Space-Based ADS-B

Implementation Progress & Distribution through REDDIG

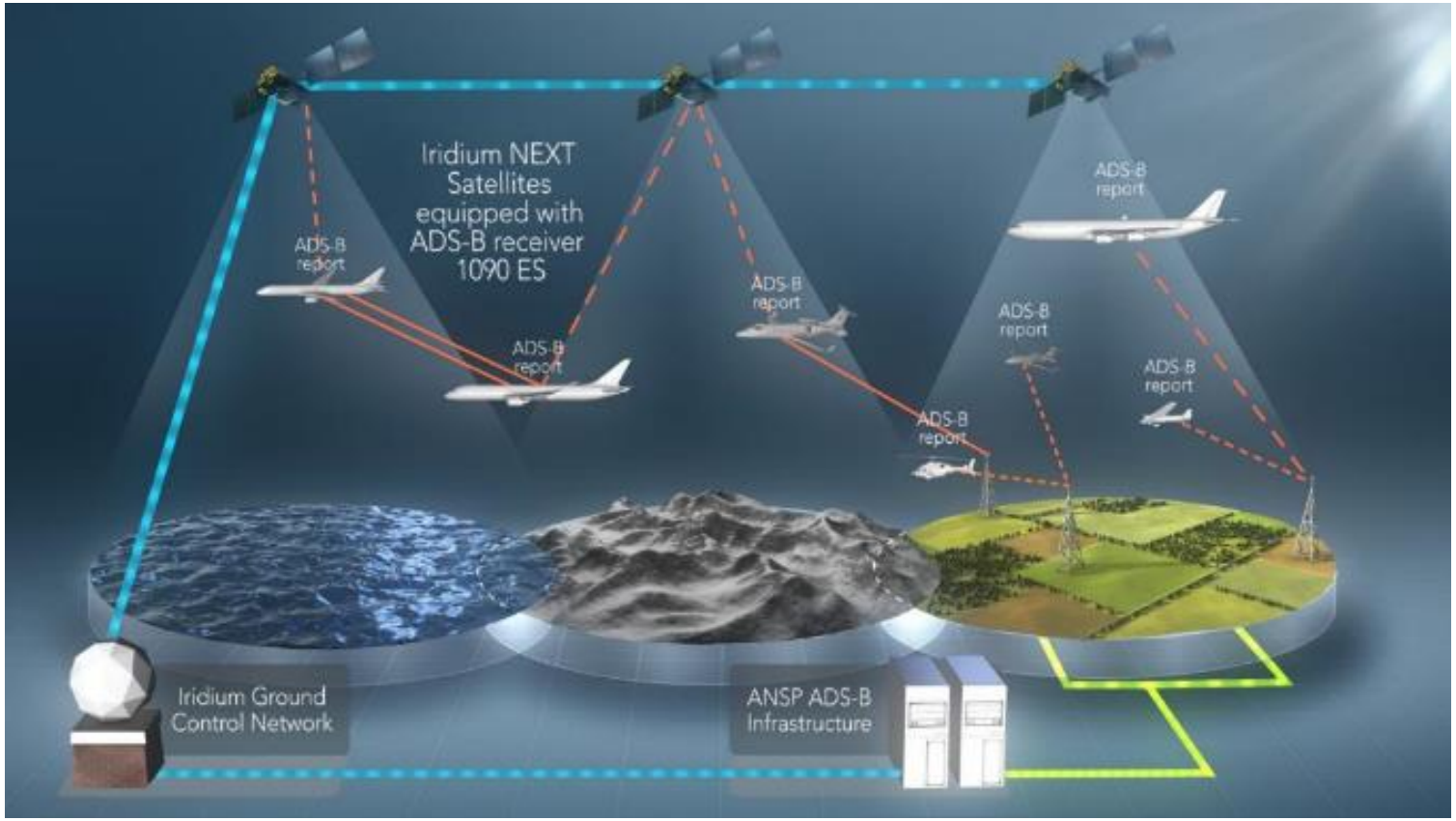
ICAO SAM IG/19 Meeting

May 26th, 2017

Space-Based ADS-B System Overview

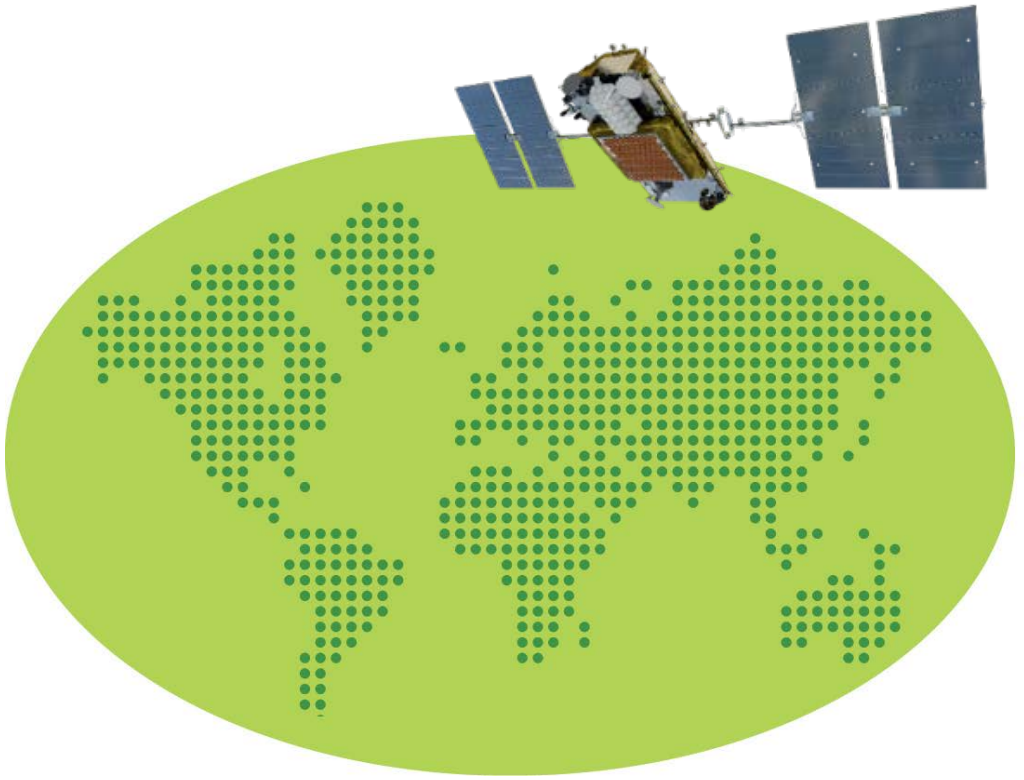
Space-Based ADS-B Concept

- Augments current radar systems with oceanic and remote air space coverage
- Delivers true pole-to-pole global coverage, with near 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



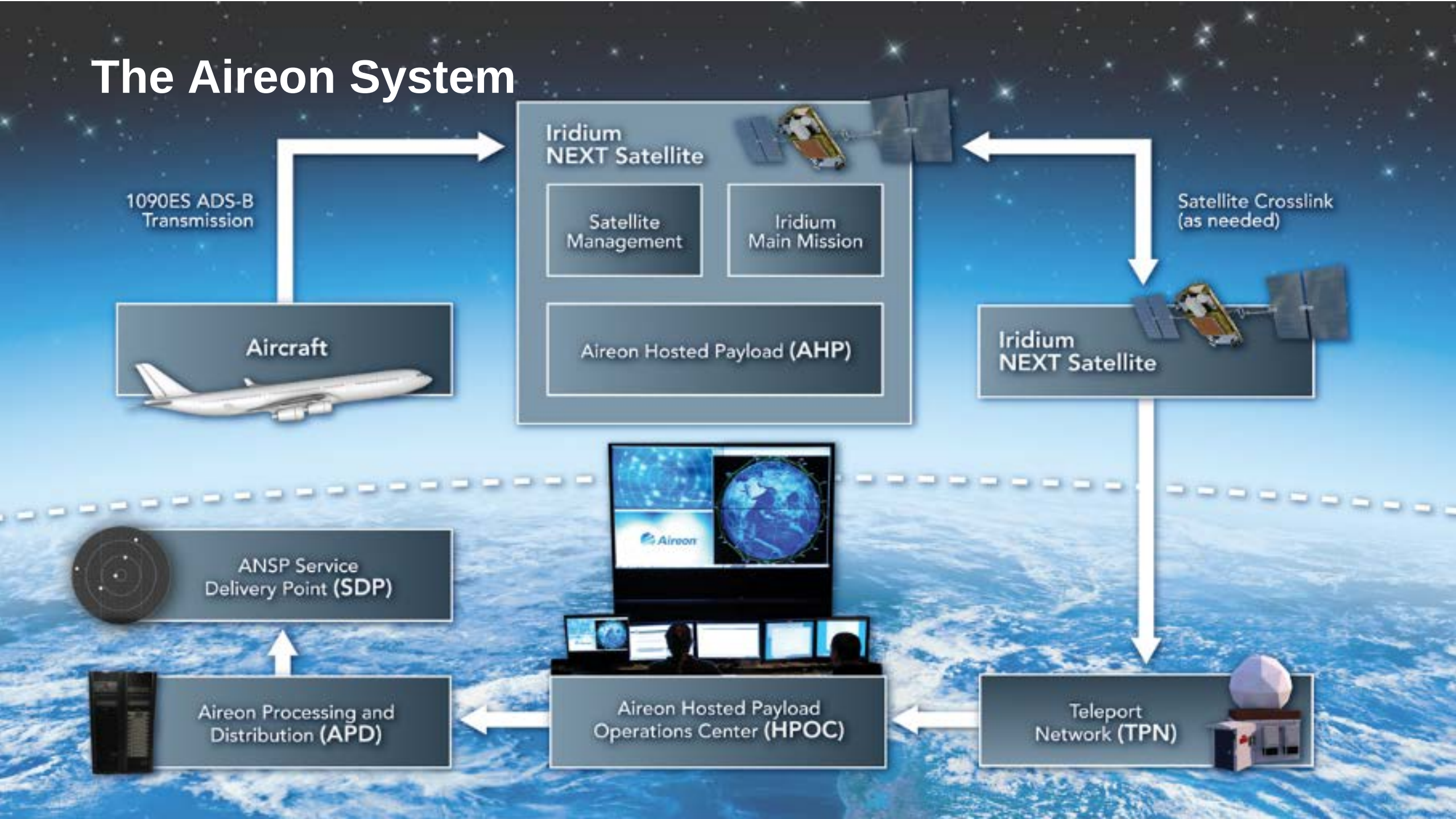
By 2018, space-based ADS-B will provide global, real-time air traffic surveillance

CURRENT GLOBAL SURVEILLANCE COVERAGE

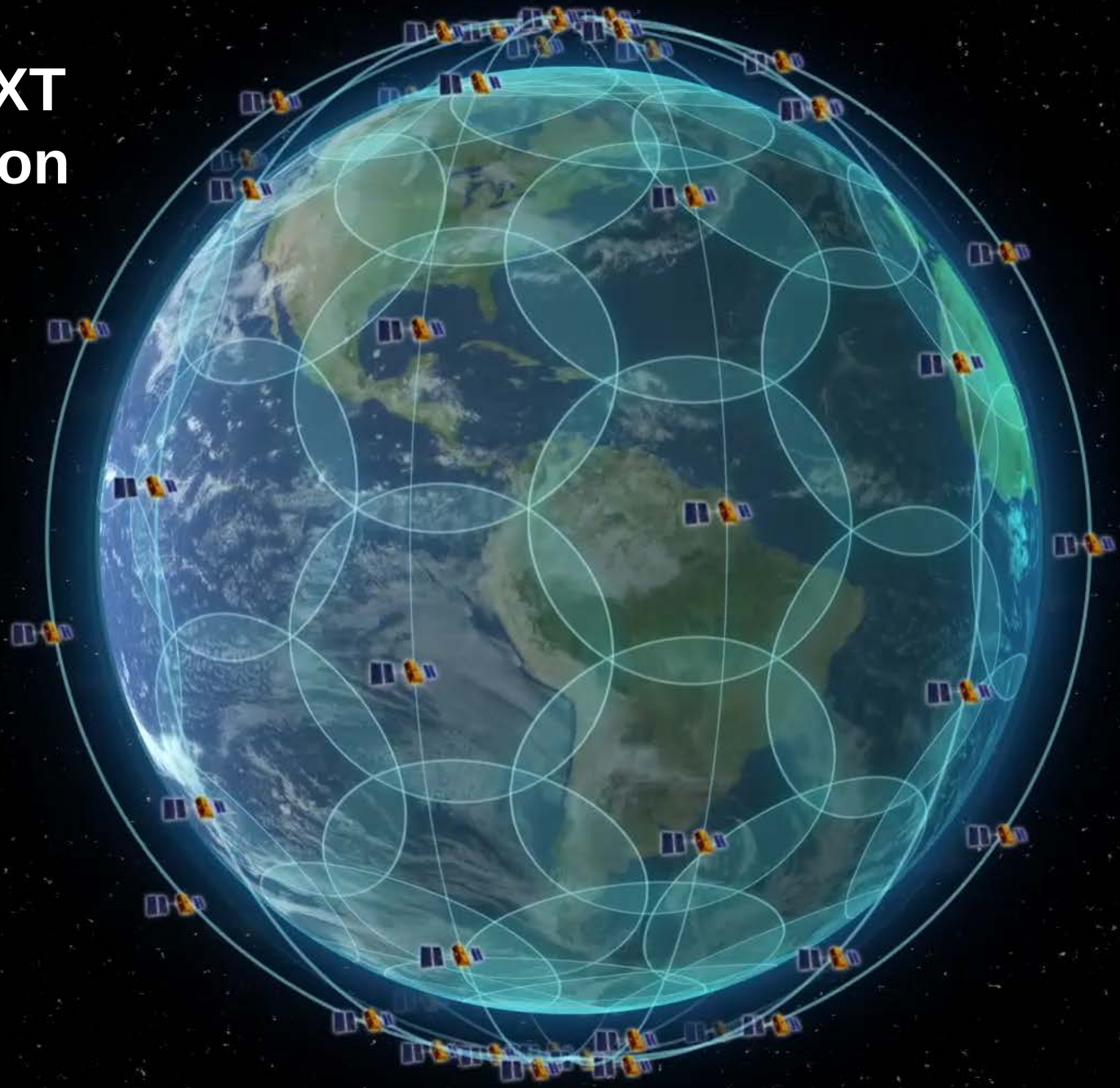


AIREON GLOBAL COVERAGE

The Aireon System



Iridium NEXT Constellation



Space-Based ADS-B Implementation Status

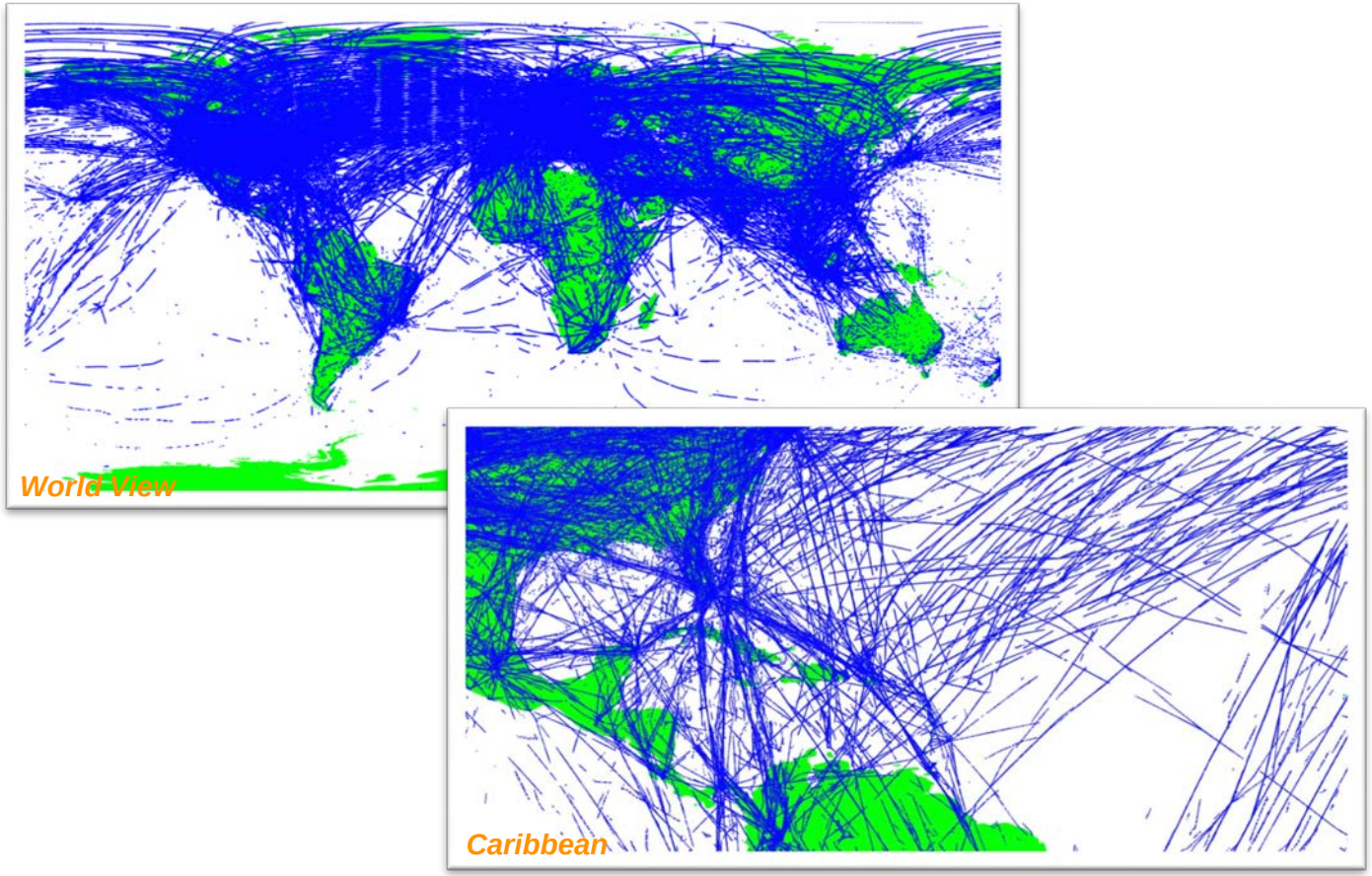
Satellite Launch Status

- First launch: January 14th, 2017
- Second launch: June 29th 2017
- Remaining launches 3-8: next 12-15 months
- Service operational: mid-2018

Photos: SpaceX

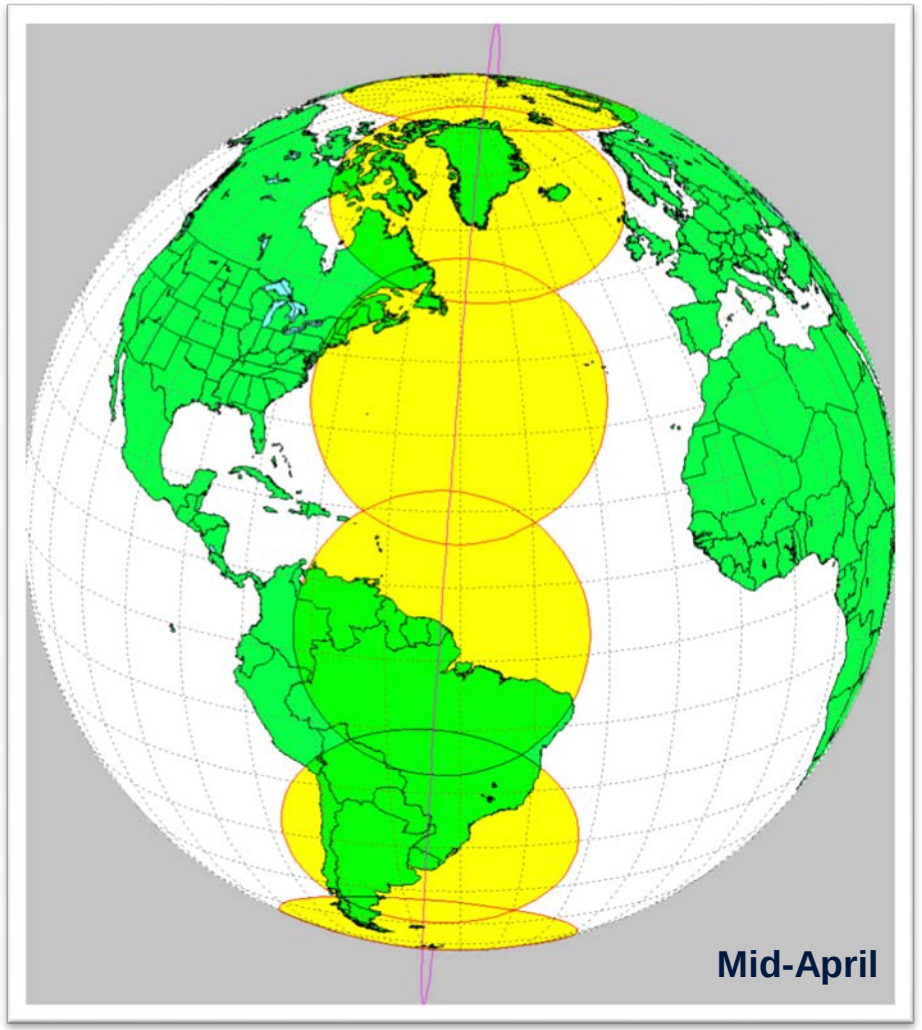
Launch 1 Coverage

Data from Eight (8) Payloads over 24 Hours

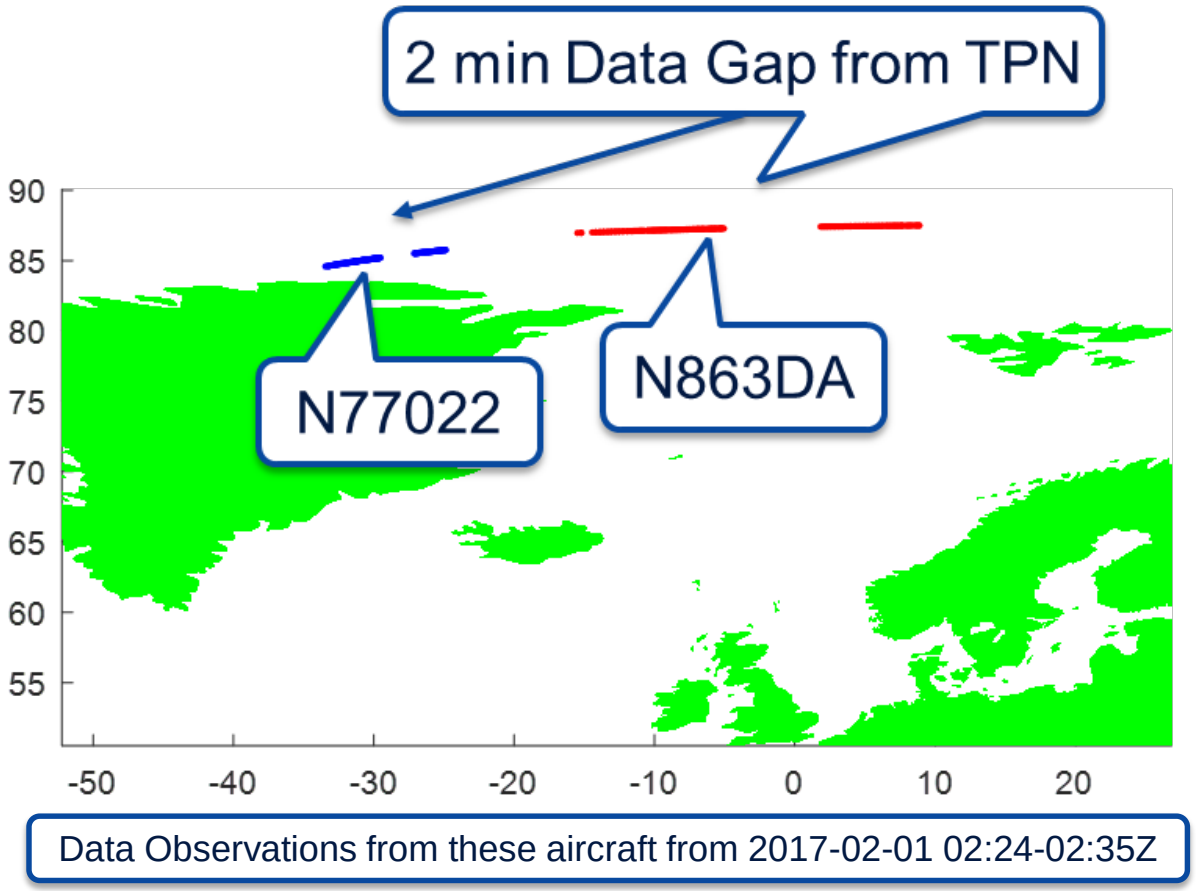


Aircraft Seen	Approximately 2.4M unique positions, per day with 8 payloads (testing not complete)
Types of Aircraft	Commercial Jets, Business Jets, General Aviation, Helicopters
Airspace Domains	Polar, Oceanic, En Route, Terminal, and Surface

Slots 1-7 and 11 are Filled



Preliminary Data: Polar Traveling Aircraft

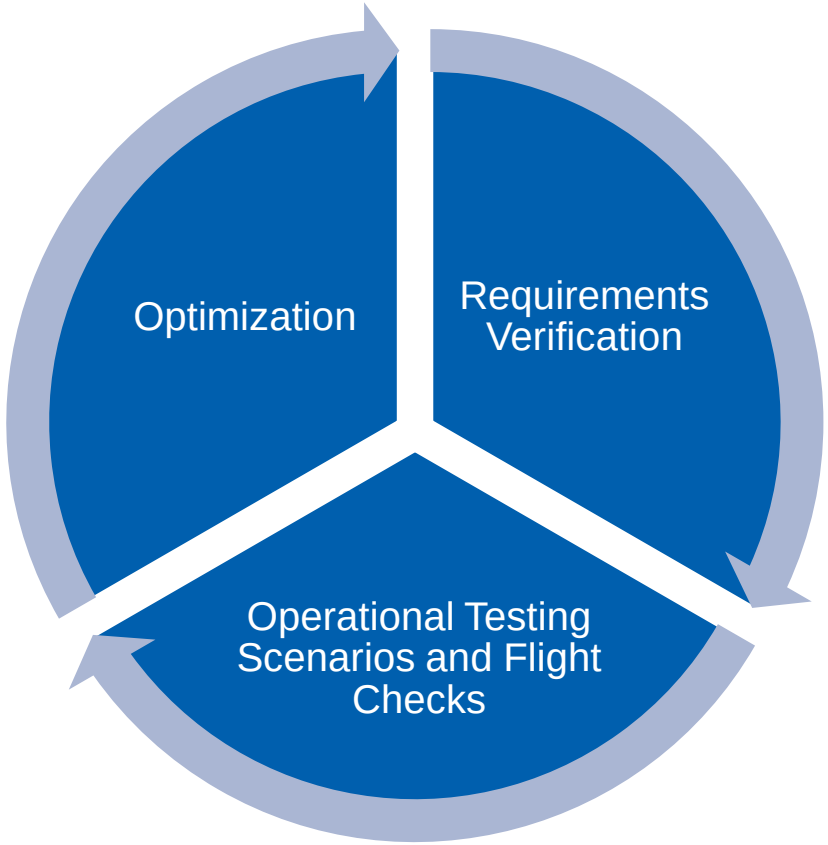


Data Observations from these aircraft from 2017-02-01 02:24-02:35Z

These two aircraft are travelling Eastbound together at about 490 knots at the same altitude (35,000') with a separation distance of ~155 NM

On Orbit Test Campaign

- Detailed antenna pattern measurement with ground transmitters
- Time Stamp Accuracy
- Bandwidth Characterization



- Commanding:
  - Test target message rate
  - Antenna schedule dwell
  - Payload Redundancy
- Status:
  - ADS-B target processing
  - Payload Redundancy

- Low-power target performance
- Track Aircraft in high-FRUIT regions
- TPM Collection (Update Interval and Latency)

Flight Test Aircraft and Tools

NAV CANADA
Test Flight
March 7th, 2017

Polaris Flight Systems
Test Flight
March 20th, 2017

FAA
Test Flight
March 30th, 2017

Performance Exceeding Design Standards For Surveillance

Test Flights for Performance Testing

- Aireon has completed three test flights with NAV CANADA, Polaris Flight Systems and the FAA.
  - This commenced the Initial Performance Verification (IPV) of the Aireon payload.
    - The first test flight was with NAV CANADA in the northern part of the continent. This was with a low-power antenna (125W) in remote airspace.
    - The second test was performed by Polaris Flight Systems with a 200W antenna in a high FRUIT environment.
    - The third test flight was done by the FAA test aircraft. This was with a low-power antenna (125W) over both oceanic and high FRUIT environments.

NAV CANADA Test Flight – March 7th, 2017

- Only one Aireon payload was providing ADS-B data due to the stepwise schedule in gradually implementing the new satellites into the constellation.
- 6,935 ADS-B messages were received during the test flight.
- The table below summarizes expected versus measured performance for some key parameters:

NAV Flight Test Plan and Aircraft

From 1 Payload	Best Expected	Best Measured
Aircraft Elevation (deg)	7.00	0.08
Slant Range (km)	2550	3229
95th % Update Int.(s)	8.00	4.09

Polaris Flight Systems Test Flight – March 20th, 2017

- Two Aireon payloads were providing ADS-B during the time of this test flight.
- The UI performance shifted due to the high density of aircraft with 1090 MHz transmissions (ADS-B, Mode S, and ATCRBS).
- There was a 95th percentile UI, which is about 10s, an improvement on the performance of the expected value of 15s for two payloads.

Polaris Flight Test Plan and Aircraft

From 2 Payloads	Best Expected	Best Measured
Aircraft Elevation (deg)	4.00	- 1.37
Slant Range (km)	2800	3392
95th % Update Int. (s)	15.00	9.97

FAA Test Flight – March 30th, 2017

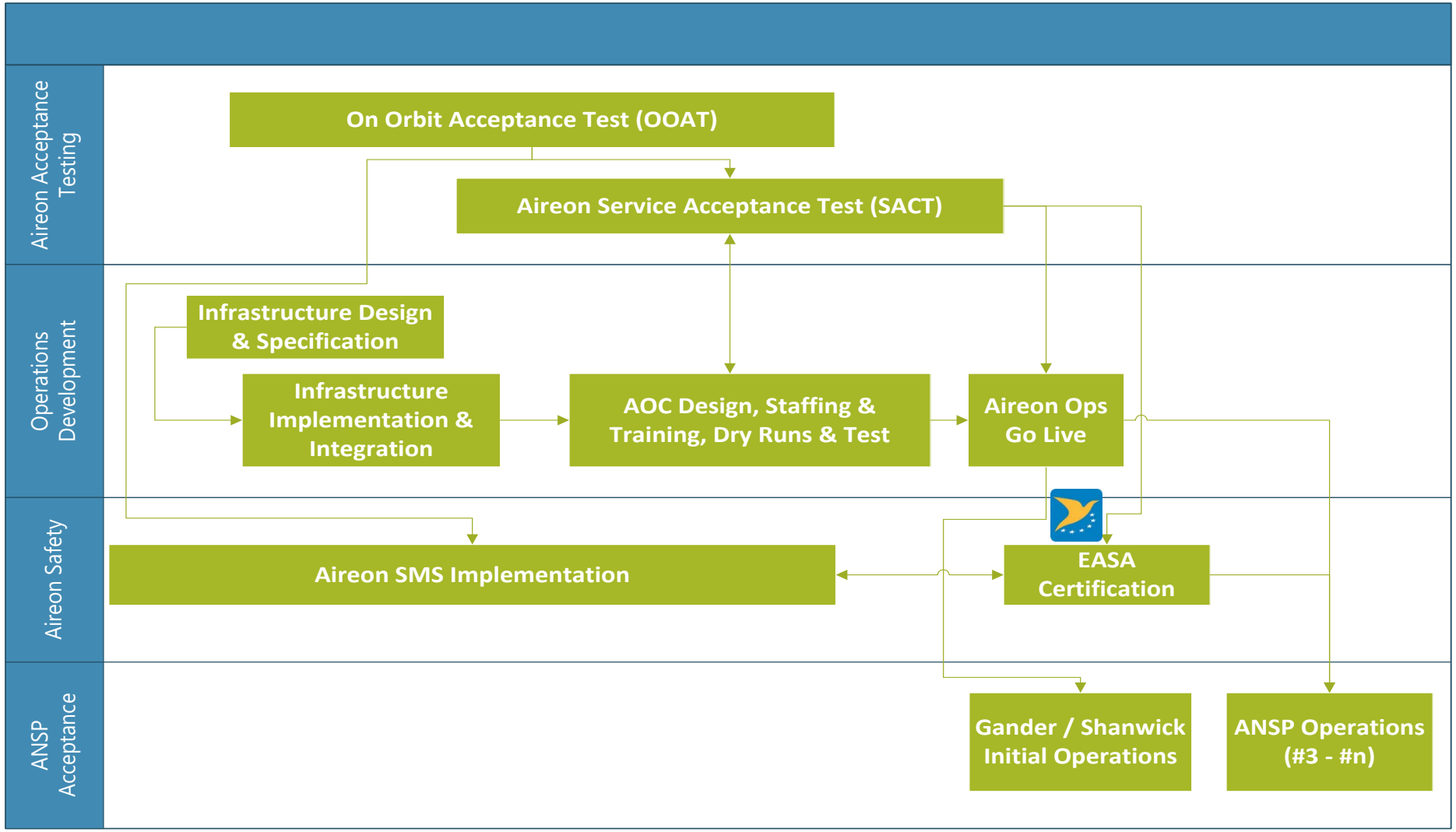
- During this flight test, three Aireon payloads were available to receive data, offering significantly more samples than if only one payload was in operation.
- The measured UI performance and the results look strikingly similar to terrestrial ADS-B coverage.
- 2,462 ADS-B messages were received during the test flight.
- The table below summarizes expected versus measured performance for some key parameters:

FAA Flight Test Plan and Aircraft

From 3 Payloads	Best Expected	Best Measured
Aircraft Elevation (deg)	7.00	- 4.58
Slant Range (km)	2550	3768
95th % Update Int.(s)	15.00	10.02

ANSP Implementation of Space-Based ADS-B

Transition to Operations

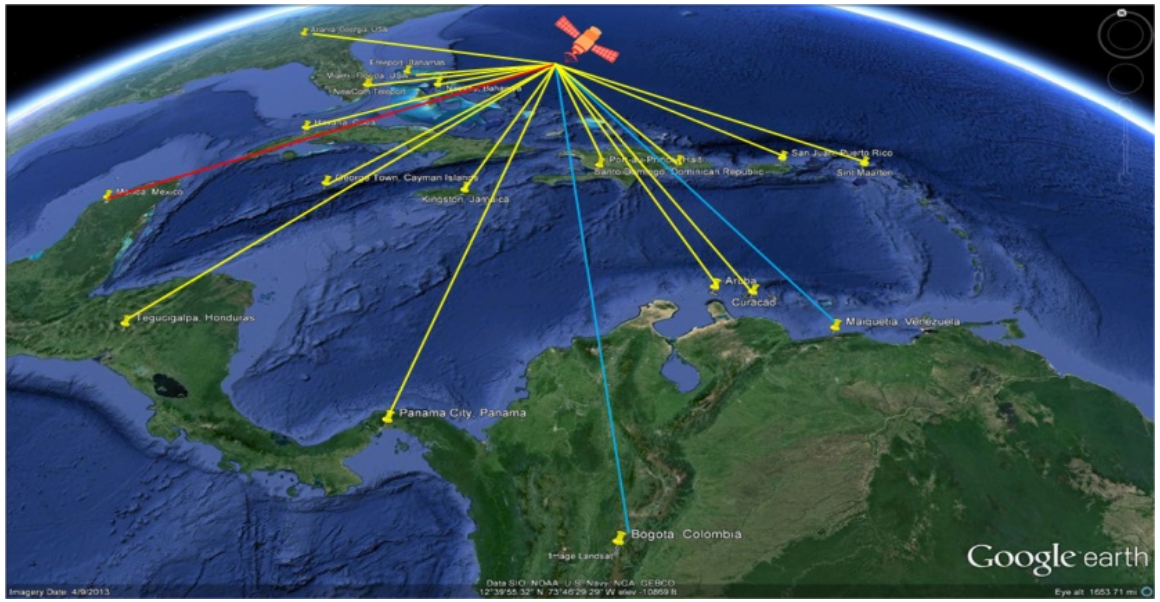


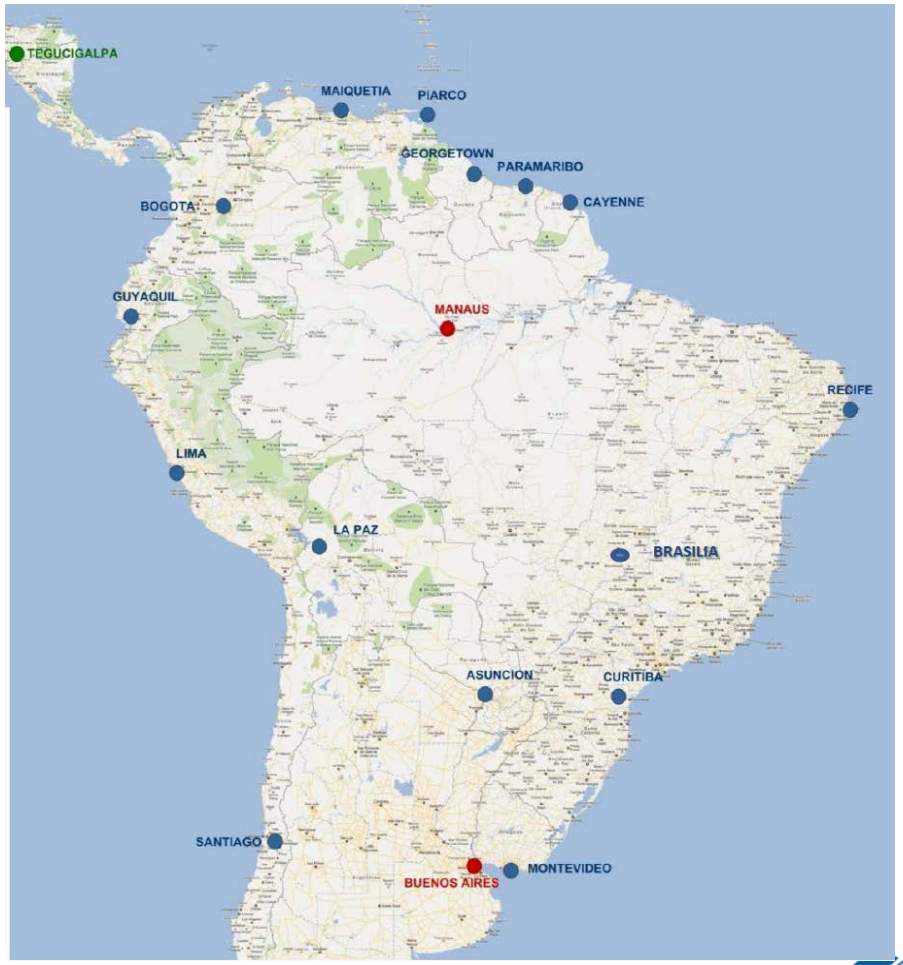
Safety is part of developing the system and maintaining operations for the life of the service

Launch Customer's Team Meeting at IAA Facilities Mar '17

Data Distribution through REDDIG Network

Analysis is underway for potential distribution in Latin America and Caribbean through MEVA III and REDDIG II

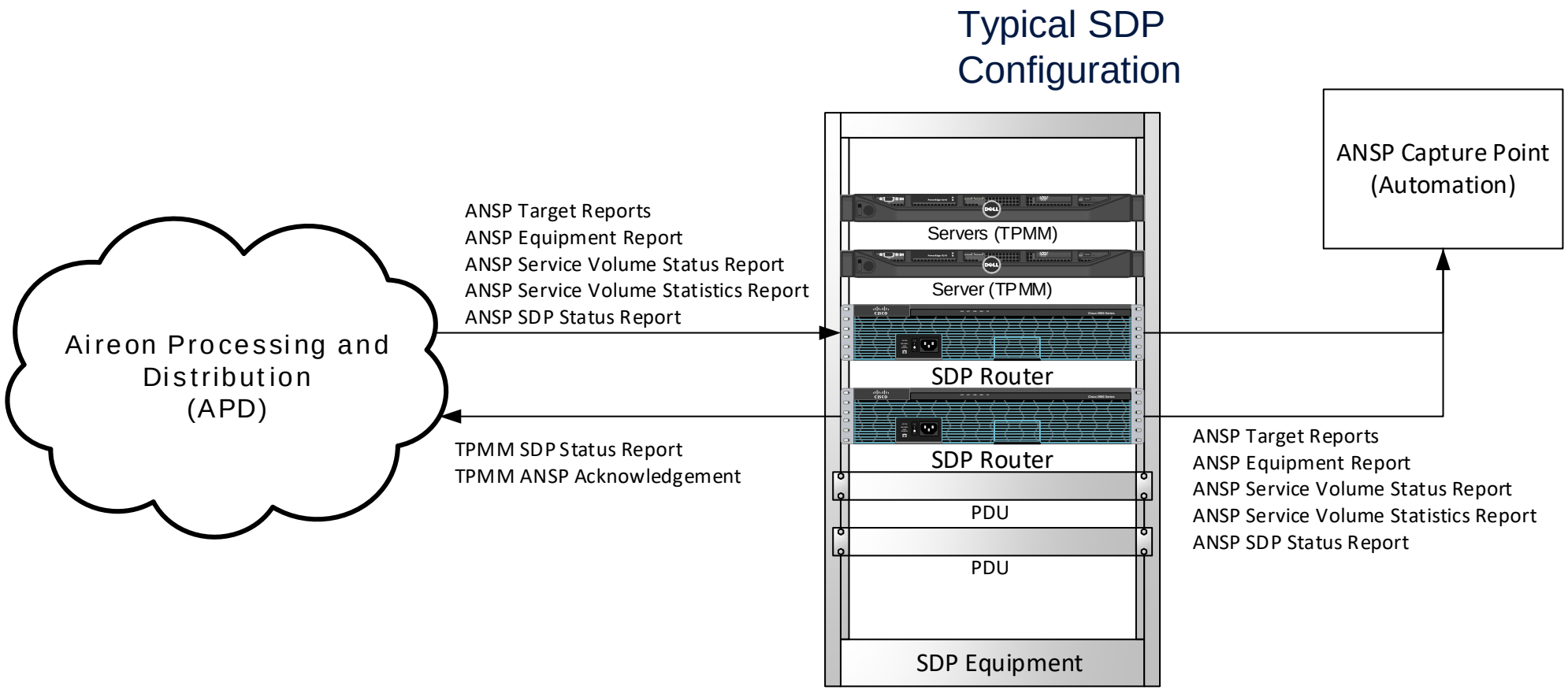




By using the Regional Networks, States can benefit from:

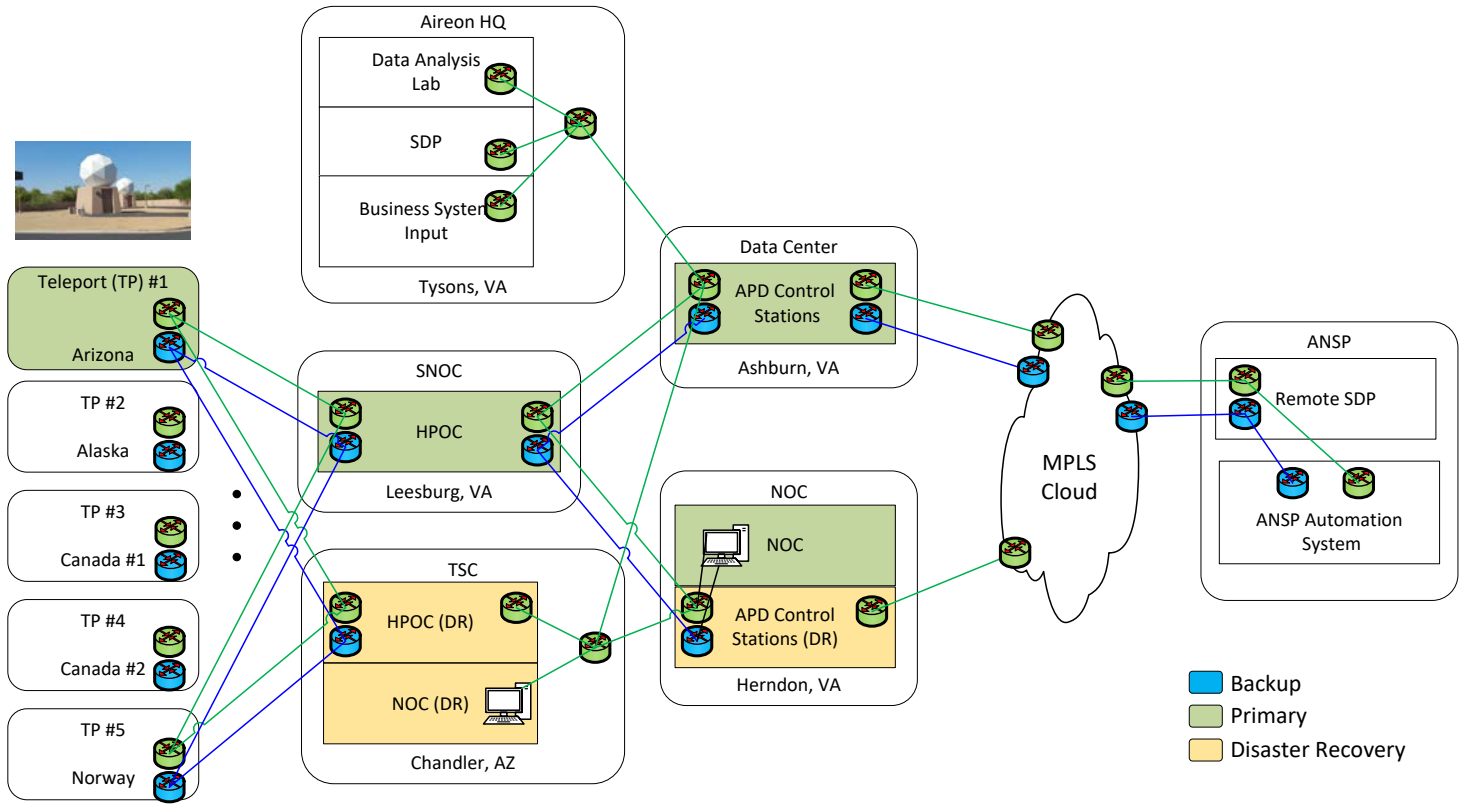
- Reduction of telco lines cost
- Reduction of SDP cost
- Platform for data sharing for ATFM, SWIM and other applications

Typical SDP Architecture (Single Node)

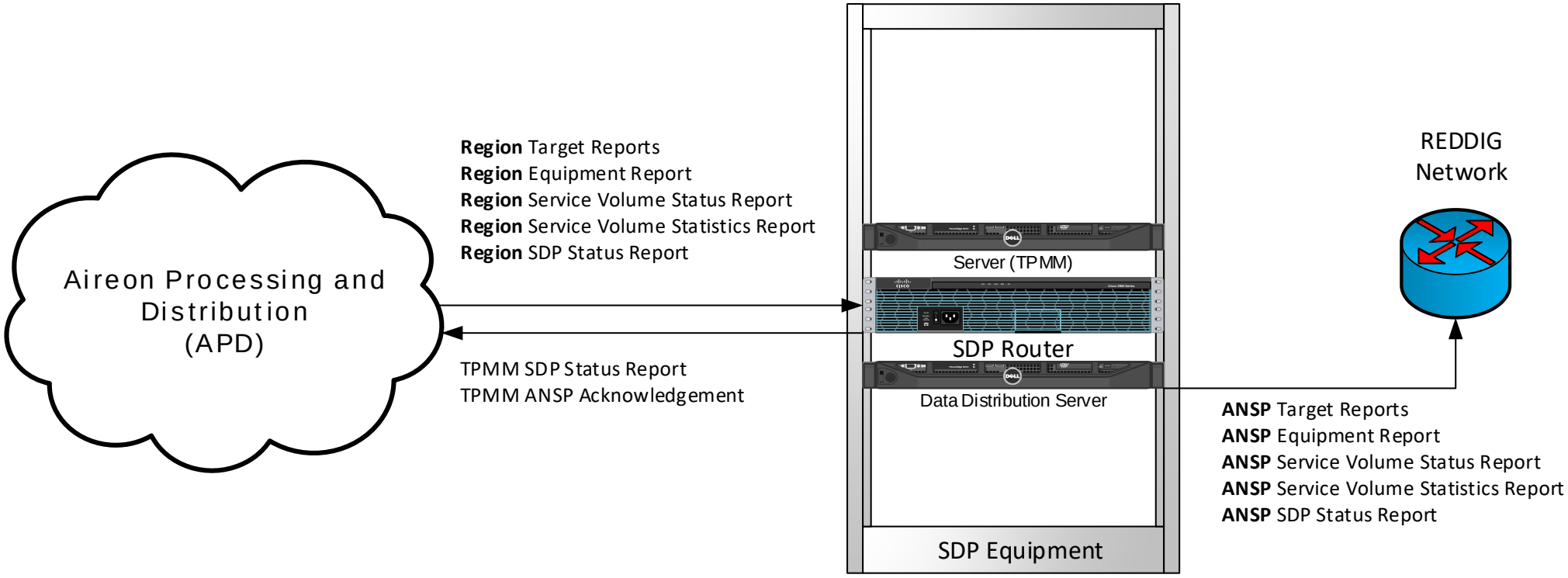


Typical SDP Network Diagram

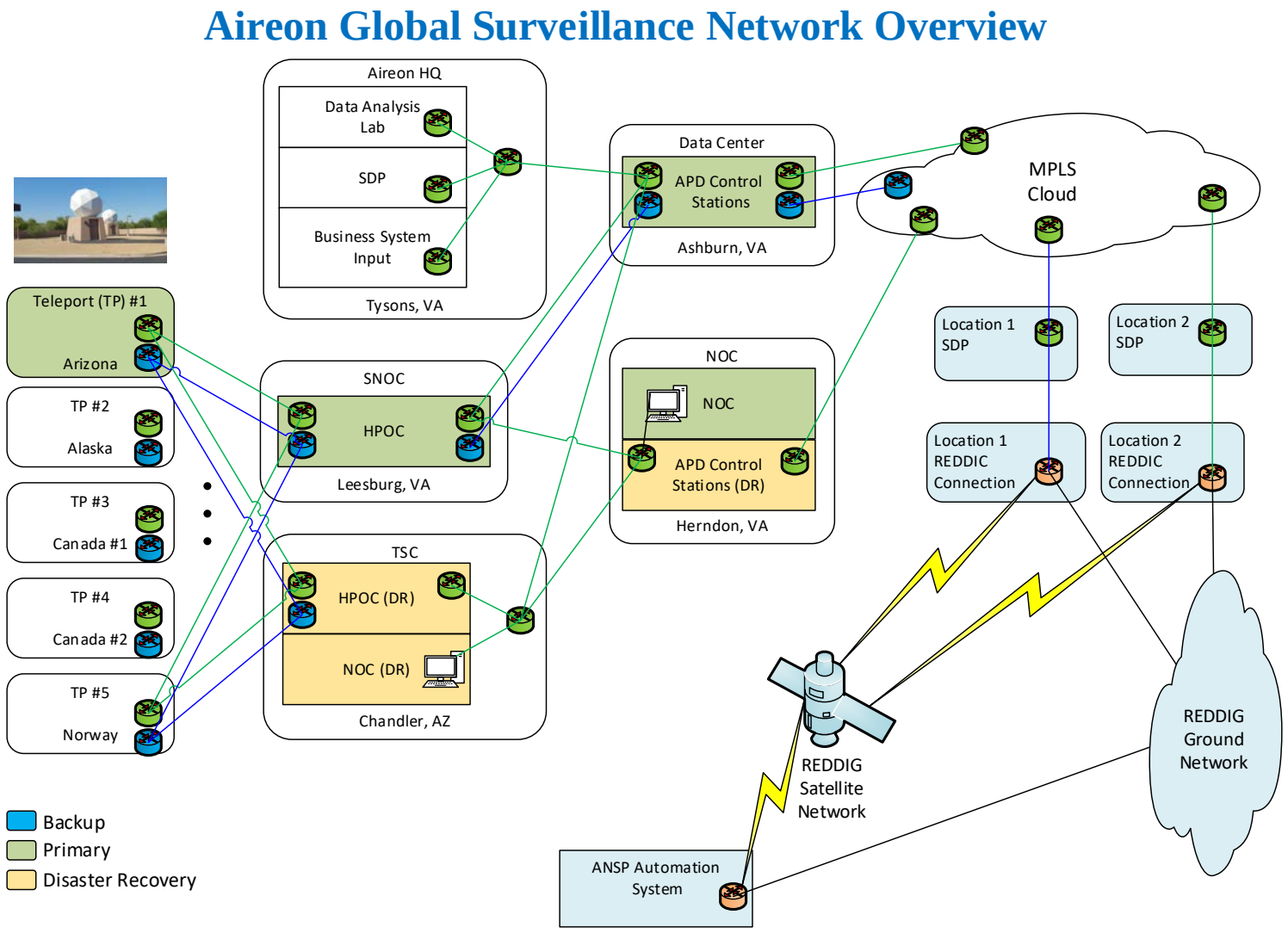
Aireon Global Surveillance Network Overview



REDDIG SDP Architecture (Dual Nodes)

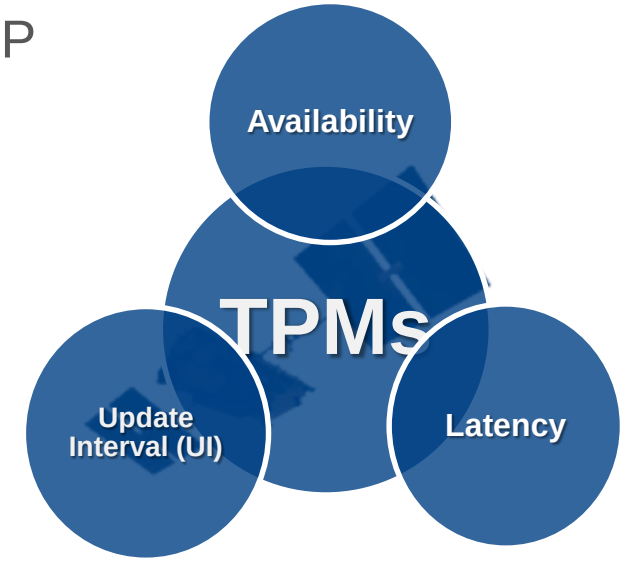


REDDIG SDP Network Diagram



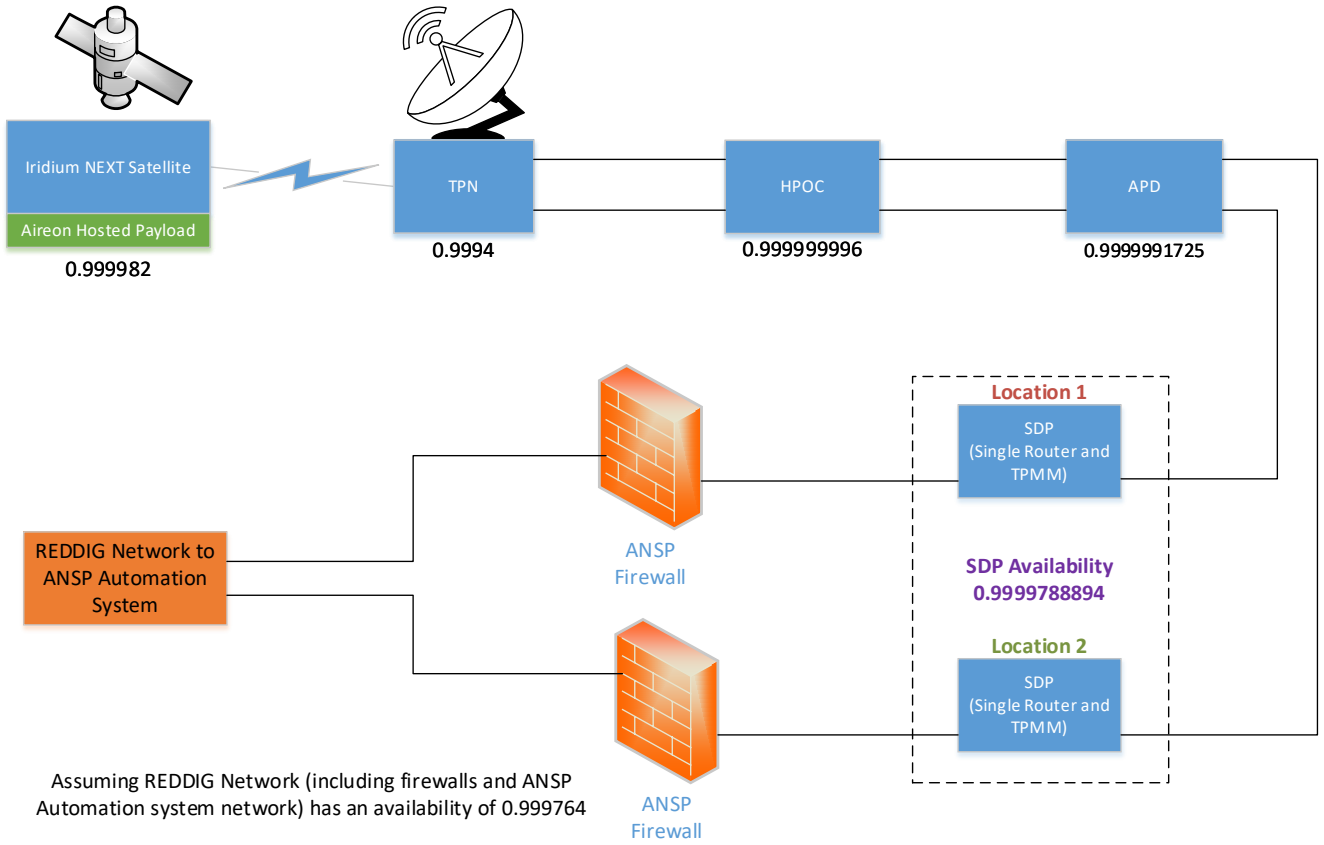
Things to Note about using the REDDIG Network

- TMPs are measured at the SDP
  - Availability - 0.999
  - Update Interval – 8s, ≥ 96%
  - Latency - ≤ 2s
    - Availability and Latency will be affected by the REDDIG network and is not included
- Data billing is calculated on what is delivered to the SDP
- Aireon will maintain configuration of all system components up to the SDP
- Aireon will maintain security up to the SDP
- We need to rely on REDDIG's system to deliver data to ANSPs across SAM region



Calculated Availability System using REDDIG Network

Availability using two single string SDPs that feed a single Automations Systems



System Availability is 0.99912

REDDIG Network Requirements

- System Availability > 0.999
- Accepts Multicast Data
- Delivery to Automation system in low latency
- Surveillance data segregation for each of the connected ANSPs
- Bandwidth: Total Estimated Bandwidth Usage of 2,061 Kbps, considering the following scenario:
  - Full Usage of all 14 States that compose SAM region
  - Full Usage in both terrestrial and oceanic airspaces
  - Full Usage in lower and upper airspaces
  - Air Traffic at levels of 2030

Estimated Data Distribution Costs

Estimated Cost using REDDIG	US$
a. SDP deployment and test costs (2 SDPs) – one-time cost	320,000
b. Telco Cost on 2 locations (single line in each location)/year – recurring cost	95,000
c. Implementation/service acceptance cost per ANSP – one-time cost	112,000

Estimated Cost per ANSP direct connection	US$
a. SDP at ANSP location-one- time cost	300,000
b. Telco Cost per ANSP (dual line)/year-recurring cost	95,000
c. Implementation/service acceptance per ANSP	112,000

Implementing Space-based ADS-B through REDDIG would have significant economic benefits for ANSPs

Conclusions and Suggested Actions

- Initial assessment shows it is feasible to distribute space-based ADS-B air traffic surveillance data, through REDDIG
- Implementing Space-based ADSD-B data distribution through REDDIG would have significant savings to ANSPs in the SAM region
- Aireon would guarantee availability to the SDP and REDDIG system guarantees availability to ANSPs sites

- Suggested Actions:
  - Take note of the information presented herein;
  - Continue with the development of the cost analysis to distribute Space-based ADS-B data to interested States through REDDIG
  - States to consider the implementation of Space-based ADS-B data services as a regional project

Thank You

NAV CANADA iridium Everywhere IAA enav NAVIAIR

Aireon

Investors, Customers and Innovators:

A company created by ANSPs for ANSPs and airlines

Iridium NEXT Satellite