



SAFE SKIES.
**SUSTAINABLE
FUTURE.**



| ICAO



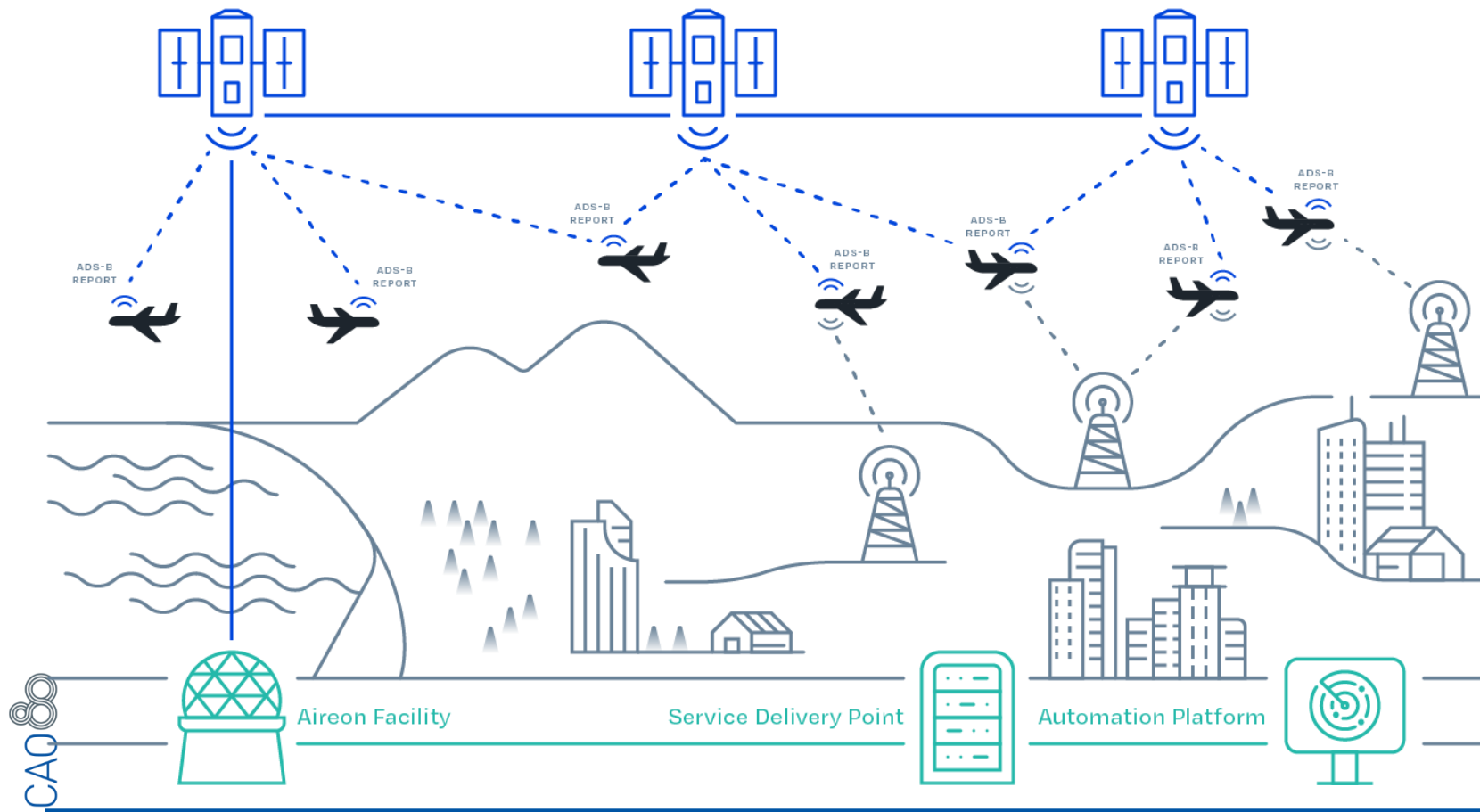
Space-based Surveillance: First 6 years of Global ATC operations and evolution into Satellite Time Difference of Arrival (TDA) to mitigate GNSS interferences

Michele Carandente

Deputy VP Air Traffic Services, Aireon

What is space-based ADS-B?

Iridium Next satellites equipped with ADS-B receiver 1090ES



Augments current radar systems with oceanic and remote air space coverage



Delivers true pole-to-pole global coverage

- Real-time delivery of "ADS-B Out" data to ANSPs
- No additional aircraft equipage by using 1090 MHz ES
- Adheres to all current and future ADS-B standards

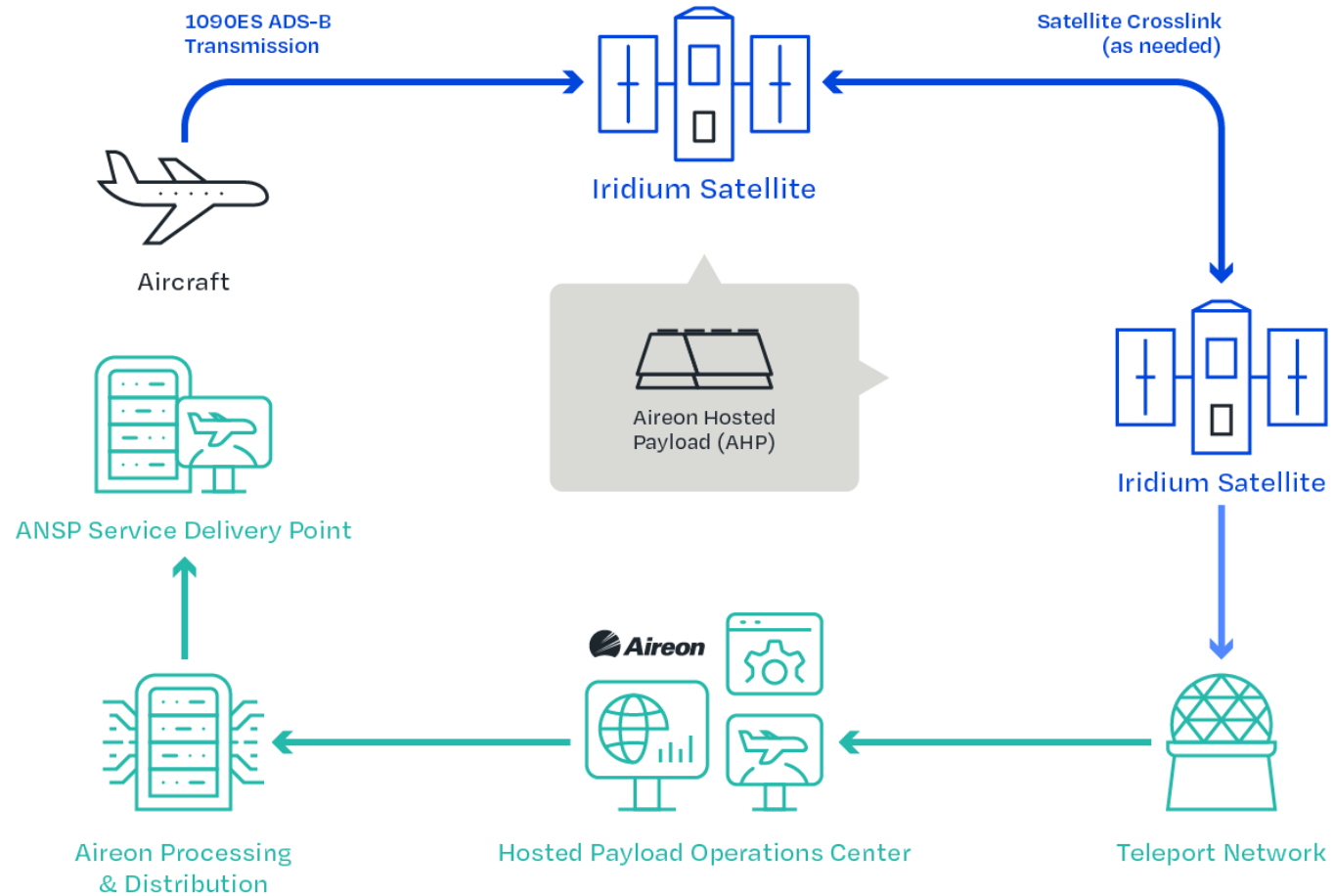


Global, Pole-to-Pole Coverage



How does space-based ADS-B work?

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A quick history of Aireon

2011

Aireon created

World's first service provider of global, real-time air traffic surveillance, regardless of location



January 2019

Iridium Constellation completed

Cutting-edge constellation with Aireon's ADS-B receivers on each satellite



April 2019

All Payloads in Orbit and Operational

All 66 Aireon ADS-B payloads active and operational



2020

Commercial Data Services introduced

Leveraging the same trusted data stream, Aireon launched AireonSTREAM™, AireonINSIGHTS™, and AireonFLOW™, designed to bring new capabilities to the broader aviation community



Today

ANSPs

More than 22 ANSPs, representing more than 40 countries, use Aireon ADS-B data to safely and efficiently manage their airspaces

New data capabilities introduced

Locate search & rescue tool, GPS monitoring, and Billing



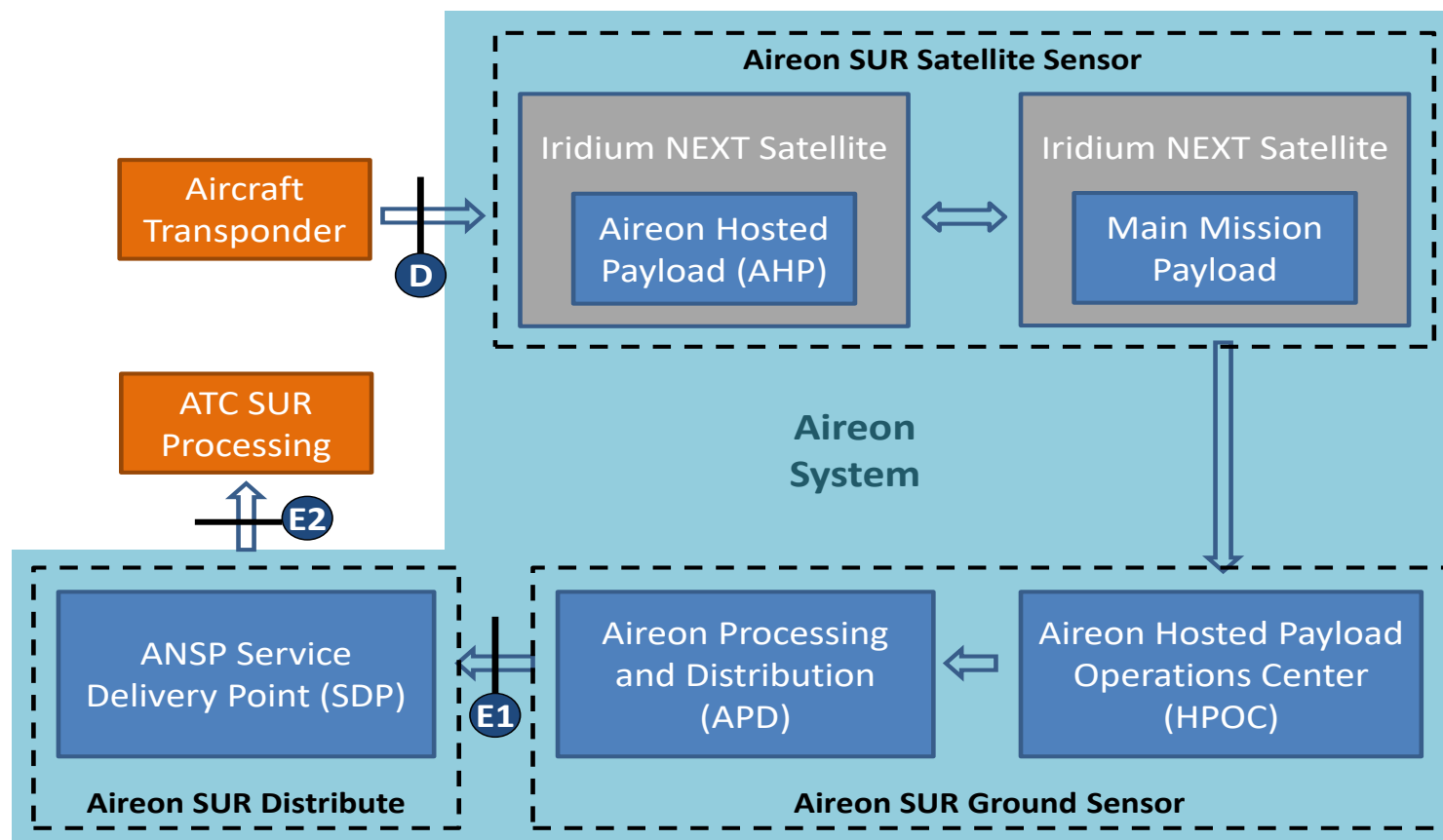
EASA certified company



European Aviation Safety Agency

Form

Application for ATM/ANS Service Provider Organisation Approval



More than half of the world's airspace relies on Aireon for ATS Surveillance





GPS Integrity

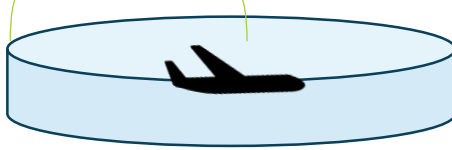


How do these messages identify position anomaly events?

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PIC	Integrity Containment Bound
15	
14	< 0.004 NM
13	< 0.013 NM
12	< 0.04 NM
11	< 0.1 NM
10	< 0.2 NM
9	< 0.3 NM
8	< 0.5 NM
7	< 0.6 NM
6	< 1.0 NM
5	< 2.0 NM
4	< 4.0 NM
3	< 8.0 NM
2	< 10.0 NM
1	< 20.0 NM
0	No integrity (or > 20.0 NM)

Position Integrity Category (PIC)
GPS Quality Uncertainty Radius

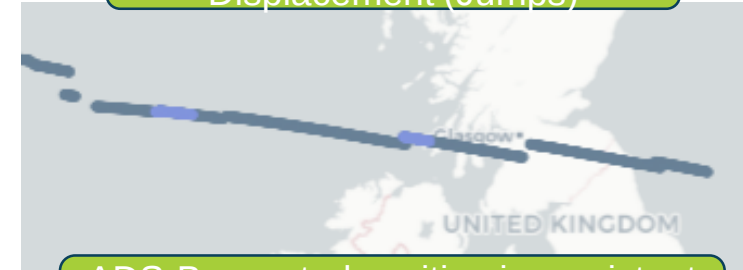


Latitude	Longitude
Unknown	Unknown



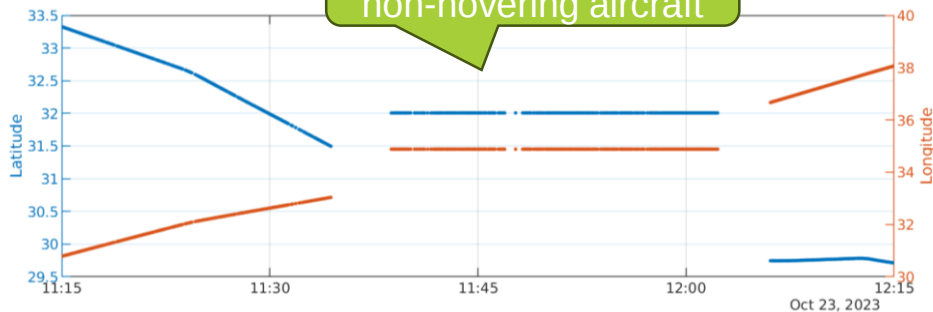
ADS-B Msgs with no
Position (FTC0)

Improbable Reported Position
Displacement (Jumps)

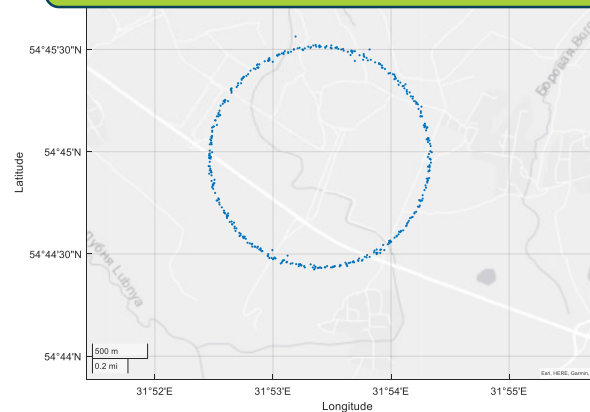


ADS-B reported position inconsistent
with independent sources

Constant position for
non-hovering aircraft



Improbable Flight Trajectory



Duplicate Address Behavior



Keywords

Position Integrity Check (PIC): a process used to assess the reliability of position data.

Independent Position Check (IPC): to verify the accuracy and reliability of a calculated position by comparing it with an independent source or reference system.



AireonPORTAL | Safety Dashboard

Data current through: 2025-03-30 UTC | Michele Carandente | Aireon

UTC: 2025-03-31 07:32:47

Start / End Date: 10-2024 - 03-2025 | Parameter: Position Integrity Category (PIC) | Units: Per 10,000

PIC Events: Aerothai, Oct 2024 to Mar 2025

Filters | Download | Rows per page: 25 | Showing: 1-3 of 3

Time of Message Receipt (UTC)	Target Address	ACID	Latitude	Longitude	Altitude (FL)	Track Angle (deg)	Duration (secs)	Ground Speed (kts)	Lowest PIC
2025-01-07 19:08:49	8852E3	THA940	12.08836	100.42005	360	323.1	197.2	501.2	0
2025-01-07 19:09:19	8852E3	THA940	12.1432	100.38155	360	327.35	60.22	455.93	0
2025-02-11 18:13:54	7502C3	MXD165	11.62646	99.5071	310	152.92	123.97	448.02	0

(H3 cell 836589ffffff)

AireonPORTAL | Safety Dashboard

Data current through: 2025-03-30 UTC | Michele Carandente | Aireon

UTC: 2025-03-31 07:33:13

Start / End Date: 10-2024 - 03-2025 | Parameter: Independent Position Check (IPC) | Units: Per 10,000

IPC Events: Aerothai, Oct 2024 to Mar 2025

Filters | Download | Rows per page: 25 | Showing: 1-1 of 1

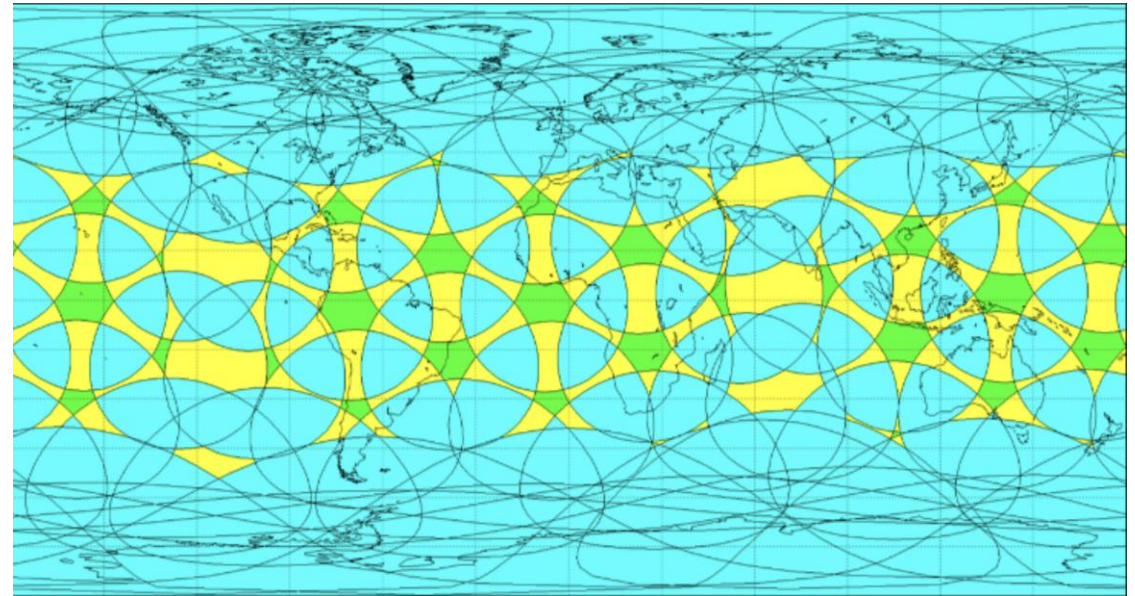
Time of Message Receipt (UTC)	Target Address	ACID	Latitude	Longitude	Altitude (FL)	Track Angle (deg)	Duration (secs)	Ground Speed (kts)	Highest PIC
2025-02-26 03:17:48	06A0AE	QTR975	17.41584	104.58371	380	225.29	323.16	1437.01	6

(H3 cell 834168ffffff)

Aireon Time Difference Of Arrival (TDOA)

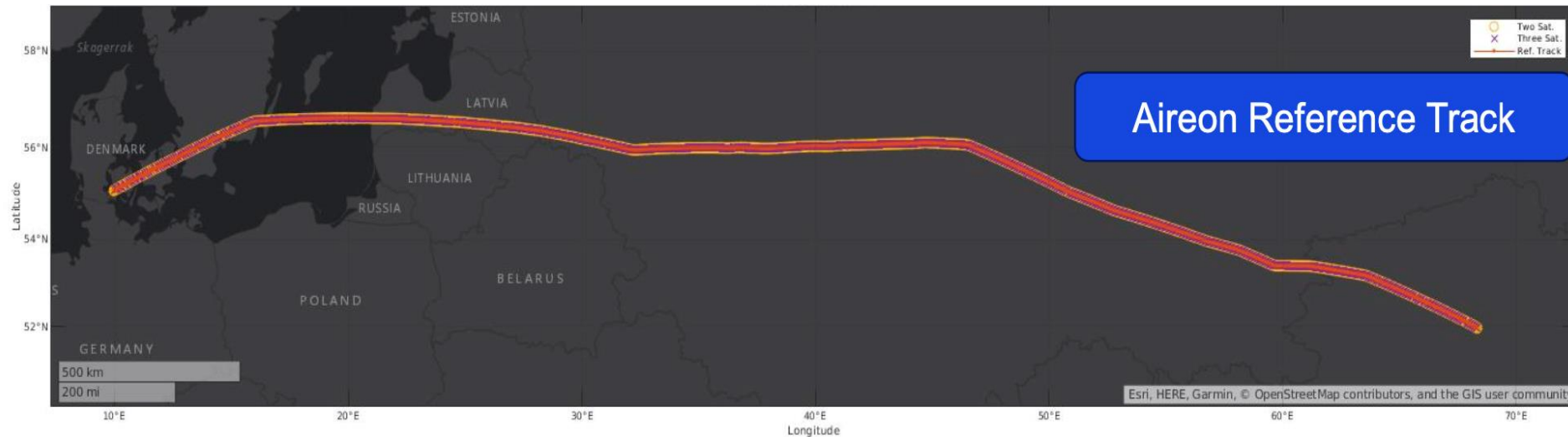
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- Global coverage, with multiple satellites receiving the same message
- Timestamp done with the Iridium clock, completely GPS independent
- Precision of up to 0.1NM
- Key enabler for a real WAM global solution



Multilateration and Reference Track

- Leveraging the precision and timing of the Iridium constellation, Aireon can detect the location of a transmitting aircraft even when the position reports are no longer valid
- Allows for the tracking of ADS-B equipped aircraft during periods of faulty avionics or when there may be environmental interference
- Provides resilient source for GPS Integrity issues



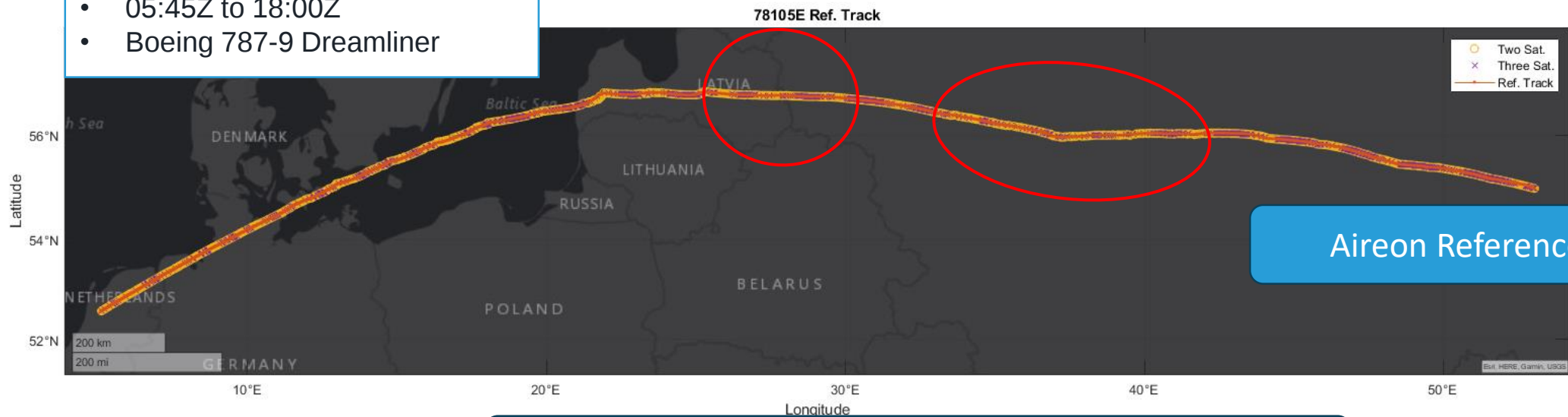
GNSS Interference and Spoofing: 25 December 2023 (CHH764)

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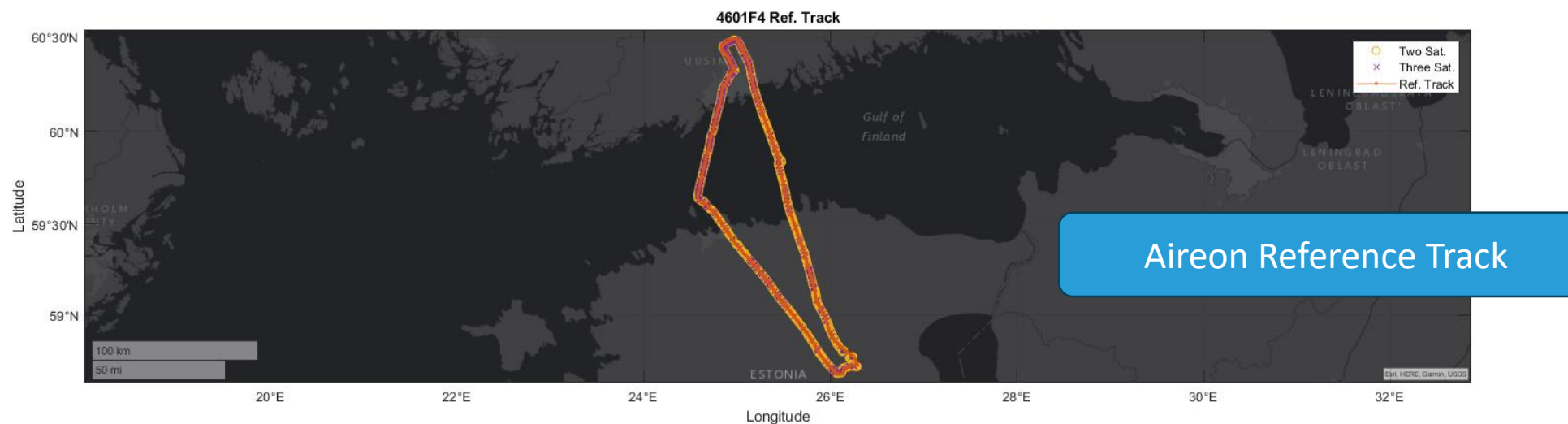
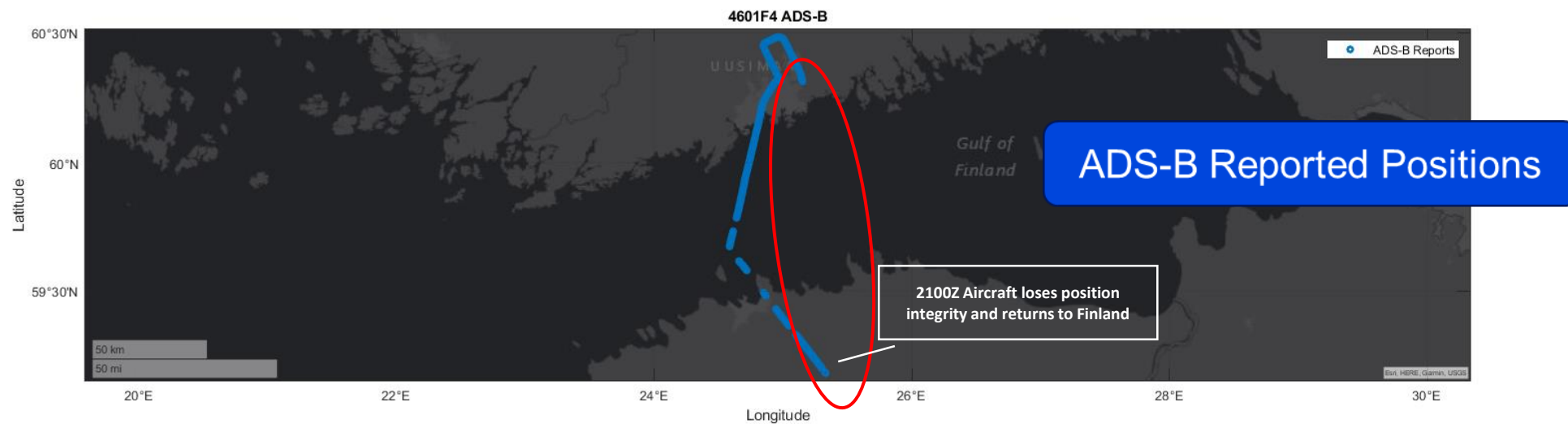
Changsha (CSX) to London (LHR):

- 05:45Z to 18:00Z
- Boeing 787-9 Dreamliner



GNSS Interference & Position Spoofing

GNSS Interference: Finland 26 April 2024



GNSS Interference

Would you like to learn more?

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WHITE PAPER

MAY 2024

Dr. Michael Garcia Chief Innovation Scientist
John Dolan Director, Modeling & Analysis/Data Science
Dr. Giuseppe Sirigu Principal Data Scientist

GPS interference and spoofing in the Baltics

Air Navigation Service Providers (ANSP) and aircraft operators rely on the integrity of the GPS signal to navigate the aircraft to its destination. Increasingly, however, the integrity of the GPS signal has become a target for interference — via nefarious actions like spoofing or jamming, or non-intentional actions like malfunctioning avionics. This trend has prompted many in the aviation industry to seek creative, technological redundancies to the GPS signal to ensure the aircraft is able to continue operating safely in the event of an interference.

Using its one-of-kind, space-based automatic surveillance broadcast (ADS-B) data, Aireon has developed a proof-of-concept multilateration solution that allows for independent position determination of ADS-B-equipped aircraft. This solution will allow Aireon to continue tracking aircraft even when they are unable to broadcast their GPS position using only their transmitted 24-bit aircraft address and the time of reception at the Aireon Hosted Payloads onboard the Iridium satellites.

This is done through a Satellite Wide Area Multilateration (SWAM) application that uses Time Difference of Arrival (TDOA) measurements from simultaneous detection of ADS-B transmissions on multiple payloads.

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NATIONAL SECURITY

Enhanced air domain awareness for the national security community



Key attributes for national security applications

- **Global:** Coverage from floor to 127,500 feet
- **Persistent:** 1-8 second update interval
- **Low latency:** normally < 2 seconds
- **High availability:** a 99.0% end-to-end system
- **Resilient:** Overlapping coverage and on-orbit spares
- **Enduring:** Historical data set from 2019
- **Focused:** RF spectrum coverage (1090MHz)
- **Trusted:** Architecture includes encryption and cyber-spoofing detection capabilities
- **Shareable:** Commercially available data is easily shared with coalition partners
- **Accessible:** Distributable from Gov Cloud planned in 2024
- **Valid:** Independent verification and validation of positional data

The National Security Community relies on surveillance and intelligence sources that can be trusted, accessed in real time, and analyzed to deliver critical insights and improve decision making. Aireon controls all methods and means of its space-based surveillance, encrypting data from collection to distribution, to ensure its validity.

Aireon's Automatic Dependent Surveillance-Broadcast (ADS-B) service delivers mission-critical, aircraft-derived information — including identity, GPS position, altitude and more. Collected by payloads hosted on the Iridium satellite constellation and delivered in real-time, it provides your surveillance and intelligence operations with an unprecedented layer of reliability, security, and flexibility, anywhere on the globe.

Since becoming operational in 2019, the Aireon system has generated an archive of location and position data of all ADS-B-equipped aircraft worldwide. Scalable to any need, Aireon's data-as-a-service subscription offerings include real-time reporting to enhance track quality, custody, and identification; while improving anomaly detection with historical data sets available to assist pattern-of-life analysis.

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WHITE PAPER

OCTOBER 2023

John Dolan Director, Modeling & Analysis/Data Science
Mike Garcia Chief Innovation Scientist
Giuseppe Sirigu Principal Data Scientist

Space-based ADS-B for GPS-independent position validation

Aircraft operators, Air Navigation Service Providers (ANSP), air traffic control organizations, and others rely heavily on data and associated systems to safely and efficiently operate and navigate aircraft throughout the airspace. From takeoff to touchdown and beyond, positional data is critical. But what happens when the systems fail? What if the GPS data is somehow compromised?

Aireon has developed a proof-of-concept multilateration solution that allows for independent position determination of ADS-B-equipped aircraft. This solution will allow Aireon to continue tracking aircraft even when they are unable to broadcast their GPS position using only their transmitted 24-bit aircraft address and the time of reception at the Aireon Hosted Payloads onboard the Iridium satellites.

This is done through a Satellite Wide Area Multilateration (SWAM) application that uses Time Difference of Arrival (TDOA) measurements from simultaneous detection of ADS-B transmissions on multiple payloads. This solution leverages traditional multilateration techniques used by terrestrial systems but applied via satellite. This is possible due to both the Iridium constellation, with its significant overlapping satellite coverage, and Iridium's ability to accurately track the position and timing of each satellite (on the order of hundreds of nanoseconds), which is shared with Aireon.

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Thank You

