Global Surveillance and Tracking of Aircraft via Satellite

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Aireon – Global Aircraft Surveillance

- Aireon is a Virginia-based company
- Commercial aircraft surveillance network providing 100% global real-time coverage
- Uses hosted payloads on Iridium’s 66 low Earth orbiting satellite constellation
Aireon: Global Space-Based Air Traffic Surveillance

- 66 Interconnected Satellites Orbiting Earth
- 100% Global Coverage
- 36+ Countries to Deploy Aireon by end of 2020
- ~12,000 Average Amount of Aircraft Seen at Once (Before Covid-19)
- 22B ADS-B Messages Available for Analysis
- 1+ Year Global Historical Aircraft Movement Data
- 1 EASA Certification
- 0.19 Seconds Average Time for ADS-B Reports to Reach ATCs
- 16 ANSPs Using Global ADS-B Surveillance
Global Customer Base
ADS-B Definition

• Automatic
  • Messages from the Aircraft are transmitted without interrogation

• Dependent
  • The content of the ADS-B message is primarily dependent on GPS
    • Radars, by contrast, determine aircraft position independent of the aircraft with the exception of the altitude (which comes from a barometric altimeter)

• Surveillance
  • Real-time, low-latency, frequent position, velocity, and ID updates to an ATC system

• Broadcast
  • The content of the message is delivered “in the clear” to anyone with a receiver…including us! The transmissions are transmitted roughly uniformly in azimuth.
ADS-B Standards

• Minimum Operational Performance Specifications (MOPS)
  • ADS-B IN RTCA DO-317A

• Ground Specifications
  • EUROCAE ED-129B
  • ED-126 ADS-B NRA
  • ED-161 ADS-B RAD
  • ED-163 ADS-B APT

• Interface Control Documents (ICDs)
  • [Eurocontrol ASTERIX](#) CAT021, CAT023, CAT025

• Systems Software Integrity Assurance
  • DO-178 and DO-278
GPS Aircraft Surveillance on a Global Scale

• ADS-B is the next generation air traffic control technology for commercial air traffic requiring all aircraft in controlled airspace to broadcast their GPS position to air traffic control

• Mandates in place in the US, Europe and other countries enabling global view of aircraft movements

• Military aircraft have waivers for the ADS-B equipment mandate

• ADS-B is a cooperative technology so non-compliant aircraft can turn off transponder (unlike primary radar surveillance)

• Global coverage from sea level to >60,000 feet

• Tracking >11,000 in real-time and over 60,000 unique targets globally
High Fidelity Data Through A Robust Architecture

• Aireon leverages the high-quality, global Iridium network

• Overlapping Iridium satellite coverage provides redundancy

• Aireon provides high fidelity surveillance data for safety-oriented air traffic control functions

• Cybersecurity architecture includes full encryption and anti-spoofing capabilities

• GPS information transmitted by aircraft 2 times per second
ADS-B Provides Very Rich Content

• ADS-B messages have extensive data elements that provide much more information than the location of the aircraft

• One example is the GPS precision quality metrics

- Aircraft Operational Status
- Data Source Identification
- Service Identification
- Service Management
- Emitter Category
- Target Report Descriptor
- Mode 3/A Code
- Time of Applicability for Position
- Time of Applicability for Velocity
- Time of Message Reception for Position
- Time of Message Reception for Velocity
- Time of Report Transmission
- Target Address
- Quality Indicators (GPS performance)
- Position in WGS-84 co-ordinates
- Flight Level
- Selected Altitude
- Final State Selected Altitude
- Air Speed
- Magnetic Heading
- Barometric Vertical Rate
- Geometric Vertical Rate
- Airborne Ground Vector
- Track Number
- Track Angle Rate
- Target Identification
- Target Status
- MOPS Version
- ACAS Resolution Advisory Report
- Surface Capabilities and Characteristics
- Data Ages
- Receiver ID

Examples of Layers of Aireon Services
Observations of GPS via ADS-B
Identification of Potential GPS Jamming/Spoofing

• Aireon collects and processes real time ADS-B data on roughly 11,000 aircraft globally

• Aireon can provide real time alerts of potential GPS issues in specific geographic areas by:
  • The ADS-B message includes a data element on GPS quality
    • This message comes from aircraft systems comparing the position determined by navigation systems, GPS and other methods on the aircraft
  • Aireon independently estimates the future aircraft position based on prior velocity and position
    • Position differences between the aircraft ADS-B position and the Aireon calculation can produce a warning of GPS interference
  • Aireon independently calculates the aircraft position independent of GPS based on ADS-B signal arrival at multiple Iridium satellites (Time Difference of Arrival - TDOA)
    • Again, position differences between the aircraft ADS-B position and the Aireon TDOA calculation can produce a warning of GPS interference
  • Aireon also can post-process archived data to provide mapping of geographic hot spots with repeated and recurring indications of GPS interference, jamming or spoofing

Aireon can provide real time indications of GPS interference and jamming
Aireon can provide awareness of historical GPS interference spots
Example of GPS Quality Monitoring and Jamming Detection

Real-time global view of aircraft GPS performance

Large Blue Dots indicate poor GPS Environment for Aircraft

Global, real-time detection and historical analytics of GPS performance, indicating issues with aircraft receiving/processing GPS and possible jamming events
Independent Position Validation
Measured vs. Reported Position

- Aireon can provide an independent position validation on all ADS-B equipped aircraft

- Aireon satellite receivers provide significant overlapping coverage of most of the globe

- The Aireon algorithm triangulates on position using time difference of arrival (TDOA) of multiple messages

- The Aireon algorithm also projects the aircraft motion when the ADS-B TDOA validation state is interrupted

Aireon tool identifies (historically or in real-time) aircraft that are trying to spoof their position to air traffic control
Aireon Position Validation

- Validation State is determined with distance between Reported Position and Reference Track as well as Confidence in Reference Track
- Continued TDOA Observations improve Reference Track Confidence

One or more satellites receive a position message
- Initiate Reference Track with Reported Position
- Reference Track is Provisional
- Validation State is Unknown

Two or more satellites receive any ADS-B message
- Update Reference Track with TDOA Observation
- Reference Track is now Available
- Validation State is now Valid or Invalid

First TDOA Opportunity

Update the Reference Track Position kinematically with the Reported Velocity and Time Elapsed

Single Satellite Detections

Multi Satellite Detections

Update the Reference Track Position with TDOA Observation
Iqaluit Ground Based Reference Transmitter (GBRT)

- The Time of Message Receipt (TOMR) must be accurate for ADS-B data to be processed in the correct order
  - Data is received from multiple payloads and is sent through different routes in the space network and may be received at APD out of TOMR order

- The high accuracy TOMR is crucial to the validation process
  - Without this TOMR independent position validation would be impossible

- Iridium provides Aireon with Precision Timing and Position (PTP) messages
  - These messages allow for satellite position accuracy of 240m and a timing accuracy of 200ns

- This time accuracy is measured using a reference transmitter operated by NAV Canada in Iqaluit that transmits Time of Transmission in an ADS-B message
Operational TDOA Opportunities

- Many observations of overlapping coverage in targets of opportunity
- In a single hour of 16 million reports found about 1 million TDOA opportunities
- Results showed samples all over the globe
Examples of Leveraging a Calculated Reference Track

• Aireon algorithms can detect aircraft that are spoofing air traffic control by providing false “GPS information” from the real location of the aircraft

• Algorithms provide confidence in good performing avionics and flags bad data

Comparison track – reported GPS vs TDOA validation

Smaller deviations detected by algorithm can also identify poorly performing avionics
Aireon’s Global Aircraft Surveillance Services

• Primary purpose is to provide aircraft surveillance for air traffic control
• Creates a network of >11,000 aircraft sensors that provide a rich data source for military and intelligence applications
• Real-time and historical monitoring of global GPS performance
• Real-time situational awareness of commercial aircraft for tactical operations
• Historical data base of aircraft movements for intelligence analysis of suspicious aircraft
• Independent validation of aircraft public GPS information
• Monitor for global anomalous 1090 MHz and ADS-B usage
Thank you!
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