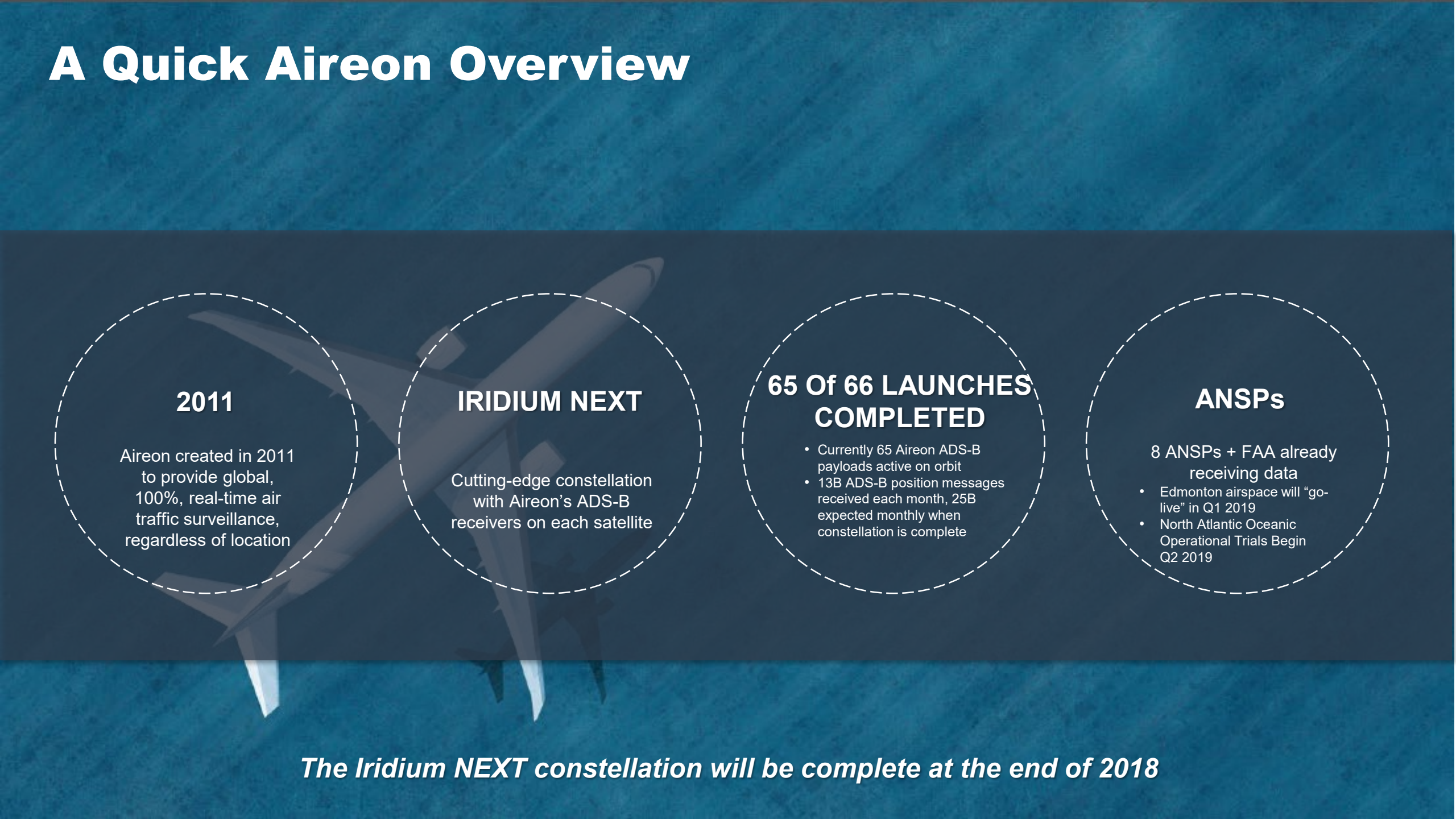
Space-based ADS-B Progress Update

ADS-B Workshop

November 2018

A Quick Aireon Overview



2011

Aireon created in 2011 to provide global, 100%, real-time air traffic surveillance, regardless of location

IRIDIUM NEXT

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

65 Of 66 LAUNCHES COMPLETED

- Currently 65 Aireon ADS-B payloads active on orbit
- 13B ADS-B position messages received each month, 25B expected monthly when constellation is complete

ANSPs

8 ANSPs + FAA already receiving data

- Edmonton airspace will "go-live" in Q1 2019
- North Atlantic Oceanic Operational Trials Begin Q2 2019

The Iridium NEXT constellation will be complete at the end of 2018

Iridium NEXT Constellation Overview

66 Total satellites in the Iridium NEXT Constellation

- 11 satellites per plane Plus
- 9 in-orbit spare satellites
- 6 ground spare satellites
- **Orbital Planes: 6**
- **Availability: ≥ 0.999**
- **Typical Lifecycle: 14 Yrs**
- **Operational Altitude: 485 miles (780 km)**
- **Final launch December 30th 2018**
- **Operational 1Quarter 2019**

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Customers – November 2018

- Current ANSPs customers:
  - ASECNA: Agency for the Safety of Air Navigation Africa and Madagascar
  - ATNS: South Africa
  - CAAS: Singapore
  - eNAV: Italy
  - NAV CANADA
  - Naviair: Denmark
  - Dutch Caribbean
  - UK NATS
  - Irish Aviation Authority (IAA)
  - Seychelles CAA
  - Isavia: Iceland

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Aireon Safety Certification

- Aireon organisation designed with safety in mind. Its majority owners are ANSPs!
- Aireon Safety Management System
- EASA Regulator Certification as Surveillance Service Provider
- EASA Regulator ongoing oversight of
  - System &
  - Organizational and functional aspects
    - Financial, Management, Safety management
    - Methods, Procedures, Competency
    - Software Assurance and System Verification
    - Contingency, reporting, ICAO standards

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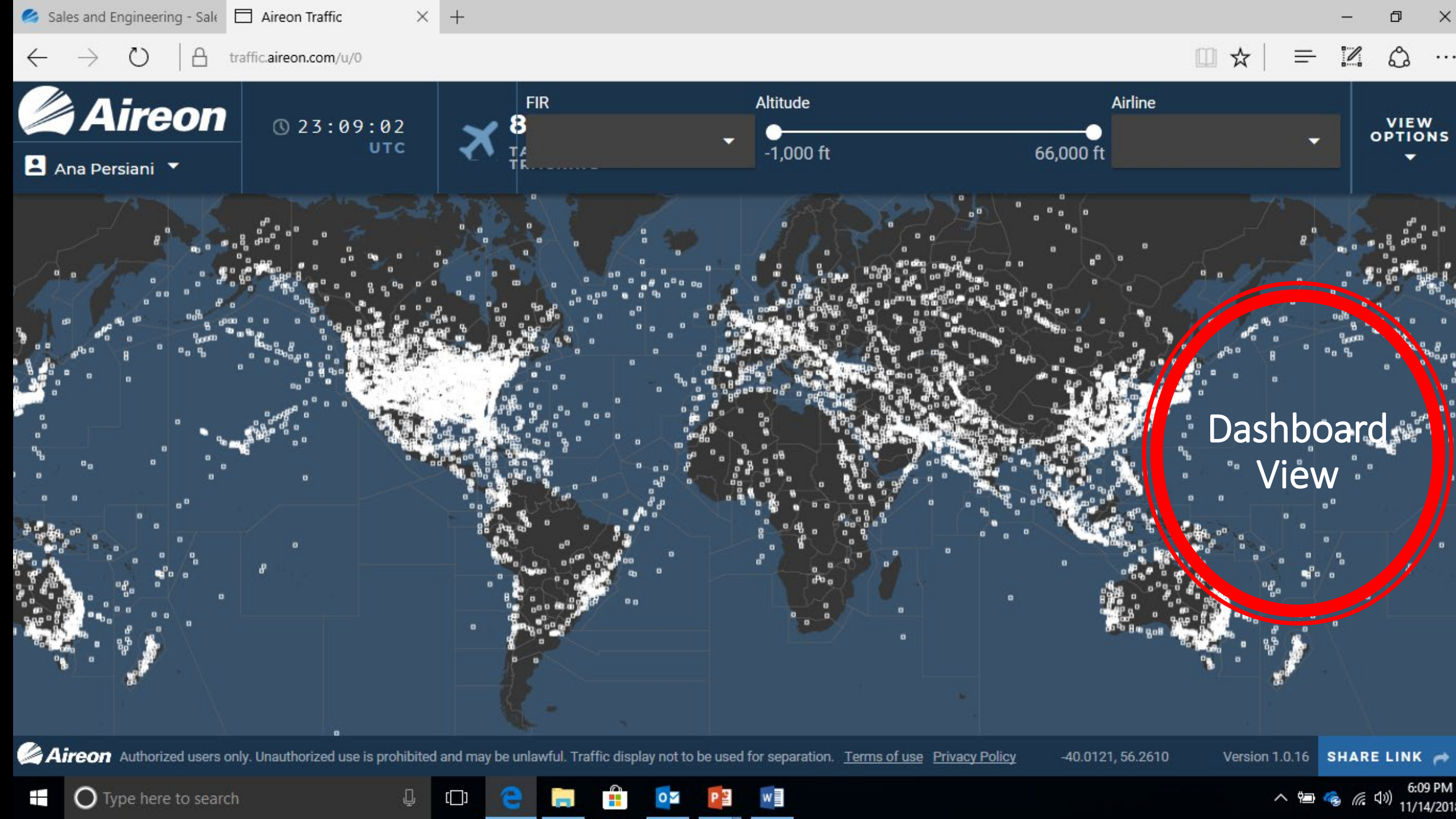
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Authorized users only. Unauthorized use is prohibited and may be unlawful. Traffic display not to be used for separation.
Terms of use
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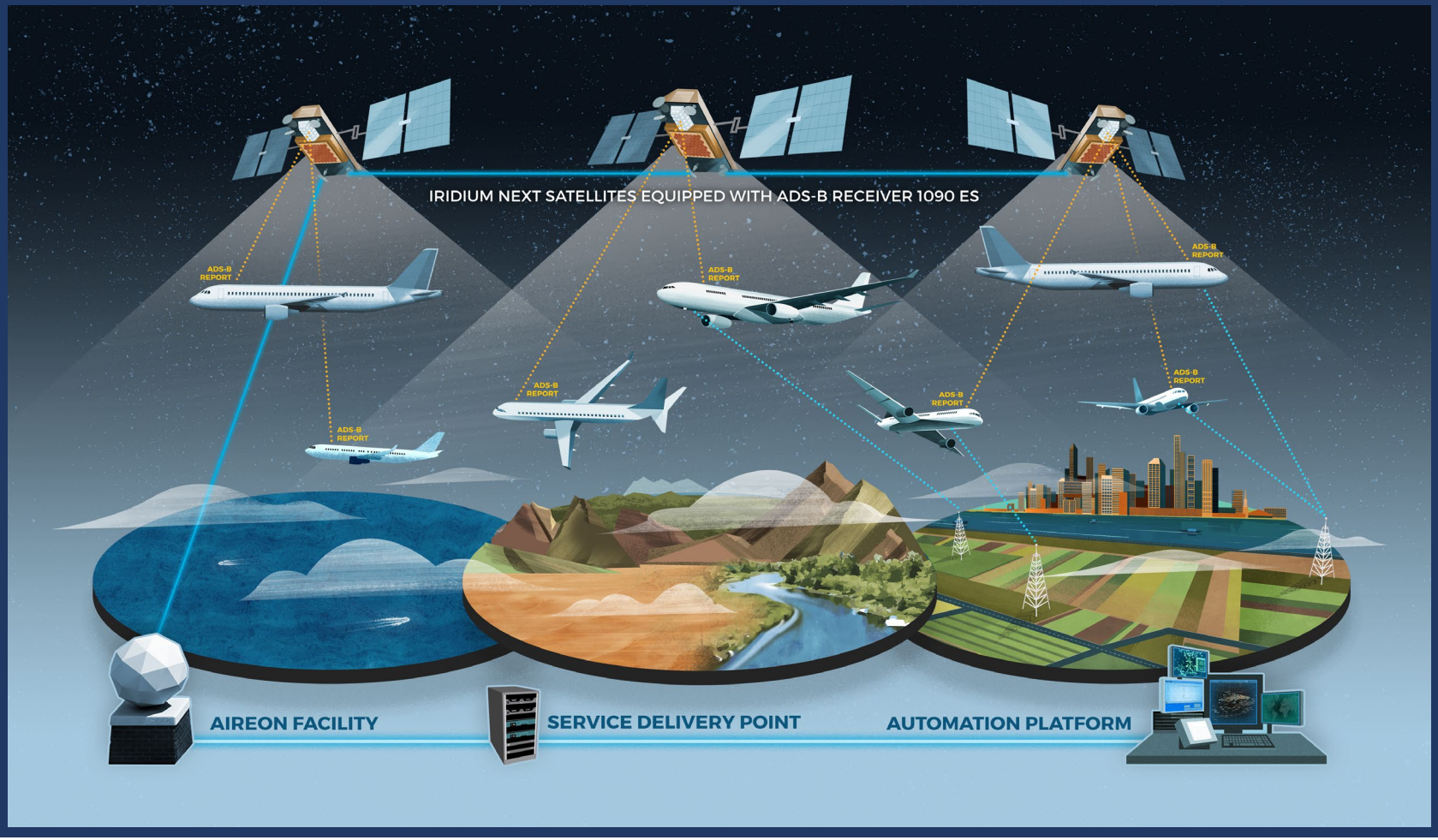
Aireon – ATS Grade Data Services Agreement



Augments current Radar Systems with oceanic and remote air space coverage.

Delivers true pole-to-pole Global Coverage with 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

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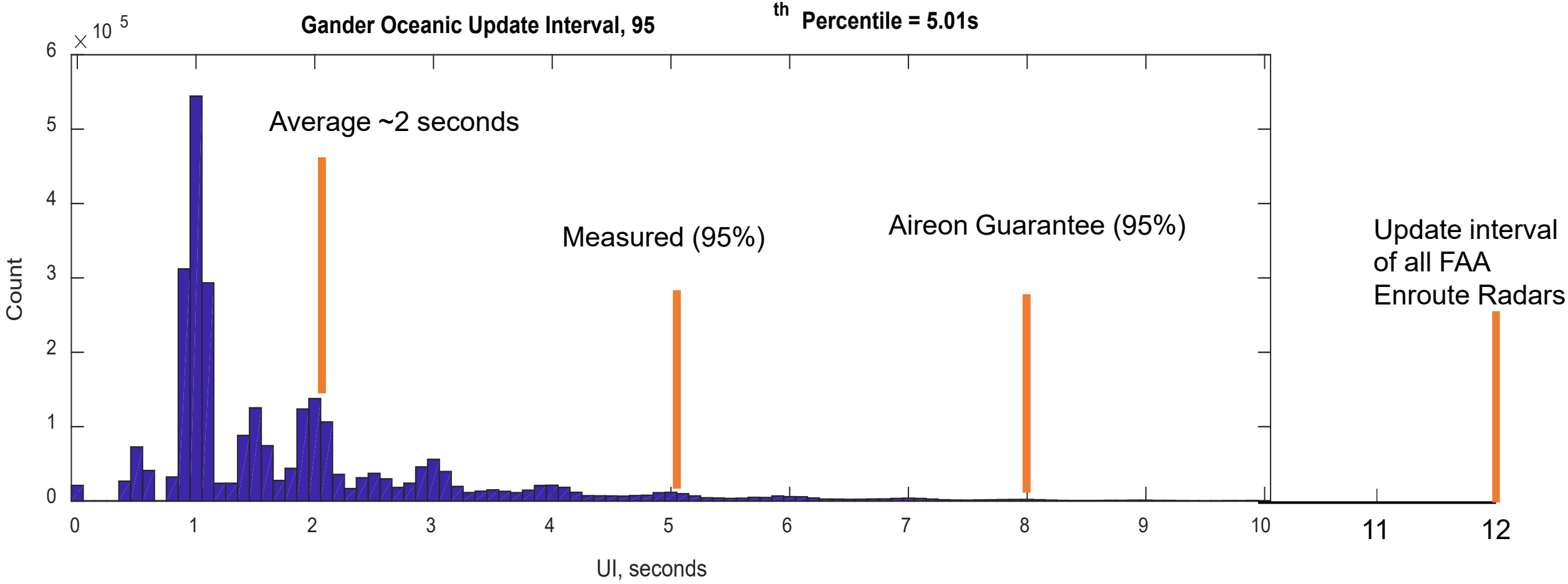
Measured Performance - Update Interval (in seconds)



* Using 44 out of 66 payloads and pre-operational constraints. Expected to further improve

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Aireon Alert (**Free Service**)

- Registration now open
- https://aireonalert.com/ & https://aireon.com/2018/08/22/aireon-alert-now-open-pre-registration/
- Aireon ALERT will only be able to provide data in an emergency situations to preregistered stakeholders

Aireon – GlobalBeacon

- GlobalBeacon is a first of its kind product from Aireon and FlightAware.

- As a turnkey solution for compliance with the International Civil Aviation Organization (ICAO) Global Aeronautical Distress Safety System (GADSS).

- GlobalBeacon enables airlines of all sizes to proactively positions themselves to respond in the event of an emergency.

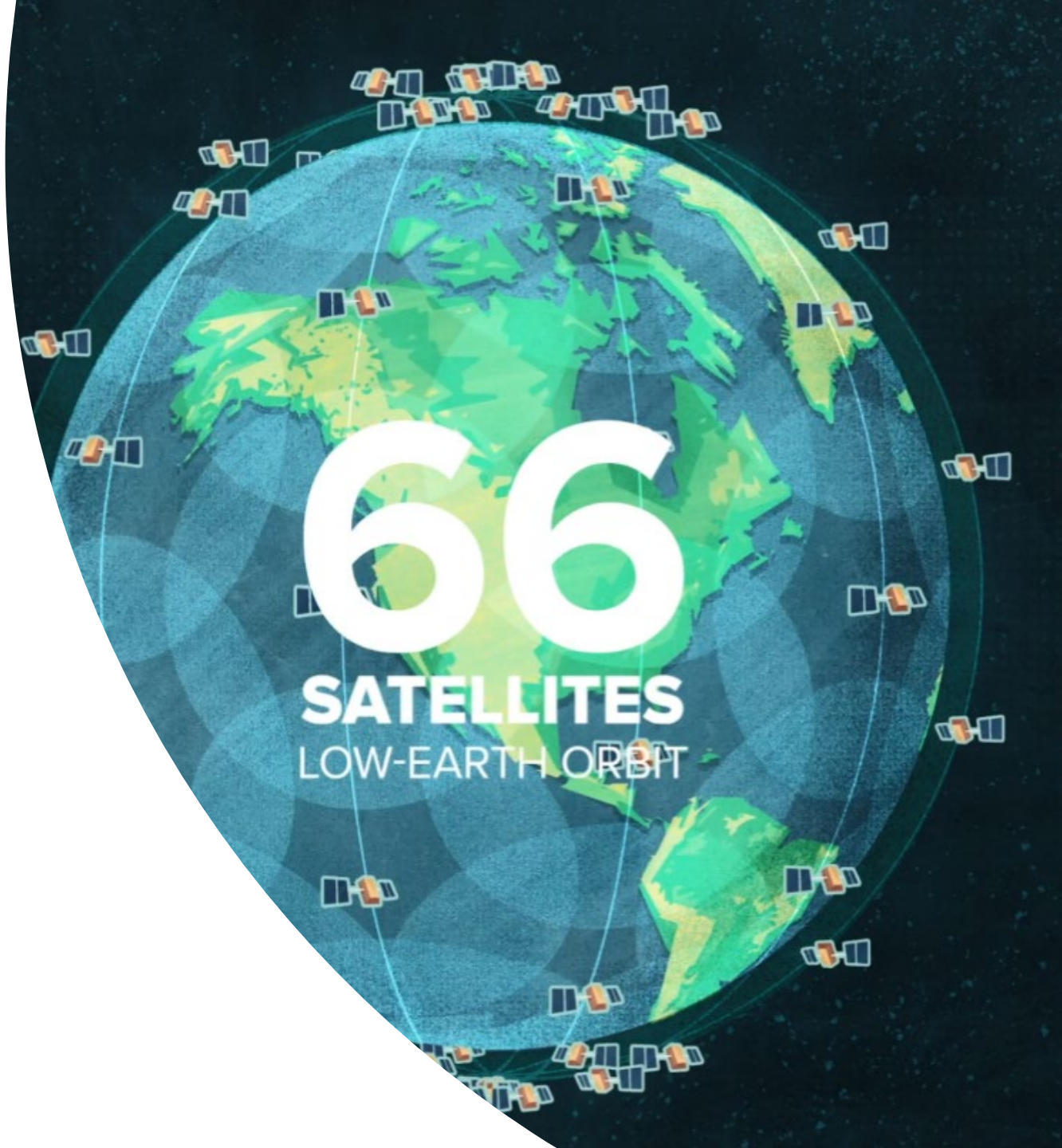
- GlobalBeacon exceeds GADSS standards and recommended practices and facilitates communication between aircraft operator and controller with constant fleet monitoring, automated distress alerts and tools that make it easy to share information.

How will GlobalBeacon work?

- 4D position information reported at a standard interval of at least once-per-minute.
- 100% global coverage for monitoring aircraft anywhere in the world.
- Automatically generates logs with 4D positions for aircraft in distress or potential distress.
- Does not require additional avionics or equipment for aircraft equipped with
- 1090MHz ADS-B OUT and a top mounted antenna.
- Works in conjunction with existing processes and tools commonly used by operators.
- Facilitates communication between operator and ATC with constant fleet monitoring, automated distress alerts and tools that make it easy to share information when needed.
- Transcends borders and Flight Information Regions (FIRs), including polar airspace.
- Easy to deploy and/or provision to any third party on behalf of the operator.

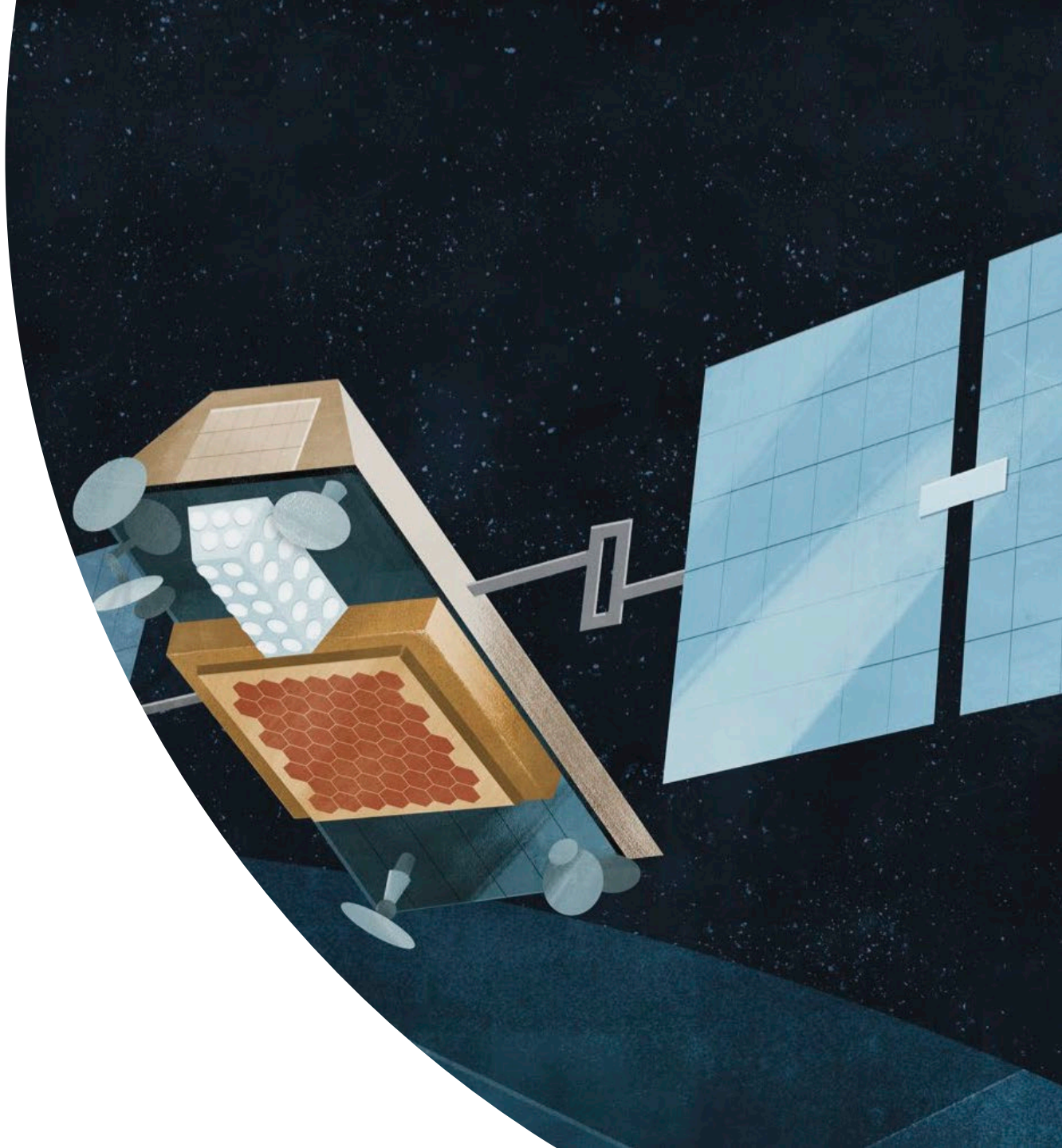
Test 1 – Independent validation of aircraft position via Space-based ADS-B.

- A risk that needs to be overcome by States and ANSPs in any ADS-B system used for separation services is the ability to verify the quality of the data being delivered.
- Incorrect or misleading surveillance information provides hazardous and misleading information to air traffic controllers. In the case of terrestrial systems, validation can be done through comparison to radar, WAM, or other surveillance sources. In the oceanic case however, this is not possible.



Test 1 – Independent validation of aircraft position via Space-based ADS-B.

- Aireon receives Precision Timing and Position (PTP) messages for both timing and satellite position to perform the Time Difference of Arrival (TDOA) calculations.
- Aireon has incorporated TDOA into a position validation algorithm allowing for verification of an aircraft's reported position independent of GNSS.
- This independent validation algorithm augments Aireon's surveillance system to be resistant to spoofers (devices that are intentionally transmitting incorrect positions), faulty avionics, and GNSS outages.
- Initially, the independent position check (IPC) flag in the CAT021 will be set based on a containment exceedance value of 5 NM.
- Closer validation values (e.g. 0.56 NM or even 0.2 NM) are being tested with very encouraging results allowing for WAM



Space-Based WAM

- Wide Area Multi-Lateration (WAM) allows for the determination of a transmitter's location using Time Difference of Arrival (TDOA)
- To form a fully independent two-dimensional solution you need a minimum of three receivers
  - Each TDOA gives you one observation to solve for one unknown
- WAM find the position of any aircraft regardless GPS and transmitted ADS-B data
  - As long as it transmits its identity, its position can be found
- Given the expanded coverage footprint the majority of the Earth's surface is covered by 3+ satellites
- The constant motion of the satellites also means that all regions will get 3+ satellite coverage over time
- This feature will be delivered to customers in 2020

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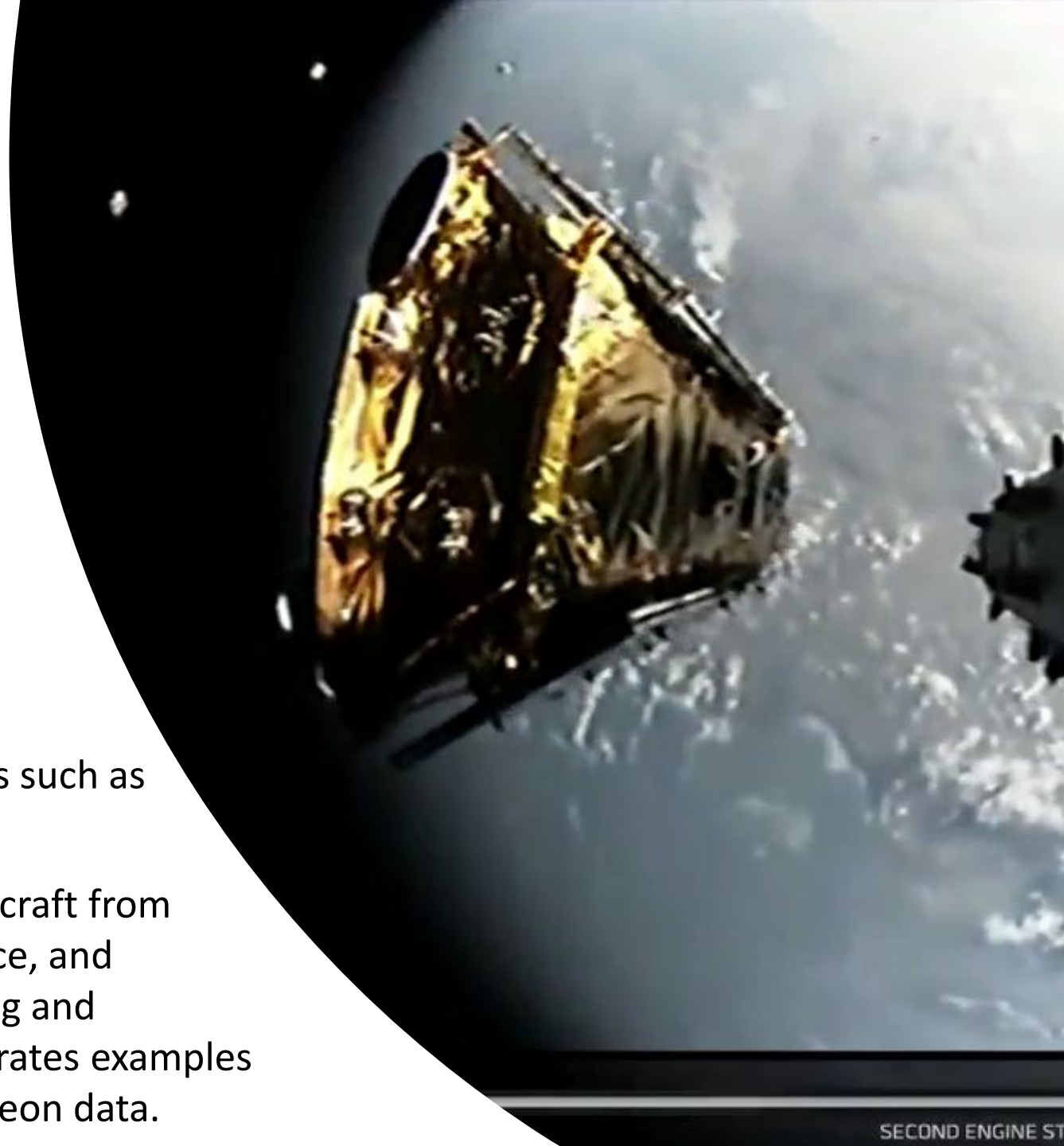
Test 2 – Using Space-based observations in identifying ACAS advisories and aircraft avionics anomalies



Aireon's nearly complete deployment of 66 payloads on the Iridium NEXT constellation has enabled global surveillance of tens of thousands of aircraft for the first time. As ADS-B equipage rises and mandates are enacted in regions around the world, observations of anomalies and outliers have increased.

Aireon is preparating a report to governing bodies such as (EASA), EUROCONTROL, the US FAA, and ICAO.

The study outlines examples of non-compliant aircraft from Aireon data, methods of detecting non-compliance, and proposes the implementation of global monitoring and reporting for regulatory agencies and it also illustrates examples of preventative and corrective TCAS RAs using Aireon data.

Test 2 – Using Space-based observations in identifying ACAS advisories and aircraft avionics anomalies

- The use of Aireon's global ADS-B dataset has uniquely enabled the compilation of both RAs and anomaly information into a single view and analysis context.
- Civil cooperative surveillance requires all actors to adhere to a set of MASPS - Minimum Aviation System Performance Standards and MOPS - Minimum Operational Performance Standards, ensuring safe and seamless operations and data exchange.
- Aireon is an active part of the aviation community and plans to offer additional services and applications in support of achieving higher levels of global interoperability.

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Test 3 – On-orbit tests and characterizations to validate technical performance metrics

- Technical Performance Metrics (TPMs):
  - **Availability:** The overall risk was contained, such that a service volume availability of ≥ 0.9999 is achievable even for areas near the equator;
  - **Latency:** Latency characteristics of 345 ms (99%) are clearly well within the same domain as terrestrial surveillance systems and in some cases faster;
  - **Update Interval**: The combined UI performance was observed to provide a seamless continuity of service from en-route (8s) to terminal/approach (5s) to surface (although surface would require a UI of 1s).

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Aireon: An Innovative Business Model

No significant project / lead time to establish full airspace coverage

- It's just ADS-B
- Global coverage in 2018

Hosted payload reduces costs

No major upfront investment requirements for ANSP's

By ANSPs for ANSPs

Pay per use, versus traditional depreciation model

Airline benefits from surveillance will significantly outweigh costs

No ground-based infrastructure

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Thank you!

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