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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 its 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 and satellite-based global positioning systems to track aircraft as computer-generated icons on a radar display screen. These systems provide 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 became required for all new aircraft in 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.
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 percent 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.
AIREON OVERVIEW

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 Low-Earth Orbit (LEO) satellite constellation, 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 satellites, with significant overlap and redundancy, built in the system to provide a safety-of-life service to the aviation Industry.

Aireon is providing the first global air traffic surveillance system using a space-based ADS-B system that makes it possible to 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 enables 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 allows 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 allows 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 is the Iridium constellation of satellites. Aireon’s space-based ADS-B receiver network relays signals from all ADS-B equipped aircraft to controllers worldwide, allowing for global air traffic surveillance, regardless of location, without requiring additional ANSP infrastructure or airline equipage.

Iridium’s low-latency, 66 cross-linked LEO — plus nine orbiting spares and an additional six ground spares — 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 satellites host the 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 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.

Today, air traffic controllers use a combination of ground-based radar, radio navigation and satellite-based global positioning systems to track aircraft as computer-generated icons on a radar display screen. These systems provide information on each aircraft’s position, altitude and airspeed, updated every few seconds.
Space-based ADS-B provides unparalleled 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 Hosted Payload (AHP), which transfers aircraft data from satellite to satellite down to Aireon’s ground-based Teleport Network (TPN) and Aireon Processing and Distribution (APD) system. With the assistance of partner, L3Harris, the APD decodes and verifies the data, and delivers the data to the appropriate stakeholder facilities that have subscribed to the Aireon service.

Aireon’s surveillance infrastructure provides 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 Traffic Alert and Collision Avoidance System (TCAS) are typically equipped with both top and bottom mount antennas to help prevent midair collisions.

### Key Technical and Performance Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td><strong>Surveillance Datalink</strong></td>
<td>1090ES ADS-B (DO-260 versions 0,1,2)</td>
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<tr>
<td><strong>Aircraft Transmitter Classes Supported</strong></td>
<td>A1/B1 or better with top-mount antenna</td>
</tr>
<tr>
<td><strong>Data Format to ANSP</strong></td>
<td>ASTERIX CAT021, CAT023, CAT025, CAT238 and FAA CAT033 and CAT023</td>
</tr>
<tr>
<td><strong>System Coverage</strong></td>
<td>Continuously global</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>≥ 99.9% (ICAO GOLD Standard for surveillance)</td>
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<tr>
<td><strong>Latency</strong></td>
<td>≤ 2s to Service Delivery Point (SDP)</td>
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<tr>
<td><strong>Update Interval</strong></td>
<td>96% of reports ≤ 8s in most areas</td>
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<tr>
<td><strong>Independent Position Validation</strong></td>
<td>Supports 1.9 NM and 5 NM validation radius for en-route and oceanic airspace</td>
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<tr>
<td><strong>Safety Certification</strong></td>
<td>European Union Aviation Safety Agency (EASA) certified to provide ATM/ANS surveillance services to support aircraft separation</td>
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POLE-TO-POLE
Global Air Traffic Surveillance
Aireon’s space-based ADS-B technology bypasses 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 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 is resulting in more efficient use of airspace and significantly enhances safety by eliminating blind spots over large parts of the world’s airspace, which are increasingly used by modern, long-range aircraft. Aireon’s space-based ADS-B system provides 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 can 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 serves 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 provides 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.
SPACE-BASED ADS-B SURVEILLANCE: HERE AND NOW

For the first time, ANSPs are able to use a global air traffic surveillance system through Aireon’s space-based ADS-B technology. Worldwide airspace now has 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 no longer have blind spots in FIRs, enabling all ADS-B equipped aircraft to be monitored, in real-time, no matter where they are.

Aireon continues to rapidly grow its customer base and expand the possibilities of use for its data. This growth is driven by the fact that Aireon provides the first-ever global set of historic and real-time air traffic surveillance-grade data on aircraft movements. This technology has the potential to transform the way they approach safety, efficiency, separation services and overall customer experience.

Aireon’s services empower partnering organizations in the aviation industry in an understandable and readable format, as well as to deliver derived information from the data. This capability provides partners with the only independent, certified and surveillance-quality aircraft position data with global coverage.

Partners gain full transparency into the Aireon-owned ADS-B system to guarantee traceability of highly accurate, highly reliable flight position information, which reduces the need to manage multiple, disparate data sources.

**Aireon’s Safety and Security Commitment**

Aireon’s distinguished safety pedigree allows for integration of the data across a spectrum of uses, from public-facing tools to highly safety-critical environments as well as analytics. Aireon is certified by the European Union Aviation Safety Agency (EASA) to provide Air Traffic ATM/ANS surveillance services, to support the separation of aircraft. This authorizes Aireon as the first-ever certified provider of aircraft surveillance-as-a-service.

- Compliance with EU Reg. 482/2008-Implementation of a software safety assurance system by ATS, Air Traffic Flow Management (ATFM), Air Space Management (ASM) and CNS services providers
- Aireon management processes
- Satellite Network Operations Center (SNOC) operations
- Aireon processing and Distribution (APD) operations
- Contingency and disaster recovery site operations
All the benefits from the EASA Certification are passed along to Aireon’s customers. The importance of data security correlates directly with Aireon’s strong commitment to safety.

Aireon is overseen and managed under the strictest policies and processes to ensure our services and systems operate in the most secure manner possible. This includes meeting the National Institute of Standards and Technology (NIST) 800-53/ ISO 27000 requirements.

From the aircraft, to the customer, and beyond, the Aireon data keeps focus on quality management. Aireon has implemented quality management procedures throughout the service management system and is guided by a commitment to continual improvement in the services provided to customers. This includes meeting the European Organization for Civil Aviation Equipment (EUROCAE) ED109/ISO 9000 requirements. The key differentiator is that Aireon’s data meets the toughest ATC standards used for separation services, by conforming to strict performance, cybersecurity and resilience requirements. Aireon is the only provider of this kind of data, with full data provenance.

**Benefits to All Aireon Customers**

**Improving Safety**

Simply put, the Aireon service provides enhanced operational safety for 100 percent of ADS-B equipped aircraft in real time. Aireon has seen a sharp increase in safety benefits through customers’ operational improvements, demonstrated by key metrics obtained via data supported by global benchmarks.

**Improving Efficiency**

Aireon allows customers to plan and fly more optimal routes, which cuts down on fuel consumption and creates consumer value in the form of lower prices. With Aireon, procedural routes — which have long been the industry’s solution to flying through unsurveilled regions — will become a thing of the past. Currently, operators on the North Atlantic region who use Aireon’s platform are increasingly allowed to fly more flexible routes to optimize their flight paths.

**Delivering Global Value**

Aireon delivers value to its customers on a global scale. Already, Aireon has enabled partners like Airbus and FlightAware to deliver data to aircraft operator customers and continue to actively expand. Additionally, the industry has already begun to take advantage of Aireon’s global commercial products — Global Beacon, Aireon ALERT — to create a more transparent, efficient and safe global airspace. As a growing and diverse range of customers continue to show that the Aireon system is applicable to a variety of challenges, there is new demand among some of the world’s largest aviation stakeholders to power innovation through a space-based ADS-B platform.