THE EXECUTIVE REFERENCE GUIDE TO
SPACE-BASED ADS-B

Delivering Global Air Traffic Surveillance To All Aviation Stakeholders
Air traffic is projected to double over the next 20 years according to the recent PricewaterhouseCoopers annual report on the state of the worldwide airline industry. Industry group, International Air Transport Association (IATA), expects aviation to support over 105 million jobs and US$6 trillion in Gross Domestic Product (GDP) by 2035. From frequent airport congestion and ongoing delays, to rising emissions and fuel costs, the aviation industry faces ongoing challenges in their efforts to increase capacity and reduce environmental impact, while making air travel safer and more reliable worldwide.

To keep up with 100 percent projected growth, Air Navigation Service Providers (ANSPs), airlines and airports are making significant investments in infrastructure to ensure Communications Navigation Surveillance (CNS) and Air Traffic Management (ATM) infrastructure can meet the demand.

The nature of today’s airspace will also change dramatically over the next decade with the introduction of significant new airspace users such as very light jets, unmanned aerial vehicles (UAVs) and even commercial space vehicles. This growing demand will require continuous and concerted upgrades to the national and global airspace systems.
Since the birth of aviation in 1903, ATM capabilities have made slow and steady progress in supporting the use of the airspace. After World War I, the United States Postal Service (USPS) began pioneering transcontinental airmail service, helping pilots navigate routes from New York to San Francisco by lighting bonfires at night, and eventually installing rotating beacons on the ground.

With the introduction of aviation radios in the 1930s, pilots were able to communicate their position relative to known navigation landmarks to air traffic controllers on the ground, who would in turn, track each plane on a position map in order to keep aircraft safely separated, clear planes for takeoff and landing, as well as transmit weather conditions to the pilot.

The advent of radar technology during World War II revolutionized aircraft surveillance, with researchers in France, Germany, Italy, Japan, the Netherlands, the Soviet Union, the United Kingdom and the United States working secretly and independently to develop separate versions of radar for their countries.

Since the end of World War II in 1945, air traffic control systems have continued to evolve from wartime advancements in radar, ground-based radio navigation and communications systems, with the primary purpose to keep airplanes safely separated gate-to-gate.

Today, air traffic controllers use a combination of ground-based radar, radio navigation, communication and satellite-based global positioning systems to track aircraft as computer-generated icons on a radar display screen, providing information on each aircraft’s position, altitude and airspeed updated every few seconds.
Before the widespread use of radar for air traffic control, pilots calculated an aircraft’s position manually using onboard instruments and navigation aids before communicating this flight information by radio to nearby air traffic controllers.

With the development of Primary Surveillance Radar (PSR) during World War II, large, expensive, rotating transmitters were used to send out high-power radio waves, sweeping through a complete 360-degrees in azimuth. These signals are reflected off of an aircraft and used to calculate its direction or bearing. Distance or range is determined by calculating the time it takes the radio waves to reach the aircraft and return to the transmitter. By combining the range with the azimuth of the target, the aircraft is pinpointed in two-dimensional space and appears as a dot on the radar display screen.

Secondary Surveillance Radar (SSR) is used to send a second, high-frequency signal from a separate antenna along with each primary radar sweep. When an aircraft equipped with a transponder receives that signal, it automatically responds by sending its own signal back to the ground station. Originally intended to request and receive an Identification, Friend or Foe (IFF) response from an aircraft in military applications, secondary radar is now typically used to supplement primary radar information by assigning a code to each particular aircraft and identifying specific dots on a radar screen.

The deployment of Global Navigation Satellite Systems (GNSS) has enabled a quantum leap in aviation navigation by delivering an autonomous, global, geospatial positioning and navigation capability. The United States’ Global Positioning System (GPS) is currently the world’s most utilized satellite-based navigation system. The GPS system uses triangulation to determine an aircraft’s exact position over the Earth to provide precise location data, such as aircraft position, track and speed to air traffic controllers and pilots, requiring data from at least three satellites for accurate 2D positioning and four satellites for 3D positioning. Several other GNSS systems are in various stages of development and deployment including the European Union’s positioning system (Galileo), India’s next-generation regional system (IRNSS), the Japanese regional system (QZSS) and China’s global navigation satellite system (Beidou), as well as the Russian GNSS system (GLONASS) that is deployed but not widely used.
Due to its precision, accuracy, reliability and ease of use, satellite-based GPS has become a preferred global navigation method in the modern aviation world, enabling the development of a relatively new aircraft surveillance technology called Automatic Dependent Surveillance Broadcast (ADS-B), which has the potential to replace traditional, ground-based radar with far more accurate and precise aircraft positioning.
Unlike ground-based radar, Automatic Dependent Surveillance - Broadcast (ADS-B) leverages satellite-based GPS technology to calculate an airplane’s precise location, speed and direction and transmits this information twice per second to ground-based ADS-B receivers.

The combination of extremely precise location and velocity information transmitted in real-time enables ADS-B to significantly improve situational awareness and enable efficiency, capacity and safety improvements in both national and international airspace.

Although the original concept for ADS-B dates back to an FAA-sponsored study in 1973, standards were not proposed until the early 1990s, with the first ADS-B ground stations successfully demonstrated in Alaska in 2001.

In 2009, Canada commissioned operational use of ADS-B to provide coverage of its northern airspace around Hudson Bay, where no radar coverage was available. Later that year, Australia became the first country to commission a nationwide ADS-B surveillance system. In 2013, Australia began requiring ADS-B equipment on aircraft operating at or above 29,000 feet, along with Hong Kong, Singapore and Indonesia.

In Europe, ADS-B equipment will be required for all new aircraft by 2016 and existing aircraft must be retrofitted by 2020, with ADS-B serving as a central part of the Single European Sky ATM Research (SESAR) initiative.
Today, ADS-B is the backbone of the United States’ Next Generation Air Transport System (NextGen), with approximately 650 ground station transceivers deployed throughout the United States to provide near-nationwide ADS-B coverage. By 2020, the FAA has mandated ADS-B equipment for all aircraft flying above 10,000 feet, within a 30-nm radius of Class B airports at any altitude or within Class C airspace.

Although ADS-B is rapidly being adopted by the world’s ANSPs, with many countries instituting mandated equipment upgrades within the next 3-5 years, several challenges must be overcome before the aviation industry can fully realize ADS-B’s potential.
GLOBAL SURVEILLANCE CHALLENGES

As the aviation industry transitions from an aging, radar-based surveillance system to a modern, satellite-based infrastructure, ADS-B has the potential to provide many benefits, from improved safety and situational awareness to reduced fuel burn and delays.

With 70% of global airspace lacking real time aircraft surveillance, the benefits of ADS-B could be limited, unless significant cost, infrastructure, coverage and harmonization challenges are addressed.

For example, the ADS-B annual operating and maintenance (O&M) costs are around US$130,000 on average. Secondary surveillance radar (SSR) systems are even more cost prohibitive, with acquisition costs of US$3 million and annual O&M costs around US$1 million, depending on the location.

Given these costs, not all ANSPs have invested equally in the necessary ground station infrastructure. Smaller ANSPs in a variety of Flight Information Regions (FIRs) lack the budget and financial resources to make the required investment to move beyond radar, resulting in patchworks of surveillance coverage.
Even if ground-based surveillance systems were more affordable, secondary radar has severe line-of-sight limitations in mountainous terrain and ADS-B ground stations are not suited for use in remote airspace, such as oceanic and polar regions, where aircraft are currently not visible to surveillance.

In addition to these constraints, each ANSP upgrades its surveillance systems on its own schedule, according to its individual needs, priorities and financial resources. This stark reality has created interoperability challenges and inefficiency in airspace usage throughout the world and a lack of harmonization between various ground stations, avionics capabilities and satellite systems.

Space may be the final frontier in ADS-B surveillance, as ANSPs, airlines, airports and industry continue to work together to address these challenges, find affordable infrastructure alternatives, eliminate surveillance blind spots and fully realize the benefits of lower-cost, satellite-based surveillance to finally provide global surveillance coverage.
Space-based ADS-B extends the same ADS-B technology currently received on ground-based receivers to space. Aireon’s high-performance payloads, hosted on the new Iridium NEXT Low-Earth Orbit (LEO) satellite constellation, will receive aircraft ADS-B messages with a high level of precision and security, and relay them to air traffic controllers in real-time.

There is a total of 66 Iridium NEXT satellites, with significant overlap and redundancy, built in the system to provide a safety-of-life service to the aviation industry.

Aireon will provide the first global air traffic surveillance system using a space-based ADS-B system that makes it possible see all ADS-B 1090 MHz equipped aircraft across the entire planet.

In partnership with NAV CANADA, Enav, NATS, the Irish Aviation Authority (IAA), Naviair, as well as Iridium Communications, Aireon will enable real-time transmission of ADS-B data to Air Traffic Management (ATM) automation platforms and air traffic controllers in every FIR on the planet.
By eliminating blind spots, Aireon’s space-based ADS-B system will allow air traffic controllers to provide airlines with increased flexibility to optimize altitudes, file more direct routes, avoid weather and deviate from filed routes, driving billions of dollars in potential fuel savings for airlines and enhancing safety for all stakeholders.

As a turn-key surveillance solution, space-based ADS-B will allow for cost-effective, seamless and rapid implementation to meet future capacity needs and support compliance with regulatory requirements. Additionally, by providing surveillance in remote regions, new routes and a multitude of benefits can be provided to all aviation stakeholders.

- **RAPID DEPLOYMENT**
- **NO BLIND SPOTS**
- **COST-EFFECTIVE**
The backbone of Aireon’s space-based ADS-B platform will be the Iridium NEXT constellation of satellites, consisting of eight launches through 2018. This space-based ADS-B receiver network will relay signals from all ADS-B equipped aircraft to controllers worldwide, allowing 100 percent global air traffic surveillance, regardless of location, without requiring additional ANSP infrastructure or airline equipage.

Iridium NEXT’s low-latency, 66 cross-linked Low Earth Orbit (LEO) satellites — plus nine orbiting spares and an additional six ground spares — will orbit approximately 485 miles above the earth, with each satellite linked to up to four others, creating a dynamic mesh network to ensure continuous availability, everywhere on the planet.

The Iridium NEXT satellites will host Aireon ADS-B receivers that relay signals from ADS-B equipped commercial aircraft to air traffic controllers on the ground in real-time.
Aireon’s ADS-B payload includes a highly sensitive receiver coupled with multiple steerable beams, capable of detecting aircraft with ADS-B compliant avionics. The orbiting receivers and overlapping satellite beams will provide the ability to detect the aircraft at a high update rate. Real-time data will then be transmitted to ground receivers through a low latency data link, allowing ANSPs to receive data through a highly-redundant processing center.

Aireon’s space-based ADS-B solution is uniquely suited to meet the technical demands of global air traffic surveillance and tracking, extending ADS-B capabilities to every FIR in the world — including current procedural oceanic, polar, desert and mountainous airspace — to provide real-time visibility of ADS-B equipped aircraft.
Aireon’s advanced, next-generation technology will provide unparalleled pole-to-pole global surveillance coverage to receive and process ADS-B signals broadcast from aircraft equipped with 1090 MHz ADS-B transponders, which operate on the same frequency as traditional Mode A/C/S transponders, including DO-260, DO-260A and DO-260B (Link Versions 0, 1 and 2, respectively), as well as DO-260B/ED-102A, the current standard.

ADS-B information broadcast from the aircraft will be received by the Aireon ADS-B Hosted Payload (AHP), which will transfer aircraft data from satellite to satellite down to Iridium’s ground-based Teleport Network (TPN) to the Aireon Processing and Distribution Center (APD) system. The APD will decode and verify the data and deliver the data to the appropriate air traffic control facilities that have subscribed to the Aireon service.

Aireon’s surveillance infrastructure will provide ANSPs with information derived from an aircraft’s onboard equipment, sensors and ADS-B transponder, including horizontal position, altitude, velocity, aircraft identification and call sign. This data is often combined by the ANSP with ground-based surveillance and flight plan information for integration with ATC systems to provide a single representation of a given aircraft.

In order to ensure reliable satellite reception, an A1 class transmitter and top mount aircraft antenna (commonly found on most commercial aircraft and private jets), is required due to the space-based nature of Aireon’s receivers. Aircraft with a Traffic Alert and Collision Avoidance System (TCAS) to help prevent midair collisions are typically equipped with both top and bottom mount antennas.

### Key Technical and Performance Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
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<tbody>
<tr>
<td>Surveillance Datalink</td>
<td>1090ES ADS-B (DO-260 versions 0, 1, 2)</td>
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<tr>
<td>Aircraft Transmitter Classes Supported</td>
<td>A1 or higher with a top-mount antenna</td>
</tr>
<tr>
<td>Data Format to ANSP</td>
<td>ASTERIX CAT021, CAT023, CAT025, CAT238 and FAA CAT033 and CAT023</td>
</tr>
<tr>
<td>System Coverage</td>
<td>Continuously Global</td>
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<tr>
<td>Availability</td>
<td>≥ 99.9% (ICAO GOLD Standard for surveillance)</td>
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<tr>
<td>Latency</td>
<td>≤ 2s to Service Delivery Point (SDP)</td>
</tr>
<tr>
<td>Update Interval</td>
<td>95% of reports ≤ 8s in most areas</td>
</tr>
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POLE-TO-POLE
GLOBAL
AIR TRAFFIC
SURVEILLANCE
Aireon’s space-based ADS-B technology will bypass the limited range of traditional radar and ADS-B ground station transceivers, delivering a surveillance solution unrestricted by location and cost.

Transformational advancements in global ADS-B coverage will provide ANSP, airline and airport stakeholders with the benefits of lower-cost air traffic surveillance, along with comparable and even higher accuracy than traditional ground-based solutions.

Space-based ADS-B will improve efficiency in several surveillance situations.
ENABLING SURVEILLANCE OVER OCEANS AND REMOTE TERRAIN

Space-based ADS-B surveillance over oceans and remote terrain has the potential to drive billions in airline fuel savings by reducing separation to 15NM and enabling climbs to optimum altitude, all while using existing avionics, which is projected to save airlines over $100 million of fuel in the first year of operation in the North Atlantic alone.

PROVIDING SURVEILLANCE IN POLAR REGIONS WHERE NO COVERAGE CURRENTLY EXISTS

Full surveillance coverage over polar regions will result in more efficient use of airspace and significantly enhance safety by eliminating blind spots over large parts of the world’s airspace, increasingly used by modern, long-range aircraft. Aireon’s space-based ADS-B system will provide flexibility for airlines to optimize altitudes, file more direct routes, avoid weather and deviate from filed routes.

COMPLEMENTING GROUND-BASED SURVEILLANCE SYSTEMS

By fusing or augmenting radar, WAM or ADS-B ground stations with space-based ADS-B data, Aireon’s ADS-B platform will support 5NM separation, allowing for a more efficient mix of surveillance technologies while eliminating the need for long-term installation projects in areas where ground-based ADS-B is cost prohibitive.

PROVIDING CONTINGENCY SURVEILLANCE

Aireon’s space-based ADS-B system will serve as a contingency layer of surveillance to provide redundancy, improve reliability, increase predictability and reduce the overall impact of legacy surveillance system maintenance, radar outages and weather interruptions.

IMPROVING SEARCH AND RESCUE RESPONSE TIMES WORLDWIDE

Aireon’s space-based ADS-B system will provide 100 percent global air traffic surveillance coverage for ADS-B equipped aircraft, allowing rescue coordination centers to receive precise GPS location and real-time tracking data for any ADS-B equipped aircraft in an apparent alert, distress phase or emergency situation that is flying beyond the reach of existing surveillance.
STAKEHOLDER BENEFITS OF SPACE-BASED ADS-B SURVEILLANCE

For the first time, ANSPs will be able to use a global air traffic surveillance system through Aireon’s space-based ADS-B technology. Worldwide airspace will have air traffic surveillance capabilities for ADS-B equipped aircraft without requiring ANSP investments in ground-based infrastructure. As a result, air traffic controllers, airlines, regulators and all aviation stakeholders will no longer have blind spots in FIRs, enabling all ADS-B equipped aircraft to be monitored, in real-time, no matter where they are. Additionally, Aireon’s space-based system can act as an added layer of surveillance, providing redundancy across all FIRs.

This groundbreaking technology will improve safety, efficiency, predictability and capacity while reducing overall infrastructure costs.

**BENEFITS FOR ANSPs**

- Improved service with reduction in separation minima
- Expanded access to user-preferred routes, altitude and (cost index) speeds
- Extended ADS-B surveillance coverage and visibility into neighboring FIRs
- Reduced impact from routine maintenance, weather and system outages
- Lower surveillance costs from augmenting or replacing existing infrastructure
- Improved safety, regulatory compliance and controller situational awareness
- Faster controller response time to abnormal situations, gross navigation errors and search and rescue operations
- Accurate aircraft movement, speed and altitude data for better analytics

**BENEFITS FOR AIRLINES**

- Increased fuel savings and reduced greenhouse gas emissions
- Expanded access to user-preferred routes, altitude and (cost index) speeds
- Enhanced safety and improved situational awareness
- Extended ADS-B surveillance coverage without major ground investments
- Improved air traffic flow management and predictability across FIRs
- More efficient and predictable airline operations and resource planning
- Accurate aircraft movement, speed and altitude data for better analytics
BENEFITS FOR AIR TRAFFIC CONTROLLERS
- Reduced oceanic separation to 15NM while maintaining safety
- Expanded access to user-preferred routes, altitude and speeds
- Enhanced situational awareness with the elimination of blind spots
- Eliminated radar stitching across sector boundaries
- Improved response to pilot requests in airspace previously without surveillance

BENEFITS FOR REGULATORS
- Improved airspace efficiency, safety, compliance search and rescue response
- Reduced environmental impact from greenhouse gas emissions
- Improved air traffic predictability from more direct flights
- Increased harmonization of next-generation surveillance standards worldwide

BENEFITS FOR PILOTS
- Expanded access to user-preferred routes (free flight) while maintaining safety
- Improved ATC response to flight plan, altitude and speed deviation requests to avoid turbulence, wind or weather on remote/oceanic routes
- Reduced impact from weather, routine radar maintenance and system outages

BENEFITS FOR PASSENGERS
- Reduced travel time and improved passenger experience from more direct routes
- Fewer weather delays from flexible flight plans, altitude and speed deviations
- Less ground delays at airports due to more optimized arrivals and departures

For more information on stakeholder benefits, please visit aireon.com