Aireon ICAO CNS SG/15 Briefing

Status of GNSS Spoofing and Jamming and Potential Mitigations

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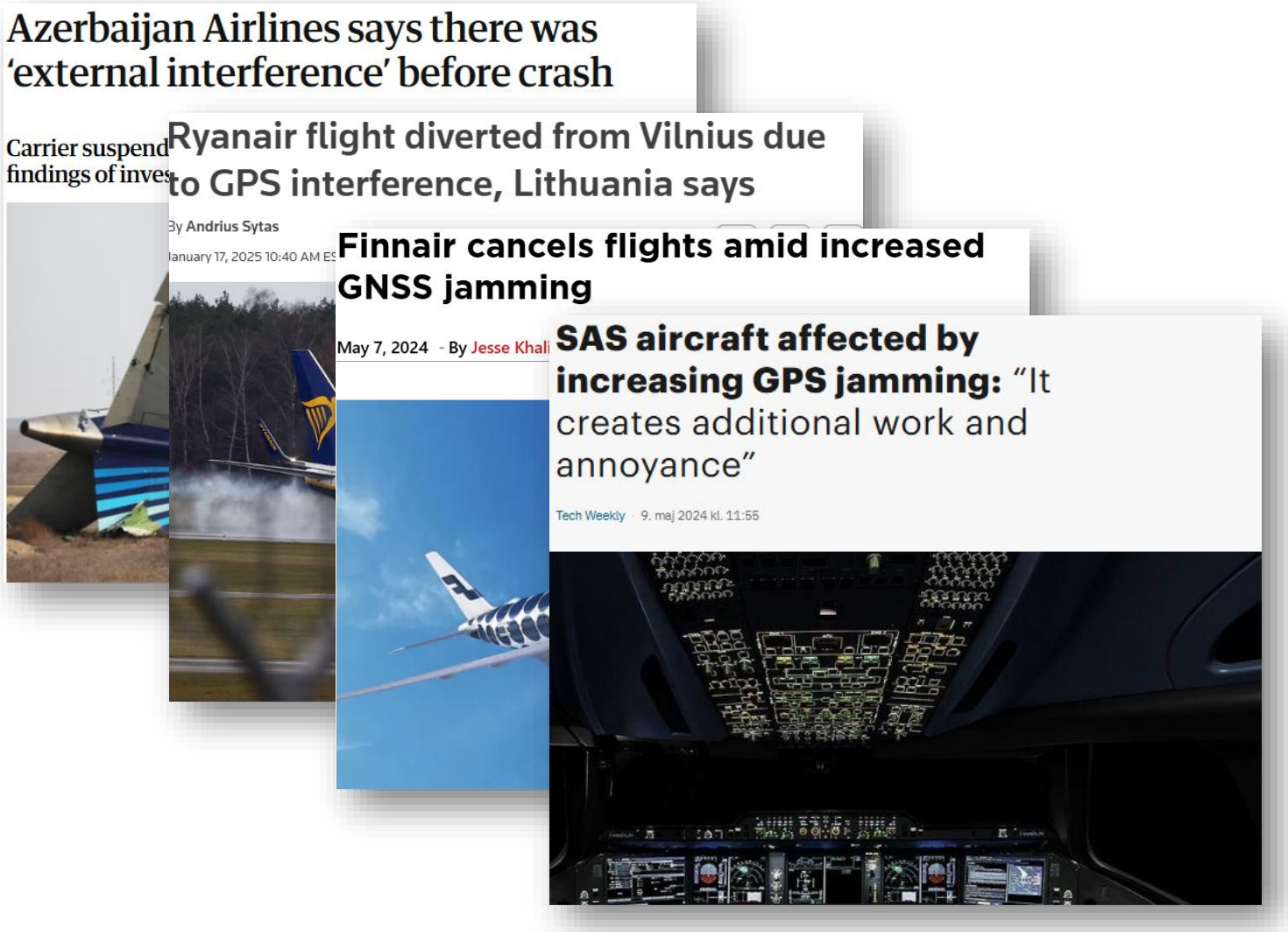
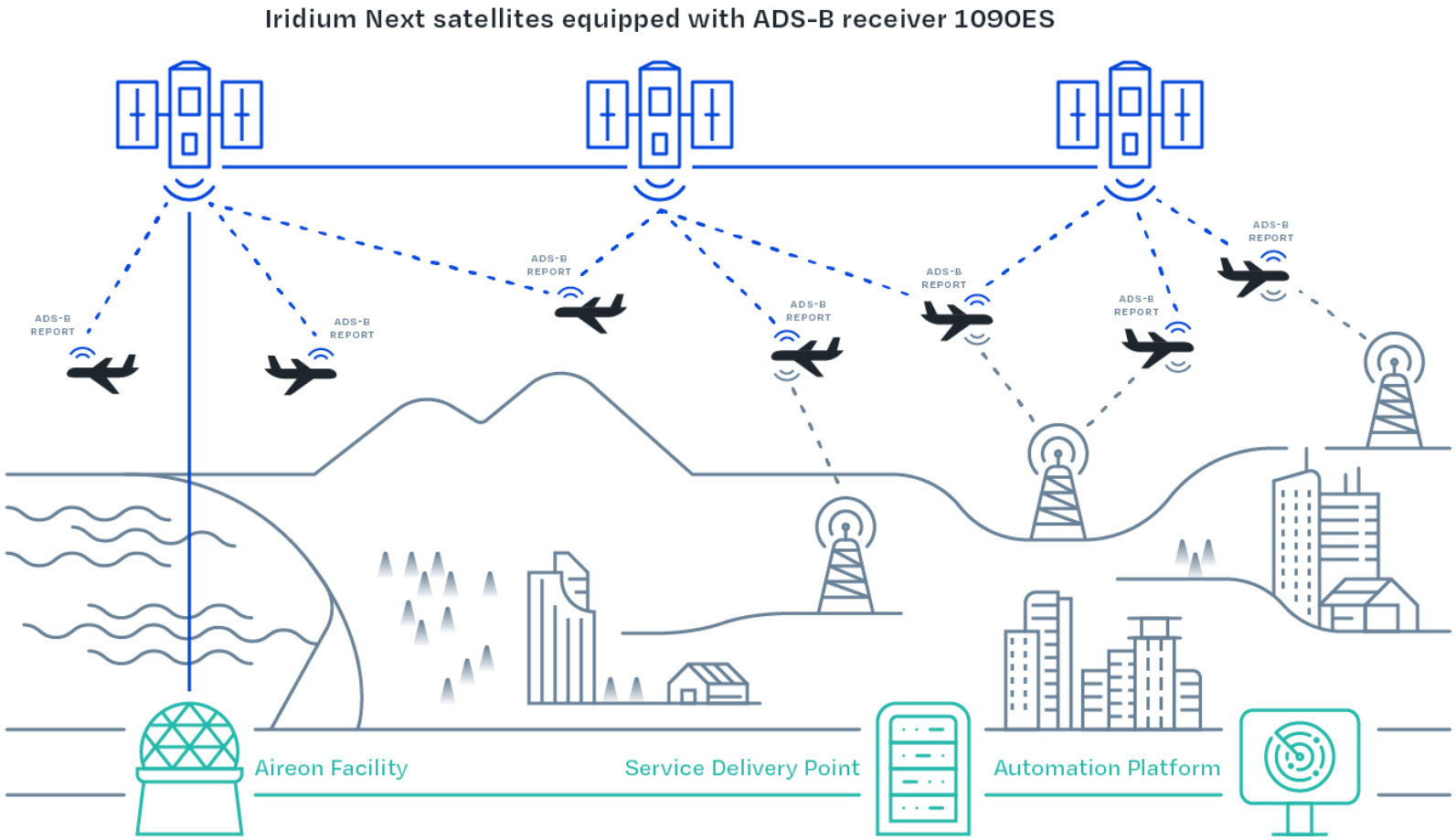
Intentional GNSS Interference: A Growing Threat to Aviation



Sources: 1) Global Navigation Satellite System GNSS Radio Frequency Interference;2) Azerbaijan Airlines says there was 'external interference' before crash | Kazakhstan | The Guardian; 3) Ryanair flight diverted from Vilnius due to GPS interference, Lithuania says | Reuters; 4) Finnair cancels flights amid increased GNSS jamming - GPS World; 5) SAS aircraft affected by increasing GPS jamming: "It creates additional work and annoyance" | Ingeniøren

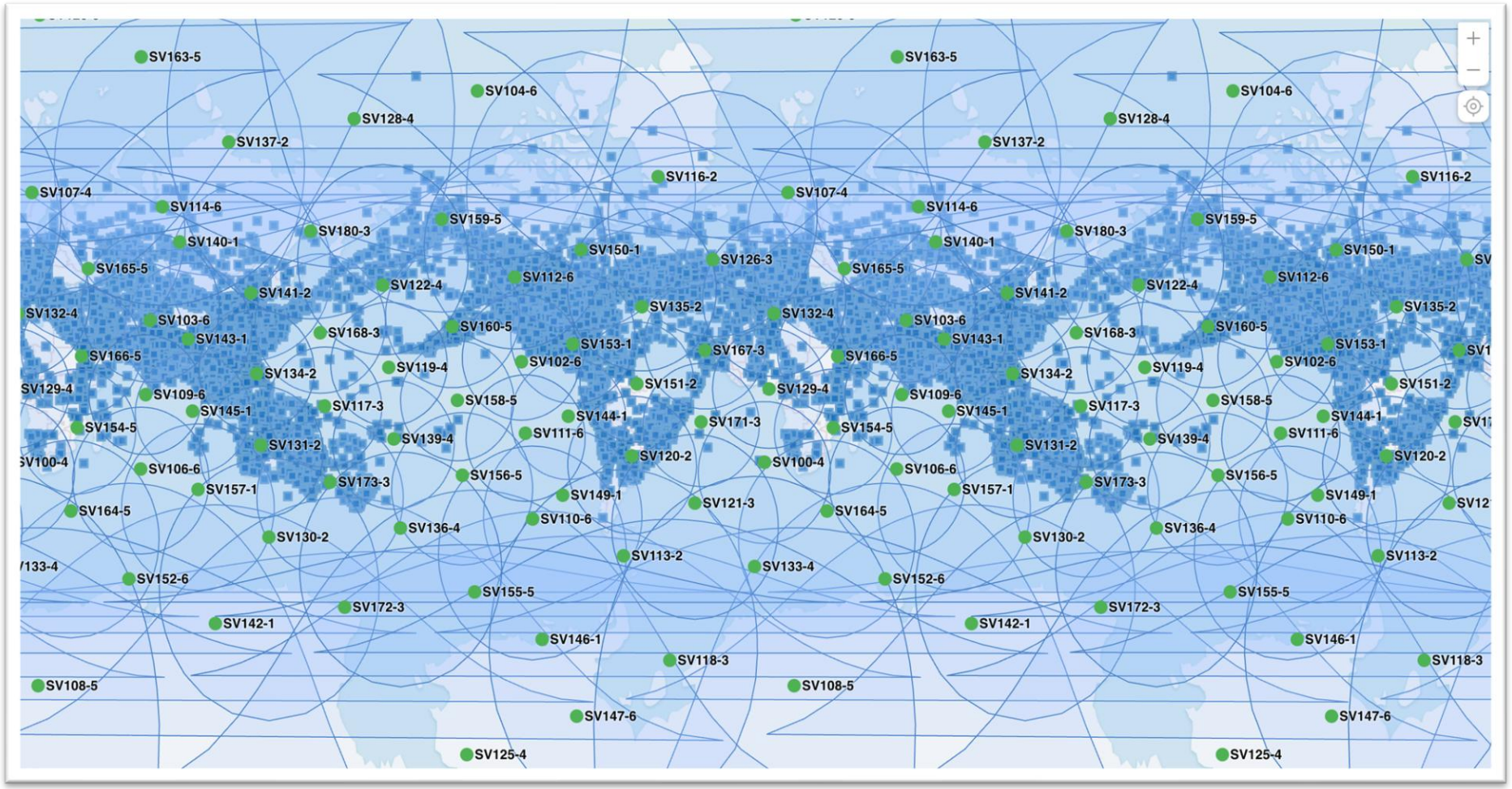
Space-based detection of ADS-B Data



- ADS-B = Automatic Dependent Surveillance - Broadcast
- Positions and velocity signals broadcast from transponders twice per second from all equipped aircraft
- Mandated for vast majority of commercial operations around the world
- Transmits on the 1090 MHz frequency; requires line of sight detection
- Space-based receivers remove topographic barriers and geographic range limitations, giving pole to pole coverage – over oceans, deserts & mountains.

Aireon’s 100% Global Space-Based ADS-B Flight Tracking Coverage

A professional, robust ADS-B receiver network, EASA certified for safety of life operations.



https://amms.aireon.com/#/world-map

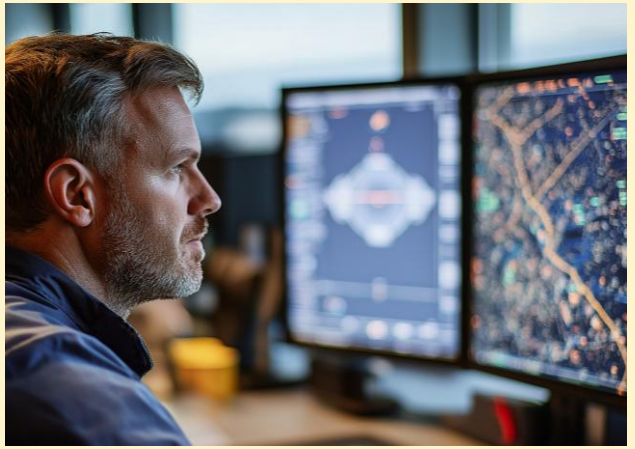
AireonVECTOR™

GPS interference detection and analysis

Continuously monitors aircraft position integrity to identify and characterize GPS jamming or spoofing events in real time.

Independent aircraft position validation

Generates GPS-independent “truth positions” using Aireon’s space-based ADS-B network and Time Difference Of Arrival algorithms to confirm aircraft locations with high confidence.



Operational resilience and continuity

Enables uninterrupted situational awareness for ANSPs, airlines, airports, and defense organizations during GPS interference events through trusted, validated tracking data.

AireonVECTOR Product Lineup

AireonVECTOR Map:

Provides global visibility into GNSS interference, spoofing, and jamming events through hourly-updated heatmaps delivered in JSON format. Enabling proactive route planning, pattern of life analysis, and crew awareness in an increasingly complex GNSS threat environment.

AireonVECTOR Monitor:

Leveraging a COTS visualization tool, AireonVECTOR Monitor provides detailed, real-time airspace data for ANSPs, allowing the users to perform detailed analytics into the sources and impacts of signal interference.

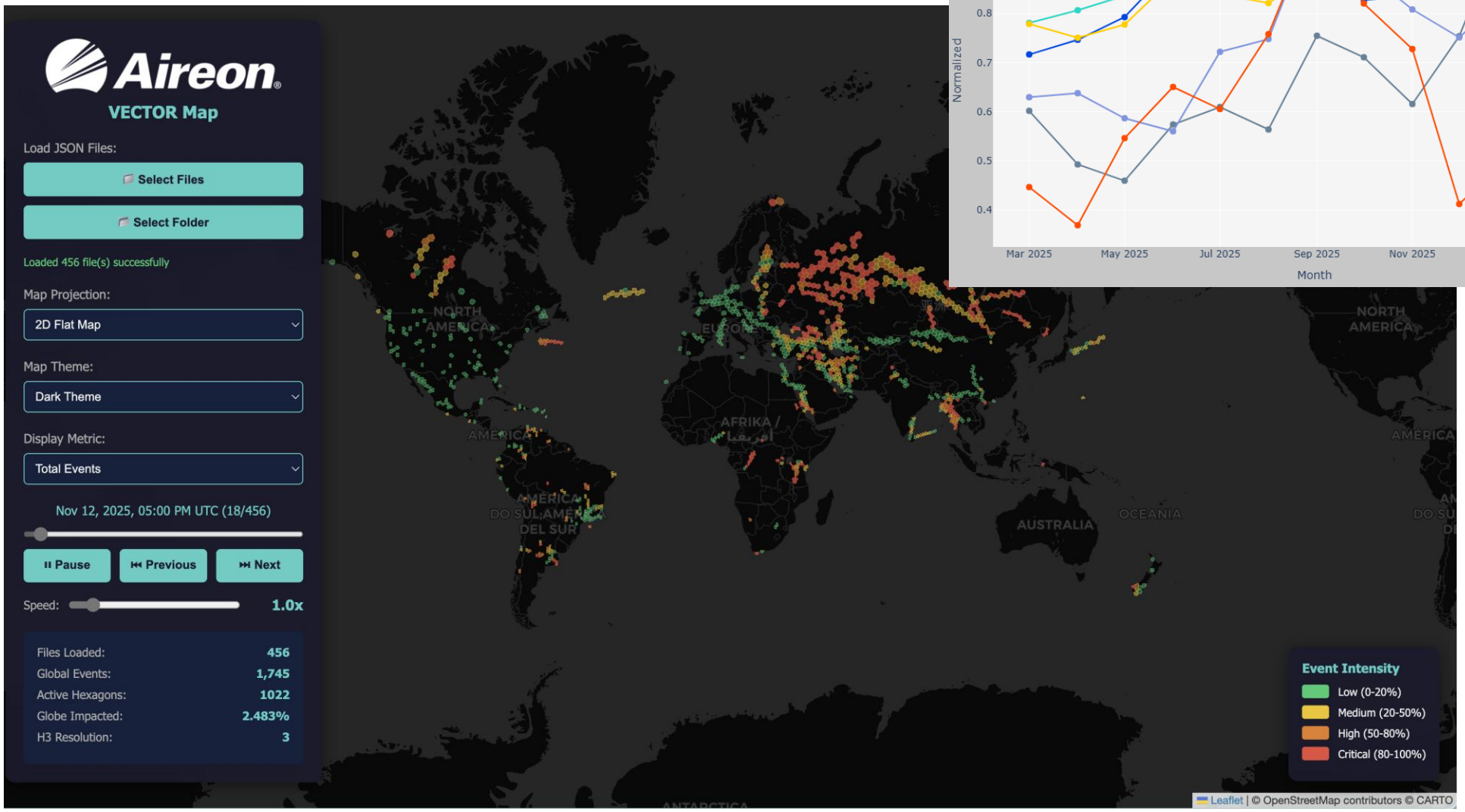
AireonVECTOR Flight:

A position track of an aircraft that is generated independent of a GPS signal. AireonVECTOR Flight generates a “truth position” of the aircraft that has its basis in the timing of satellite receipt of ADS-B transmissions to produce a location that is independent of GPS-reported position.

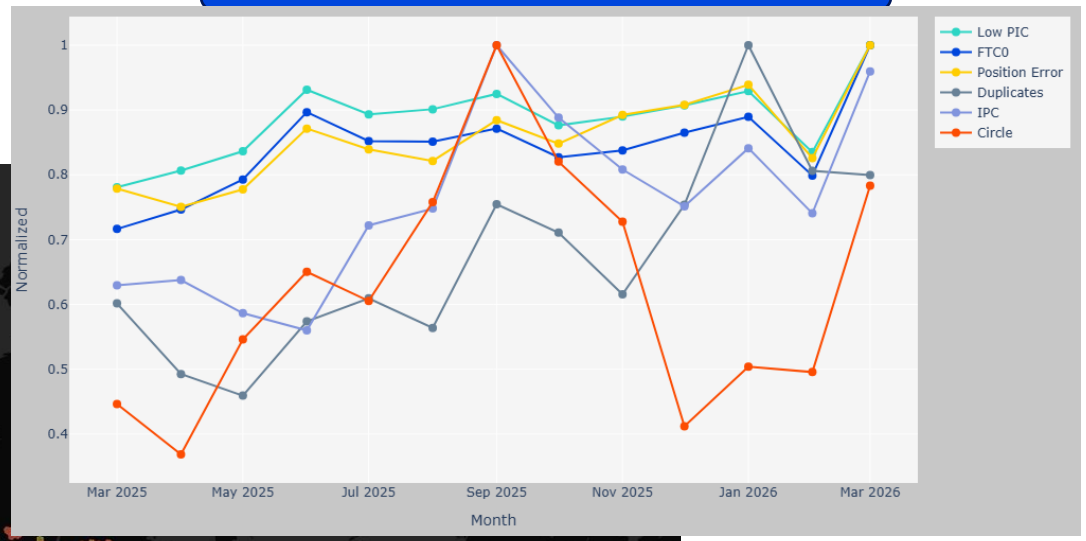
AireonSTREAM powered by VECTOR:

Aireon VECTOR enhances AireonSTREAM by providing superior flight tracks even in the presence of high interference by combining ADS-B messages received directly via Aireon’s satellite network with AireonVECTOR’s calculated aircraft positions.

AireonVECTOR Map – Visualisation



Normalized Anomaly Rates



What is VECTOR Flight?

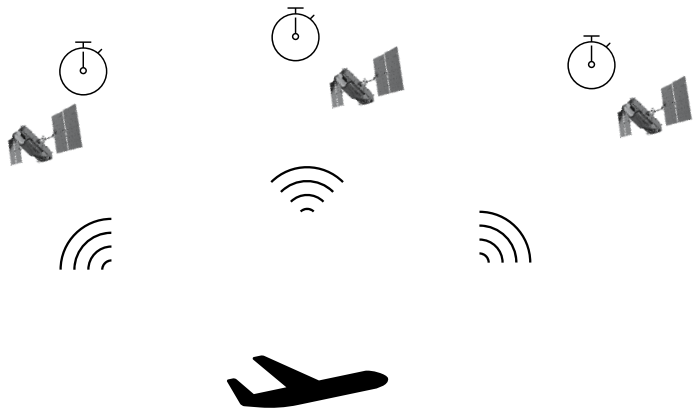
Validated aircraft location, spoofing detection, and enhanced aircraft positioning - from space

- Independent aircraft position data derived from Aireon's global, real-time satellite network with proprietary algorithms computes a "reference position" without relying on the aircraft's GPS
- Delivers: Unmatched, validated GNSS spoofing and interference detection and resilience

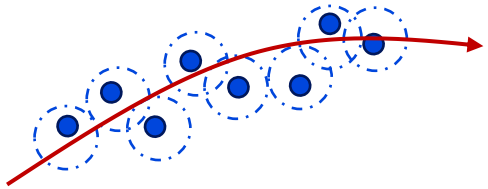
Why it matters	VECTOR delivers	What you gain
• On-board avionics are susceptible to GNSS Spoofing and Jamming. • The threat of interference is growing. Aviation must be resilient to ensure safe, efficient operations	• Proprietary algorithms derive an independent "reference position." • System automatically detect divergence between reference and cockpit-reported position—in real time.	• Immediate detection of GPS integrity degradations • Continuous surveillance in areas with high interreference • One data service scalable from single-flight alerting to fleet-wide analytics.

How does VECTOR Flight Work?

1. **Aircraft Transmits a Signal -** The aircraft's transponder emits a signal over 1090Mhz

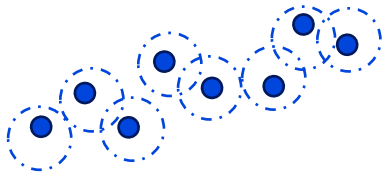


2. **Multiple Space-Based Receivers Detect the Signal**
• The signal arrives at different receivers at slightly different times due to varying distances.



3. **Time-Difference Measurements**
• Each receiver precisely timestamps the signal's arrival.
• The system calculates the time differences between multiple receivers.

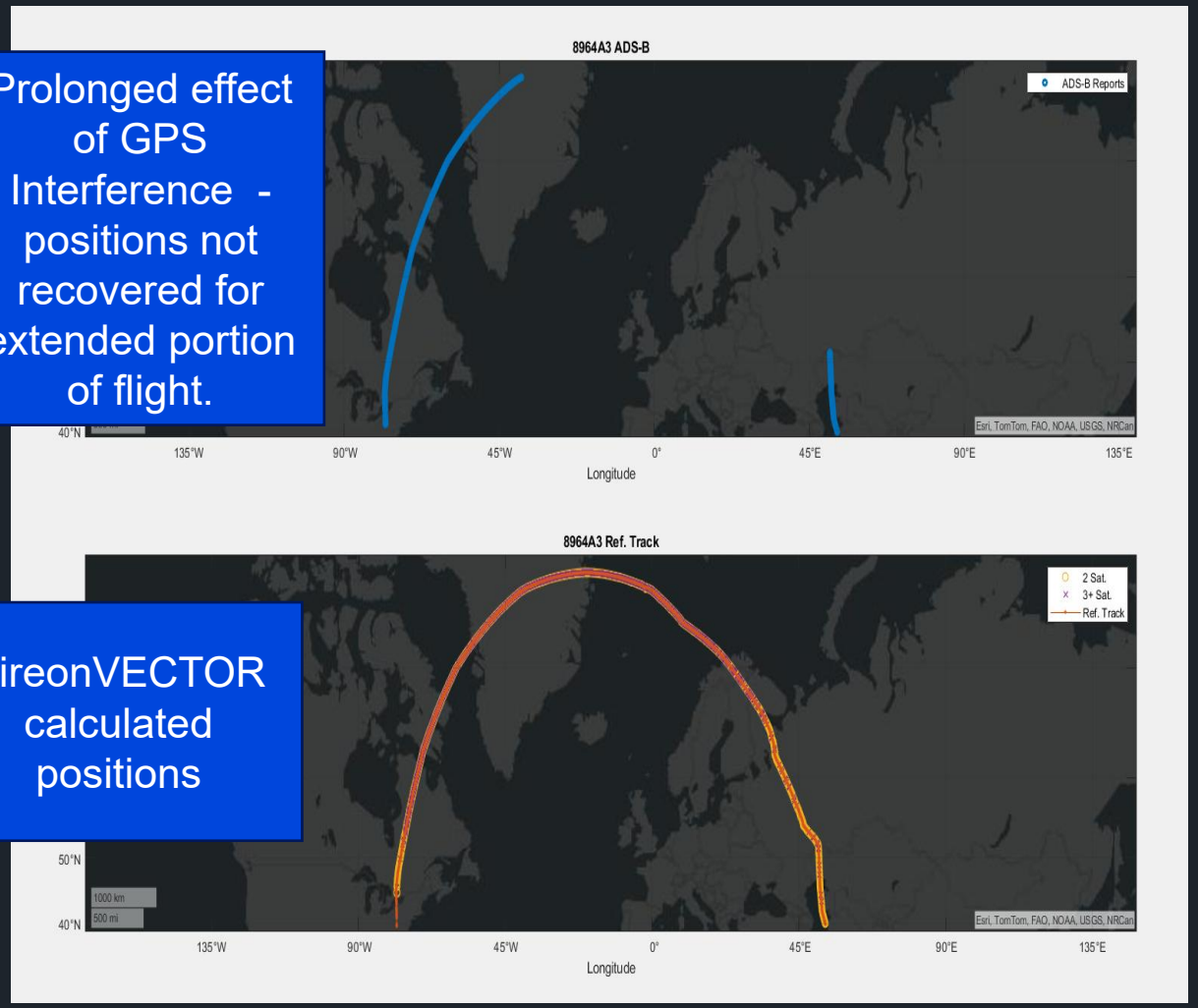
$$R = \begin{bmatrix} c^2\sigma_{t_2} + D_2(TP_{pos}T^T + R_{pos_2})D_2^T & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & c^2\sigma_{t_N} + D_N(TP_{pos}T^T + R_{pos_N})D_N^T \end{bmatrix} + (c^2\sigma_{t_1} + D_1(TP_{pos}T^T + R_{pos_1})D_1^T)$$



4. **Position Calculation Using Kinetic Modeling of Aircraft Performance**
• The TDOA algorithm uses time-difference equations to determine the aircraft's position along hyperbolic curves.
• Multiple intersections provide a precise geolocation.

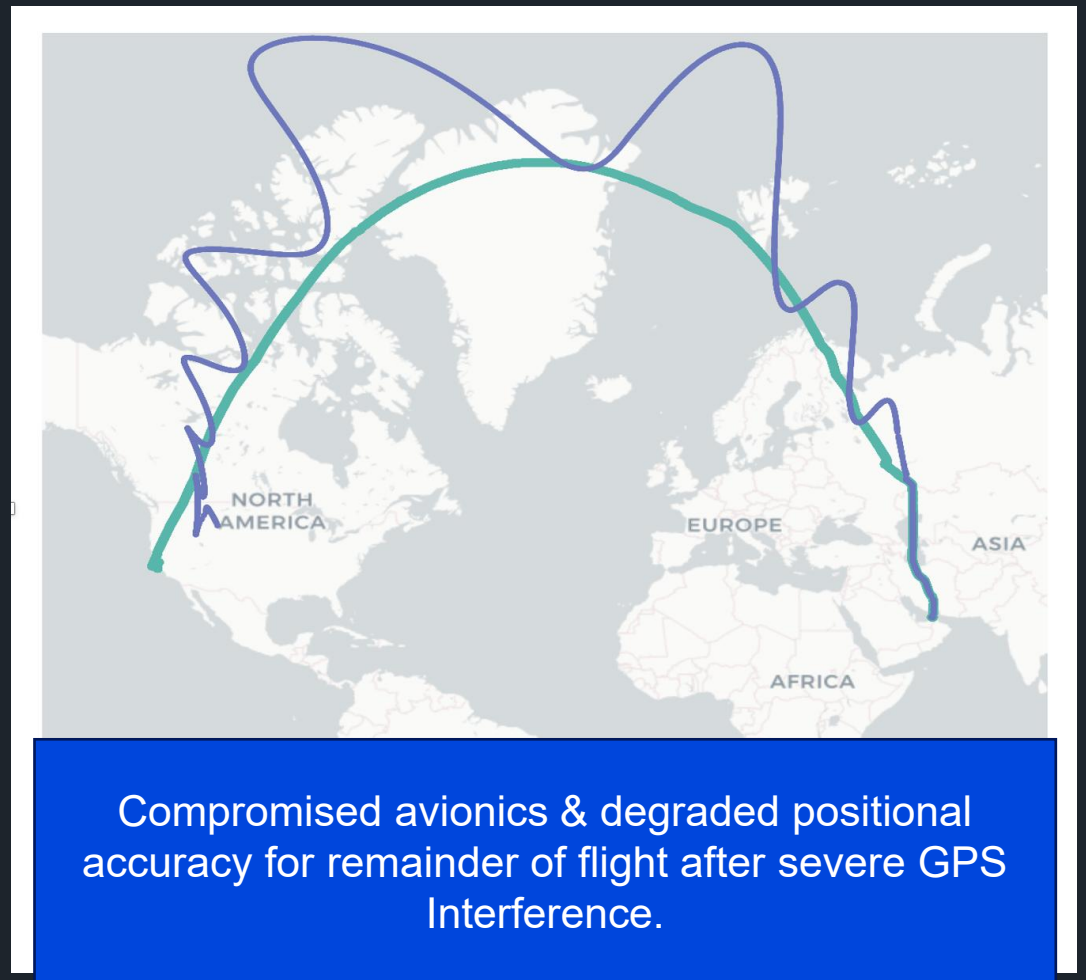
GNSS Interference: Prolonged effects and Mitigation via AireonVECTOR

Prolonged effect of GPS Interference - positions not recovered for extended portion of flight.



AireonVECTOR calculated positions

Due to Aireon's global receiver network, aircraft positions can be calculated pole to pole.

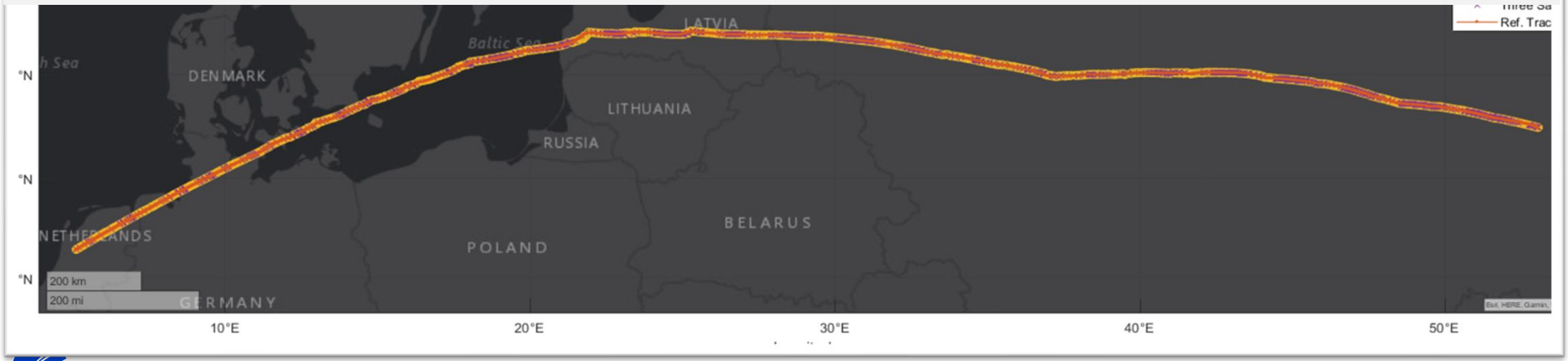


Compromised avionics & degraded positional accuracy for remainder of flight after severe GPS Interference.

AireonVECTOR Flight – in Action

Boeing 787-9, Flight from Changsha (CSX) to London (LHR)

AireonVECTOR Positions

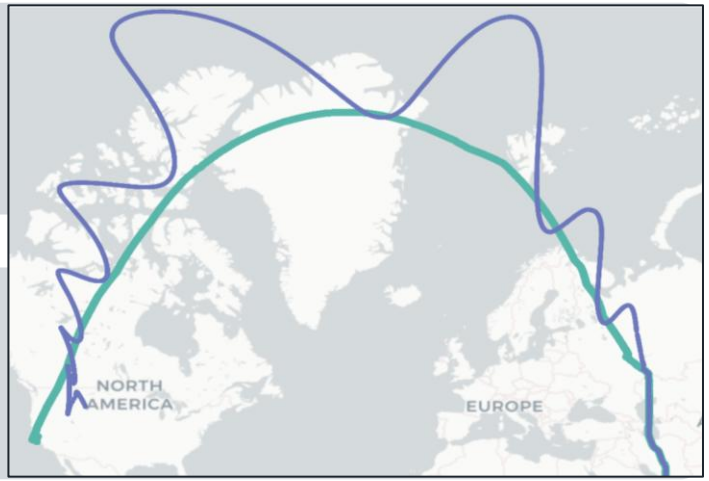


Summary

Patterns of Interference and Spoofing – Aided by Aireon data and applications – enable enhanced situational awareness and decision making

Aireon has created a series of products

To help monitor anomalies (AireonVECTOR)



Space-based sensing is advantageous

Provides “complete picture” of these events

Analysis of full fidelity collections "in real time" provides opportunity to:

- Accurately deconflict airspace
- Establish complete pattern of life analysis and alerting for anomalies
- Provide shareable indications and warning of navigation warfare events
- Enable further characterization and localization by other sensors

Thank You

Aireon.com

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