SP405 – Application of Space-based ADS-B to Air Traffic Management & ATFM

ICAO ATMS Symposium Nanjing November 2018

A Strategic Partnership with AIREON

Space-based ADS-B

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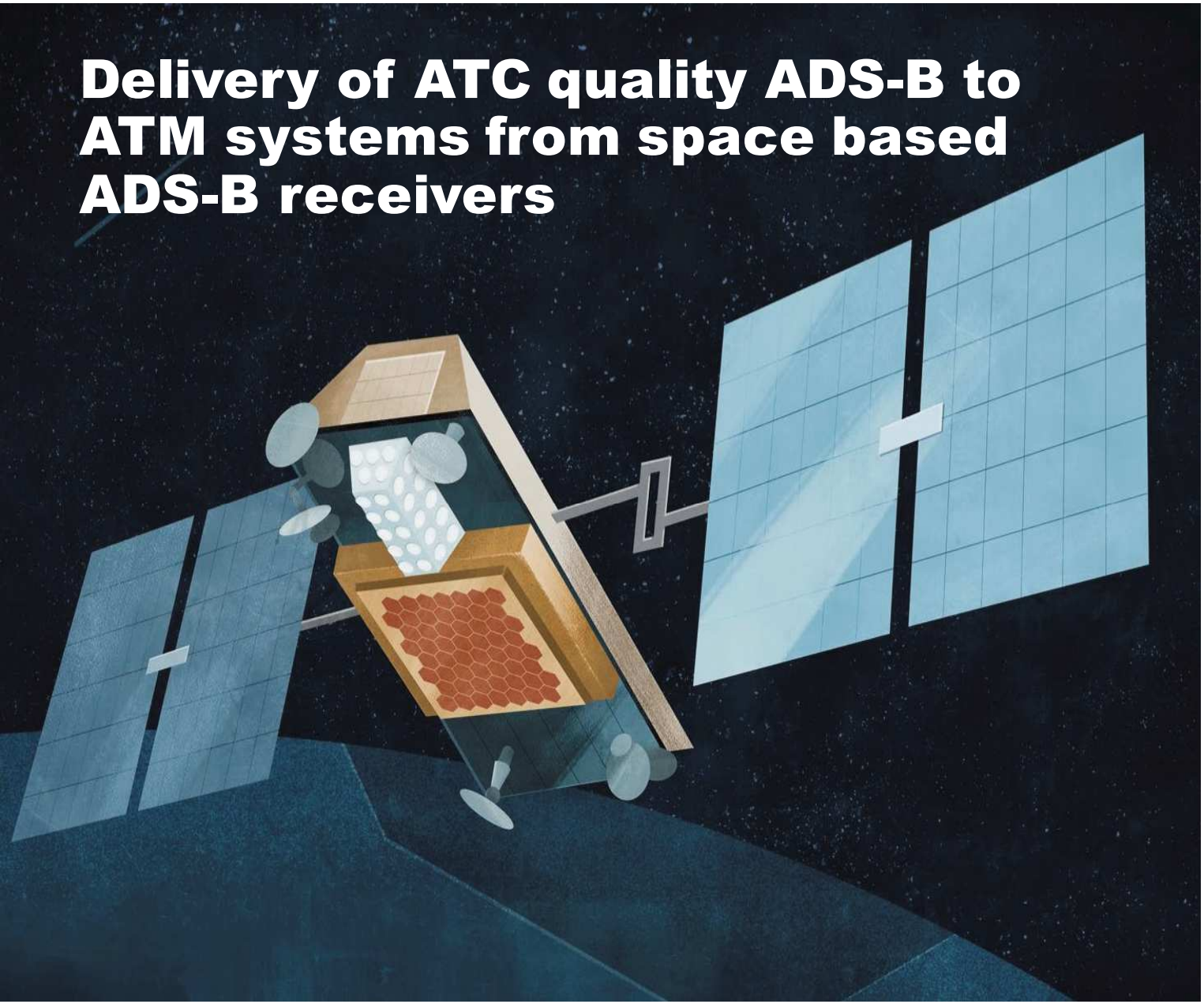
Delivery of ATC quality ADS-B to ATM systems from space based ADS-B receivers



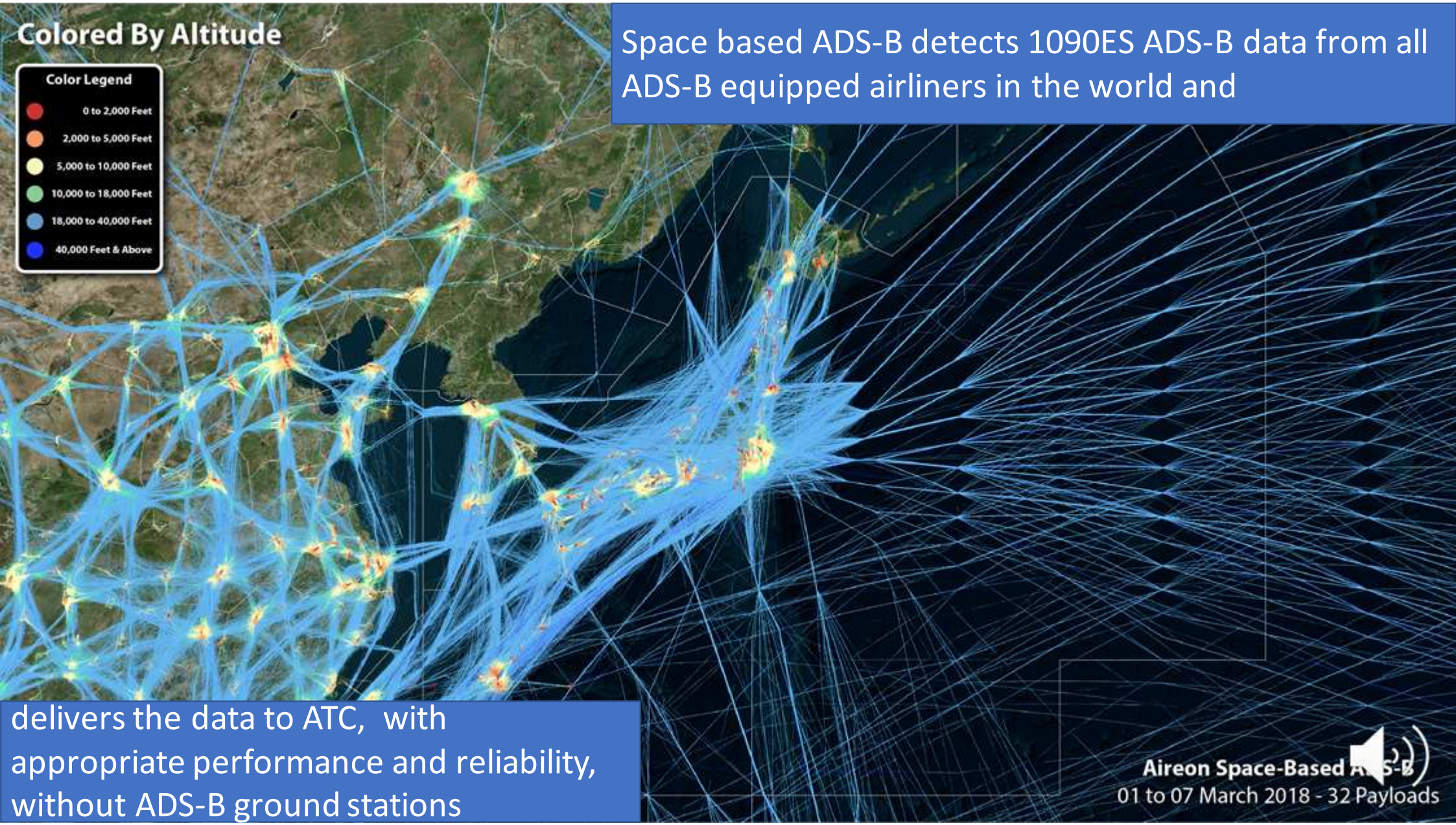
- Surveillance – everywhere!
- Reliability : Fully redundant and fault tolerant design
- Low latency & short update interval
- System design to ensure cyber security hardness
- Will be certified by EASA
- Independent of terrestrial constraints – weather outages, power, malicious acts and natural disasters

Designed as an ATC surveillance system

Aireon

Surveillance as a Service v. conventional ownership

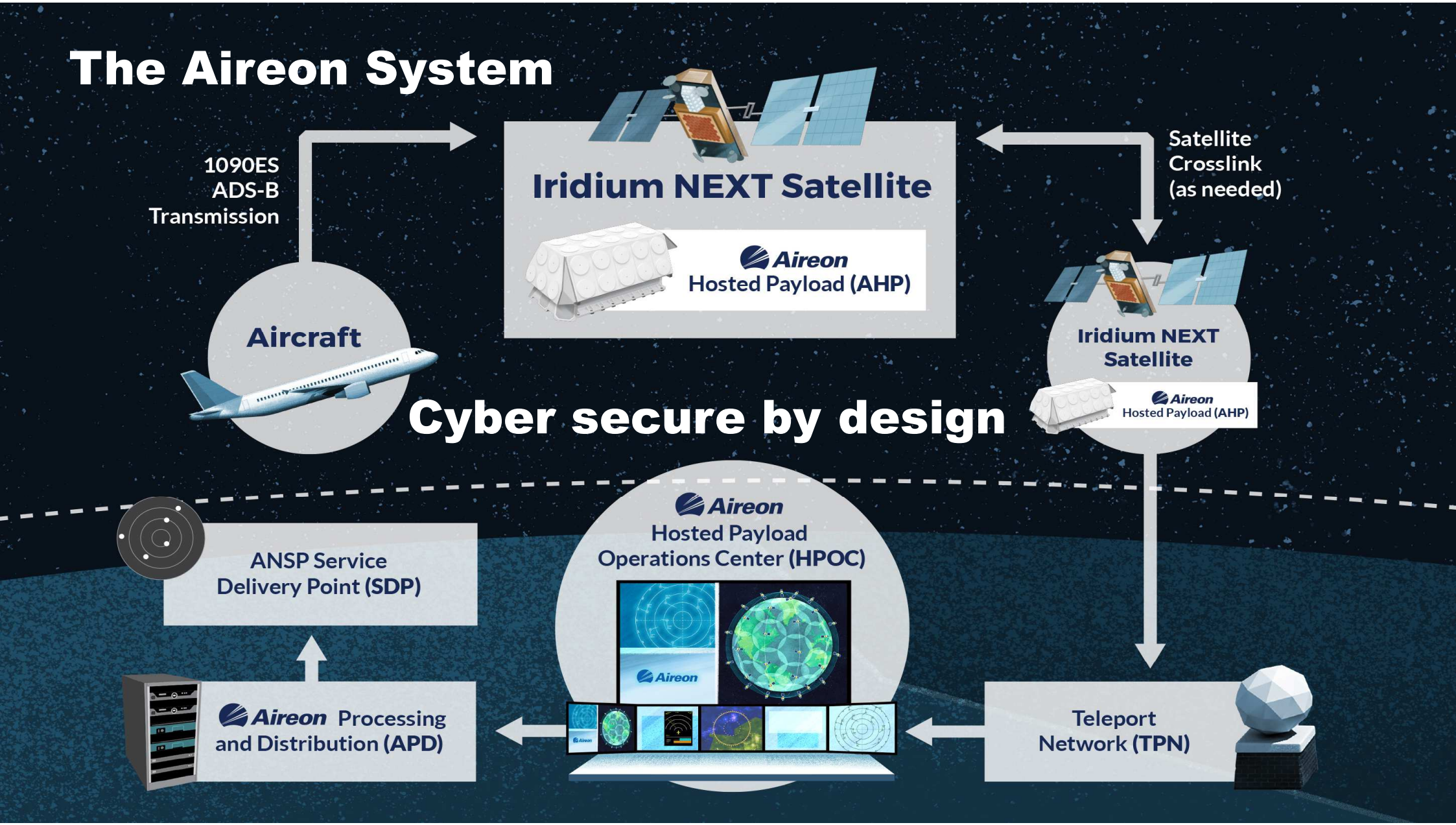
Service model	*Ownership model*
System installation	
Flexible deployment	Time consuming
System support	
Support off site by AIREON	Manually intensive maintenance
Payment structure	
Limited up front capital	High up front capital costs
Total cost of ownership	
Low initial cost, known ongoing cost	High initial costs & uncertain maintenance cost
Technology longevity	
Rapid technology evolution	Shorter time to technology obsolescence
Cyber security	
Cyber security hardness	Multiple vulnerabilities

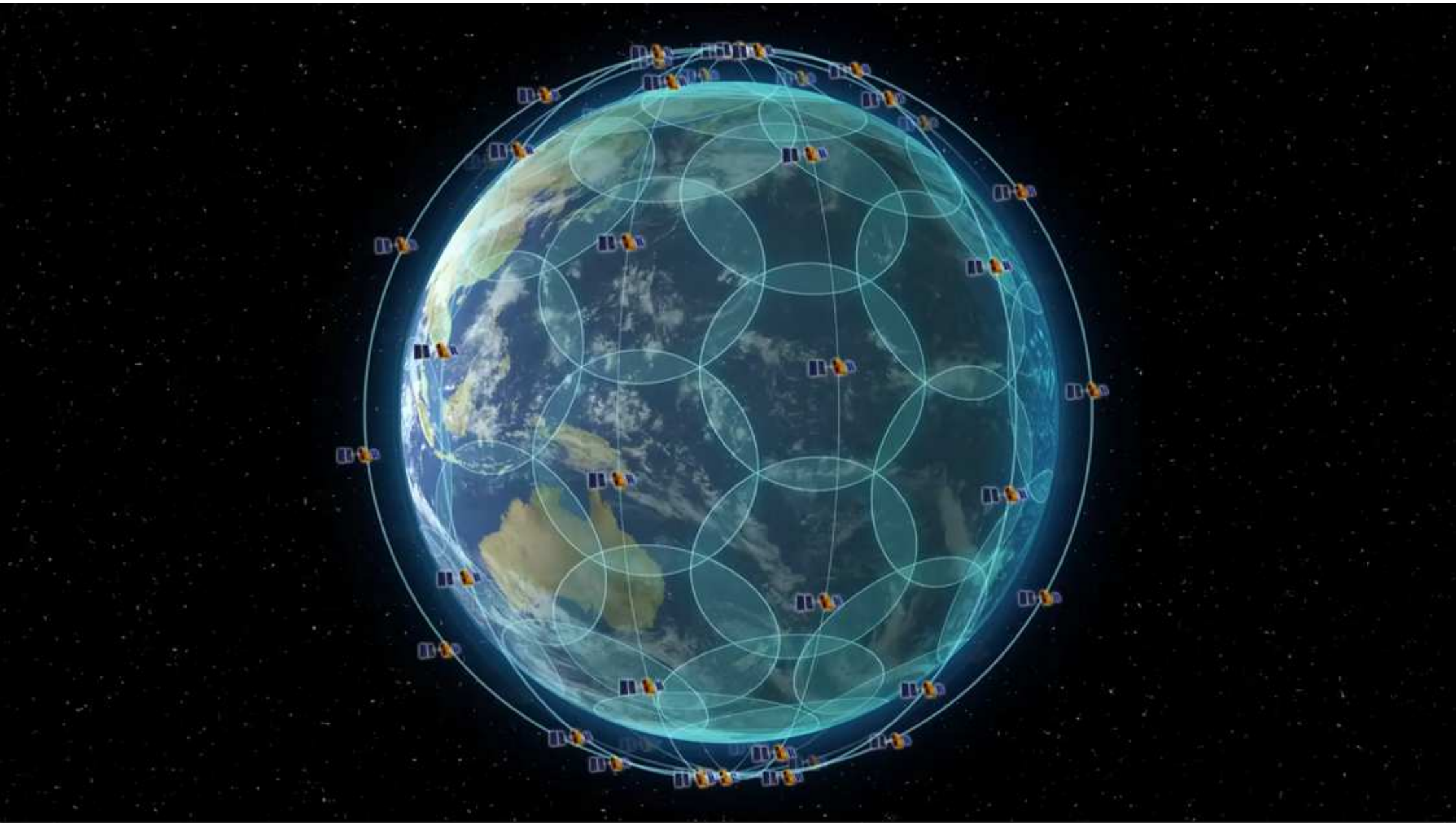


Space based ADS-B detects 1090ES ADS-B data from all ADS-B equipped airliners in the world and

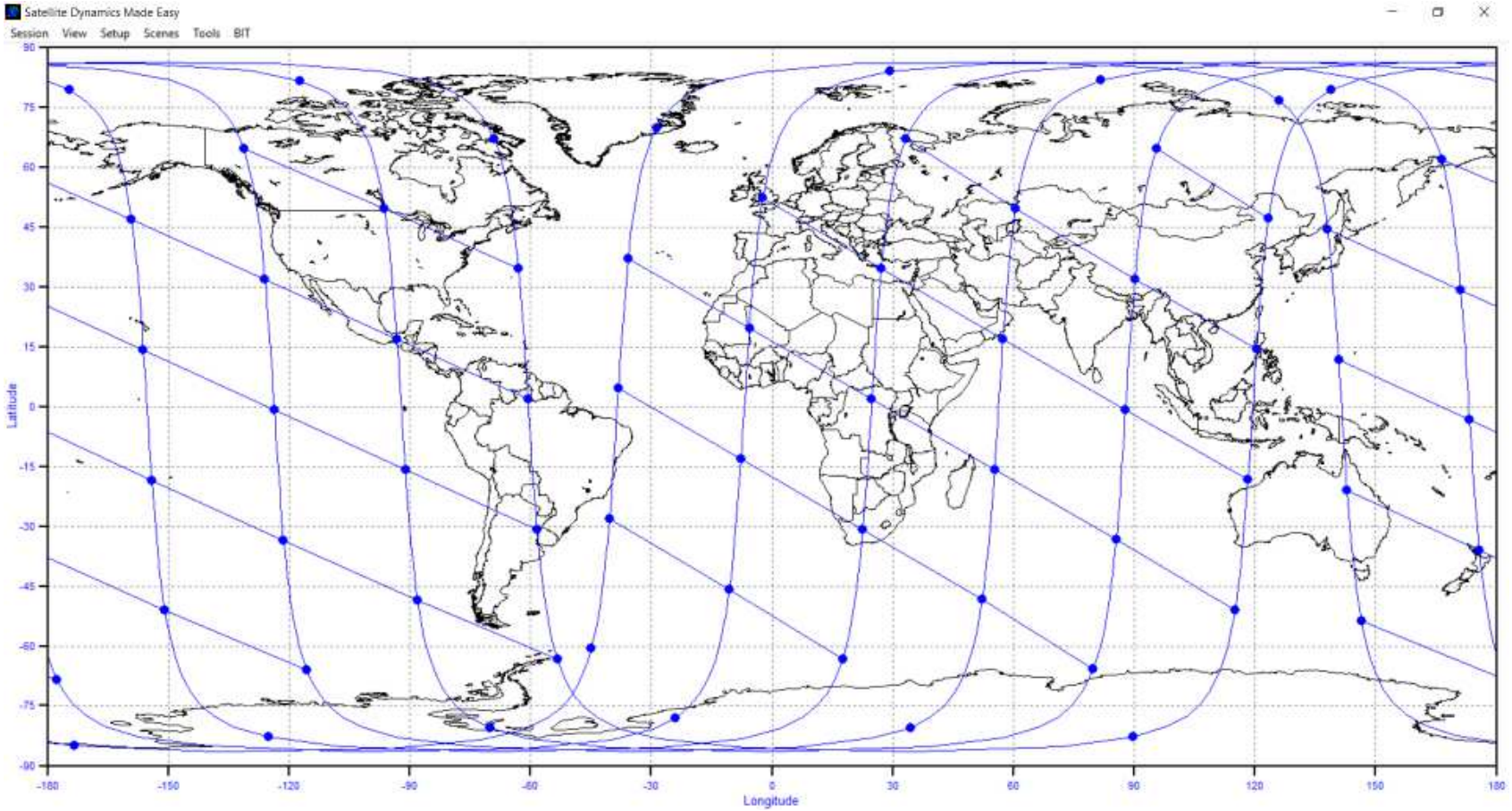
delivers the data to ATC, with appropriate performance and reliability, without ADS-B ground stations

The Aireon System



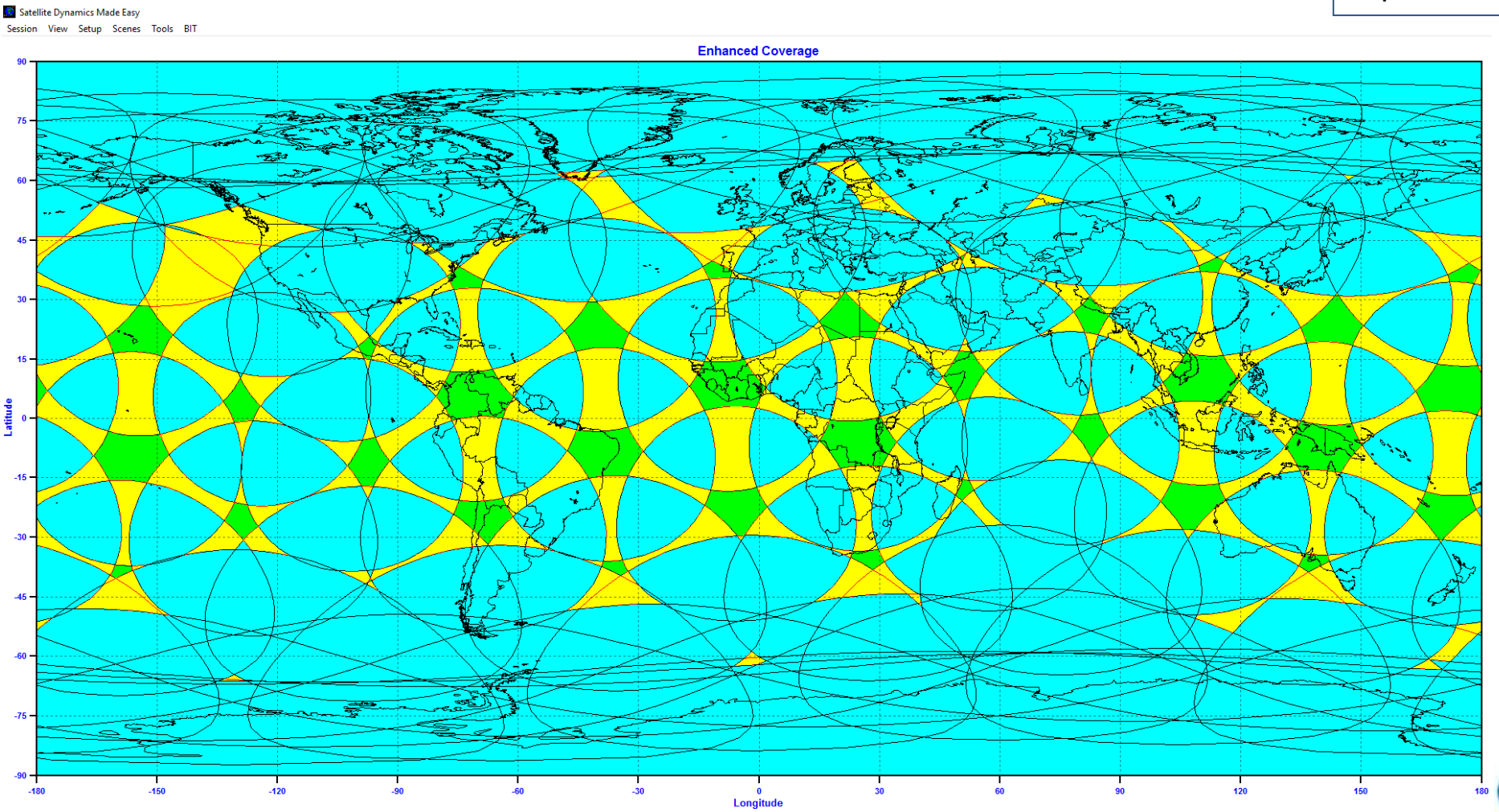


Iridium NEXT Crosslinks – The Mesh Network



Final Satellite footprint

Single Coverage
Double Coverage
Triple Coverage



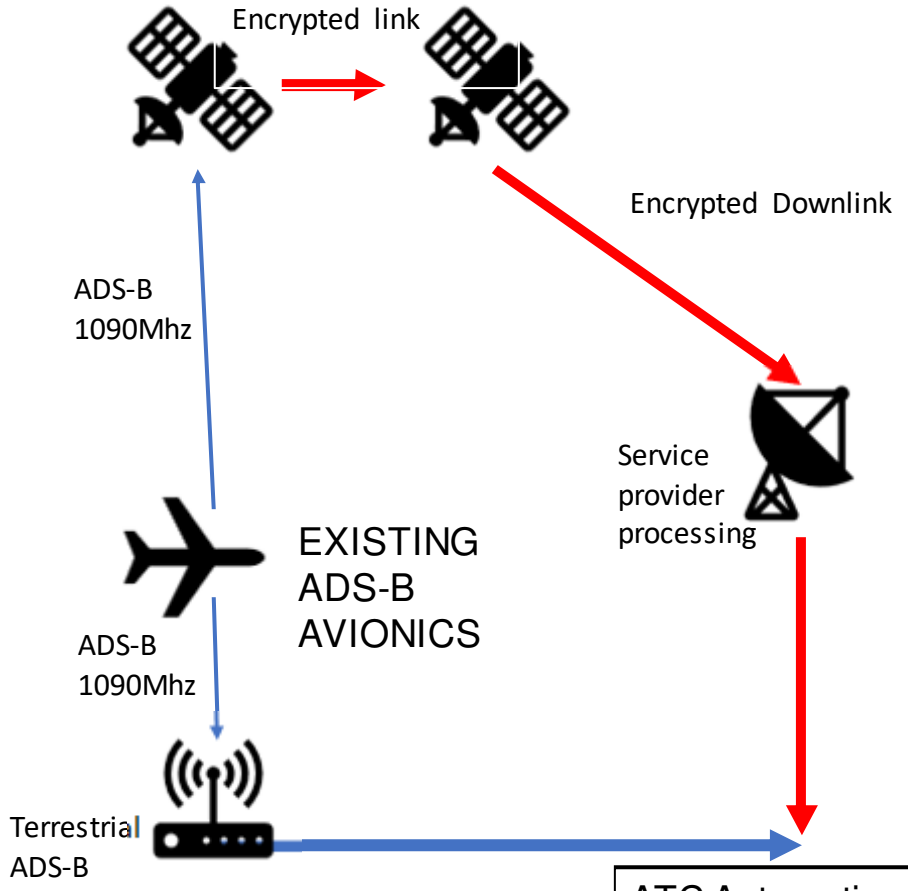
Certification as ATS Surveillance provider

- AIREON System (Technology and Organization) will achieve Certification from European Aviation Safety Agency (EASA) as an ATS surveillance provider
- For non European Regulators this Certification gives confidence
- Local ANSP still needs to complete implementation Safety Case for their Regulator

Interface to ATM Automation

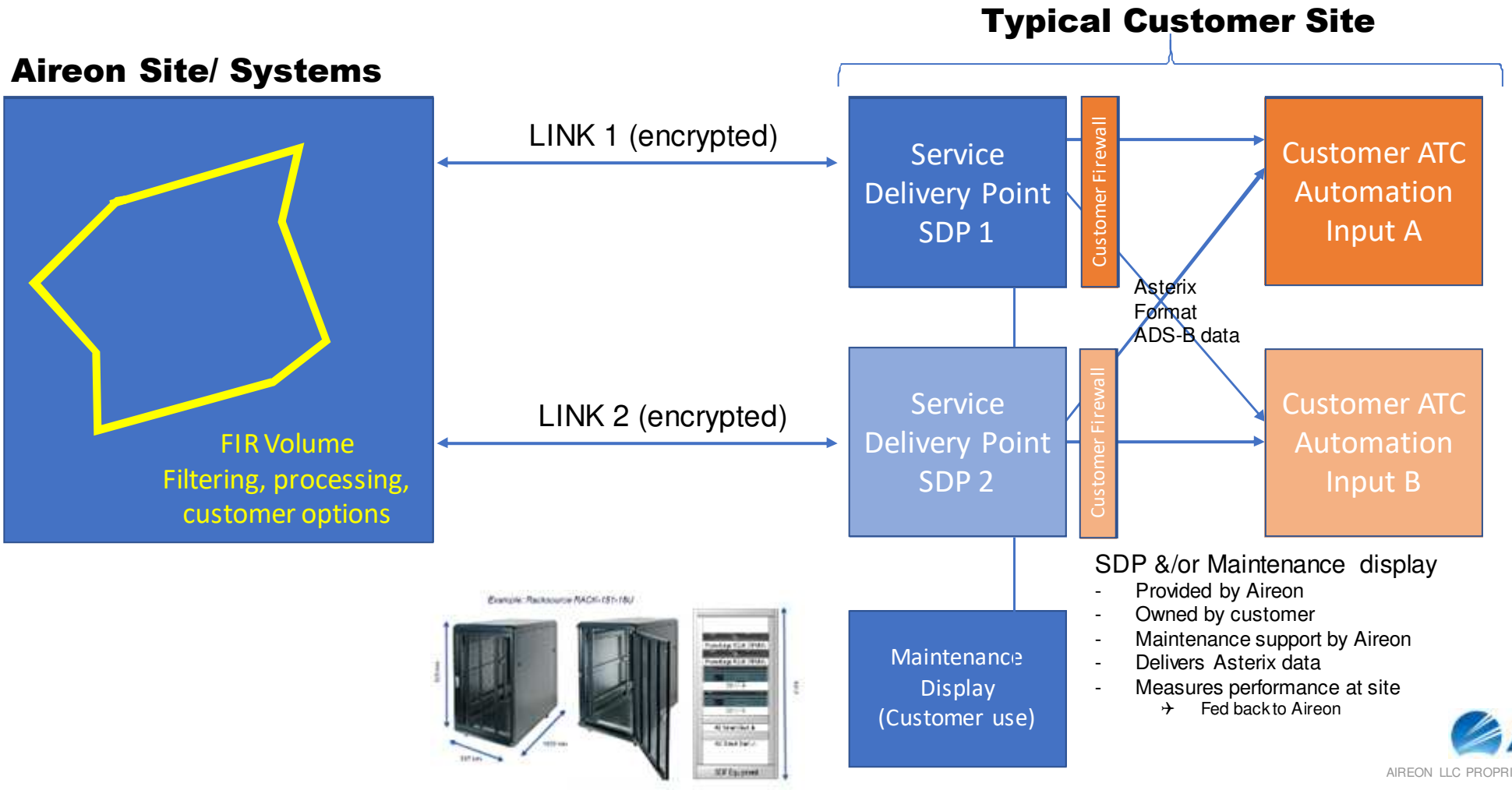
Integration of Space based ADS-B into ATM
Space-based ADS-B is just ADS-B

- Some States have already deployed ADS-B
  - ADS-B into ATC automation
  - ATC procedures
  - Operational use
  - Regulation is important too
- If so, they have already done the difficult things
  - Space based ADS-B is an easy addition to ATC
- Its like a "super capable" – extra ADS-B ground station
  - That covers the whole world (or your part of it)



ATC Automation Requirements and Space-based ADS-B Paper
https://www.icao.int/APAC/Meetings/2018%20SURICG3/WP12_ICCAIA%20AI.3%20%20-%20Space%20based%20ADS-B%20and%20ATC%20automation%20%20GD%20final%20review.pdf

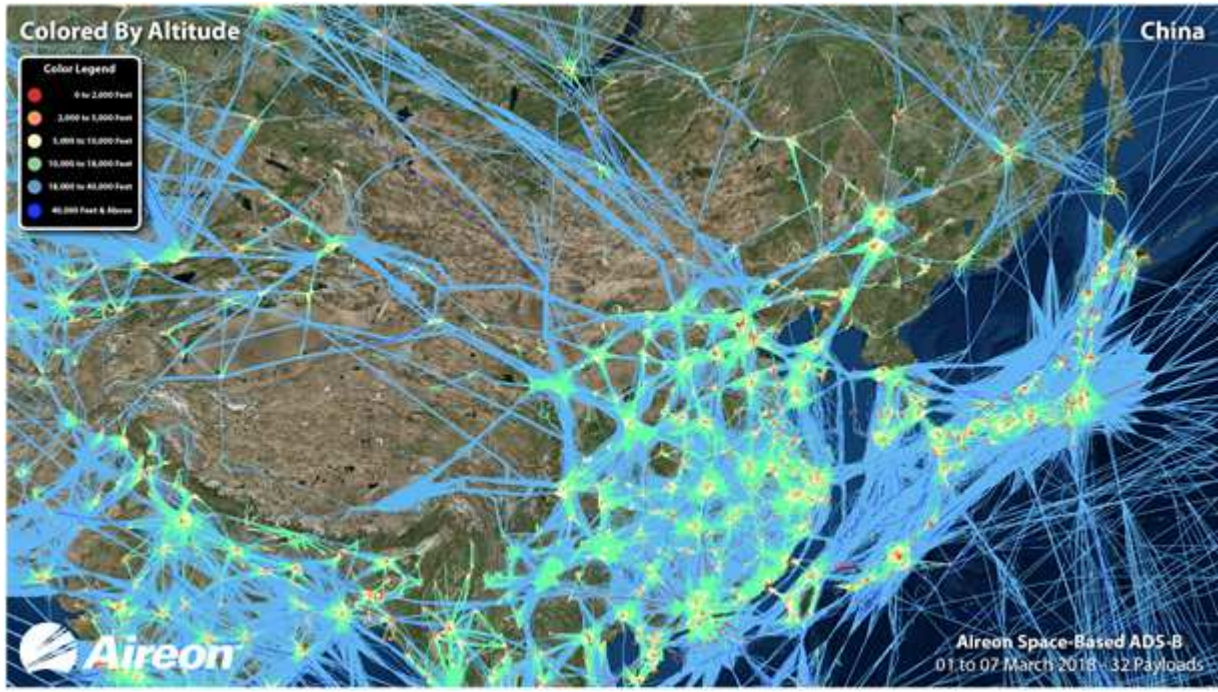
Aireon Space-based ADS-B SERVICE is delivered from a Service Delivery Point (SDP)



ATC Use

ATC Use of Space based ADS-B

- **Provide Surveillance where there is none**
  - Ocean & Mountainous regions
  - Remote towers and airports
- **Complement existing surveillance**
  - Improve update rate
  - Improve reliability of service
  - Adjacent FIR contingency/ FIR boundary safety
- **Avoid cost of terrestrial surveillance**
  - Instead of new terrestrial ground stations or radar
  - Replace aged terrestrial ground stations or radar
- **Surveillance backup - unaffected by natural disasters**
  - Low cost country wide surveillance
  - Software & hardware independent of ground surveillance
  - Always active, Easy to integrate



ATFM

How do you currently predict arrival time at FIR?
- before ATC co-ordination of transfer

FIR 1

FIR 2

FIR 3

FIR 4

- Late departure

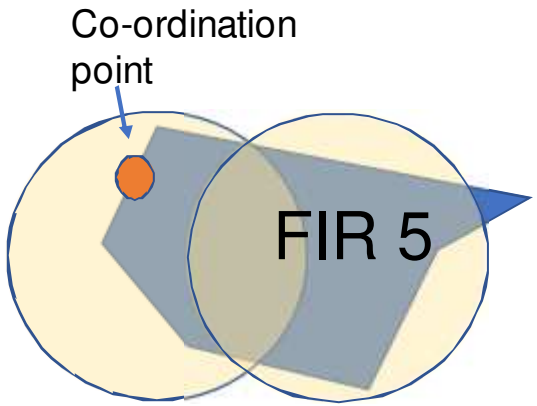
- Wind change

- ATC intervention

- Around newly activated restricted area

- Weather deviation

Departure Airport

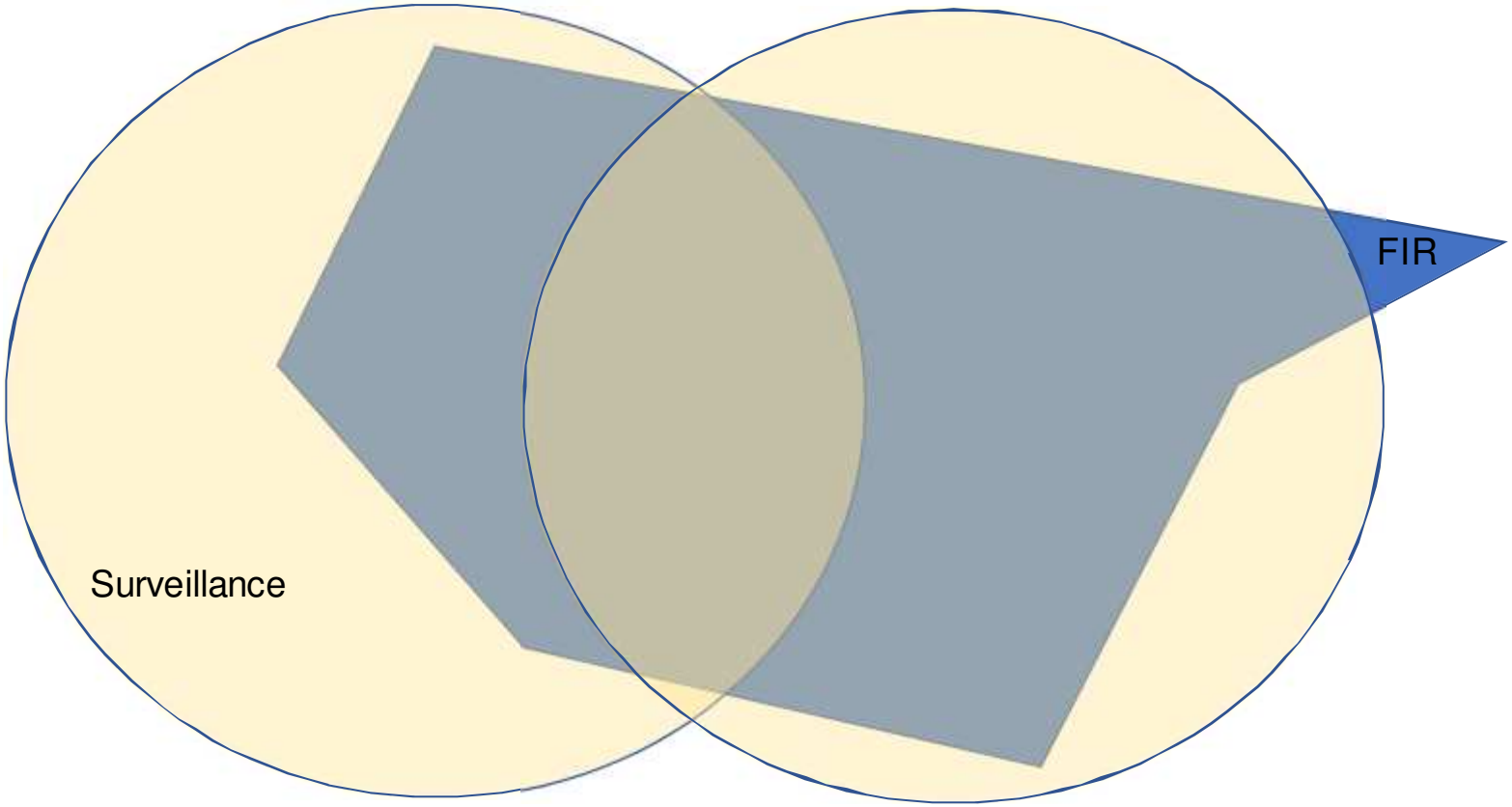


FPL – ETD, EET
DEP – EST/CPL/ABI

WHAT is the FAILURE rate?

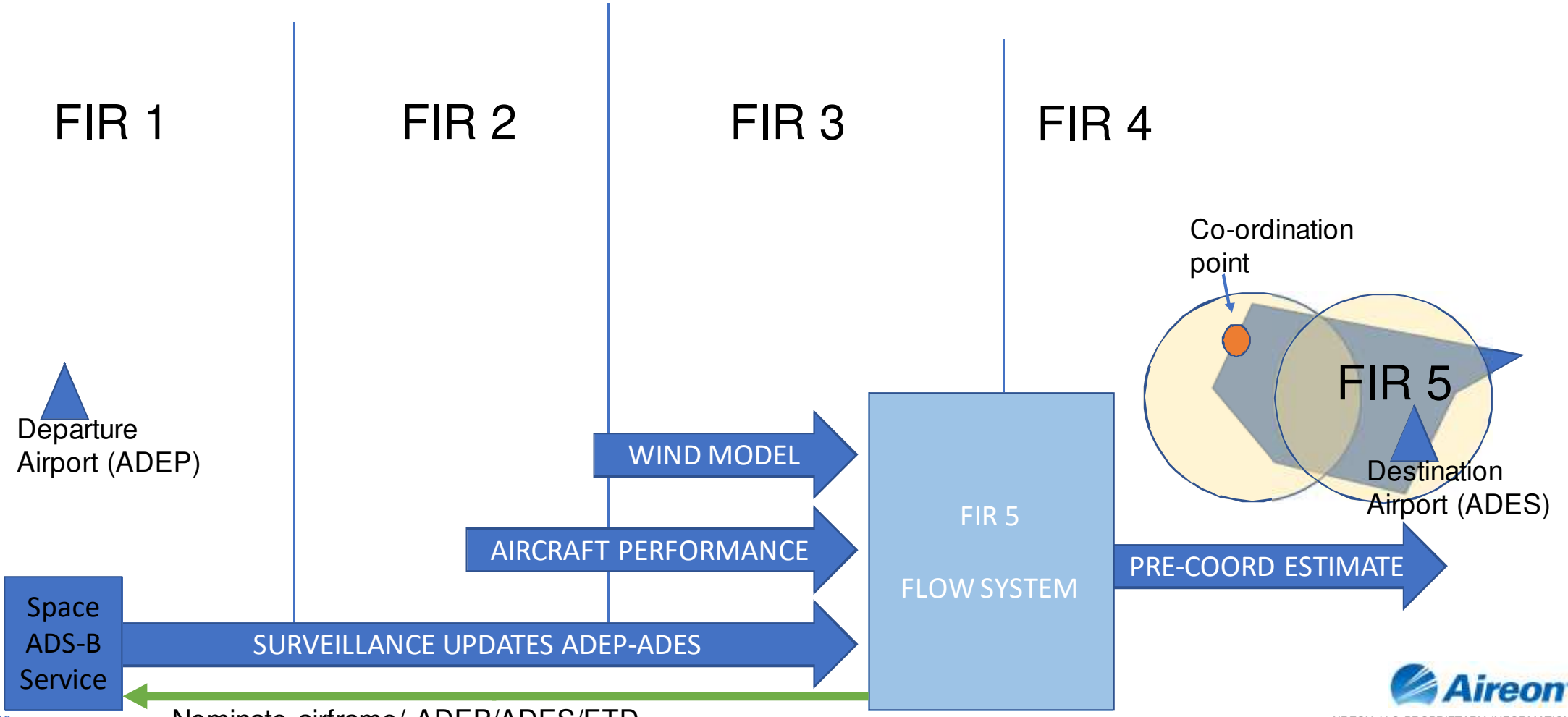
ANSP surveillance is normally :

Your own FIR plus a moderate distance into adjacent FIR



Aireon has Surveillance data worldwide

What if you got surveillance from ADEP to ADES?



Beijing ATC could receive data on CPA899 Newark to Beijing whilst over Canada !

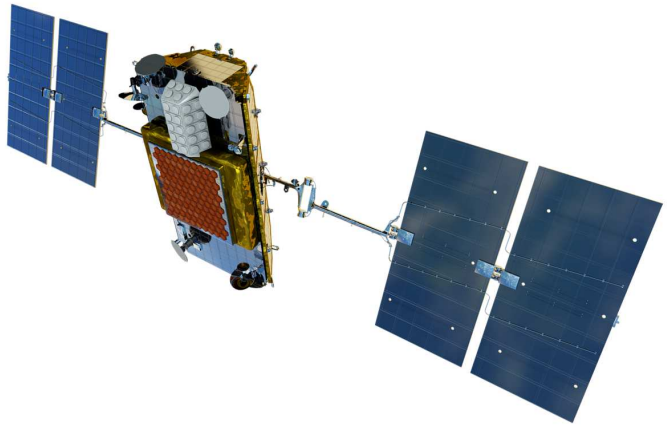
- A possible contribution to design of new ATFMS
- Would this be useful?

Conclusion

Space based ADS-B

- **Performance has been demonstrated**
  - Leveraged on Iridium satellite experience
    - ~**20 years experience** maintaining## 24/7/365 service of LEO satellites
    - 2nd generation Iridium satellites
  - Satellite diversity
    - Spare satellites in orbit, component diversity on each satellite
    - Mesh network of communication to earth
    - Worldwide network of downlinks and processing

- **Aireon understands ATC**
  - Owned by ANSPs
  - Company & system designed for ATC (design, processes, people)
  - Certification and Oversight by EASA (European Aviation Safety Agency)



Iridium 2nd generation : with ADS-B receiver

First generation Iridium satellite

Demonstrated performance since November 1, 1998

Conclusion

- **Space based Surveillance as a SERVICE fully operational in early 2019**
  - Global coverage independent of terrestrial constraints
  - Suitable for ATS Separation
  - Easily interfaced to an ATM platforms

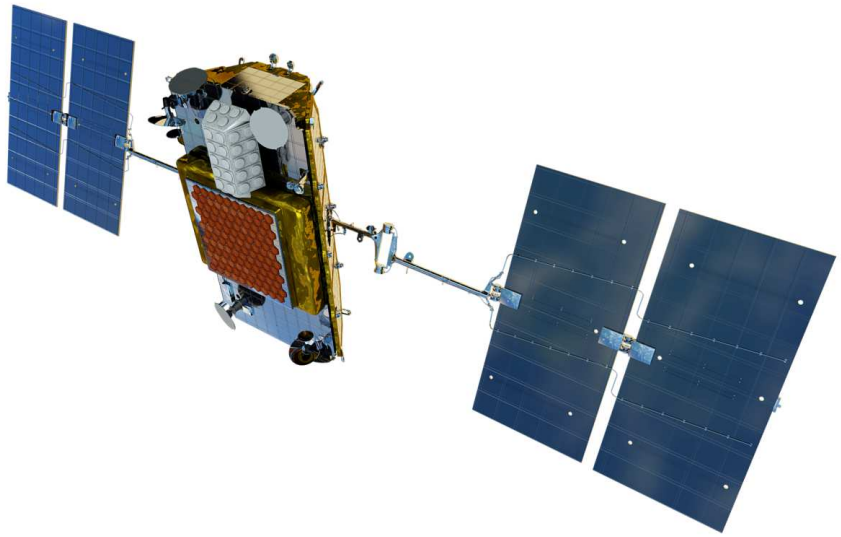
- **Will transform the provision of air traffic management - A potential paradigm shift for ATC and ATFM**
  - Will change the surveillance mix used by ANSPs
  - Will change ATC methods in previously non surveillance airspace
  - Potential “Departure to Destination“ surveillance – anywhere, worldwide


Joining futures
Space-based ADS-B
NAV CANADA
iridium Everywhere
enav
NATS
IAA
NAVIAIR
Aireon℠
AIREON LLC PROPRIETARY INFORMATION

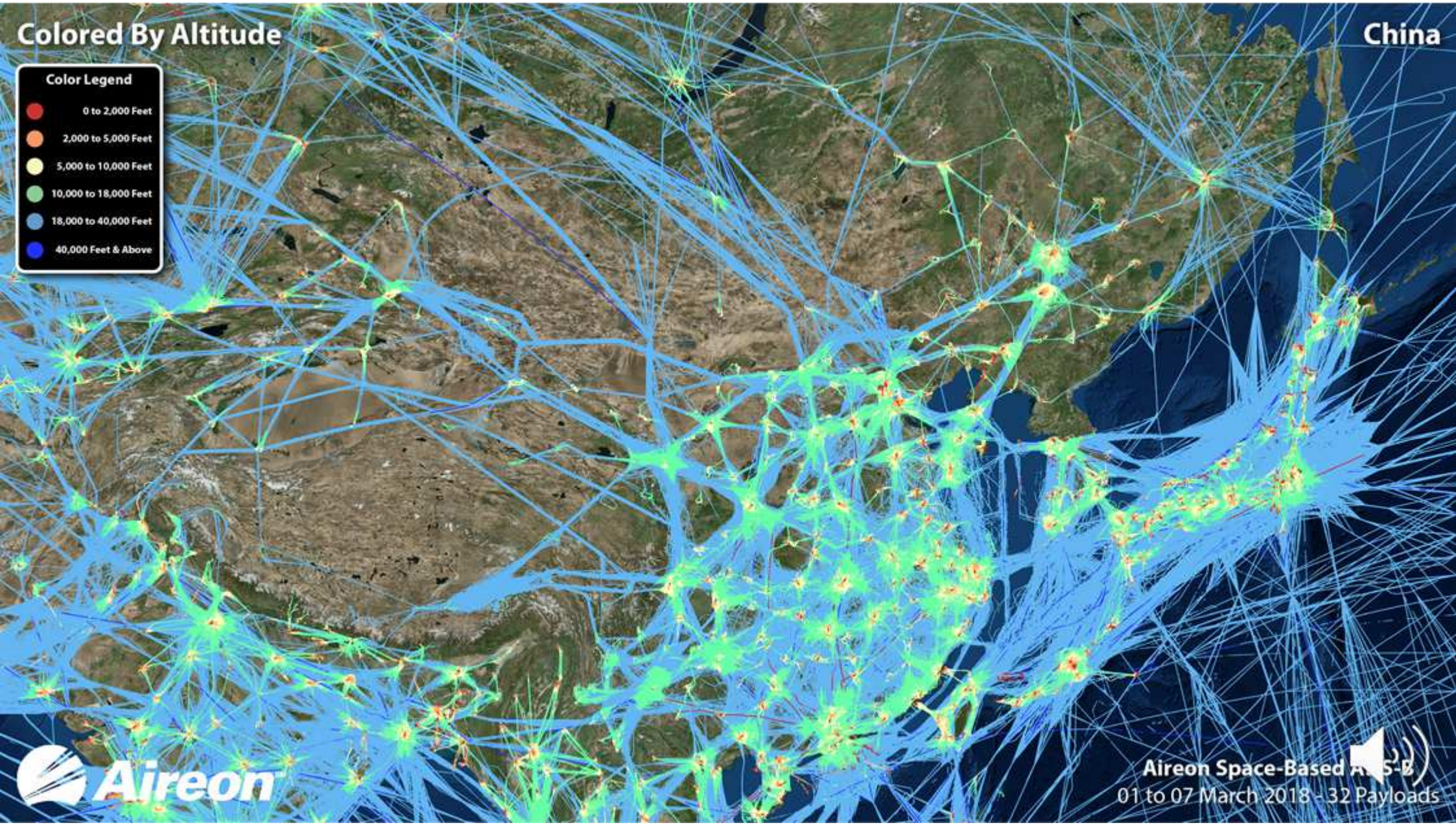
Spare slides

Space-based ADS-B compared to terrestrial ADS-B

Space-based specific ATM Automation items



- Correct Asterix format version & processing
  - ✈ Consider Integrity/accuracy threshold issues
  - ✈ Ignore unexpected Asterix categories
  - ✈ Variable update interval processing
- Latency test (allow 2 seconds)
- QNH data if below transition level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18,000 to 40,000 Feet
40,000 Feet & Above
Aireon
Aireon Space-Based ADS-B
01 to 07 March 2018 - 32 Payloads

Performance requirements for radar like separation

- VHF communication
- Appropriate update interval (typically 5 sec for 3 NM, 12 sec for 5 NM)
- Appropriately low latency (<2 sec)
- High reliability to support vectoring (typically no common point of failure)
- High availability

DOC 4444

8.7.3 Separation minima based on ATS surveillance systems

8.7.3.1 Unless otherwise prescribed in accordance with 8.7.3.2 (with respect to radar), 8.7.3.3 or 8.7.3.4, or Chapter 6 (with respect to independent and dependent parallel approaches), the horizontal separation minimum based on radar and/or ADS-B shall be 9.3 km (5.0 NM).

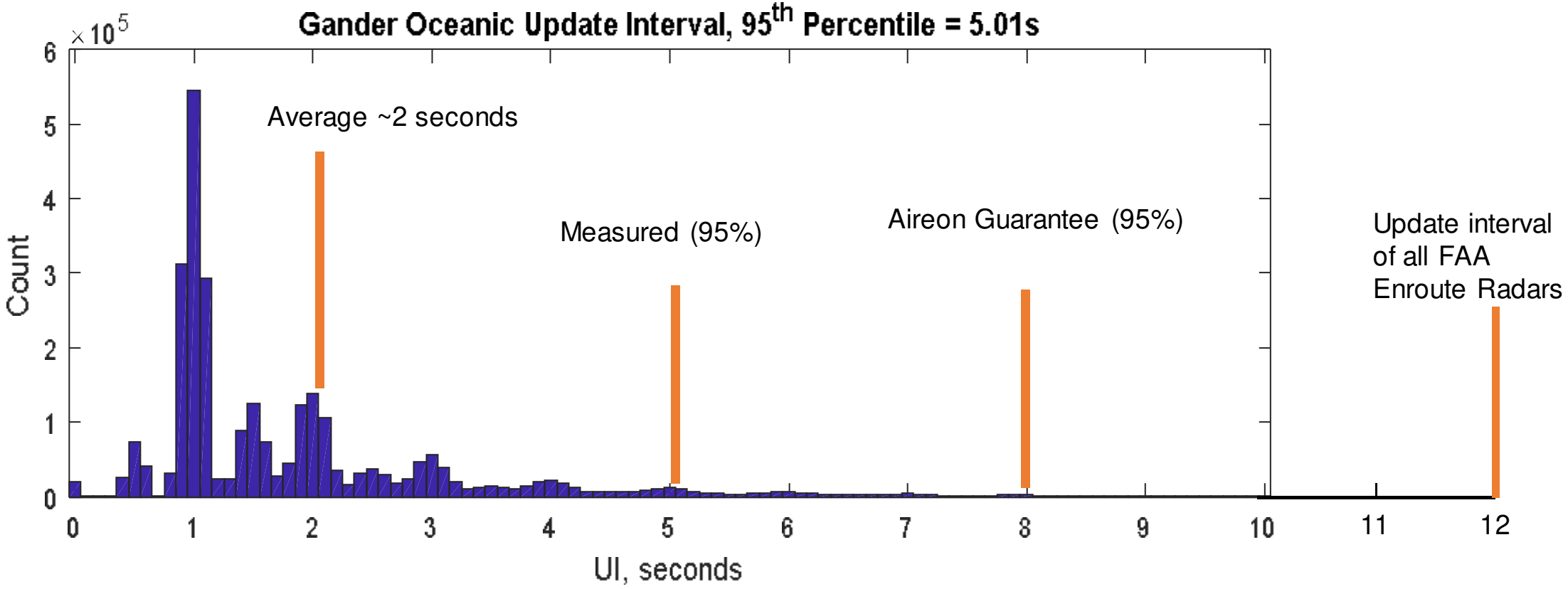
8.7.3.2 The radar separation minimum in 8.7.3.1 may, if so prescribed by the appropriate ATS authority, be reduced, but not below:

a) 5.6 km (3.0 NM) when radar capabilities at a given location so permit; and

b) 4.6 km (2.5 NM) between succeeding aircraft which are established on the same final approach track within 18.5 km (10 NM) of the runway end. A reduced separation minimum of 4.6 km (2.5 NM) may be applied, provided:

i) the average runway occupancy time of landing aircraft is proven, by means such as data collection and

Aireon Measured Performance Update Interval (in seconds)

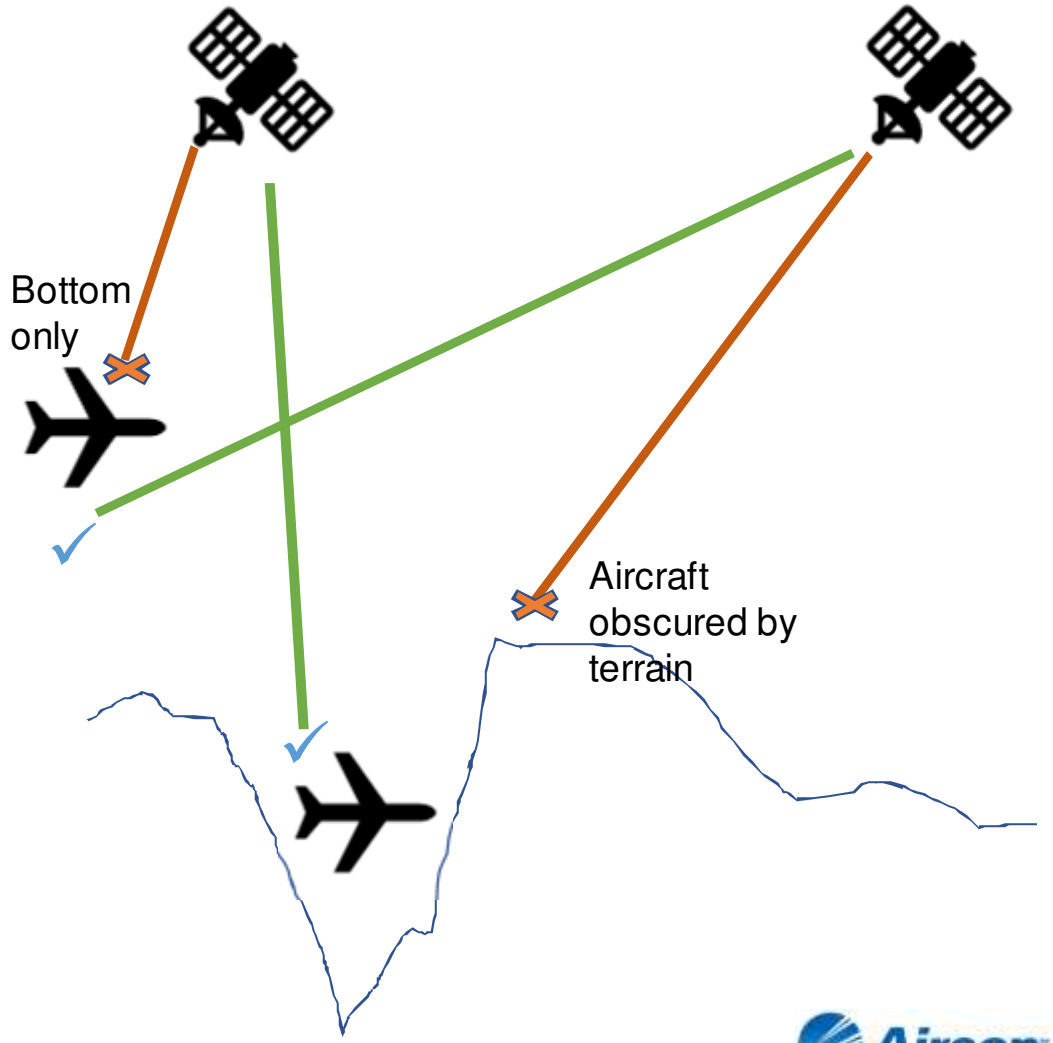


30/ minute	15/ minute	7.5/ minute	5/ minute

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

Detection performance

- Update performance guaranteed for
  - ✈ Aircraft with 125 watt ADS-B transmitter from top antenna
    - All TCAS capable aircraft have top antenna
- Bottom mounted antenna aircraft
  - ✈ Are detected but performance guarantee not yet available.
    - Analysis & testing incomplete



ASIA PACIFIC DIRECTOR GENERALS of CIVIL AVIATION January 2018 Beijing Declaration

https://www.icao.int/APAC/Meetings/2018%20APACMC/Report%20of%20APACMC_FINAL_13%20Feb.%202018.pdf

2.0 Air Navigation Services

2.1 Commit to implementation by 2022 of the Asia/Pacific Seamless Air Traffic Management (ATM) Plan to enhance ATM capacity and harmonization in the region, including a focus on:

(a) Transitioning from Aeronautical Information Service (AIS) to Aeronautical Information Management (AIM) System;

(b) Performance Based Navigation (PBN) implementation;

(c) Common ground/ground telecommunication infrastructure to support Air Navigation Services (ANS) applications;

(d) An enhanced level of civil/military cooperation;

(e) Enhanced surveillance capability including Automatic Dependent Surveillance- Broadcast (ADS-B) technology;

(f) Air Traffic Flow Management/Collaborative Decision Making (CDM) implementation for high density airports; and

(g) include air navigation in national planning frameworks such as National Development Plans (NDPs) supported by National Air Navigation Plans

ASIA PACIFIC ICAO APANPIRG29 support:

As global ATS surveillance capability will be operational and certificated early in 2019,

*States should **consider** implementation of this technology*

to improve safety and efficiency in airspace currently without continuous and seamless surveillance.

This technology enables some States to leapfrog legacy surveillance capabilities and helps ensure that 'no State is left behind'.

ICAO AIR NAVIGATION CONFERENCE OCTOBER 2018

International Civil Aviation Organization

WORKING PAPER

AN-Conf/13-WP/176
19/9/18
English only

THIRTEENTH AIR NAVIGATION CONFERENCE

Montréal, Canada, 9 to 19 October 2018

COMMITTEE A

Agenda Item 3: Enhancing the global air navigation system
3.5: Other ATM issues

PROGRESSING GLOBAL ATS SURVEILLANCE BENEFITS THROUGH SPACE-BASED ADS-B

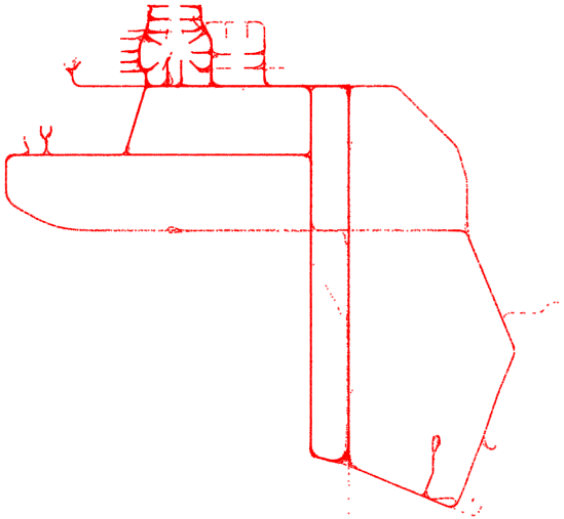
(Presented by the Civil Air Navigation Services Organisation (CANSO))

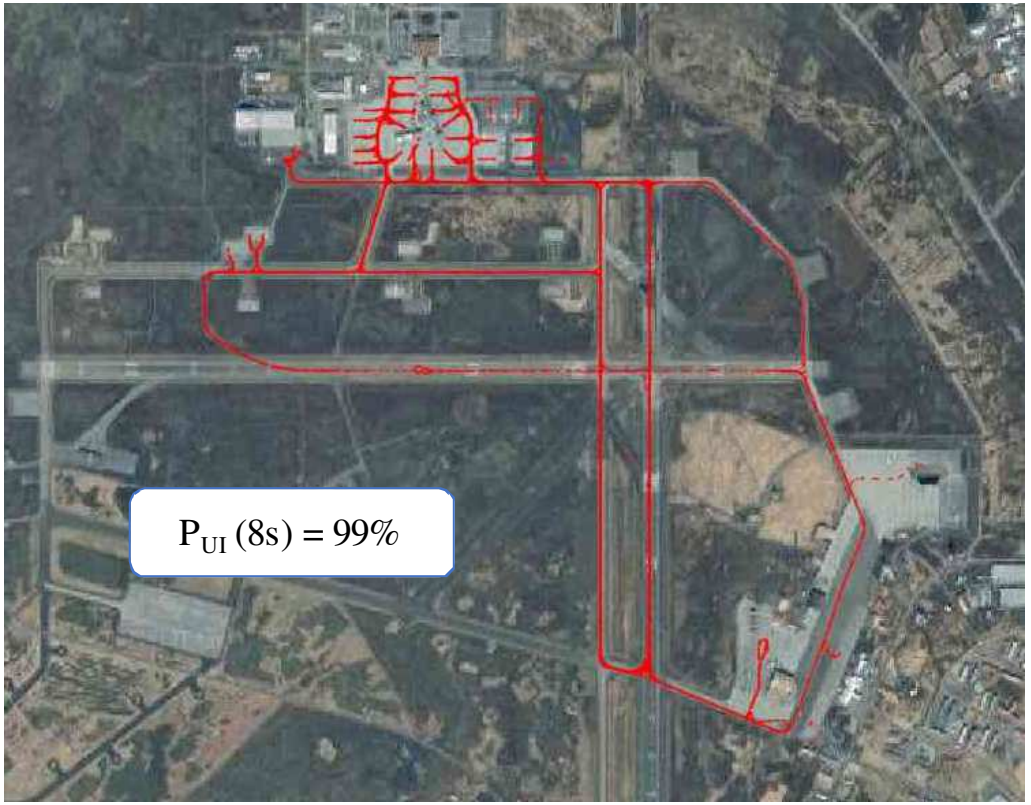
CIVIL AIR NAVIGATION SERVICE ORGANISATION

CANSO invites the Conference to note the promising testing results of space based ADS-B as a global ATS surveillance capability and the significant benefits the introduction of such capability can bring to help deliver this industry's main safety and efficiency goals

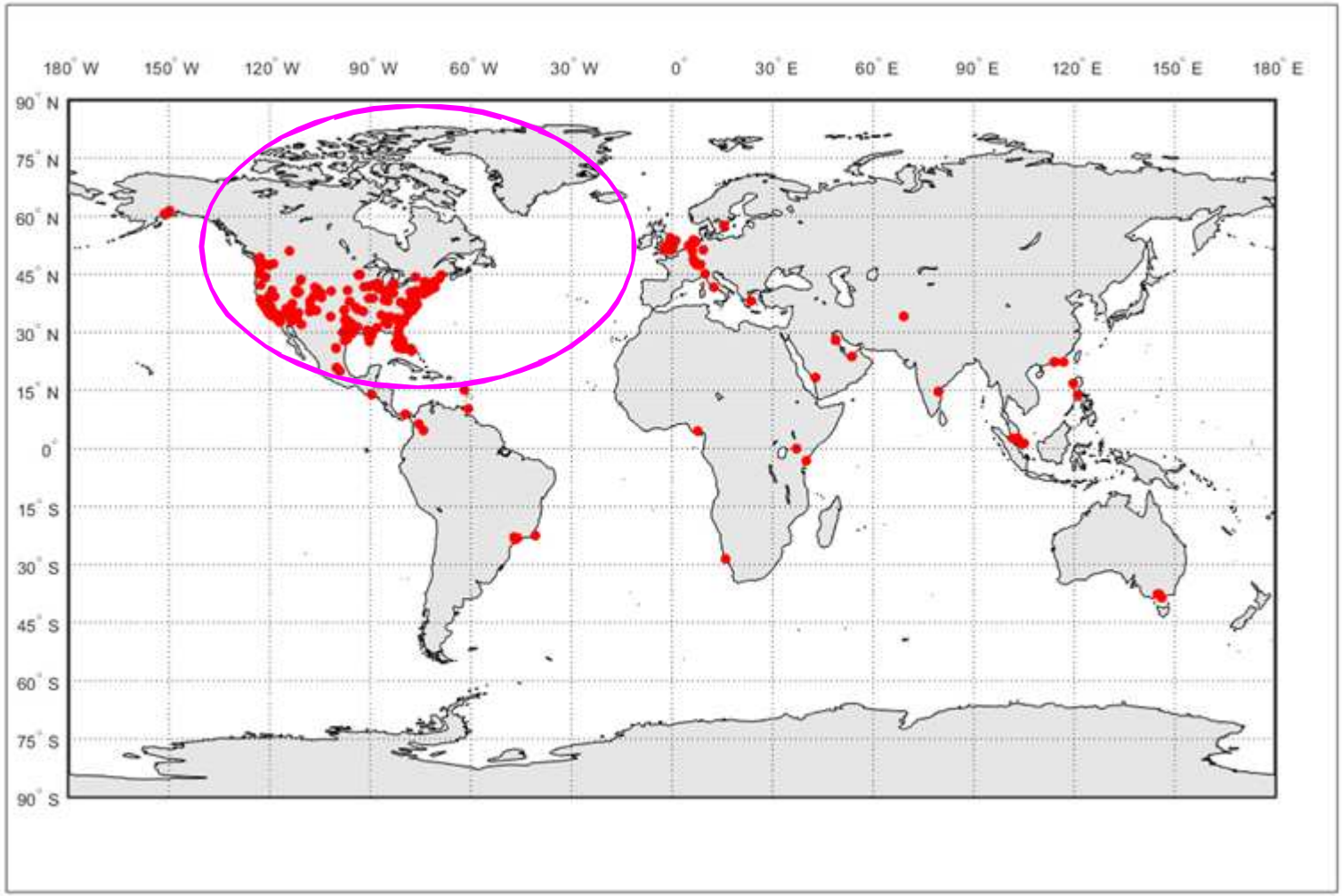
Keflavík, Iceland: Surface Overlay Example

- Using 3 days of Aireon ADS-B data from 1 September to 3 September, a surface overlay plot was generated.
- This plot shows ADS-B equipped aircraft on runways, taxiways, and gate/stands.





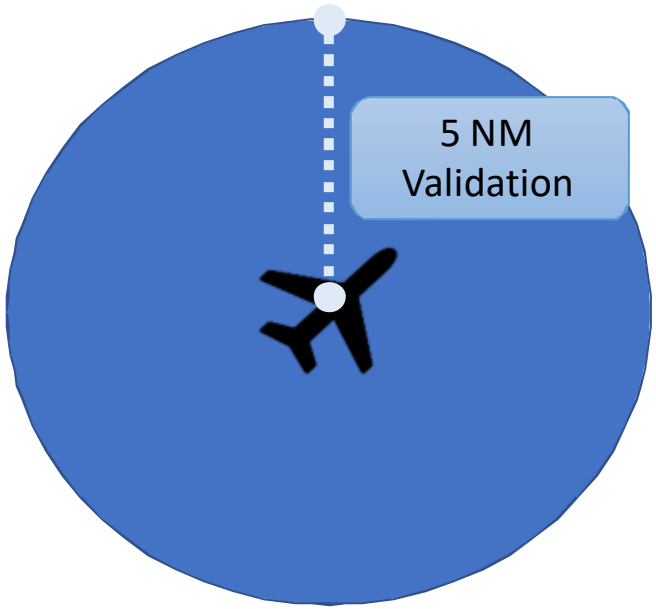
Example of TCAS RA Monitoring from space (DO260B only)



Issue : Position Validation

- **Validation of position is part of the design**
  - Applying all available pragmatic techniques
    - ✈ Eg: Kinematic tests

- **Time Difference of Arrival (TDOA)**
  - ✈ TDOA at multiple space receivers
  - ✈ Aireon will initially flag any reports that are inconsistent by 5 miles
  - ✈ Additional values being researched and validated
    - A more detailed review of this capability is planned to be shared during the Enhanced Solutions for Aircraft and Vehicle Surveillance Applications (ESAVS) conference in Berlin in October 2018



Iridium Next Launches & Aireon Data Status

Launch Status

Eighth and FINAL Launch: 30th December 2018

- Full Iridium NEXT constellation completed by end of Q4 2018
- The Aireon service will be live in Q1 2019
- Nav Canada first operational customer late 2018
- Sign today and fully operational within 12 months maximum

Space-based ADS-B is a cost-effective technology in comparison to other surveillance infrastructure

Cost/Km2 at 10,000 feet

Country	SSR	GB ADS-B	SB ADS-B
Chile	27,07	8,12	0,20
Colombia	5,08	1,52	1,17
Ecuador	22,31	6,69	0,77
Perú	7,97	2,39	0,60

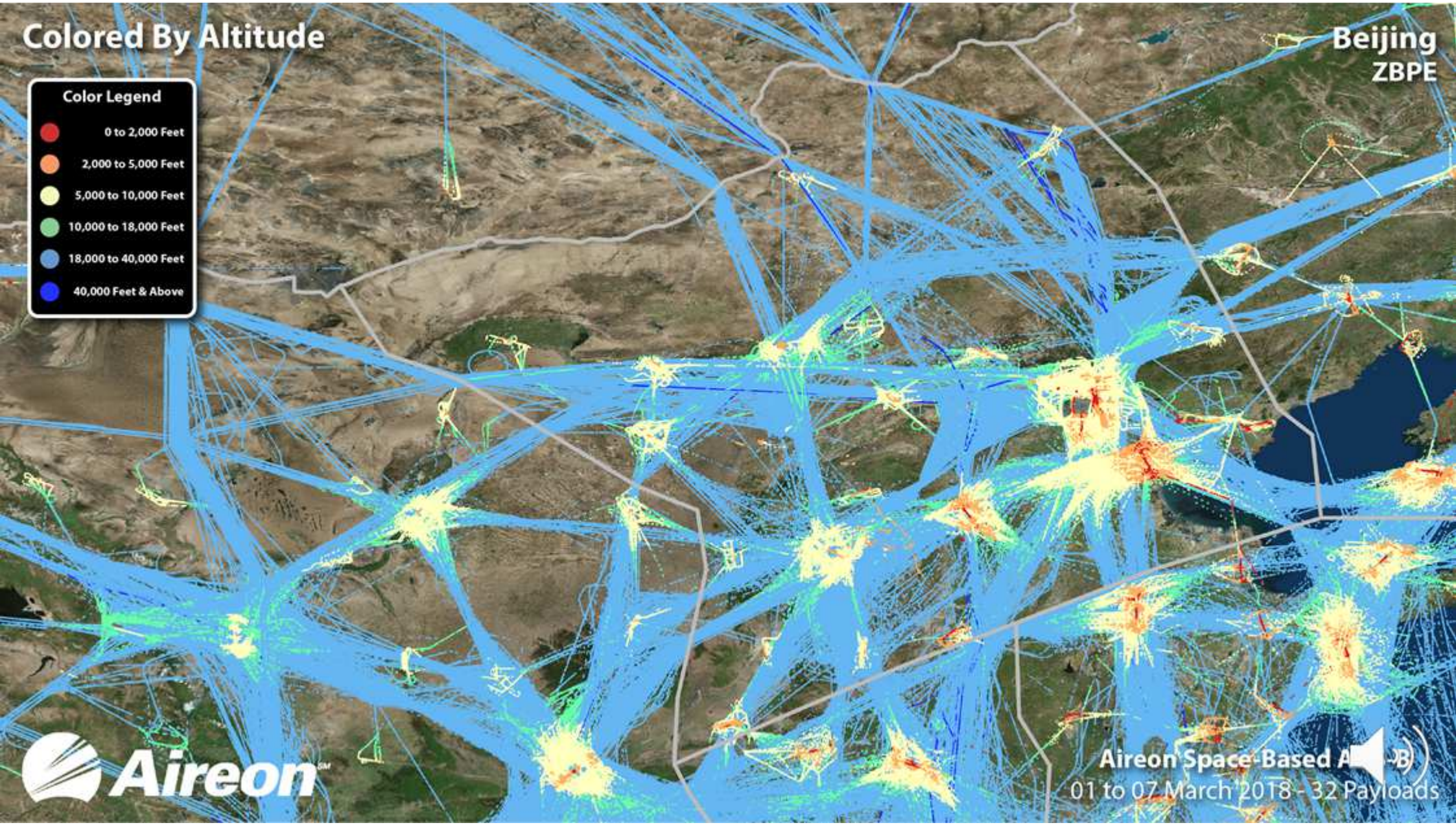
Cost/Km2 at 15,000 feet

Country	SSR	GB ADS-B	SB ADS-B
Chile	22,76	6,83	0,20
Colombia	3,92	1,18	1,17
Ecuador	15,42	4,63	0,77
Perú	5,19	1,56	0,60

Cost/Km2 at 25,000 feet

Country	SSR	GB ADS-B	SB ADS-B
Chile	17,05	5,11	0,20
Colombia	2,5	0,75	1,17
Ecuador	9,49	2,85	0,77
Perú	2,26	0,68	0,60

Source: ICAO SAM Feasibility study space-based ADS-B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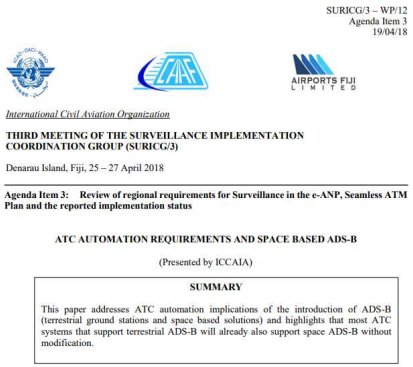
Beijing
ZBPE
Aireon
01 to 07 March 2018 - 32 Payloads

Integration of ADS-B into ATM

- Interface standard
- Use of DO260, DO260A and DO260B
- Testing ADS-B quality indicators
- Ensuring that latency effects are mitigated
- Tracking – and ADS-B update rate
- Removal of duplicate messages
- Removal of old messages
- Removal of false messages
- Flight plan coupling
- Flight plan indicators
- QNH data
- ADS-B track symbols
- Operation of safety nets
- Importance of Route Adherence Monitoring

- Transition from radar environment to ADS-B environment
- ATC simulation capabilities
- Site monitor processing and ADS-B service monitoring
- ADS-B outage prediction
- Blacklist capabilities
- Identify duplicate 24-bit addresses
- Recording capabilities
- Analysis capabilities

Applies equally to Terrestrial ADS-B & Space based ADS-B



SURICG/3 – WP/12
Agenda Item 3
19/04/18

International Civil Aviation Organization

THIRD MEETING OF THE SURVEILLANCE IMPLEMENTATION COORDINATION GROUP (SURICG/3)

Denarau Island, Fiji, 25 – 27 April 2018

Agenda Item 3: Review of regional requirements for Surveillance in the e-ANP, Seamless ATM Plan and the reported implementation status

ATC AUTOMATION REQUIREMENTS AND SPACE BASED ADS-B

(Presented by ICCAIA)

SUMMARY

This paper addresses ATC automation implications of the introduction of ADS-B (terrestrial ground stations and space based solutions) and highlights that most ATC systems that support terrestrial ADS-B will already also support space ADS-B without modification.

ATC Automation Requirements and Space-based ADS-B Paper
https://www.icao.int/APAC/Meetings/2018%20SURICG3/WP12_ICCAIA%20AI.3%20%20-%20Space%20based%20ADS-B%20and%20ATC%20automation%20%20GD%20final%20review.pdf