STATEMENT OF DR. AGAM N. SINHA
BEFORE THE HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE, SUBCOMMITTEE ON AVIATION HEARING ON NEXTGEN: THE FAA'S AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) CONTRACT

October 17, 2007

DR. AGAM N. SINHA
SENIOR VICE PRESIDENT AND GENERAL MANAGER
THE MITRE CORPORATION
CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT
7515 COLSHIRE DRIVE
MCLEAN, VA 22102-7539

(703) 983-6410

**STATEMENT OF DR. AGAM N. SINHA
BEFORE THE HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE, SUBCOMMITTEE ON AVIATION HEARING ON NEXTGEN: THE FAA'S AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) CONTRACT
October 17, 2007**

Good afternoon Chairman Costello and Members of the Subcommittee. Thank you for inviting me to participate in today's hearing on NextGen: The FAA's Automatic Dependent Surveillance - Broadcast (ADS-B) Contract. My name is Agam Sinha and I am a Senior Vice President at The MITRE Corporation. I am also the General Manager of MITRE's Center for Advanced Aviation System Development (CAASD), which is the FAA's Federally Funded Research and Development Center (FFRDC).

After a brief overview of the motivation for and workings of ADS-B, I will discuss why ADS-B is a cornerstone of the Next-Generation Air Transportation System (NextGen). This will be followed by a high-level description of the benefits ADS-B could deliver in the NextGen timeframe, including some of the early benefits that will accrue to the Federal Aviation Administration (FAA) and the National Airspace System (NAS) users under the FAA's current ADS-B program. An estimate of ADS-B costs is presented followed by a summary of the main messages.

Motivation for ADS-B

ADS-B is a well-defined, long-tested and globally accepted system concept for air traffic control (ATC) surveillance. Today's ADS-B concepts originated over 15 years ago. Since that time, operational applications have been proposed and defined, standards have been established, and avionics and ground stations have been developed and tested. Although first made operational in the U.S., ADS-B now is being accepted and introduced around the world for ATC applications. It is used for tracking aircraft both while in flight and on the airport surface. Aircraft pilots and ground-vehicle drivers also use ADS-B to monitor positions and velocities of other aircraft and ground vehicles.

ADS-B provides improved aircraft location information over most other civil ATC surveillance systems, including airborne sensors used by the Traffic Alert and Collision Avoidance System (TCAS) as well as ground-based sensors such as en route and terminal radars and Airport Surface Detection Equipment (ASDE). The aircraft surveillance performance improvement of ADS-B is enabled through on-board position determination using the Global Positioning System (GPS) and its augmentation systems, such as the FAA's Wide Area Augmentation System (WAAS). Using GPS/WAAS, the position is accurate to within +/- 3 feet horizontally. Unlike radar, the position accuracy of ADS-B does not change based on the distance between the target and the sensor. While a radar's error in measuring the target's distance from the radar remains constant at approximately +/- 50 feet (based on modern radars used in the NAS, such as the Air Traffic Control Beacon Interrogator-6 [ATCBI-6] and the Airport Surveillance Radar-11 [ASR-11]), a radar's error in measuring the target's azimuth (angle around the radar) varies from +/- 100 feet at 10 miles from the radar to +/- 500 feet at 40 miles from the radar. For air traffic management purposes, both ADS-B and radar[1] report an aircraft's altitude as measured by the aircraft's barometric altimeter, which is accurate to +/- 100 feet.

In addition to reporting a 3-dimensional position, ADS-B also reports an aircraft's or ground-vehicle's velocity – both speed and direction of movement. As is true for position information, the velocity information is determined by on-board navigation systems. This directly-reported velocity information is consistently more accurate than that which can be derived by the ground system based on successive aircraft position reports from radar.

A key distinction between ADS-B and radar is the update rate of aircraft position. ADS-B transmits position reports once per second, whereas terminal radars generate reports once every 4 to 5 seconds and en route radars generate reports once every 10 to 12 seconds. The faster position reporting can improve the display of target movement as well as the performance of software applications that use target reports as input.

ADS-B reports currently include information beyond a target's position and velocity, for example:

- International Civil Aviation Organization (ICAO) aircraft identifier, which is unique to each aircraft
- Information characterizing the accuracy and integrity of the reported position and velocity
- Other aircraft parameters, such as magnetic heading.

An aircraft's intended flight path could be included as information in future ADS-B messages to improve ATC services, including conflict prediction and resolution, metering, and route conformance monitoring. Draft standards have been defined for reporting aircraft intent information.

ADS-B ground stations can be sited and installed more easily than radars, permitting aircraft surveillance in heretofore inaccessible geographic locations, such as the Gulf of Mexico and Alaska. This ease of siting is based, in part, on the reduced size, weight, and power requirements of ADS-B ground station electronics, which require no moving parts and simpler antenna structures.

There are two fundamentally distinct types of ADS-B avionics configurations, commonly known as "ADS-B out" and "ADS-B in." "ADS-B out" describes a configuration in which an aircraft or ground vehicle transmits ADS-B reports but does not receive reports

[1] In this case and in other references to radar in this testimony, the radars of interest are Secondary Surveillance Radars (SSRs). SSRs interrogate transponders onboard aircraft for identification, altitude, and other information; they are a "cooperative" system. SSRs are more accurate and generally considered more informative than primary radars, which depend on radar signal reflections alone and thus are a "non-cooperative" system. Today, SSRs are the principal means of ATC surveillance.

from other aircraft, ground vehicles, or ADS-B ground stations. "ADS-B in" describes a capability in which an aircraft or ground vehicle not only transmits reports, per the "ADS-B out" description, but also receives reports from other aircraft, ground vehicles or ADS-B ground stations.

When "ADS-B in" is used, the information contained in the received reports typically is shown on an electronic display. For aircraft, the display is termed a Cockpit Display of Traffic Information (CDTI). Most cockpit displays are expected to be provided as part of multi-function displays. In addition to displaying traffic information, these displays can show graphical and textual weather information, as well as other flight information (e.g., pilot reports [PIREPs] from other aircraft and notices to airmen [NOTAMs]).

Cockpit Display of Traffic Information

Explanation of ADS-B

ADS-B is a form of surveillance in which an aircraft or ground vehicle continuously determines its own position and velocity and periodically transmits this information along with an identifier and other pertinent information for receipt by ATC, as well as by other aircraft and ground vehicles.

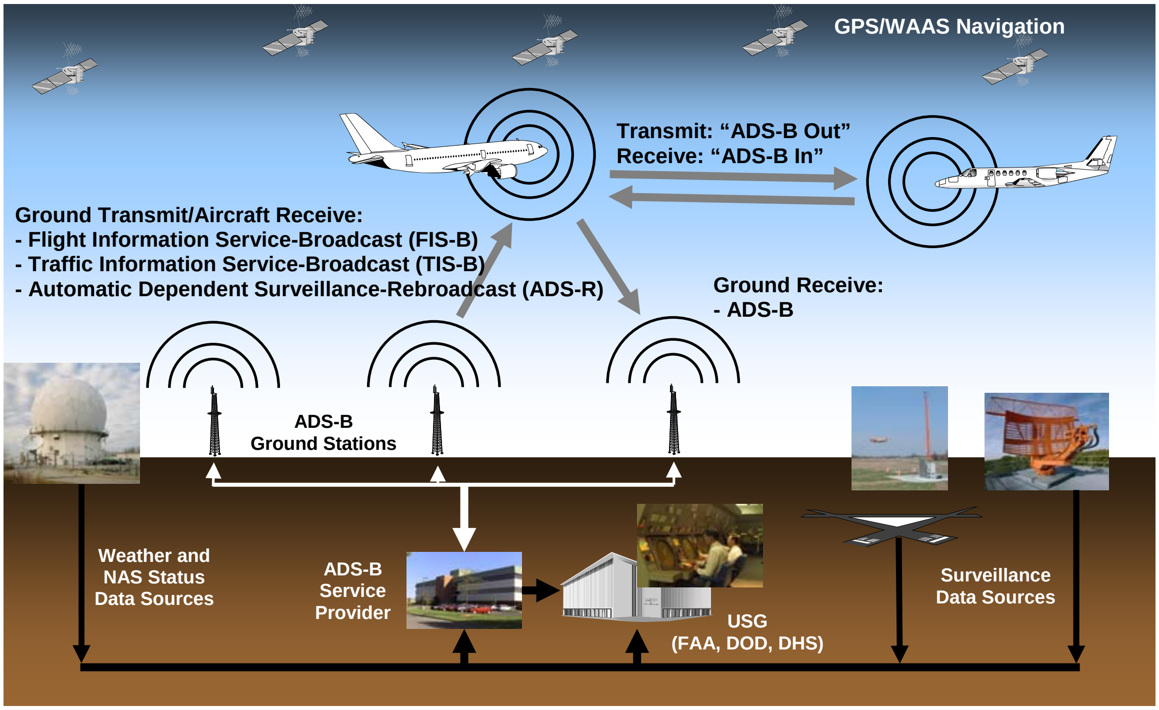
ADS-B transmissions are automatic. No pilot action is required, nor is any stimulus required from an external system (as is required for aircraft transponders, which only transmit in response to radar or TCAS interrogations).

ADS-B is a dependent system, in that it relies on the aircraft or ground vehicle to determine its own position and velocity. This information is determined by the aircraft's or ground-vehicle's navigation system. GPS augmented with WAAS is the preferred navigation reference source for aircraft because it provides the best accuracy, integrity, and availability of the sources available to pilots today.

ADS-B is a surveillance system which provides an aircraft's or ground-vehicle's 3-dimensional position (latitude, longitude, and altitude), velocity, identification, and other pertinent information.

ADS-B messages are broadcast for receipt by all ADS-B receivers in line of sight and within radio transmission range. The ADS-B receivers could be ADS-B ground stations as well as "ADS-B in" units on aircraft and ground-vehicles. The messages are transmitted over a digital data link which meets ICAO and FAA standards for ADS-B transmissions.

ADS-B Functional Diagram



ADS-B ground stations send the received messages to FAA-defined service delivery points. The service delivery points are located at or near air traffic control facilities, where automation systems process the ADS-B messages and generate air traffic displays for controllers, flow managers, and other positions. The messages also can be sent to other approved recipients, such as the Department of Defense (DOD) and the Department of Homeland Security (DHS). Authorized commercial entities can also receive ADS-B surveillance information; however, the information will be time delayed and appropriately filtered.

In addition to receiving ADS-B messages, the ground stations transmit Flight Information Services - Broadcast (FIS-B) and Traffic Information Services - Broadcast (TIS-B) messages. Flight information for the FIS-B messages, which can be processed and displayed by "ADS-B in" avionics, includes weather and non-control advisory information derived from various NAS information sources (e.g., the FAA's NOTAM system and Next-Generation Weather Radars [NEXRAD]). TIS-B is an essential service during the transition to ADS-B, as it allows aircraft equipped with "ADS-B in" to see other proximate aircraft that do not yet have any ADS-B capability, but are visible to other FAA surveillance systems. Since ADS-B can operate on either of two FAA-approved radio frequencies, 978 MHz or 1090 MHz, a ground broadcast service known as ADS – Rebroadcast (ADS-R) will cross-link information between users on different frequencies.

One critical design element of the ADS-B system is a backup concept for ensuring continuity of surveillance during system outages. Since ADS-B depends on the aircraft's navigation system, a potential point of failure is the navigation reference source – typically GPS augmented with WAAS. The FAA, working with government and industry stakeholders, examined several alternative backup concepts to mitigate the negative impact on ADS-B caused by a GPS outage. It was determined that the best option was to keep about half of the existing radars – enough to provide coverage at the 40 busiest terminal areas and all en route airspace over 18,000 feet above mean sea level.

Importance of ADS-B for NextGen

By 2025, the annual number of U.S. aircraft operations is expected to increase to 1.4 – 2 times today's level of 116 million. Some estimates are even higher depending on the business growth models of very light jets and shifts to smaller aircraft. The current air transportation system will not be able to accommodate this growth. NextGen is the U.S. Government's plan to modernize the NAS, addressing the impact of air traffic growth by increasing NAS capacity and efficiency while simultaneously improving safety, reducing environmental impacts, and increasing user airspace access. The FAA is implementing ADS-B as a cornerstone NextGen capability to enable a host of new user benefits. These benefits are achieved through a combination of new procedures and technologies deployed to better manage passenger, air cargo, general aviation, and air traffic operations.

NextGen Surveillance Information Services, including the improved surveillance accuracy, integrity, latency, and availability made possible by ADS-B, will enable:

- Reduced aircraft separation standards to improve NAS capacity
- Comprehensive tracking of aircraft and vehicles operating in the air and on the airport surface to improve safety, security, and operational effectiveness
- Improved access to underutilized airspace and airports
- Improved 4-dimensional trajectory information for better gate-to-gate aircraft operating efficiency and flight path conformance monitoring

- Flexible assignment of responsibilities on the ground and to the cockpit, as needed, to support distributed decision-making and workload balancing
- Adaptive, flexible spacing and sequencing of aircraft on the ground and in the air
- Improved collaborative air traffic management among flight and airport operators, service providers, and other stakeholders.

Add to these improvements the reduced weather impacts to traffic flow and airport access made possible by the use of an accurate weather picture and other advisory information shared between air traffic control and the cockpit (via FIS-B in appropriately equipped aircraft), and we can see that ADS-B is an enabler of several key NextGen capabilities.

Benefits of ADS-B

Expected ADS-B benefits are presented here in order of the needed avionics capability (the aforementioned "ADS-B out" and "ADS-B in"), then the geographical location, and finally the operational improvement. The total benefit values for those expected outcomes estimated from the years 2007 to 2035 total over $5B in present-value dollars.

About $400M of the expected $5B benefits pool are FAA savings due to avoidance of the costs of radar maintenance, upgrade, replacement, and new installations. A significant portion of these benefits comes after the effective date of a planned equipage mandate for "ADS-B out" avionics, circa 2020. It is at this time that some radars can start to be decommissioned by the FAA since ADS-B service will exist nation-wide for the affected airspace. (The ADS-B mandate will be defined by airspace class, and not all NAS airspace will require ADS-B equipage.)

Most of the expected $5B benefits pool, about $4.5B, is expected to accrue to NAS users – air transport and general aviation aircraft that can fly more efficiently, in greater numbers and to more places, and in a safer manner due to ADS-B.

Flying with the mandated "ADS-B out" avionics, pilots in the contiguous U.S. (CONUS), Hawaii, and Caribbean airspace currently covered by radar service[2] will be able to realize:

- More efficient en route conflict prediction and resolution capability, shaving miles off of flights due to fewer and shorter conflict maneuvers afforded by ADS-B position accuracies
- Improved runway throughput due to more efficient en route metering to arrival fixes afforded by ADS-B position and velocity accuracies
- More efficient ATC management of aircraft on the surface, and increased surface safety from upgrades to the Airport Surface Detection Equipment.

[2] With a few (regional) exceptions, ADS-B ground infrastructure "coverage" is targeted for areas currently afforded radar coverage since there is a desire by the FAA to not diminish radar-based ATC services in any portion of the NAS.

Flying with the mandated "ADS-B out" avionics, pilots in portions of U.S. airspace currently not covered by radar service will be able to realize (in addition to some of the aforementioned benefits):

- Increased Instrument Flight Rules (IFR) capacity due to the change from procedural to radar/ADS-B separation standards
- Lower-altitude route access based on ATC enabled by ADS-B surveillance
- Improved search and rescue services through better fleet monitoring afforded by ADS-B position reports.

Flying with voluntary "ADS-B in" avionics, pilots in the CONUS, Hawaii, and Caribbean airspace currently covered by radar service will be able to realize:

- Enhanced visual acquisition and conflict detection provided by displayed ADS-B surveillance reports of proximate aircraft
- Improved weather and NAS status situational awareness provided through FIS-B reports
- Enhanced visual approaches through the transfer of some aircraft spacing responsibility to pilots in select operations (e.g., CDTI-assisted visual separation [CAVS] and Merging and Spacing [M&S] operations)
- Improved airport surface situational awareness through the display of surface traffic (aircraft and ground vehicles) and airport maps on aircraft displays
- Better final approach and runway occupancy awareness through the display of arriving, departing and surface traffic, and an airport map.

Flying with the voluntary "ADS-B in" avionics, pilots in U.S. airspace currently not covered by radar service will be able to realize (in addition to some of the aforementioned benefits):

- Fewer aircraft accidents through improved traffic and weather situational awareness afforded by ADS-B, TIS-B, and FIS-B. (This benefit already has been demonstrated under the FAA's Capstone program in what had been a high accident rate area in southwest Alaska. Aircraft equipped with Capstone avionics experienced a decline in the cumulative accident rate relative to non-equipped aircraft of almost 50% from 1999 to 2006.)
- Increased access to remote locations through additional IFR approaches.

Additional ADS-B benefit potential exists, but its scope and magnitude are not fully known. Some of this potential exists in concepts in varying stages of exploration, while other concepts are yet to be defined. Some examples of the concepts being explored are:

- Improved approach operations in IMC, allowing throughput closer to that of Visual Meteorological Conditions (VMC) operations, due to "seeing" proximate aircraft on a CDTI, including:
    - paired approaches to closely spaced (700' to 1200') parallel runways in IMC

    - independent approaches to parallel runways down to 2500' spacing in IMC
- Improved departure operations in the most congested terminal areas by reductions in departure spacing afforded through delegation to flight crews
- Improved safety
    - in the air through enhancements to onboard collision avoidance systems
    - on the airport surface through direct cockpit warnings of potentially conflicting traffic
- Reduced controller workload through more equitable sharing of spacing and separation assurance responsibility between ATC and pilots.

There is a direct correlation between the concepts listed here and the previously estimated NextGen benefits. For these example concepts as well as others, it is important to maintain or start the necessary research and development in order to achieve timely implementation.

Cost of ADS-B

The FAA's cost for nation-wide ADS-B service through 2025 is estimated to be $1.9 billion. The NAS users' (exclusive of military aircraft) cost for 100 percent avionics equipage of "ADS-B in" capability is estimated to be $4.5 billion, although it is projected that not all users need or will elect to equip. A more likely scenario is that a mix of mandated "ADS-B out" and voluntary "ADS-B in" equipage costing users about $2.6 billion will materialize by the time the planned mandate takes effect in 2020 (at which time removal of legacy radars can begin). It is imperative that program implementation risks and resources for ADS-B and the other NAS systems it leverages be managed closely so that the full set of projected benefits can be achieved.

Summary

In closing, let me summarize my main messages:

- ADS-B is a well-defined, long-tested, and globally accepted surveillance technology that provides better performance than legacy technologies. Today's ADS-B concepts originated over 15 years ago. Since that time, operational applications have been proposed and defined, standards have been established, and avionics and ground stations have been developed and tested.

- ADS-B offers benefits in NAS capacity, efficiency, and safety. These benefits come from both mandated "ADS-B out" and voluntary "ADS-B in" capabilities and they accrue to both the FAA and NAS users. The initial set of applications enabled by the FAA's current ADS-B program is expected to generate benefits totaling $5B between 2007 and 2035.

- The timely realization of ADS-B benefits is dependent on achieving appropriate ground automation system upgrades, avionics equipage rates, and operational procedure development. It is important that these activities, in conjunction with a strong commitment to ADS-B by the FAA and NAS user community, proceed in lockstep with the ADS-B ground infrastructure implementation. NAS users who choose to equip with “ADS-B in” capability instead of the minimum capability that will be required circa 2020 (“ADS-B out”) can start to reap benefits early.

- ADS-B is a cornerstone capability for NextGen, as several of the key NextGen operational improvements require it. With its current ADS-B program, the FAA is taking a first step in transforming the NAS to accommodate NextGen. As this transformation unfolds, more ADS-B applications will be identified. The realization of these new applications will require continued emphasis on the necessary research and development to mature them as well as the identification of efficient means to implement the most promising ones in the NAS.

Mr. Chairman, this concludes my testimony. I would be happy to answer any questions the Committee may have.