current method of handling air traffic flow will not be able to adapt to the volumes, density, and approach to managing air traffic in the future. The need for significant improvements towards operational efficiency and reduced environmental impacts, as well as resumed growth, will create significant challenges. Moreover, the diversity of aircraft is forecast to grow as the use of unmanned aircraft systems and very light jets are developed for special operations.

The FAA believes that ADS–B technology is a key component in achieving many of the goals set forth in the NextGen Integrated Plan. This final rule is a major step toward strategically "establishing an agile air traffic system that accommodates future requirements and readily responds to shifts in demand from all users," by embracing a new approach to surveillance that can lead to greater and more efficient airspace use. ADS–B technology not only assists in the transition to a system with less dependence on ground infrastructure and facilities, but also creates capabilities for precision and accuracy, which in turn will make the system more operationally and environmentally efficient.

Statement of the Legal Basis and Objectives

The FAA's authority to issue rules regarding aviation safety is found in Title 49 of the United States Code. Subtitle I, Section 106, Federal Aviation Administration, describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in Subtitle VII, Part A, Subpart I, Section 40103, Sovereignty and Use of Airspace, and Subpart III, Section 44701, General Requirements. Under section 40103, the FAA is charged with prescribing regulations on: (1) The flight of aircraft, including regulations on safe altitudes; (2) the navigation, protection, and identification of aircraft; and (3) the safe and efficient use of the navigable airspace. Under section 44701, the FAA is charged with promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce.

This final rule is within the scope of sections 40103 and 44701 because it promulgates aircraft performance requirements to meet advanced surveillance needs that will accommodate projected increases in operations within the NAS. As more aircraft operate within the U.S. airspace, improved surveillance performance is necessary to continue balancing air transportation growth with the agency's mandate for a safe and efficient air transportation system.

Projected Reporting, Record Keeping and Other Requirements

As required by the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), the FAA submitted a copy of the new information collection requirements in this final rule to the Office of Management and Budget for its review. See discussion in Section III elsewhere in this preamble.

Overlapping, Duplicative, or Conflicting Federal Rules

The FAA is not aware that the final rule will overlap, duplicate or conflict with existing Federal rules.

Significant Issues Raised by Public Comments to the Initial Regulatory Flexibility Analysis

In the NPRM, the FAA addressed the impact of the proposed rule on small-business part 91, 121, and 135 operators with less than 1,500 employees. The proposal noted that a substantial number of small entities would be significantly affected by the proposed rule.

One individual commented and challenged the assumption that only small businesses directly involved in aviation would be affected. The commenter explained that many businesses use aircraft indirectly in their operations and that higher aircraft equipage costs will affect overall business costs. The commenter believed that one half of all non-turbine GA aircraft are involved in small business activity.

Publicly available data regarding internal company financial statistics for GA operators is limited. Therefore, the FAA estimated the financial impact by obtaining a sample population of GA operators from (1) the U.S. DOT Form 41 filings, (2) World Aviation Directory, and (3) ReferenceUSA. The FAA applied this sample to U.S. Census Bureau data on the Small Business Administration Web site. This was done to develop an estimate of the total number of small businesses affected by the proposed rule.

The FAA agrees that GA operators use airplanes for indirect business use and has determined that this final rule will have a significant impact on a substantial number of small businesses.

Estimated Number of Small Firms Potentially Impacted

Under the RFA, the FAA must determine whether a rule significantly affects a substantial number of small entities. This determination is typically based on small entity size and cost thresholds that vary depending on the affected industry.

Using the size standards from the Small Business Administration for Air Transportation and Aircraft Manufacturing, the FAA defined companies as small entities if they have fewer than 1,500 employees.

The FAA considered the economic impact on small-business part 91, 121, and 135 operators. Many of the GA aircraft that are operating under part 91 are not for hire or flown for profit, so the FAA does not include these operators in its small business impact analysis.

This final rule will become effective in 2020. Although the FAA forecasts traffic and air carrier fleets to 2040, our forecasts are of a generic nature and do not forecast the number of small entities. These forecasts also do not estimate whether an operator will still be in business or will be a small business entity. Therefore the FAA uses current U.S. operator's revenues and applies the industry-provided costs to determine if this final rule will have a significant impact on a substantial number of small entity operators.

The FAA obtained a list of part 91, 121 and 135 U.S. operators from the FAA Flight Standards Service. Using information provided by the U.S. DOT Form 41 filings, World Aviation Directory, and ReferenceUSA, the FAA eliminated operators that are subsidiary businesses of larger businesses and businesses with more than 1,500 employees from the list of small entities. In many cases, the employment and annual revenue data are not public, so the FAA did not include these companies in its analysis. For the remaining businesses, the FAA obtained company revenue and employment from the above three sources.

The methodology discussed above resulted in a list of 34 U.S. part 91, 121 and 135 operators, with less than 1,500 employees, who operate 341 airplanes. Due to the sparse amount of publicly available data on internal company financial statistics for small entities, it was not feasible to estimate the total population of small entities affected by this final rule. The total population of U.S. part 91, 121 and 135 operators, with less than 1,500 employees, has the potential to be large. We used this sample set of small business operators to develop percentage estimates to apply to the U.S. Census Bureau data to estimate the population.

These 34 U.S. small entity operators are a representative sample. The sample was used to assess the cost impact on the total population of small businesses who operate aircraft affected by this final rulemaking. This representative sample was then applied to the U.S. Census Bureau data on the Small Business Administration's Web site to develop an estimate of the total number of affected small business entities.

The U.S. Census Bureau data lists small entities in the air transportation industry that employ less than 500 employees. Other small businesses may own aircraft and may not be included in the U.S. Census Bureau air transportation industry category. Therefore our estimate of the number of small entities affected by this final rule will likely be understated. The estimate of the total number of affected small entities is developed below.

Cost and Affordability for Small Entities

To assess the cost impact to small business part 91, 121 and 135 operators, the FAA contacted manufacturers, industry associations, and ADS–B equipage providers to estimate ADS–B equipage costs. The FAA requested estimates of airborne installation costs, by aircraft model, for the output parameters listed in the "Equipment Specifications" section of the Regulatory Impact Analysis.

To satisfy the manufacturers' request to keep individual aircraft pricing confidential, the FAA calculated low, baseline, and high range of costs by equipment class. The baseline estimate equals the average of the low and high industry cost estimates. The dollar value ranges consist of a wide variety of avionics within each aircraft group. The aircraft architecture within each equipment group can vary, causing different carriage, labor, and wiring requirements for the installation of ADS–B. Volume discounting, versus single line purchasing, also affects the dollar value ranges. On the low end, the dollar value may represent a software upgrade or original equipment manufacturer (OEM) option change. On the high end, the dollar value may represent a new installation of upgraded avionic systems necessary to assure accuracy, reliability and safety. The FAA used the estimated baseline dollar value cost by equipment class in determining the impact to small business entities.

The FAA estimated each operator's total compliance cost as follows: Multiplying the baseline dollar value cost (by equipment class) by the number of aircraft each small business operator currently has in its fleet. The FAA summed these costs by equipment class and group. The FAA then measured the economic impact on small entities by dividing the estimated baseline dollar value compliance cost for their fleet by the small entity's annual revenue.

Each equipment group operated by a small entity may have to comply with different requirements in the final rule, depending on the state of the aircraft's avionics. In the "ADS–B Out Equipage Cost Estimate" section of the Regulatory Impact Analysis, the FAA details its methodology to estimate operators' total compliance cost by equipment group.

For small entity operators in the sample population of 34 small aviation entities, the ADS–B cost is estimated to be: (1) Greater than 2% of annual revenues for about 35% of the operators; and (2) greater than 1% of annual revenues for about 54% of the operators. Applying these percentages to the air transportation industry category of the 2006 U.S. Census Bureau data, the ADS–B cost is estimated to be: (1) Greater than 2% of annual revenues for at least 1,015 small entities; and (2) greater than 1% of annual revenues for at least 1,562 small entity operators.

As a result of the above analysis, the FAA has determined that a substantial number of small entities will be significantly affected by the rule. Every small entity that operates an aircraft in the airspace defined by this final rule will be required to install ADS–B out equipage and therefore will be affected by this rulemaking.

Business Closure Analysis

For commercial operators, the ratio of costs to annual revenue shows that 7 of 34 small business air operator firms would have ratios in excess of 5%. Since many of the other commercial small business air operator firms do not make their annual revenue publicly available, it is difficult to assess the financial impact of this final rule on their business. To fully assess whether this final rule could force a small entity into bankruptcy requires more financial information than is publicly available.

In the NPRM, the FAA requested comment and supporting justification, from small entities, to assist the FAA in determining the degree of hardship the final rule will have on these entities. Comments were also requested on feasible alternative methods of compliance. The FAA did not receive any comments specific to this request.

Competitive Analysis

The aviation industry is an extremely competitive industry with slim profit margins. The number of operators who entered the industry and have stopped operations because of mergers, acquisitions, or bankruptcy litters the history of the aviation industry.

The FAA analyzed five years of operating profits for the affected small-entity operators listed above, and was able to determine the operating profit for 18 of the 34 small business entities. The FAA discovered that the average operating profit for 33% of these 18 affected operators was negative. Only four of the 18 affected operators had average annual operating profits that exceeded $10,000,000.

In this competitive industry, cost increases imposed by this regulation will be hard to recover by raising prices, especially by those operators showing an average five-year negative operating profit. Further, large operators may be able to negotiate better pricing from outside firms for inspections and repairs, so small operators may need to raise their prices more than large operators. These factors make it difficult for small operators to recover their compliance costs by raising prices. If small operators cannot recover all the additional costs imposed by this regulation, market shares could shift to the large operators.

Small operators successfully compete in the aviation industry by providing unique services and controlling costs. The extent to which affected small entities operate in niche markets will affect their ability to pass on costs. Currently small operators are much more profitable than established major scheduled carriers. This final rule will offset some of the advantages of lower capital costs of older aircraft.

Overall, in terms of competition, this rulemaking reduces small operators' ability to compete.

Disproportionality Analysis

The disproportionately higher impact of the final rule on the fleets of small operators results in disproportionately higher costs to small operators. Due to the potential of fleet discounts, large operators may be able to negotiate better pricing from outside sources for inspections, installation, and ADS–B hardware purchases.

Based on the percent of potentially affected current airplanes over the analysis period, small U.S. business operators may bear a disproportionate impact from the final rule.

Analysis of Alternatives

Alternative One

The status quo alternative has compliance costs to continue the operation and commissioning of radar sites. The FAA rejected this status quo alternative because it is becoming operationally obsolete to use ground-based radars to track congested airways and pass information among control centers for the duration of flights. The current system is not able to upgrade to the NextGen capabilities, nor accommodate the estimated increases in air traffic, which would result in mounting delays or limitations in service for many areas.

Alternative Two

Alternative Two would employ a technology called multilateration. Multilateration is a separate type of secondary surveillance system that is not radar-based and has limited deployment in the U.S. At a minimum, multilateration requires at least four ground stations to deliver the same volume of coverage and integrity of information as ADS–B, because of the need to "triangulate" the aircraft's position.

Multilateration is a process that determines aircraft position by using the difference in time of arrival of a signal from an aircraft at a series of receivers on the ground. Multilateration meets the need for accurate surveillance and is less costly than ADS–B (however, more costly than radar), but cannot achieve the same level of benefits as ADS–B, such as system capacity and environmental improvements. Multilateration would provide the same benefits as radar, but the FAA estimates that the cost of providing multilateration (including the cost to sustain radar until multilateration is operational), would exceed the cost to continue full radar surveillance.

Alternative Three

Alternative Three would provide relief by having the FAA provide an exemption to small air carriers from all requirements of this rule. This alternative would mean that small air carriers would rely on the status quo ground-based radars to track their flights and pass information among control centers for the duration of the flights.

As discussed previously, ADS–B Out cannot be used effectively as the primary surveillance system if certain categories of airspace users are subject to separate surveillance systems. The small air carriers operate in the same airspace as the larger carriers and general aviation. Such an exemption would require two primary surveillance systems, which adds the cost of an additional surveillance system without improving the existing benefits. Thus, this alternative is not considered to be acceptable.

Alternative Four

Alternative Four exempts small-piston engine GA operators from the requirements of this final rule. This final rule provides minimal benefits to small-piston engine GA operators, while adding significant costs by mandating these operators to retrofit and equip about 150,000 small piston engine GA airplanes with ADS–B Out. Even though the FAA determined that the percentage of small piston engine GA airplanes operating at the top Operational Evolution Plan 35 airports is less than 5%, the number of GA operations within a 30-nautical-mile radius of these airports is significant. This alternative was not considered acceptable because ADS–B equipage for all aircraft operating in the airspace subject to this rule is essential to gaining the overall stated ADS–B benefits, realizing savings associated with radar decommissioning, and the expansion of potential future benefits.

Alternative Five

This alternative is the final ADS–B rule. ADS–B does not employ different classes of receiving equipment or provide different information based on its location. Therefore, controllers will not have to account for transitions between surveillance solutions as an aircraft moves closer to or farther away from an airport. To address congestion and delay, fuel consumption, emissions, and future demand for air travel without significant delays or denial of service, the FAA found ADS–B to be the most cost-effective solution to maintain a viable air transportation system. ADS–B provides a wider range of services to aircraft users and could enable applications that are not available with multilateration or radar.

International Trade Impact Analysis

The Trade Agreements Act of 1979 (Pub. L. 96–39), as amended by the Uruguay Round Agreements Act (Pub. L. 103–465), prohibits Federal agencies from establishing standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Pursuant to these Acts, the establishment of standards is not considered an unnecessary obstacle to the foreign commerce of the United States, so long as the standard has a legitimate domestic objective, such the protection of safety, and does not operate in a manner that excludes imports that meet this objective. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards. The FAA has assessed the potential effect of this final rule and determined that it will impose the same unit costs on domestic and international entities and thus has a neutral trade impact.

Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (in 1995 dollars) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a "significant regulatory action." The FAA currently uses an inflation-adjusted value of $136.1 million in lieu of $100 million. This rule is not expected to impose significant costs on small governmental jurisdictions such as State, local, or tribal governments. However, the rule will result in an unfunded mandate on the private sector because it will result in expenditures in excess of the $136.1 million annual threshold. The FAA considered two alternatives to the rule, as described above, and four alternatives in the regulatory flexibility analysis described above.

VI. Executive Order 13132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action will not have a substantial direct effect on the States, or the relationship between the Federal Government and the States, or on the distribution of power and responsibilities among the various levels of government, and, therefore, does not have federalism implications.

VII. Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the FAA, when modifying its regulations in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish appropriate regulatory distinctions. The FAA did not receive any comments on whether the proposed rule should apply differently to intrastate aviation in Alaska. The FAA has determined, based on the administrative record of this rulemaking, that there is no need to make any regulatory distinctions applicable to intrastate aviation in Alaska.

VIII. Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined that this rulemaking action qualifies for the categorical exclusion identified in paragraph 312f and involves no extraordinary circumstances.

IX. Regulations That Significantly Affect Energy Supply, Distribution, or Use

The FAA has analyzed this final rule under Executive Order 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). The FAA has determined that it is not a "significant regulatory action" under Executive Order 13211. This is because, while it is a "significant regulatory action" under Executive Order 12866 and DOT's Regulatory Policies and Procedures, it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. In fact, adoption of this final rule offers the potential to produce reductions in energy use in the NAS.

X. Availability of Rulemaking Documents

You can get an electronic copy of rulemaking documents using the Internet by—

1. Searching the Federal eRulemaking Portal at *http://www.regulations.gov;*
2. Visiting the FAA's Regulations and Policies Web page at *http://www.faa.gov/regulations_policies/;* or
3. Accessing the Government Printing Office's Web page at *http://www.gpoaccess.gov/fr/index.html.*

You can also get a copy by sending a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680. Be sure to identify the amendment number or docket number of this rulemaking.

Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, *etc.*). You may review DOT's complete Privacy Act statement in the **Federal Register** published on April 11, 2000 (Volume 65, Number 70; Pages 19477–78) or you may visit *http://DocketsInfo.dot.gov.*

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires the FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. If you are a small entity and you have a question regarding this document, you may contact your local FAA official, or the person listed under the **FOR FURTHER INFORMATION CONTACT** heading at the beginning of the preamble. You can find out more about SBREFA on the Internet at *http://www.faa.gov/regulations_policies/rulemaking/sbre_act/.*

List of Subjects in 14 CFR Part 91

Aircraft, Airmen, Air traffic control, Aviation safety, Incorporation by Reference, Reporting, and recordkeeping requirements.

The Amendment

■ In consideration of the foregoing, the Federal Aviation Administration amends chapter I of 14 CFR as follows:

PART 91—GENERAL OPERATING AND FLIGHT RULES

■ 1. The authority citation for part 91 continues to read as follows:

Authority: 49 U.S.C. 106(g), 1155, 40103, 40113, 40120, 44101, 44111, 44701, 44704, 44709, 44711, 44712, 44715, 44716, 44717, 44722, 46306, 46315, 46316, 46504, 46506–46507, 47122, 47508, 47528–47531, articles 12 and 29 of the Convention on International Civil Aviation (61 stat. 1180).

■ 2. Amend § 91.1 by revising paragraph (b) to read as follows:

§ 91.1 Applicability.

* * * * *

(b) Each person operating an aircraft in the airspace overlying the waters between 3 and 12 nautical miles from the coast of the United States must comply with §§ 91.1 through 91.21; §§ 91.101 through 91.143; §§ 91.151 through 91.159; §§ 91.167 through 91.193; § 91.203; § 91.205; §§ 91.209 through 91.217; § 91.221, § 91.225; §§ 91.303 through 91.319; §§ 91.323 through 91.327; § 91.605; § 91.609; §§ 91.703 through 91.715; and § 91.903.

* * * * *

■ 3. Amend § 91.130 by revising paragraph (d) to read as follows:

§ 91.130 Operations in Class C airspace.

* * * * *

(d) *Equipment requirements.* Unless otherwise authorized by the ATC having jurisdiction over the Class C airspace area, no person may operate an aircraft within a Class C airspace area designated for an airport unless that aircraft is equipped with the applicable equipment specified in § 91.215, and after January 1, 2020, § 91.225.

* * * * *

■ 4. Amend § 91.131 by revising paragraph (d) to read as follows:

§ 91.131 Operations in Class B airspace.

* * * * *

(d) *Other equipment requirements.* No person may operate an aircraft in a Class B airspace area unless the aircraft is equipped with—

(1) The applicable operating transponder and automatic altitude reporting equipment specified in § 91.215 (a), except as provided in § 91.215 (e), and

(2) After January 1, 2020, the applicable Automatic Dependent Surveillance-Broadcast Out equipment specified in § 91.225.

■ 5. Amend § 91.135 by revising paragraph (c) to read as follows:

§ 91.135 Operations in Class A airspace.

* * * * *

(c) *Equipment requirements.* Unless otherwise authorized by ATC, no person may operate an aircraft within Class A airspace unless that aircraft is equipped with the applicable equipment specified in § 91.215, and after January 1, 2020, § 91.225.

* * * * *

■ 6. Amend § 91.217 by redesignating paragraphs (a) through (c) as paragraphs (a)(1) through (a)(3), redesignating the introductory text as paragraph (a) introductory text, and by adding paragraph (b) to read as follows:

§ 91.217 Data correspondence between automatically reported pressure altitude data and the pilot's altitude reference.

* * * * *

(b) No person may operate any automatic pressure altitude reporting equipment associated with a radar beacon transponder or with ADS–B Out equipment unless the pressure altitude reported for ADS–B Out and Mode C/S is derived from the same source for aircraft equipped with both a transponder and ADS–B Out.

■ 7. Add § 91.225 to read as follows:

§ 91.225 Automatic Dependent Surveillance-Broadcast (ADS–B) Out equipment and use.

(a) After January 1, 2020, and unless otherwise authorized by ATC, no person may operate an aircraft in Class A airspace unless the aircraft has equipment installed that—

(1) Meets the requirements in TSO–C166b, Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS–B) and Traffic Information Service-Broadcast (TIS–B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz); and

(2) Meets the requirements of § 91.227.

(b) After January 1, 2020, and unless otherwise authorized by ATC, no person may operate an aircraft below 18,000 feet MSL and in airspace described in paragraph (d) of this section unless the aircraft has equipment installed that—

(1) Meets the requirements in—

(i) TSO–C166b; or

(ii) TSO–C154c, Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS–B) Equipment Operating on the Frequency of 978 MHz;

(2) Meets the requirements of § 91.227.

(c) Operators with equipment installed with an approved deviation under § 21.618 of this chapter also are in compliance with this section.

(d) After January 1, 2020, and unless otherwise authorized by ATC, no person may operate an aircraft in the following airspace unless the aircraft has equipment installed that meets the requirements in paragraph (b) of this section:

(1) Class B and Class C airspace areas;

(2) Except as provided for in paragraph (e) of this section, within 30 nautical miles of an airport listed in appendix D, section 1 to this part from the surface upward to 10,000 feet MSL;

(3) Above the ceiling and within the lateral boundaries of a Class B or Class C airspace area designated for an airport upward to 10,000 feet MSL;

(4) Except as provided in paragraph (e) of this section, Class E airspace within the 48 contiguous states and the District of Columbia at and above 10,000 feet MSL, excluding the airspace at and below 2,500 feet above the surface; and

(5) Class E airspace at and above 3,000 feet MSL over the Gulf of Mexico from the coastline of the United States out to 12 nautical miles.

(e) The requirements of paragraph (b) of this section do not apply to any aircraft that was not originally certificated with an electrical system, or that has not subsequently been certified with such a system installed, including balloons and gliders. These aircraft may conduct operations without ADS–B Out in the airspace specified in paragraphs (d)(2) and (d)(4) of this section. Operations authorized by this section must be conducted—

(1) Outside any Class B or Class C airspace area; and

(2) Below the altitude of the ceiling of a Class B or Class C airspace area designated for an airport, or 10,000 feet MSL, whichever is lower.

(f) Each person operating an aircraft equipped with ADS–B Out must operate this equipment in the transmit mode at all times.

(g) Requests for ATC authorized deviations from the requirements of this section must be made to the ATC facility having jurisdiction over the concerned airspace within the time periods specified as follows:

(1) For operation of an aircraft with an inoperative ADS–B Out, to the airport of ultimate destination, including any intermediate stops, or to proceed to a place where suitable repairs can be made or both, the request may be made at any time.

(2) For operation of an aircraft that is not equipped with ADS–B Out, the request must be made at least 1 hour before the proposed operation.

(h) The standards required in this section are incorporated by reference with the approval of the Director of the Office of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. All approved materials are available for inspection at the FAA's Office of Rulemaking (ARM–1), 800 Independence Avenue, SW., Washington, DC 20590 (telephone 202–267–9677), or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.* This material is also available from the sources indicated in paragraphs (h)(1) and (h)(2) of this section.

(1) Copies of Technical Standard Order (TSO)–C166b, Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS–B) and Traffic Information Service-Broadcast (TIS–B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz) (December 2, 2009) and TSO–C154c, Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS–B) Equipment Operating on the Frequency of 978 MHz (December 2, 2009) may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, DOT Warehouse M30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785; telephone (301) 322–5377. Copies of TSO –C166B and TSO–C154c are also available on the FAA's Web site, at *http://www.faa.gov/aircraft/air_cert/design_approvals/tso/.* Select the link "Search Technical Standard Orders."

(2) Copies of Section 2, Equipment Performance Requirements and Test Procedures, of RTCA DO–260B, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS–B) and Traffic Information Services-Broadcast (TIS–B), December 2, 2009 (referenced in TSO–C166b) and Section 2, Equipment Performance Requirements and Test Procedures, of RTCA DO–282B, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS–B), December 2, 2009 (referenced in TSO C–154c) may be obtained from RTCA, Inc., 1828 L Street, NW., Suite 805, Washington, DC 20036–5133, telephone 202–833–9339. Copies of RTCA DO–260B and RTCA DO–282B are also available on RTCA Inc.'s Web site, at *http://www.rtca.org/onlinecart/allproducts.cfm.*

■ 8. Add § 91.227 to read as follows:

§ 91.227 Automatic Dependent Surveillance-Broadcast (ADS–B) Out equipment performance requirements.

(a) *Definitions.* For the purposes of this section:

ADS–B Out is a function of an aircraft's onboard avionics that periodically broadcasts the aircraft's state vector (3-dimensional position and 3-dimensional velocity) and other required information as described in this section.

Navigation Accuracy Category for Position (*NAC_P*) specifies the accuracy of a reported aircraft's position, as defined in TSO–C166b and TSO–C154c.

Navigation Accuracy Category for Velocity (*NAC_V*) specifies the accuracy of a reported aircraft's velocity, as defined in TSO–C166b and TSO–C154c.

Navigation Integrity Category (NIC) specifies an integrity containment radius around an aircraft's reported position, as defined in TSO–C166b and TSO–C154c.

Position Source refers to the equipment installed onboard an aircraft used to process and provide aircraft position (for example, latitude, longitude, and velocity) information.

Source Integrity Level (SIL) indicates the probability of the reported horizontal position exceeding the containment radius defined by the NIC on a per sample or per hour basis, as defined in TSO–C166b and TSO–C154c.

System Design Assurance (SDA) indicates the probability of an aircraft malfunction causing false or misleading information to be transmitted, as defined in TSO–C166b and TSO–C154c.

Total latency is the total time between when the position is measured and when the position is transmitted by the aircraft.

Uncompensated latency is the time for which the aircraft does not compensate for latency.

(b) *1090 MHz ES and UAT Broadcast Links and Power Requirements*—

(1) Aircraft operating in Class A airspace must have equipment installed that meets the antenna and power output requirements of Class A1, A1S, A2, A3, B1S, or B1 equipment as defined in TSO–C166b, Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS–B) and Traffic Information Service-Broadcast (TIS–B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz).

(2) Aircraft operating in airspace designated for ADS–B Out, but outside of Class A airspace, must have equipment installed that meets the antenna and output power requirements of either:

(i) Class A1, A1S, A2, A3, B1S, or B1 as defined in TSO–C166b; or

(ii) Class A1H, A1S, A2, A3, B1S, or B1 equipment as defined in TSO–C154c, Universal Access Transceiver (UAT) Automatic Dependent Surveillance–Broadcast (ADS–B) Equipment Operating on the Frequency of 978 MHz.

(c) *ADS–B Out Performance Requirements for NAC $_{P,}$ NAC_V, NIC, SDA, and SIL*—

(1) For aircraft broadcasting ADS–B Out as required under § 91.225 (a) and (b)—

(i) The aircraft's NAC_P must be less than 0.05 nautical miles;

(ii) The aircraft's NAC_V must be less than 10 meters per second;

(iii) The aircraft's NIC must be less than 0.2 nautical miles;

(iv) The aircraft's SDA must be 2; and

(v) The aircraft's SIL must be 3.

(2) Changes in NAC_P, NAC_V, SDA, and SIL must be broadcast within 10 seconds.

(3) Changes in NIC must be broadcast within 12 seconds.

(d) *Minimum Broadcast Message Element Set for ADS–B Out.* Each aircraft must broadcast the following information, as defined in TSO–C166b or TSO–C154c. The pilot must enter information for message elements listed in paragraphs (d)(7) through (d)(10) of this section during the appropriate phase of flight.

(1) The length and width of the aircraft;

(2) An indication of the aircraft's latitude and longitude;

(3) An indication of the aircraft's barometric pressure altitude;

(4) An indication of the aircraft's velocity;

(5) An indication if TCAS II or ACAS is installed and operating in a mode that can generate resolution advisory alerts;

(6) If an operable TCAS II or ACAS is installed, an indication if a resolution advisory is in effect;

(7) An indication of the Mode 3/A transponder code specified by ATC;

(8) An indication of the aircraft's call sign that is submitted on the flight plan, or the aircraft's registration number, except when the pilot has not filed a flight plan, has not requested ATC services, and is using a TSO–C154c self-assigned temporary 24-bit address;

(9) An indication if the flightcrew has identified an emergency, radio communication failure, or unlawful interference;

(10) An indication of the aircraft's "IDENT" to ATC;

(11) An indication of the aircraft assigned ICAO 24-bit address, except when the pilot has not filed a flight plan, has not requested ATC services, and is using a TSO–C154c self-assigned temporary 24-bit address;

(12) An indication of the aircraft's emitter category;

(13) An indication of whether an ADS–B In capability is installed;

(14) An indication of the aircraft's geometric altitude;

(15) An indication of the Navigation Accuracy Category for Position (NAC_P);

(16) An indication of the Navigation Accuracy Category for Velocity (NAC_V);

(17) An indication of the Navigation Integrity Category (NIC);

(18) An indication of the System Design Assurance (SDA); and

(19) An indication of the Source Integrity Level (SIL).

(e) *ADS–B Latency Requirements*—

(1) The aircraft must transmit its geometric position no later than 2.0 seconds from the time of measurement of the position to the time of transmission.

(2) Within the 2.0 total latency allocation, a maximum of 0.6 seconds can be uncompensated latency. The aircraft must compensate for any latency above 0.6 seconds up to the maximum 2.0 seconds total by extrapolating the geometric position to the time of message transmission.

(3) The aircraft must transmit its position and velocity at least once per second while airborne or while moving on the airport surface.

(4) The aircraft must transmit its position at least once every 5 seconds while stationary on the airport surface.

(f) *Equipment with an approved deviation.* Operators with equipment installed with an approved deviation under § 21.618 of this chapter also are in compliance with this section.

(g) *Incorporation by Reference.* The standards required in this section are incorporated by reference with the approval of the Director of the Office of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. All approved materials are available for inspection at the FAA's Office of Rulemaking (ARM–1), 800 Independence Avenue, SW., Washington, DC 20590 (telephone 202–267–9677), or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.* This material is also available from the sources indicated in paragraphs (g)(1) and (g)(2) of this section.

(1) Copies of Technical Standard Order (TSO)–C166b, Extended Squitter Automatic Dependent Surveillance–Broadcast (ADS–B) and Traffic Information Service–Broadcast (TIS–B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz) (December 2, 2009) and TSO–C154c, Universal Access Transceiver (UAT) Automatic Dependent Surveillance–Broadcast (ADS–B) Equipment Operating on the Frequency of 978 MHz (December 2, 2009) may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, DOT Warehouse M30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785; telephone (301) 322–5377. Copies of TSO –C166B and TSO–C154c are also available on the FAA's Web site, at *http://www.faa.gov/aircraft/air_cert/design_approvals/tso/.* Select the link "Search Technical Standard Orders."

(2) Copies of Section 2, Equipment Performance Requirements and Test Procedures, of RTCA DO–260B, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS–B) and Traffic Information Services-Broadcast (TIS–B), December 2, 2009 (referenced in TSO–C166b) and Section 2, Equipment Performance Requirements and Test Procedures, of RTCA DO–282B, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS–B), December 2, 2009 (referenced in TSO C–154c) may be obtained from RTCA, Inc., 1828 L Street, NW., Suite 805, Washington, DC 20036–5133, telephone 202–833–9339. Copies of RTCA DO–260B and RTCA DO–282B are also available on RTCA Inc.'s Web site, at *http://www.rtca.org/onlinecart/allproducts.cfm.*

9. Amend appendix D to part 91 by revising section 1 introductory text to read as follows:

APPENDIX D TO PART 91—AIRPORTS/LOCATIONS: SPECIAL OPERATING RESTRICTIONS

Section 1. Locations at which the requirements of § 91.215(b)(2) and § 91.225(d)(2) apply. The requirements of §§ 91.215(b)(2) and 91.225(d)(2) apply below 10,000 feet above the surface within a 30-nautical-mile radius of each location in the following list.

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Issued in Washington, DC, on May 21, 2010.

J. Randolph Babbitt,

Administrator.

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