FAA FACES SIGNIFICANT RISKS IN IMPLEMENTING THE AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST PROGRAM AND REALIZING BENEFITS

Federal Aviation Administration

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Memorandum

U.S. Department of Transportation
Office of the Secretary of Transportation
Office of Inspector General

Subject: ACTION: FAA Faces Significant Risks in Implementing the Automatic Dependent Surveillance – Broadcast Program and Realizing Benefits
Federal Aviation Administration
Report Number AV-2011-002

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From: Lou E. Dixon
Principal Assistant Inspector General for Auditing and Evaluation

Reply to Attn. of: JA-1

To: Federal Aviation Administrator

This report presents the results of our review of the Federal Aviation Administration's (FAA) Automatic Dependent Surveillance-Broadcast (ADS-B) program.[1] ADS-B is a satellite-based surveillance technology that also uses aircraft avionics and ground-based systems to provide information on aircraft location to pilots and air traffic controllers. ADS-B has the potential to fundamentally change the way air traffic is managed in the United States, and FAA expects that it will enhance capacity, improve safety, and play a critical role in the planned transition to the Next Generation Air Transportation System (NextGen).

At the request of the Chairmen of the House Committee on Transportation Infrastructure and Subcommittee on Aviation, we examined FAA's plans for implementing ADS-B. Specifically, our objectives were to (1) examine key risks to FAA's successful implementation of ADS-B and (2) assess the strengths and weaknesses of FAA's contracting approach. This report summarizes our assessment of FAA's progress to date and provides our recommendations for reducing risk in developing and deploying ADS-B technology and strengthening contract oversight. We conducted this audit in accordance with generally accepted government auditing standards prescribed by the Comptroller General of the United States. Exhibit A details our scope and methodology.

[1] ADS-B is "automatic" because no external interrogation is required and is "dependent" because it relies on equipment on board aircraft to transmit flight information to controllers and pilots.

RESULTS IN BRIEF

FAA is making progress in implementing ADS-B at limited locations and working with airspace users to refine the use of the new technology. However, FAA's plans to deploy ADS-B throughout the National Airspace System (NAS) and realize expected benefits face significant risks and challenges.

The greatest risks to successfully implementing ADS-B are airspace users' reluctance to purchase and install new avionics for their aircraft and FAA's ability to define requirements for the more advanced capabilities. Users have raised justifiable concerns about evolving requirements and uncertain equipage costs and benefits. For example, based on FAA's analysis, the costs for users to equip with ADS-B avionics could range from $2.5 billion to $6.2 billion. Moreover, while FAA is planning to mandate equipage for "ADS-B Out" by 2020, it plans to initially provide ADS-B surveillance information that essentially replicates existing domestic radar coverage—resulting in few new benefits to airspace users. Most new capabilities and benefits, such as enhancing airspace capacity, rely on "ADS-B In" and the display of information in the cockpit.[2] However requirements and costs for ADS-B In may not be mature for at least 2 years. FAA also has yet to fully define requirements for modifying its existing automation systems that will display ADS-B information to controllers. Problems with integrating ADS-B on displays at the initial operating sites indicate this will be a significant challenge to nationwide deployment. Until FAA effectively addresses these uncertainties associated with equipage and requirements for ADS-B's advanced capabilities, progress with ADS-B will be limited, and the potential for cost increases, delays, and performance shortfalls will continue.

In addition to implementation issues that may delay deployment, risks within FAA's acquisition and contract approach for ADS-B could also increase the overall program cost. Specifically, while FAA's contract includes controls and analytical tools to measure progress with cost and schedule baselines, FAA did not conduct a comprehensive financial analysis before deciding that a service-based contract would save the Government more money than the traditional method of owning and operating the system. In fact, only months after it briefed Congress that this approach would save the Government $821 million, FAA revised its estimated cost savings to $628 million. FAA's data show that if the Agency had owned the system through the first phase of ADS-B (establishing ground infrastructure), the Government could have saved over $600 million in that phase alone. FAA officials acknowledge that the analysis used to justify the service-based approach and cost savings was flawed but asserted that over the long term,

[2] "ADS-B Out" allows aircraft to broadcast more accurate flight position data to controllers on the ground. "ADS-B In" will allow for display of key flight information in the cockpit, such as allowing pilots to "see" other aircraft.

the cost-benefit equation changes in favor of the contractor owning and operating the system. Yet, FAA has not updated its cost and benefit analysis to support the service-based approach. FAA will also pay the contractor over $1 billion for broadcast services—before airspace users are required to equip in 2020 and congested airports see significant delay reductions. The contractor will be paid regardless of whether important efforts, such as modifying controller displays, remain on track. Moreover, there are unresolved questions with the contract that could increase the cost of the ADS-B ground system. For example, the contract does not have specific estimates for providing ADS-B In services to aircraft that will rely on different broadcast frequencies. Unless FAA addresses these concerns, the larger risk of minimal return on Federal investment and indefinite delays in achieving NextGen goals remains. We are making recommendations to help FAA reduce risk with ADS-B implementation and enhance contract oversight.

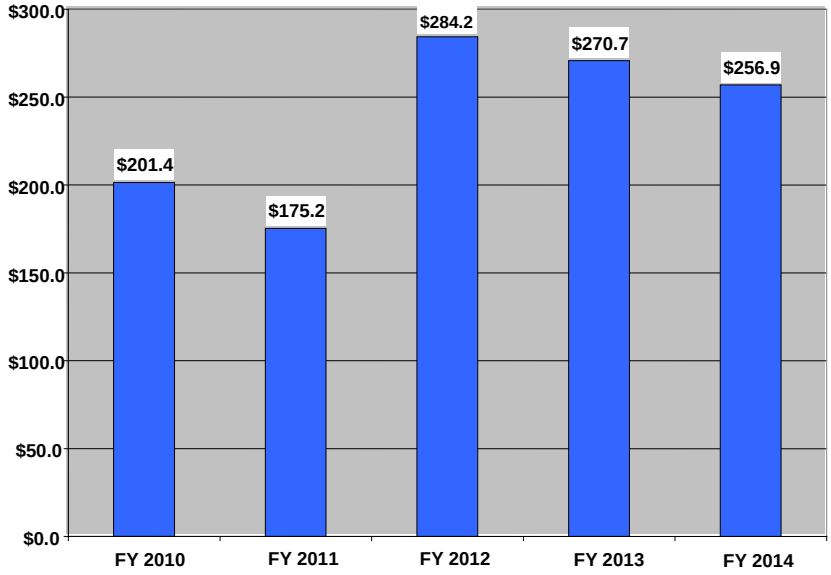
BACKGROUND

According to FAA, ADS-B will supplement and ultimately replace ground-based radar because an ADS-B-equipped aircraft can provide controllers and pilots in other aircraft with faster updates of important flight information (e.g., aircraft identification, position, altitude, direction, and speed). Specifically, ADS-B transmits position information once per second, whereas radar systems in the vicinity of airports generate reports once every 4 to 5 seconds. Also, unlike radar, the accuracy of ADS-B does not change based on the distance between the aircraft and the sensor. In 1998, FAA began examining ADS-B as an alternative to radar at several locations, including Alaska and the Ohio River Valley.

In 2007, FAA awarded a contract to ITT Corporation for $1.8 billion—if all options are exercised through 2025—to develop and deploy the ADS-B ground infrastructure and start broadcasting services. FAA plans to implement ADS-B in two segments. Segment 1 (establish ground infrastructure for five key sites) is contracted under a cost-plus incentive fee agreement in which FAA covers the cost for any additional requirements.[3] Segment 2 (equipment needed to fully deploy ADS-B nationwide) is contracted under a fixed-price arrangement in which ITT covers the cost of deploying enough radios to meet requirements. FAA approved nearly $1.7 billion in capital costs through 2014, to support ADS-B implementation. FAA is planning to spend just over $200 million in fiscal year (FY) 2010. The total life-cycle cost through 2035 of the ADS-B effort is uncertain but estimated to be about $4.0 billion—this includes $2.3 billion in capital costs not yet formally "baselined." The following figure illustrates FAA's spending plans for ADS-B for the next 5 years.

[3] Miami, Florida; Louisville, Kentucky; Philadelphia, Pennsylvania; the Gulf of Mexico; and Juneau, Alaska.

Figure. ADS-B Spending Plan FY 2010 to FY 2014
(Dollars in Millions)



Source: FAA's 2010 budget enacted and Capital Investment Plan 2010-2014

A key ADS-B priority is its air-to-air applications—this technology is a major step in the NextGen transition and a primary benefit expected by airspace users. In FY 2008 and FY 2009, Congress provided more funding than FAA requested to specifically advance these ADS-B capabilities. Congress has shown significant support for the ADS-B program overall since its inception in 2007, with $510 million provided during the first 3 years of the program.

In October 2007, FAA published a Notice of Proposed Rule Making (NPRM) for ADS-B outlining a mandate for airspace users to equip with new avionics for ADS-B "Out" by 2020. The NPRM was issued after review by FAA's industry/Government Aviation Rulemaking Committee (ARC). The ARC recommended key actions FAA must take to increase user equipage. These include approving ADS-B-based aircraft separation standards that meet current ones and expediently deploying ADS-B where reduced separation standards will offer users the most value. The proposed rule generated considerable debate among stakeholders who expressed concerns about undefined costs, benefits, and technical requirements. Based on public comments, FAA asked the ARC for additional recommendations. In 2008, the ARC made 36 recommendations, including studying frequency congestion concerns, adjusting ADS-B standards and requirements, and incentivizing airspace users to equip with new systems.[4]

The ARC cautioned that FAA should delay the proposed 2020 date for ADS-B equipage if ground station coverage, automation systems improvements, and

[4] Report from the ADS–B Aviation Rulemaking Committee to the FAA, September 26, 2008.

controller training slip beyond 2013. Based on industry comments, FAA adjusted its plans for ADS-B and issued the final rule in May 2010.

ADS-B IMPLEMENTATION FACES A WIDE RANGE OF RISKS THAT WILL IMPACT COSTS AND EXPECTED BENEFITS

FAA is in a difficult position with ADS-B because it is managing the parallel development and implementation of the air and ground components of a new satellite-based technology. Implementing ADS-B is a high-risk, complex undertaking that will require coordinated, billion-dollar investments from FAA and industry over the next decade. Our review identified the following five major risks that will have a direct bearing on the cost, schedule, and expected benefits of ADS-B: airspace users' reluctance to equip, changing requirements and controller/pilot procedures for ADS-B In technologies, frequency congestion affecting ADS-B broadcasts, delays in integrating ADS-B with air traffic management systems, and potential security vulnerabilities.

Airspace Users Are Reluctant To Equip with ADS-B Due to Undefined Costs and Benefits

Airspace users have raised legitimate questions about the costs to equip aircraft, evolving requirements for ADS-B In, and a lack of clearly defined benefits for enhancing capacity and reducing delays. FAA considers their concerns as a major risk to the successful implementation of ADS-B. Skepticism in the aviation community is largely due to prior experiences with other FAA programs, and users are concerned that ADS-B could become another situation where they equip with a new technology but FAA never follows through with the requisite ground infrastructure. For example, FAA cancelled a Microwave Landing System in the 1990s because of industry concerns and opposition. More recently, in 2003, FAA cancelled the Controller-Pilot Data Link Communications Program due to uncertain benefits, technical problems, and cost growth issues.[5] As a result, FAA faces difficult challenges in determining how to move forward with ADS-B and spur airspace users to purchase and install new avionics.

ADS-B equipage cost estimates for airspace users vary widely. FAA's equipage estimates reflect considerable uncertainty and require further refinement. FAA estimates that the aggregate cost for airspace users to equip with ADS-B avionics could range from $2.5 billion to $6.2 billion. In addition, these estimates generally exclude the cost associated with taking transport aircraft out of service to install new technology. As shown in table 1, estimated unit costs to equip aircraft also vary significantly.

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[5] OIG Report Number AV-2004-101, "Observations on FAA's Controller-Pilot Data Link Communications Program," September 30, 2004. OIG reports are available on our website: www.oig.dot.gov.

Table 1. Unit Cost Estimates for Equipping Aircraft with ADS-B

Airspace User	Technology	ADS-B Out		ADS-B In	
		Low	High	Low	High
Air Transport Aircraft	1090 MHz Extended Squitter	$32,000	$174,640	$162,250	$670,000
General Aviation	Universal Access Transceiver (UAT) 978 MHz	$7,644	$10,920	$10,444	$29,770

Source: OIG analysis of data from FAA's Surveillance and Broadcast Services

Several factors can affect the equipage cost estimates. These factors include aircraft age and type, the broadcast link airspace users decide to purchase, and the services users expect to obtain. One of the primary variables for ADS-B cost estimates is whether airspace users need other new avionics or upgrades to existing aircraft systems. For example, some users may be required to purchase:

- new or upgraded Global Positioning System (GPS) receivers or flight management system for aircraft. This will depend on the performance level of their current aircraft navigation systems.
- avionics for the Wide Area Augmentation System—a satellite-based navigational system—to augment the GPS signal according to FAA standards.
- new ADS-B avionics, in addition to those previously installed, to comply with updated standards in FAA's recently issued ADS-B rule. While all new aircraft being produced by Airbus and Boeing will be able to broadcast ADS-B without modification, other large, commercial aircraft equipped with the 1090 ES[6] alternative may not be compliant with the proposed rule.

Evolving requirements for "ADS-B In" make it difficult for FAA to develop cost estimates for users to equip with this technology—which will add new cockpit displays capable of displaying traffic information. FAA expects that once airspace users have invested in ADS-B Out as mandated, they will then voluntarily equip to realize the additional capabilities of ADS-B In (see table 2 below). However, ADS-B In is still in its early stages, and requirements for the full range of its applications envisioned in planning documents continue to change. FAA has established groups to develop a strategy for ADS-B In, including an ARC and a Steering Committee, but without mature requirements, reliable cost estimates, and defined benefits to offset those costs airlines are unlikely to expend resources to further modify aircraft. Further, because FAA adopted less stringent performance standards with the recently published rule in May 2010, airspace users may have to equip multiple times to take full advantage of ADS-B In capabilities.

[6] Air Transport Aircraft transponders operate using 1090 MHz Extended Squitter (1090 ES).

Table 2. Anticipated Benefits of ADS-B

ADS-B "Out" *Allows aircraft to broadcast position and other flight data to ground systems for en route, terminal, and surface operations*
• Enables more accurate data on aircraft position than current radar • Provides surveillance coverage where radar coverage is limited or non-existent • Yields cost savings from decommissioning secondary surveillance radar
ADS-B "In" *Requires new cockpit displays; allows aircraft to receive and display air traffic information in the cockpit*
• Provides the above benefits, plus others, such as enhancing capacity at congested airports under all weather conditions • Enables air to air applications that could change current air traffic control concepts

Source: OIG analysis of RTCA staff paper and FAA's benefits analysis

FAA faces challenges in quantifying and delivering ADS-B benefits for airspace users. The question of benefits—and what it will take to obtain them—will drive the transition to ADS-B. In the near term, ADS-B will not provide capacity benefits or relief from delays at many of the Nation's most congested airports. This is because the first stage of ADS-B implementation will be limited to specific geographic locations, including select airports on the East Coast, such as Philadelphia and Miami, and airports where existing radar coverage is limited, such as Alaska and the Gulf of Mexico.

Thus far, ADS-B has been beneficial in areas with limited radar coverage; for example, it has proven valuable in search and rescue missions. FAA and the industry expect to see tangible benefits from ADS-B in the Gulf of Mexico from reduced separation between aircraft (from 50 to 5 nautical miles). However, FAA still faces the challenges of quantifying and delivering the benefits from ADS-B in the continental United States where radar coverage exists and determining how to use new procedures to enhance capacity and reduce delays in congested airspace.

In the near term, however, FAA expects ADS-B Out to provide "radar-like" separation services. Coupled with new automation, this could allow for more efficient merging and spacing of air traffic within *existing* separation standards and improve detection of conflicts between aircraft. However, FAA has yet to fully quantify related benefits—such as enhanced controller productivity and more efficient management of the airport surface—and validate that ADS-B will meet or exceed the current level of separation services. To achieve these goals, FAA must effectively develop, certify, and implement the new procedures needed to separate aircraft at high capacity locations through the NAS based on ADS-B information. These procedures include significant changes to existing automation systems, such as new tools for controllers. In the longer term, industry officials

point out that ADS-B will be key to enhancing capacity but must be integrated with other NextGen initiatives (e.g., 4D trajectory management and data link communications for controllers and pilots).[7]

Due to industry concerns about whether ADS-B can provide equivalent separation services, FAA sponsored research and modeling that examined the use of radar and ADS-B targets for separating air traffic.[8] The studies show that ADS-B should be able to provide surveillance that is at least as good as radar if not better. However, automation systems will need to compensate for differences in ADS-B and radar with respect to update and error rates that will in turn provide controllers with reliable information. Table 3 identifies the existing criteria for separating aircraft that ADS-B must meet. The most stringent criteria focus on 4,300-foot spacing on parallel, independent approaches.

Table 3. ADS-B Required To Meet Existing Separation Criteria

Existing Aircraft Separation Criteria	**Separation Range** (in nautical miles)
En Route Environment	5.0
Terminal Environment	3.0
Approach	2.5
Staggered, Dependent Approach	1.5
Parallel, Independent Approaches	4,300 feet

Source: FAA's Surveillance and Broadcast Services Briefing: Report on Modeling Results for Separation Standards with ADS-B

FAA is testing ADS-B's ability to manage and separate traffic at the key sites. However, a critical question remains open—whether ADS-B could allow a reduction in existing separation standards. FAA is examining whether separation standards at high altitude could be safely reduced from 5 to 3 miles, which could lead to significant benefits for airspace users.

FAA faces important policy questions regarding incentives to spur ADS-B equipage. Given ADS-B's wide-ranging cost estimates and undefined benefits, many within the aviation community (i.e., airspace users and avionics manufacturers) and FAA believe that incentives will be required to help spur aircraft equipage. As stakeholders point out, there is a precedent for helping airspace users equip specifically with ADS-B avionics. FAA purchased ADS-B avionics for operators in Alaska as part of the Capstone initiative. This provided

[7] 4D trajectory management is an automation system that will rely on advanced software to assign and monitor flights.

[8] Report on Modeling Results for Separation Standards with ADS-B, August 29, 2007. This research was performed by the Massachusetts Institute of Technology/Lincoln Labs, the Johns Hopkins University/Applied Physics Laboratory, and the Mitre Corporation.

FAA with a base of properly equipped aircraft and allowed the Agency to examine the costs and benefits of the new technology.

Our work shows that incentives for ADS-B deployment could take a number of forms. These include purchasing equipment for operators, an investment tax credit, an adjustment to current excise taxes for ADS-B-equipped aircraft, or research and development tax credits specifically for avionics manufacturers. In 2008, the ARC's report called for FAA to establish agreements with operators, subsidize the purchase and installation of new avionics, and accelerate ADS-B deployment at designated locations. FAA has since established several agreements with airlines and avionics manufacturers and purchased equipment for some airspace users.

FAA has never managed such a large effort to equip commercial aircraft. Therefore, the aviation community will need a clear understanding of what the incentives would be used for as well as their strengths and weakness, timing, and potential impacts. Cost sharing mechanisms have merit because they help share risks between the Government and airspace users. If FAA does use equipage incentives, it must properly design them to achieve objectives at minimal cost to taxpayers.

Requirements for ADS-B In and Cockpit Displays Continue To Evolve and Will Influence Pilot and Controller Roles

Most new capabilities and benefits in FAA's plans to enhance capacity through NextGen rely on "ADS-B In" and the display of information in the cockpit. According to airspace users, without ADS-B In's cockpit capabilities and related air-to-air applications, ADS-B will provide insufficient benefits. However, FAA has not yet certified the type of cockpit display (in the pilot's forward field of view) needed to achieve ADS-B In capabilities due to safety concerns.

Once FAA certifies the cockpit display, airlines must either install new ones or modify their existing displays. However, since FAA has yet to clearly define ADS-B In requirements or estimated costs and benefits, it will be difficult to get users to equip. An aviation industry expert from Boeing pointed out that the effectiveness of cockpit displays depends on large numbers of aircraft being equipped; otherwise the display might be hazardous as it would give pilots a sense of confidence that should not be expected. Table 4 below illustrates how ADS-B and cockpit displays can enhance situational awareness and help fundamentally change how air traffic is managed when the display is in the pilot's forward field of view.

Table 4. Anticipated Capabilities of ADS-B In

Situational Awareness
Enhances the flight crew's knowledge of traffic both in the air and on the ground, thus improving their decision process for the safe and efficient management of flight. No changes in separation tasks or responsibility are required.
Spacing
Flight crews are responsible for spacing with designated aircraft in response to Air Traffic Control instruction. The separation minima are unchanged, and separation responsibility remains with controller.
Delegated Separation
The controller delegates separation responsibility to the flight crew for specific aircraft during certain operations.
Self Separation
The flight crew is responsible for separation to a given minima from all other traffic for the duration of any particular phase of flight.

Source: FAA's Surveillance and Broadcast Services Program Office, December 2007

We found that FAA faces considerable work to establish requirements and standards for ADS-B In. In its September 2008 report, the ARC recommended that FAA, in partnership with industry, define a strategy for ADS-B In by 2012. According to ADS-B program officials, they will define ADS-B In requirements and benefits through multiple workgroups and a new ARC, which is slated to begin work this summer. FAA also states that it has established a workgroup to conduct research and analysis on high-value advanced ADS-B In applications. According to FAA, the criteria for some of the more demanding ADS-B In applications should be completed by 2012. However, FAA's decision to adopt less stringent performance requirements in the recently published final rule for ADS-B may further slow progress to transition to ADS-B In capabilities.

Given that most benefits users anticipate rely on ADS-B In, FAA must obtain some consensus with industry on the specific applications it plans to consider. FAA has—and continues—to work with airspace users to refine ADS-B In applications and requirements. For example, the United Parcel Service (UPS) has been instrumental in pioneering ADS-B and the first generation of cockpit display applications for enhanced "see and avoid" capabilities. FAA is also providing $6 million to assist US Airways and an avionics manufacturer to equip up to 20 Airbus aircraft, with the goal of assessing the economic and operational value of ADS-B at Philadelphia's airport and on some transatlantic flights.

Finally, the full potential of ADS-B In will require consideration of human factors, such as new procedures for pilots and controllers. As FAA officials point out, the Agency must conduct rigorous safety assessments to ensure changes do not impact

safety or introduce new hazards. Therefore, FAA needs to prioritize efforts, examine sequencing of capabilities, and resolve the display requirements, including human factors considerations for both pilots and controllers.

Frequency Congestion Concerns for the Broadcast of ADS-B for Transport Aircraft Could Limit Its Air-to-Air Benefits

The frequency planned for ADS-B broadcasts to large commercial carriers could become overcrowded when FAA adds ADS-B signal traffic. Currently, FAA and airspace users rely on the same frequency for other important systems, such as ground-based secondary radar, runway incursion systems, and aircraft collision avoidance systems. There is concern that the broadcast of ADS-B could cause signal interference problems with these systems. This is one reason that FAA decided to rely on two separate frequencies[9] for ADS-B and the contractor decided to increase the number of ground radio stations from 500 to 794.

Frequency congestion could particularly impact ADS-B usage in high-density airspace, such as the Northeast Corridor (e.g., Washington, DC, and New York). As FAA expands ADS-B implementation between 2020 and 2035, problems with signal interference could increase and occur around more major airports across the country, such as Chicago, Los Angles, Dallas Forth Worth, and Atlanta. Unless FAA mitigates this problem, the number and type of air-to-air applications for ADS-B In will be limited due to the reduced range—or distance—of the ADS-B In signal. Table 5 illustrates the expected requirements for some of the planned uses of the ADS-B In signal.

[9] FAA will implement ADS-B via two separate broadcast links that will operate at one of two frequencies—1090 megahertz (MHz) for air carrier and commuter fleets and 978 MHz for air taxi and general aviation fleets. The 978 MHz band has more available bandwidth and can therefore provide graphic weather information and other data—a service needed by non-commercial fleets that do not communicate with airline dispatchers.

Table 5. Minimum Aviation System Performance Standards for ADS-B In

Minimum Performance Standards	Range (in nautical miles)
• Enhanced Visual Acquisition • Conflict Detection	10
• Station Keeping • Airborne Conflict Management	20
• Merging • Conflict Management • In-Trail Climb	40
• Long Range Conflict Management	90 (desired - 120)

Source: Report from the ADS-B Aviation Rulemaking Committee to the Federal Aviation Administration, September 26, 2008.

The frequency congestion problem is complex, but a number of techniques, such as multi-sector aircraft antennae and additional ADS-B ground stations could help ensure adequate air-to-ground and air-to-air reception. However, solutions to address frequency congestion may require changes to the ADS-B baseline or equipment on aircraft, which would increase the program cost. Currently, FAA does not plan to make changes until 2020 when airspace users are required to purchase and install ADS-B equipment. The ARC recommended that FAA study the issue of congestion and consider the mitigation efforts needed to ensure a 45-nautical mile range for ADS-B In applications. In response, FAA is examining potential solutions and exploring the specific changes needed for ADS-B air and ground components and existing systems (including airborne traffic collision and avoidance systems).[10]

Integrating ADS-B with FAA's Existing Automation Systems for Controllers Could Delay Its Implementation

Before FAA can implement ADS-B nationwide, it will need to modify the automation systems controllers use to separate aircraft. Currently, most of these systems—in both the terminal and en route environments—do not process and display ADS-B information. FAA will also need to adjust the format of flight plans to properly identify ADS-B-equipped aircraft. Without these changes, users will be unable to operate ADS-B air traffic surveillance applications. FAA has elevated this issue to high risk, and the ADS-B program office is providing $150 million in Segment 1 to other FAA lines of business to modify their respective automation systems.

FAA is testing ADS-B information on controller displays at key sites but has experienced a number of problems and limitations. For example, FAA has

[10] According to FAA documents, realizing the air-to-air performance of ADS-B in the long term may depend on a replacement of ground radars or other technology (i.e. passive multilateration) and modifying the Traffic Collision and Avoidance System to exploit ADS-B signals.

experienced problems with integrating ADS-B on controller displays at Louisville, Kentucky. Controllers report that ADS-B targets (i.e., the location of aircraft on their display screens) split or drift, causing false alerts; therefore, controllers often opt to limit their ADS-B usage. However, as noted in FAA test reports, assessments at this point do not fully reflect the ADS-B end-state because there is a limited number of properly equipped aircraft and no approved standards for ADS-B In operations.

An important step to mitigate problems with ADS-B is implementing "fusion." Fusion in this context is defined as taking all surveillance data available for an aircraft and using the best data or combination of data to determine aircraft position and intent. FAA is working to refine fusion capability on the Louisville Common Automated Radar Terminal System. Table 6 shows the progress and challenges with implementing ADS-B with existing FAA automation systems—all of which will impact ADS-B deployment.

Table 6. Key Automation Platforms Requiring Modifications for ADS-B

Standard Terminal Automation Replacement System (STARS) *Manufactured by Raytheon and used at 51 medium sites to manage traffic in the vicinity of airports*
• FAA modified STARS to display ADS-B information at the Philadelphia TRACON. • STARS processors, displays, and network equipment face end-of-life issues. • STARS processors at 47 of 52 sites will be unable to support ADS-B beyond 2013 when large numbers of airspace users are expected to equip with the new technology.
Common Automated Radar Terminal System (CARTS) *Manufactured by Lockheed Martin and used at 11 large and 99 small sites to manage traffic in the vicinity of airports*
• FAA modified CARTS at Louisville, Kentucky, to accept and display ADS-B information. • FAA tested CARTS with UPS ADS-B-equipped aircraft and achieved initial operating capability in November 2009. • Additional CARTS work is required for the large sites such as New York and Chicago. • CARTS processors at 7 of the 11 large sites have limited ability to accept major improvements, including ADS-B. • The 99 small sites, as presently configured, cannot support any major improvements.
En Route Automation Modernization (ERAM) *Developed by Lockheed Martin; will be used to manage high-altitude traffic at 20 planned sites*
• ERAM has experienced problems during testing at its first site (Salt Lake City), the severity of which is unknown. • FAA is delaying initial ADS-B functionality to later ERAM software releases that have not been baselined. ADS-B will initially be incorporated into ERAM Release 1 in a virtual radar format; later releases will accept ADS-B format for full functionality. • FAA has not determined the allocation of ADS-B requirements among future ERAM software releases.

Source: OIG analysis of ADS-B automation program documentation

Potential Security Vulnerabilities in Using ADS-B To Manage Air Traffic Will Require Periodic Reassessment

ADS-B implementation has important security implications for the National Airspace System and the transition to NextGen. The Department of Defense (DOD)—a key stakeholder in FAA's NextGen development efforts—raised concerns that because ADS-B technology makes it possible to receive information about aircraft without a ground station, a lack of needed precautions could make the position of aircraft available to virtually anyone.

The September 2008 ARC report highlights other potential vulnerabilities with ADS-B that malicious cyber attacks may attempt to exploit. Examples include interfering with ADS-B transmissions, jamming ADS-B broadcasts, and introducing false targets into the system. Failure to address these concerns early in the ADS-B program could result in cost increases and schedule delays.

While the ADS-B signal is vulnerable like other satellite transmissions, mitigations or countermeasures are possible. In commenting on FAA's proposed ADS-B rule, stakeholders, including DOD, stressed the need to develop some level of encryption of ADS-B signals to prevent adversaries from using the system to disrupt air traffic. DOD has asked FAA for a thorough security assessment involving DOD and the Department of Homeland Security to determine ADS-B risks and appropriate countermeasures.

FAA is working with the National Security Agency and the Director of National Intelligence to get a better understanding of ADS-B vulnerabilities and has completed a classified report. According to FAA, the report concluded that while the ADS-B transmission gives more accurate data on aircraft position than previous technology, many other factors are involved in coordinating and executing an attack on an aircraft, which severely limits the likelihood of success. Nevertheless, FAA must maintain focus on this issue to adequately address any threats and vulnerabilities. Given the substantial support ADS-B receives from Federal investments, FAA should also inform Congress of the results of vulnerability assessments and identify the countermeasures necessary to address known vulnerabilities. In December 2009, we began a review of information technology security and controls over the ADS-B system and will continue to monitor these issues.[11]

[11] OIG Audit Announcement, "Audit Initiated of Security and Controls of the Automatic Dependent Surveillance–Broadcast System," December 8, 2009.

FAA'S ACQUISITION STRATEGY HAS NOT BEEN UPDATED, AND CONSIDERABLE UNKNOWNS COULD IMPACT THE COST OF THE ADS-B CONTRACT

FAA chose to rely on a service-based contract approach to implement ADS-B. Despite subsequent data showing that FAA could have saved significantly with a traditional acquisitions approach for at least the first phase of the program, FAA still has not conducted an updated cost analysis to ensure it is pursuing the most cost effective way to introduce a new surveillance technology. FAA must update ADS-B cost and benefit information given the complexity and unresolved implementation issues of the contract, which could cost the U.S. Government almost $2 billion if all options are exercised. Moreover, it is difficult for decision makers to track current and potential costs due to the contract's structure, which "bundles" costs for various ADS-B services. FAA will be challenged to address these issues without the right skill mix among staff responsible for developing and managing ADS-B; however, FAA has not yet assessed staffing gaps or actions needed to ensure the Agency can effectively oversee the contractor once it begins operating the ADS-B ground system.

FAA Has Not Updated the Cost and Benefit Analysis of Its Contract Approach for Developing the ADS-B Ground System

FAA is relying on a service-based contract, which means it will not own the ADS-B ground infrastructure. FAA will own the data transmitted between aircraft and the ground but not the hardware, software, or ground stations. In a more traditional acquisition, FAA would specify the functional design and hardware deliverables and would ultimately own the equipment.

FAA decided on this contract approach without a comprehensive analysis of the costs involved. In May 2007, FAA provided Congress with data that showed a service-based approach for ADS-B would cost about $821 million less than a traditional acquisition approach. Yet, several months later, FAA increased its cost estimates to reflect the need for additional ADS-B ground stations, which reduced its cost savings estimate to about $628 million. Table 7 shows the differences between the service-based approach and more traditional FAA acquisition in cost estimates FAA provided to the FAA's Joint Resources Council (JRC).

Table 7. Adjusted Cost Differential from FAA Ownership and Service Approach ($ in Millions)

Program Office Estimates as of :	Traditional Government-Owned Approach	Service Provider Approach	Expected Cost Savings
May 2007	$ 3,745.60	$ 2,923.90	$ 821.70
August 2007*	$ 5,022.77	$ 4,394.48	$ 628.29
Difference	$ 1,277.17	$ 1,470.58	$ -193.41

Source: FAA's Surveillance and Broadcast Service Program Office JRC Cost Estimates, August 2007 and FAA analysis, "Service Provider vs. Government owned"

ADS-B officials state there is no need to do a complete analysis to fully update the latest Government estimate to account for changes (including the change in ground stations) in order to have an "apples to apples" comparison. This is despite FAA data showing that it may have been more cost beneficial for the Government to own the system until completion of Segment 1. For example, according to FAA's data, the Government could have saved approximately $600 million in Segment 1 alone ($1.77 billion for Government-owned cost versus $2.37 billion via service provider owned and operated). FAA points out that over the long term, the cost-benefit equation changes in favor of ITT owning and operating the system. According to ADS-B program officials, the independent Government estimates used to support the costs were flawed because the Agency incorrectly allocated more radios than required under Segment 2 of the program. This further demonstrates why FAA should have updated the analysis.

FAA decision makers need a full understanding of the cost parameters of FAA's approach for implementing ADS-B given the key role it is expected to play in NextGen and the evolving requirements for ADS-B In. Therefore, FAA should update its analysis and validate that its preferred approach remains cost beneficial before committing to an additional $2.7 billion by 2012 to proceed with the nationwide implementation of ADS-B air and ground capabilities.

The ADS-B Contract Is a Complex Financial Agreement That Will Require Rigorous Oversight To Protect Government Interests

FAA is using a hybrid contract that includes elements such as a cost-plus incentive fee arrangement for the development of the ground system, firm fixed-price subscription charges for the broadcast of ADS-B services, and time and materials arrangements for engineering work. Each type of contract mechanism has unique risks and management challenges.

Segment 1, or the first 3 years of the contract, is predominately a cost-plus incentive fee agreement that places the majority of risk with the Government

because FAA must pay the cost for any cost overruns associated with additional work to meet existing requirements. Under this arrangement, FAA reimburses the contractor for all costs incurred for work performed up to a cost target; this encourages the contractor to accomplish work specifications at target costs. This first segment focuses largely on developing and installing the ground infrastructure for five key sites. FAA has a number of controls in place on the contract to incentivize or penalize the contractor for cost overruns for the first segment. The bulk of the remaining contract relies on fixed-price subscription charges. Under the fixed-price contract, the contractor is obligated to perform the stated effort within the fixed price of the contract and assumes the risks of any cost increases. Table 8 below describes the elements of the ADS-B contract.

Table 8. Elements of the ADS-B Contract

Contract Line Item Number (CLIN)	**Supplies /Services**	**Contract Type**	**Costs**
CLIN 0001	Development and Installation	Cost Plus Incentive Fee	$ 207,576,480
CLIN 0002	Equipment Usage Charges	Firm Fixed Price	30,952,941
CLIN 0018 (3 years)	Engineering Services	Time and Material	4,500,000
Subtotal			**$ 243,029,421**
Options (FY 2009-FY 2025)			
CLIN 0003 thru 0014	Subscription Charges (Essential & Critical Service)	Firm Fixed Price	$ 1,398,508,646
CLIN 0015 thru 0017	Program Management	Firm Fixed Price	84,823,266
CLIN 0018	Engineering Services	Time and Material	30,004,404
CLIN 0019 thru 0034	Subscription Charges (Including Weather Services)	Firm Fixed Price	108,625,534
Subtotal			**$1,621,961,849**
Grand Total			**$1,864,991,270**

Source: OIG analysis of FAA's ADS-B contract

FAA will pay the contractor on average over $90 million annually for broadcast services before airspace users are required to equip by 2020. The contractor will be paid regardless of whether important efforts remain on track, including modifications to various controller displays and automation equipment, finalizing requirements for ADS-B In, procedure development, and controller training programs. Under the current plan, FAA will have spent almost $2 billion on the ground infrastructure, but neither the traveling public nor airspace users will realize significant benefits in terms of delay reduction at already congested airports until 2020.

The ADS-B contract also allows ITT to sell "value-added services to airspace users." The contractor must seek approval from FAA before releasing the surveillance data, and the Agency is expected to provide criteria for filtering the

data. These services could include enhanced weather products for specific regions (like the Gulf of Mexico) and sales of traffic information. FAA officials commented that airports may be interested in purchasing information on aircraft position and location for a better understanding of facility utilization and better surface management.

FAA believes that the sale of value-added services will help reduce the overall costs with ADS-B and therefore made it an essential element of the business model for the contractor. The contract states that the Government and the contractor will share revenue from the sale of these services. Several industry representatives have stated that ITT and FAA's value-added services need greater clarity and raised concerns that these services appear to be a "back-door method" to augment FAA's budget.

At this juncture, however, it is difficult to predict the demand for services and what stakeholders will value over the life of the ADS-B contract. Further, there may be other entities that can share or provide information on the location of aircraft on the surface at high-activity airports or weather to pilots. For example, FAA is currently testing enhanced information sharing with an existing ground-based system for surface surveillance at New York's John F. Kennedy airport.[12] FAA should assess ongoing and planned efforts to share more information as part of NextGen and determine whether the assumptions and profitability of value-added services specifically for ADS-B remain valid. If value-added services do not materialize, the underlying business case for the ADS-B contractor may not be achievable and cause problems for FAA in managing the implementation of a key NextGen technology. FAA indicated that its Chief Operating Officer is chairing meetings on information sharing as part of NextGen and the role of the ADS-B contractor regarding value-added services.

Unresolved Questions Exist That Could Materially Affect the Government's Liability and Overall Cost for Implementing the ADS-B Ground System

According to FAA, the Agency has minimized contract risks because most of the contract is fixed price (including the capital and operating costs), which places the majority of risk with the contractor. This assumes, however, that requirements are firm and achievable and that there is a clear end state to ADS-B. We identified several unknowns within the contract that could materially affect the cost of the ADS-B effort and the Government's liability.

[12] A key element of this effort is Airport Surface Detection Equipment-Model X (ASDE-X), planned for deployment at 35 airports, including JFK. This system displays aircraft and vehicle positions and identification to aid air traffic controllers in preventing ground collisions on the airport surface and reducing runway incursions.

The contract does not require critical services throughout the NAS. The ADS-B contract does not include cost estimates to support critical services for all sites throughout the life of the contract.[13] The ADS-B contract states that the contractor shall provide both critical and essential services at an estimated cost of $1.4 billion at defined sites as specified by the Government. The contract includes about $1.3 billion in subscription charges for essential services but only $62 million for critical services, which have far more demanding performance requirements.

The contract includes charges supporting a total of 323 service volumes, or about 239 sites that will provide ADS-B services.[14] These totals are different because multiple service volume types (i.e., en route, terminal, and/or surface operations) can support one site. However, we found the contract does not require that critical services be provided at all sites or include life cycle costs at numerous sites (such as Washington, Boston, and Chicago) that will have critical services. For example, for 24 of the 25 sites, the contract only includes ADS-B critical service charges supporting the en route operations for 1 year but did not state any price for the remaining years through 2025. In addition, the contract only includes costs for 35 airports to obtain critical services supporting surface operations, and 10 of those 35 have costs for only 1 year. As a result, FAA has not specified to decision makers how the contractor will provide critical ADS-B services supporting the en route and airport surface domains throughout the National Airspace System over the life of the contract.

Development risks with broadcasting ADS-B on two distinct links could increase costs. The contract does not provide cost estimates specifically for the development of a critical service called Automatic Dependent Surveillance-Rebroadcast (ADS-R). Because FAA will rely on two links, it must rebroadcast the ADS-B information to all aircraft to get the benefits from ADS-B In. It is important to ensure that different aircraft (equipped with different broadcast links) can "see" each other. The timely delivery of ADS-R signals will be necessary to enable advanced applications such as runway safety information. There is potential for cost growth as FAA officials told us that they expect some changes to requirements. One FAA official stated that it may be cost prohibitive to implement ADS-R nationwide.

In addition to uncertain costs, ADS-R presents added risks of faults, failures, and delays in the ground hardware and software required to merge and rebroadcast information on two links. Various representatives from airline associations expressed concern that ADS-R may not be technically feasible and that it may lack

[13] Essential services will be used by pilots as advisory information, whereas critical services will be used to separate and manage aircraft.

[14] In addition to the 239 sites, there are 25 more sites where ADS-B weather services will be provided.

sufficient growth capacity to support future applications, including collision avoidance. For example, information based on ADS-R could lack the precision necessary for some important applications, such as merging and spacing and ultimately allowing pilots to "self-separate." In addition, the system could present false targets to pilots during critical phases of flight.

FAA, however, believes that it can mitigate these risks and that they will not result in performance issues for targeted ADS-B In applications. Nevertheless, the development of ADS-R remains a key risk to full ADS-B implementation, and its true costs remain unknown.

The number of ADS-B ground radio stations could grow and increase contract costs. The number of ADS-B ground radio stations and their installation costs are key cost drivers for the ADS-B program. Due to changing requirements between air and ground elements, the need for additional ground stations is uncertain and could increase FAA's contract costs and therefore the Government's liability. For example, FAA's own analysis increased the estimated system deployment costs by over $1 billion regardless of public or private ownership of the ground system.

FAA states that the contractor will deliver more than 300 ground systems as part of Segment 1 of the contract under the cost plus agreement. However, FAA proposed that aircraft be equipped with both a top and bottom antenna to support ADS-B Out and future ADS-B In applications. Many stakeholders oppose these requirements due to the increased costs. As FAA points out, there are legitimate reasons for more than one antenna to achieve sufficient update rates for controllers. Nevertheless, the ARC urged FAA to consider allowing aircraft with a single antenna to fly through high-density airspace and recommended that FAA explore how the drawbacks of single antenna could be offset by adding additional ground stations. In the final rule for ADS-B, FAA decided to rely on a single bottom-mounted antenna, which could translate into more ground stations.

Currently, FAA estimates it will need almost 800 ground radio stations to provide service to 323 segments of airspace, or "service volumes." For example, each major airport constitutes a specific service volume. FAA estimates that 60 service volumes will be required to provide surveillance for the Nation's 20 facilities that manage high-altitude traffic. As FAA points out, the number of radio stations is subject to change as the Agency conducts more detailed site surveys. Until FAA completes all site surveys, the total number of radio stations FAA is responsible for under the first segment remains uncertain.

FAA will procure the remaining 454 radio stations needed to complete ADS-B deployment nationwide under Segment 2 of the contract, which makes ITT responsible for the cost of deploying enough radios to meet requirements. ITT

will recover its costs through fixed-price subscription charges. FAA states that there will be no risk to the Government if additional ground stations or towers are needed during Segment 2. This is because the contract does not specify the number of radios or towers. Nevertheless, the number of radio stations will be important to obtain the necessary coverage and level of performance with ADS-B for safe, efficient operations, particularly in congested airspace.

A September 2009 joint government and industry task force report on NextGen's mid-term implementation made recommendations that if accepted, could also impact the ADS-B contract.[15] The task force stated that FAA should expand the volume of what "radar-like services" will be provided by redefining the contract with ITT to deliver ADS-B data in "non-radar" airspace. It also noted that FAA should expand ADS-B to additional locations. The initial focus is low altitude airspace, where radar is not available, within 35 to 40 miles of airports in Washington, D.C., and New York. If FAA reallocates requirements between air and ground elements or adds locations, it could result in a change to the contract. Such a change would entitle the contractor to request an equitable adjustment to the contract's price and schedule.

The ADS-B contract misclassified essential service charges as critical service charges for the Gulf of Mexico service volumes. We found a $16 million variance for subscription charges supporting Segment 1 critical services through 2016 (see table 9). While the contract states the value is about $2 million, our review of the pricing table found costs totaling about $18 million. According to ADS-B program officials, although the contract pricing spreadsheet shows ADS-B critical services under the Gulf of Mexico (GOMEX) Service Volume, it should have been included as an essential service price. FAA officials acknowledge that this same condition exists with contract line items that identify charges between 2017 through 2025.

Table 9. Contract Misclassification of Essential Services as Critical Services (Dollars in Millions)

Contract Line Item Number (CLIN)	Subscription Charges (thru 2016)	Total Costs		Discrepancy Amount
		CLIN	Pricing Table	
0003	Segment 1: Critical Services	$2,072,944	$18,101,786	$16,028,842
0006	Segment 1: Essential Services	$311,873,778	$295,844,936	($16,028,842)

Source: OIG analysis of FAA's ADS-B contract

[15] RTCA NextGen Mid-Term Implementation Task Force, NextGen Mid-Term Implementation Task Force Report, September 9, 2009.

Based on concerns we raised with the program office, FAA modified the ADS-B contract in June 2010 to make the CLINs and pricing tables consistent. FAA modified the pricing spreadsheets by deleting ADS-B critical service charges from GOMEX service volumes and reclassifying them under essential services. This will ensure that the contract accurately reflects what ADS-B critical and essential services the contractor is liable to provide and that both parties agree on their respective charges.

The ADS-B Contract Structure Bundles and Comingles Tasks and Costs, Making It Difficult for Decision Makers To Track Capital and Operating Costs

The basic structure of the ADS-B contract makes it difficult for FAA to accurately track costs. For example, the first contract line item number (CLIN-0001) supports the development and installation of the ADS-B ground infrastructure for approximately $207 million. However, various tasks and their associated costs for developing this system (e.g., program management, hardware and software design, procurement/production, and site installation) are embedded or bundled together within this one contract line item. This makes it difficult to trace actual development and unit production costs, including how many radio stations will be needed to support Segment 1.

We are also concerned that the contract currently comingles the costs of capital assets (the equipment required to broadcast the ADS-B signal) and a variety of operating costs within the contract line items. For example, based on recent ITT estimates, $295.2 million is associated with capital assets for radio stations and complementary hardware and software that fall within two distinct contract line items (CLINS 0006 and 0012)).[16] The subscription charges for these two contract line items total $676.1 million. However, ITT's cost proposal for these two contract line items also includes operating costs, such as rent, utilities, operations, and maintenance for radio stations, control stations, and service delivery points, plus service monitoring costs. The contract does not separately identify or track any of these operating costs elsewhere. As a result, it will be difficult for FAA and the contractor to identify and verify the capital and operating costs incurred or billed under this contract.

For example, FAA conducted an extensive review of the contractor's cost proposal in 2007 and reported to the Office of Management and Budget (OMB) that capital costs for about $150 million were required for the contract. However, in August 2009, FAA advised us that ITT had since estimated that ADS-B capital costs—including amounts for research and development, bid and proposal, and general

[16] FAA reported these assets as capital leases to the Office of Management and Budget officials that represent the net present value of future payments.

and administrative costs—were $348 million. Additionally, in August 2009 FAA's legal counsel determined that the assets being constructed for ADS-B did not meet the criteria for a capital lease. This means that additional radio stations, equipment, software, and implementation costs may be required. FAA needs to understand what the expected capital costs are for the system; track the types of capital and operating costs billed to identify potential cost overruns; and monitor progress by determining whether ADS-B is meeting program goals in terms of cost, schedule, and performance.

Capital costs for expenditures, construction, equipment, software, and implementation costs should be separately estimated, recorded, and billed. Such accountability helps to identify operating costs and prevents "hiding" of related cost overruns in capital accounts as construction progresses. Since operating costs are period costs they should be easily identified and excluded from capital charges in subscription fees billed to FAA. In January 2010, FAA agreed with our observation that the contract provided the Agency with the means to require the contractor to separately track and bill the Government for capital costs at no additional expense. In June 2010, FAA issued a contract modification to exercise this option.

Basic Management Controls Over the ADS-B Contract Are Lacking

While FAA's contract for ADS-B has controls that are important for managing and overseeing a complex acquisition, we identified a number of areas where FAA could strengthen them. Specifically, FAA convened an oversight and review board that meets monthly and relies on Earned Value Management (EVM)—an analytical tool—to monitor progress in meeting cost and schedule targets.[17] However, EVM will primarily be used for the first segment of the contract. This is a concern given the problems we have identified with basic contract administration, such as undocumented contract changes, and the question of whether FAA has the in-house expertise to effectively oversee the contractor once the ground infrastructure is in place.

Mechanisms to track progress with cost and schedule parameters are limited to the first segment of the contract. Our July 2009 management advisory to FAA raised a number of concerns about its methods for assessing progress with ADS-B. For example, the contractor's EVM data showed that the estimated solution development cost to complete ADS-B ground infrastructure through September 2009 was approximately $111.8 million; however, this activity was initially budgeted to cost about $84.1 million. Despite this $27.7 million variance,

[17] Earned Value Management System (EVM) is a management tool that provides for integrating technical, cost, and schedule information about contract performance. This information enables FAA to proactively manage contracts.

the contracting officer was reporting that the contractor was meeting ADS-B cost goals.

In an updated analysis we reviewed, we questioned why the contractor EVM data reported as of September 2009 indicated the estimated costs and fees to develop and install ADS-B would exceed the contract total by approximately $7 million (from $207 million to $214 million). FAA officials acknowledge there have been a number of changes to requirements that increased the ADS-B development and installation costs.

FAA is planning to use EVM to measure progress with ADS-B development and installation activities, which are under a cost-plus incentive fee arrangement. This represents only the first segment of the contract, which was originally valued just over $207 million (or approximately 10 percent of the total contract value). However, FAA points out that EVM is generally not used for fixed-price contract elements, which make up the later segments of the ADS-B contract. FAA would benefit from establishing a mechanism to track and monitor the costs of the remaining ADS-B implementation activities associated with fixed-price elements.

FAA needs to correct improper contract administration practices and document contract modifications. Our July 2009 management advisory also raised concerns that FAA's contracting officer for ADS-B was not documenting contract changes in a timely manner. FAA's Acquisition Management System guidance specifies that contract modifications should be properly documented to describe the changes made to the scope of work, the contract price, the period of performance, and other contract terms. During our review, we analyzed 13 contract modifications that primarily funded development and installation activities.

We found that although FAA's contracting officer had provided funds to the contractor, he did not identify the changes in the scope of the work, the prices, periods of performance, or other terms. For example, in March 2009, the ADS-B contracting officer issued a contract modification funding the contract to approximately $124 million but did not define the additional scope of work to be performed. As a result, FAA agreed to pay the contractor more than $60 million without the proper documentation needed to adequately account for what the contract would perform.

Documenting contract changes is a fundamental contracting officer responsibility. Unless the contract includes a clear definition of the work and its prices, the Government is at risk of overpaying or paying for something it does not want. In response to our concerns, FAA has placed additional resources to help improve overall contract administration.

FAA does not yet have the in-house expertise to effectively oversee ADS-B. As we have noted in multiple reports and testimonies, the right skill mix is essential to develop and manage NextGen initiatives, and this is particularly true for ADS-B. For example, FAA must ensure that all 323 planned service volumes are working as intended on a regular basis. It will be difficult for the Agency to build and sustain sufficient in-house knowledge of how the system actually works and how problems are solved since it will neither own the hardware, ground stations, and related software nor be responsible for the operation and maintenance of the ground system.

Further, much of the ADS-B infrastructure will be embedded in commercial equipment and networks. FAA knowledge may diminish once contractors assume sole responsibility for operating and maintaining the satellite-based system. The key personnel skills that are needed for effective ADS-B oversight include telecommunications, signal processing, and knowledge of the GPS constellation. However, FAA has not assessed the in-house skills it needs to oversee the ADS-B ground infrastructure. Without this information, we are concerned that FAA could find itself in the unenviable position of knowing very little about a system that is expected to be the foundation of NextGen.

CONCLUSION

ADS-B is a cornerstone NextGen technology and has the potential to significantly enhance capacity and safety. However, FAA faces multiple challenges and considerable risks in implementing ADS-B. FAA must provide Congress and airspace users with a plan to address the challenges, mitigate the risks, and assess the costs and benefits of its decisions. Until FAA addresses challenges such as equipage, requirements, system integration, and contract management issues, realization of ADS-B program goals will remain uncertain and NextGen initiatives will be delayed.

RECOMMENDATIONS

To reduce risk with ADS-B implementation, FAA needs to:

1. Accelerate efforts to establish requirements for ADS-B In and certify cockpit displays for enhancing pilot situational awareness to improve operations at high-density airports.

2. Further quantify and validate controller productivity enhancements that can result from displaying ADS-B information on controller displays and the additional automation needed to maximize these ADS-B benefits.

3. Develop and fund a targeted human factors research effort for pilots and controllers for ADS-B In requirements (display and procedures) in order to prioritize efforts and examine the proper sequence for introducing new capabilities.

4. Work with the U.S. intelligence community to assess potential threats to the ADS-B system and ways to mitigate them.

To enhance oversight of the ADS-B contract, FAA needs to:

5. Update the cost benefit analysis for the acquisition to ensure that FAA's plan is still appropriate before committing the additional funds for a nationwide deployment of the ADS-B ground infrastructure.

6. Clarify the use of ADS-B value-added services and reexamine assumptions about the ability of ITT to sell them in light of other planned NextGen efforts to greatly expand information sharing between FAA and stakeholders.

7. Specify the cost and schedule for providing ADS-B critical services to all en route and airport surface domains over the life of the contract.

8. Assess the technical readiness of ADS-R and any risks to its development and determine which locations will need ADS-R.

9. Determine and obtain the necessary in-house expertise to effectively monitor the contractor's efforts and oversee the ADS-B ground infrastructure over the long term.

AGENCY COMMENTS AND OFFICE OF INSPECTOR GENERAL RESPONSE

We discussed the results of our review with FAA's Assistant Chief Counsel, Acquisition and Commercial Law Division, and the Director of Surveillance and Broadcast Services and provided FAA with our draft report on September 2, 2010. We received the Agency's formal response on September 28, 2010. FAA concurred with seven of our nine recommendations but did not provide a target completion date for recommendation 2 and partially concurred with recommendations 5 and 7. FAA's complete response is included as an appendix to this report.

Specifically, for recommendation 2, FAA stated that it is finalizing negotiations with the National Air Traffic Controllers Association (NATCA) about the nature and extent of controller participation in potential ADS-B modifications to controller displays. FAA noted—and we agree—that controller productivity

enhancements could arise from procedural changes, not necessarily changes to the automation systems. While FAA's efforts with NATCA are an important step, FAA must determine what levels of productivity it can realistically achieve and what new technology and procedures it will need to do so. This will help boost industry confidence in FAA's ability to not only deliver technology but also benefits to airspace users. Therefore, FAA needs to provide our office with target action dates for completing ongoing work with the controllers to identify potential modifications to procedures and automation platforms.

For recommendation 5, FAA agreed that it needs to update the cost benefit analysis but stated that it is premature to update the benefits portion at this time since benefits are tied to the equipage rate. While users are not mandated to equip until 2020, FAA proposed doing an interim sample of the equipage rate between 2015 and 2016, at which time it will validate the cost benefit analysis against the original baseline. We note, however, that our recommendation also included validating that FAA's acquisition approach is still appropriate since FAA may spend an additional $2.7 billion to implement ADS-B. FAA needs to conduct this analysis sooner rather than later given the central role ADS-B will play in revamping air traffic management. Therefore, we reiterate that FAA should validate that its preferred approach remains cost beneficial before committing additional funds by the planned Joint Resources Council in 2012, which will baseline and fund activities for 2014 and beyond.

For recommendation 7, FAA agreed that the lifecycle contract costs for critical services require clarification. FAA stated, however, that it is difficult to reflect this in contract pricing tables, which show only the initial costs for critical services. FAA proposed to issue a contract modification by October 31, 2010, in lieu of reissuing the pricing tables. This contract modification will clarify pricing assumptions to state when charges for ADS-B critical services are included under Essential Services for a specific service volume if the pricing table does not separately reflect them. Moreover, FAA is planning to refine its schedule for establishing critical services for all locations by FY 2014. FAA's response meets the intent of our recommendation and if implemented will increase contract transparency. However, we plan to keep this recommendation open until the end of FY 2014 so we can verify whether the ADS-B contract includes cost estimates to support critical services for all sites throughout the life of the contract.

ACTION REQUIRED

FAA's proposed actions for all nine recommendations are responsive, and we consider them addressed but open pending completion of the planned actions. In accordance with DOT Order 8000.1c, we request that FAA provide us with a target completion date for recommendation 2 and reconsider its completion date

for recommendation 5. We appreciate the courtesies and cooperation of Department of Transportation, FAA, and various stakeholder representatives during this audit. If you have any questions concerning this report, please contact me at (202) 366-1427 or Kevin Dorsey, Program Director, at (202) 366-1518.

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cc: FAA Assistant Administrator for Financial Services/CFO
FAA Deputy Administrator
Assistant Secretary for Aviation and International Affairs
FAA Chief of Staff
FAA Director, Audit and Evaluation
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EXHIBIT A. OBJECTIVES, SCOPE, AND METHODOLOGY

At the request of the Chairmen of the House Committee on Transportation Infrastructure and the House Subcommittee on Aviation, we examined FAA's plans for implementing ADS-B. Specifically, our objectives were to (1) examine key risks to FAA's successful implementation of ADS-B and (2) assess the strengths and weaknesses of FAA's proposed contracting approach.

To achieve our objectives, we analyzed contract data, budget data, acquisition documents, cost and schedule projections and other supporting documentation provided by FAA. We also reviewed the ADS-B contract and relevant contractor financial and performance reports from ITT Corporation, the prime contractor. We reviewed FAA's ADS-B budget and cost estimates and ADS-B strategy documents for reasonableness and cost effectiveness. We examined FAA expenditure data for ADS-B, to determine how much has been spent since the program's inception and for FAA's legacy systems to determine if ADS-B is achieving cost and benefit goals. We also analyzed the FAA's Notices of Proposed Rulemaking for the ADS-B system.

We interviewed key FAA and ADS-B program officials at FAA Headquarters in Washington, D.C. We also met with industry officials and union representatives. We interviewed ITT Corporation officials to discuss the contract and the status of the system's development, installation, and implementation.

We conducted this performance audit between August 2007 and June 2010. The audit was performed in accordance with Generally Accepted Government Auditing Standards prescribed by the Comptroller General of the United States. As required by those standards, we obtained evidence that we believe provides a reasonable basis for our findings and conclusions based on our audit objectives.

EXHIBIT B. KEY ADS-B IMPLEMENTATION MILESTONES

Thus far, FAA has completed a number of important ADS-B actions on schedule. For example, FAA has completed a critical design review[18] of the ground system and ADS-B ground systems have been deployed at the first key site in Miami, Florida. The Miami systems have been declared suitable for operational use and are providing services to a limited number of pilots in properly equipped aircraft.[19]

Between 2009 and 2014, FAA plans to complete the ground infrastructure, and fully integrate ADS-B with existing FAA automation systems that controllers currently rely on to manage traffic, and provide weather services. Further refinement of additional air-to-air applications (for ADS-B-In) and the decommissioning of radars are planned for the 2015 to 2025 timeframe. Table B-1 shows the key milestones for ADS-B implementation.

Table B-1. ADS-B Key Milestones

Milestone	Projected/Actual Completion Date
In Service Decision—Miami	November 2008
Initial Operating Capability—Louisville	November 2009
Initial Operating Capability—Gulf of Mexico	December 2009
Initial Operating Capability—Philadelphia	March 2010
Initial Operating Capability—Juneau	April 2010
Publish Final Rule for ADS-B Out	May 2010
In Service Decision for Critical Services	September 2010
Complete ADS-B NAS-wide Infrastructure Deployment	September 2013

Source: FAA Contract—ADS-B Program, August 24, 2007

[18] A critical design review validates that the contractor's overall design of the system meets the contract requirements.

[19] It is important to note that the ADS-B ground systems deployed in Miami are broadcasting "essential" services (advisory information) to pilots as opposed to broadcasting "critical" services or the down-linking of information to FAA automation systems that will be used for separating aircraft.

EXHIBIT C. MAJOR CONTRIBUTORS TO THIS REPORT

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Kevin Dorsey	Program Director
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APPENDIX. AGENCY COMMENTS

Federal Aviation Administration

Memorandum

Date: September 28, 2010

To: Matthew E. Hampton, Deputy Assistant Inspector General for Aviation and Special Program Audits

From: Clay Foushee, Director, Audit and Evaluation

Prepared by: Anthony Williams, x79000

Subject: OIG Draft Report: FAA Faces Significant Risks in Implementing the Automatic Dependent Surveillance - Broadcast Program and Realizing Benefits

The Automatic Dependent Surveillance-Broadcast (ADS-B) program is a cornerstone of the Federal Aviation Administration's (FAA) overall approach to evolving air traffic control, from its present state into the Next Generation Air Transportation System (NextGen) approach; increasing safety and the overall efficiency of the National Airspace System. While it employs a complex multifaceted approach, it is built upon the straightforward concept of leveraging Global Positioning System technology to give the pilot and controller the access to better information for making safe aviation decisions. The FAA appreciates the Office of Inspector General (OIG) report's recognition of the strides that FAA has achieved and agrees that the program offers the potential for significant long term benefits. At the same time, it is a long term program that requires the careful coordination of disparate participants, with varying perspectives ranging from cost, to effectiveness, to national security.

FAA Involved Stakeholders and ADS-B Development

FAA obtained stakeholder input throughout the ADS-B program and ensured that decisions were transparent, objective and appropriate. FAA enlisted the participation of diverse stakeholders to help refine requirements for both ground and avionics system elements. Significant industry involvement resulted in a performance-based contract that incentivized the contractor to perform - and actual results are essentially on-time and under budget. The ADS-B signal provides the controllers more accurate data than previously available and FAA is soliciting controller feedback on how best to display and use that data across each automation platform. The ADS-B final rule for equipage was issued on May 27, 2010 after Aviation Rulemaking Committee (ARC) and significant industry input. The FAA coordinated with the Radio Technical Commission for Aeronautics (RTCA) and other aviation organizations before issuing a Technical Standard Order (TSO) which defines ADS-B "Out" manufacturer requirements for avionics. The

FAA has also established an advisory circular which identifies the requirements for avionics installation. This stability in requirements is expected to allow the avionics industry to manufacture, certify and install rule-compliant equipment well in advance of the 2020 required date.

FAA Defining Advanced ADS-B Requirements

FAA is now defining the more advanced requirements for ADS-B "In" applications. Due in part to program success to-date, increased demand for avionics applications by the user community may present the FAA with the future choice of whether to modify ADS-B air or ground components. The plan for ADS-B "In" high value advanced applications is to define requirements through the Applications Integrated Work Plan Steering Committee and Work Group, and from an Aviation Rulemaking Committee convened July 2010. If these ADS-B "In" requirements are cost beneficial, the FAA will decide whether to add to the existing program or contract baseline.

RECOMMENDATIONS AND RESPONSES

Recommendation 1. Accelerate efforts to establish requirements for ADS-B In and certify cockpit displays for enhancing pilot situational awareness to improve operations at high-density airports.

FAA Response: Concur. In July 2010, FAA formed an ARC to explore ADS-B In. The FAA has agreements with several airline partners (e.g., United Parcel Service, United, US Air, etc.) to equip aircraft and collect data. The airline partners have subcontracts with avionics manufacturers and those efforts will lead to certified avionics. Cockpit displays are expected to be the most expensive type of avionics. As the FAA and industry research potential high-value ADS-B "In" applications, part of that work will involve prioritizing which applications would require a cockpit display. The ARC is chartered to deliver a final report on its recommendations by September 30, 2011. It will also complete all follow on work and prepare a summary report detailing recommended next steps by June 1, 2012.

Recommendation 2. Further quantify and validate controller productivity enhancements that can result from displaying ADS-B information on controller displays and the additional automation needed to maximize these ADS-B benefits.

FAA Response: Concur. The FAA is nearing completion of negotiations with the National Air Traffic Controllers Association about the nature and extent of controller participation in evaluating any potential modifications. Potential productivity enhancements could arise from procedural changes and do not necessarily involve changes to the automation system. The FAA will analyze the costs and benefits between contemplated procedural and automation changes in its decision making process. As part of the FAA's business case, the benefits of providing improved surveillance data via ADS-B Out to air traffic control decision support tools such as User Request Evaluation Tool (URET) and Traffic Management Advisor (TMA) were quantified. The present value of increasing the utility of these decision tools was estimated to be $802 million for URET and $417 million for TMA. The URET benefits begin to be accrued in 2017 after the decision support tool is migrated to the R-Side (radar) while the TMA benefits

were not to be accrued until 2020 due to uncertainty of achieving the benefit prior to full user equipage.

Additionally, the implementation of a ground based interval management system in conjunction with ADS-B Out provides air traffic control with the ability to support optimal profile descents in busier traffic environments translating to $796 million in present value dollars between 2014 and 2035.

Recommendation 3. Develop and fund a targeted human factors research effort for pilots and controllers for ADS-B In requirements (display and procedures) in order to prioritize efforts and examine the proper sequence for introducing new capabilities.

FAA Response: Concur. The Agency will evaluate any recommendations from the ADS-B 'In' ARC and RTCA efforts. All recommendations will be addressed and incorporated into the Joint Resources Council (JRC) in 2012 which will baseline and fund activities 2014 and beyond.

DO-317 A, the standard for cockpit based ADS-B 'In' applications, is under development as a joint RTCA/EuroCAE product. Development of this standard will be completed by the end of fiscal year (FY) 2011 third quarter. After DO-317A is published, a TSO – certification requirements for avionics invoking it will be published within 3 months (by FY 2011 fourth quarter).

The Agency has conducted multiple focused human factors research efforts to date related to ADS-B 'In' and has plans to continue conducting this research in the future. Examples of research efforts include and/or will include: Surface Indications with Alerts - conducted 5 human-in-the-loop (HITL) studies (between 2008-2010) plus additional simulation and flight test HITL studies (February 2010); In Trail Procedures (ITP) - white paper on ITP display issues and potential resolutions (March 2010), demonstration of ITP display concepts (July 2010), human factors flight simulator evaluation (September 2010), human factors flight test evaluation (February 2011); Interval Management - HITL simulations (April 2007, June 2008, July 2008, September 2008, December 2008, August 2009), field tests (June 2010, August 2010), and additional HITL simulations (beginning FY11 if the ARC endorses). There will also be Traffic Situation Awareness with Alerts human factors studies completed by 2012.

Recommendation 4. Work with the U.S. intelligence community to assess potential threats to the ADS-B system and ways to mitigate them.

FAA Response: Concur. FAA is conducting an ongoing dialogue with DoD and the intelligence community and making annual updates to its Security Certification and Authorization Package (SCAP). The next authorization date (SCAP update) is October 29, 2010.

Recommendation 5. Update the cost benefit analysis for the acquisition to ensure that FAA's plan is still appropriate before committing the additional funds for a nationwide deployment of the ADS-B ground infrastructure.

FAA Response: Partially Concur. The FAA agrees with the need to eventually update the cost benefit analysis, but disagrees with the timing of the recommendation. It is premature to update the benefits portion of the cost benefit analysis because the benefits are tied to the equipage rate.

Appendix. Agency Comments

The FAA approved and baselined the nationwide deployment of ADS-B at the August 2007 JRC meeting. Using the latest July 2010 Earned Value Management data, FAA planned to spend $522,762,990 by that point and actually spent $488,038,680. The plan included attaining Initial Operating Capability at four key sites and publishing a rule for ADS-B Out, all of which have been accomplished. The program Cost Performance Index is 1.04 and program Schedule Performance Index is 0.97, indicating a healthy program.

The ADS-B In Service Decision (ISD) occurred on September 22, 2010. At this time, an analysis of approved versus spent dollars will be conducted as part of a decision to continue nationwide deployment of the system.

The ADS-B Out rule was recently published (May 2010) and the compliance date is not until 2020. The cost benefit analysis will be updated once a substantial level of equipage is in place to realize and calculate the planned benefits. In the interim, the Agency will sample the equipage rate between 2015 - 2016 and validate the cost benefit analysis as compared to the baseline.

Recommendation 6. Clarify the use of ADS-B value-added services and reexamine assumptions about the ability of ITT to sell them in light of other planned NextGen efforts to greatly expand information sharing between FAA and stake holders.

FAA Response: Concur. The FAA agrees that plans to share data with the aviation industry and others should be carefully coordinated. The ADS-B contractor was not promised exclusive use of ADS-B data - but the value of that data feed could be diluted to the extent that similar aviation data becomes available from alternate sources. The FAA is in the process of creating a new organization (ATO-V, Mission Support Services) with overall responsibility for coordinating data release issues. The ability of ITT to sell value added services in light of other planned NextGen efforts may be aided by segregating data related to FAA "core" activities from data to be used for other customer activities such as asset tracking and resale of surveillance data to third parties. Actual sale of value added services is dependent on equipage rates, customer demand, and ITT marketing.

The Surveillance Broadcast Services (SBS) program office has initiated discussions with ITT regarding which value added services would be most attractive to potential customers and would provide an effective stream of revenue. The ITT value added ADS-B architecture has been approved by FAA. A Beta Test period has been initiated where data is currently being provided to several users. The Beta Test will aid in determining how the delivered data could be displayed and utilized. The SBS program office is developing a governance policy (to be in place by calendar year 2010) which will guide the type of data which will be released and the authorized usage by each customer. It is envisioned the Beta Test will last approximately 6 months. After the Beta Test is completed, ITT will charge customers for data. At that time, a system will have been developed which will include the data release approval process and a related revenue reporting system. The SBS program office has also authorized ITT to establish a link for display of ADS-B value added data to Alaskan pilots to enable them to assess the potential of value added products.

Recommendation 7. Specify the cost and schedule for providing ADS-B critical services to all Enroute and airport surface domains over the life of the contract.

Appendix. Agency Comments

FAA Response: Partially Concur. The FAA agrees that the contract pricing tables do not in some instances separately identify pricing for ADS-B Critical Services and that it is not always clear in those tables whether the costs are included in the pricing.

The stated cost for providing Critical Services is a layer of the overall cost because the contract pricing assumptions stated that the Critical Services would be built upon the pre-established Essential Services network. Accordingly, there is an initial charge for establishing Critical Services, after which the cost of providing Critical Services are included in the Service Volume Essential Services prices.

The schedule for establishing Critical Services (based on the contract's pricing tables) for remaining locations is:

FY 2011:	6
FY 2012:	97
FY 2013:	109
FY 2014:	86
Total:	298 locations

In lieu of reissuing the pricing tables with a specific cost and schedule for ADS-B Critical Services, existing contract provisions for pricing assumptions will be clarified to state that where there is no separate ADS-B Critical Services subscription charge in the pricing table, the charge is included in the Essential Services charge for that service volume. A contract modification will be completed by October 31, 2010.

Recommendation 8. Assess the technical readiness of Automatic Dependent Surveillance-Rebroadcast (ADS-R) and any risks to its development and determine which locations will need ADS-R.

FAA Response: Concur. ADS-R was baselined for situational awareness as part of the essential services ISD in November 2008, before reaching ISD extensive testing and validation was completed to ensure technical readiness. All sites will be deployed with ADS-R capability by 2014. When high value ADS-B 'in' applications are baselined ADS-R will be reassessed, which will include all necessary testing and validation.

Recommendation 9. Determine and obtain the necessary in-house expertise to effectively monitor the contractor's efforts and oversee the ADS-B ground infrastructure over the long term.

FAA Response: Concur. The FAA is continually assessing the extent to which various skill sets are necessary as part of its annual Acquisition Workforce Planning. In addition, there were two SBS ISD action plans related to staffing identified and approved within Category 8 of the ISD checklist which will be closed by June 2011.

Overall, the OIG report provides a useful summary of the issues and perspectives involved with ADS-B development. The FAA appreciates the time that the OIG office took to carefully review the ADS-B program and to speak with Agency officials.

Appendix. Agency Comments