

Space Based ADS-B

Transforming the Way you See the Sky

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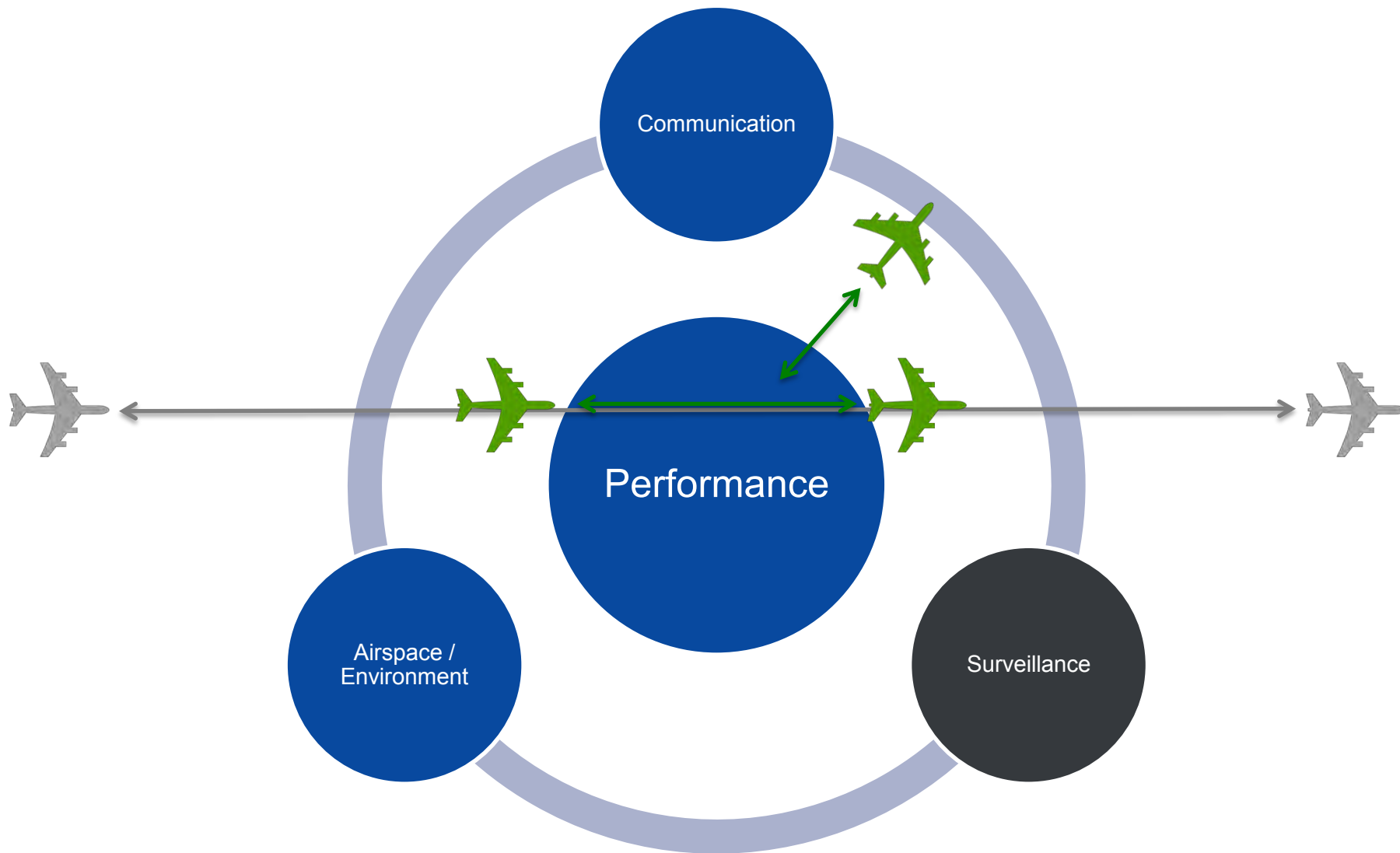
Investors Partners Innovators



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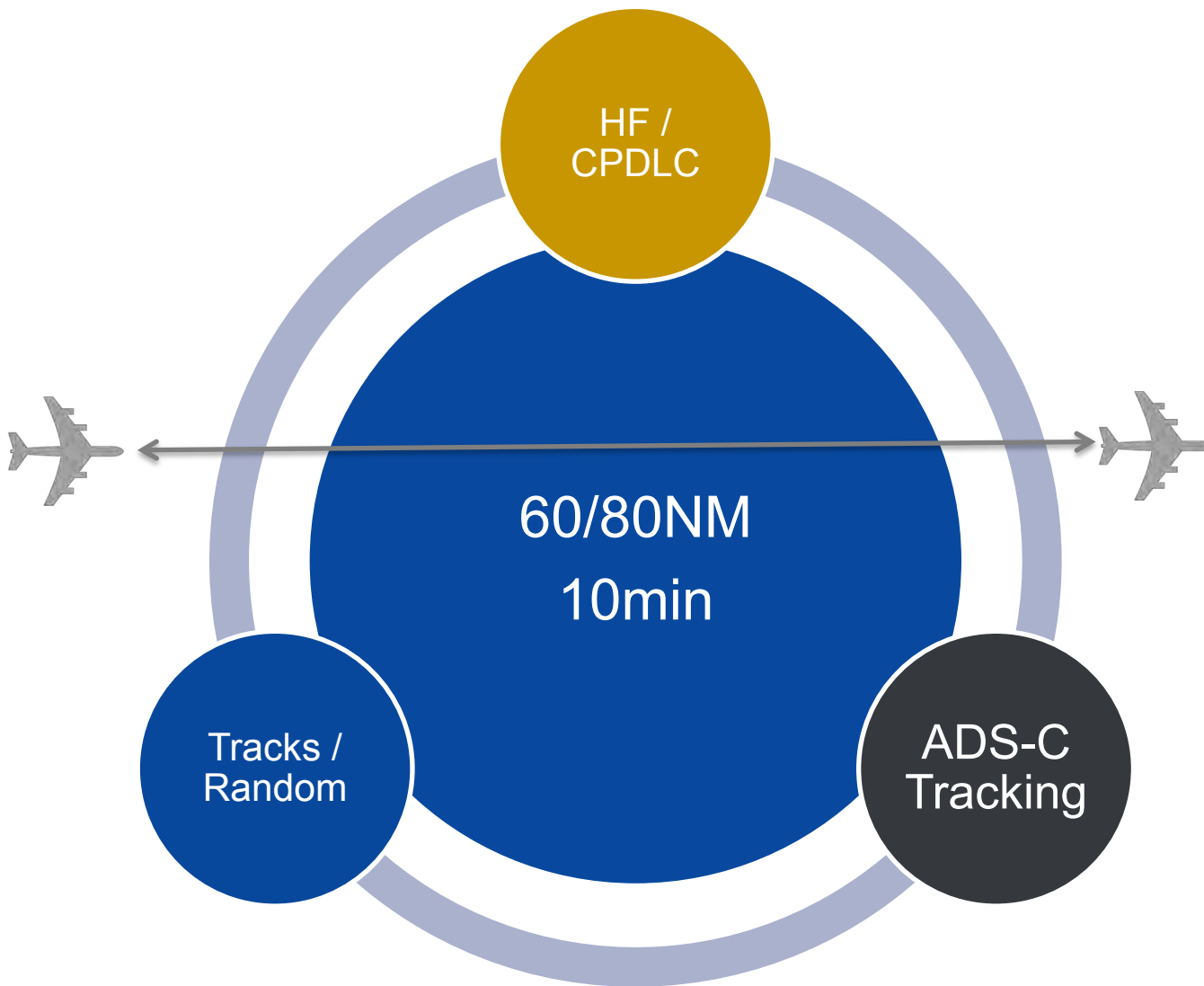


Enabling Operational Performance



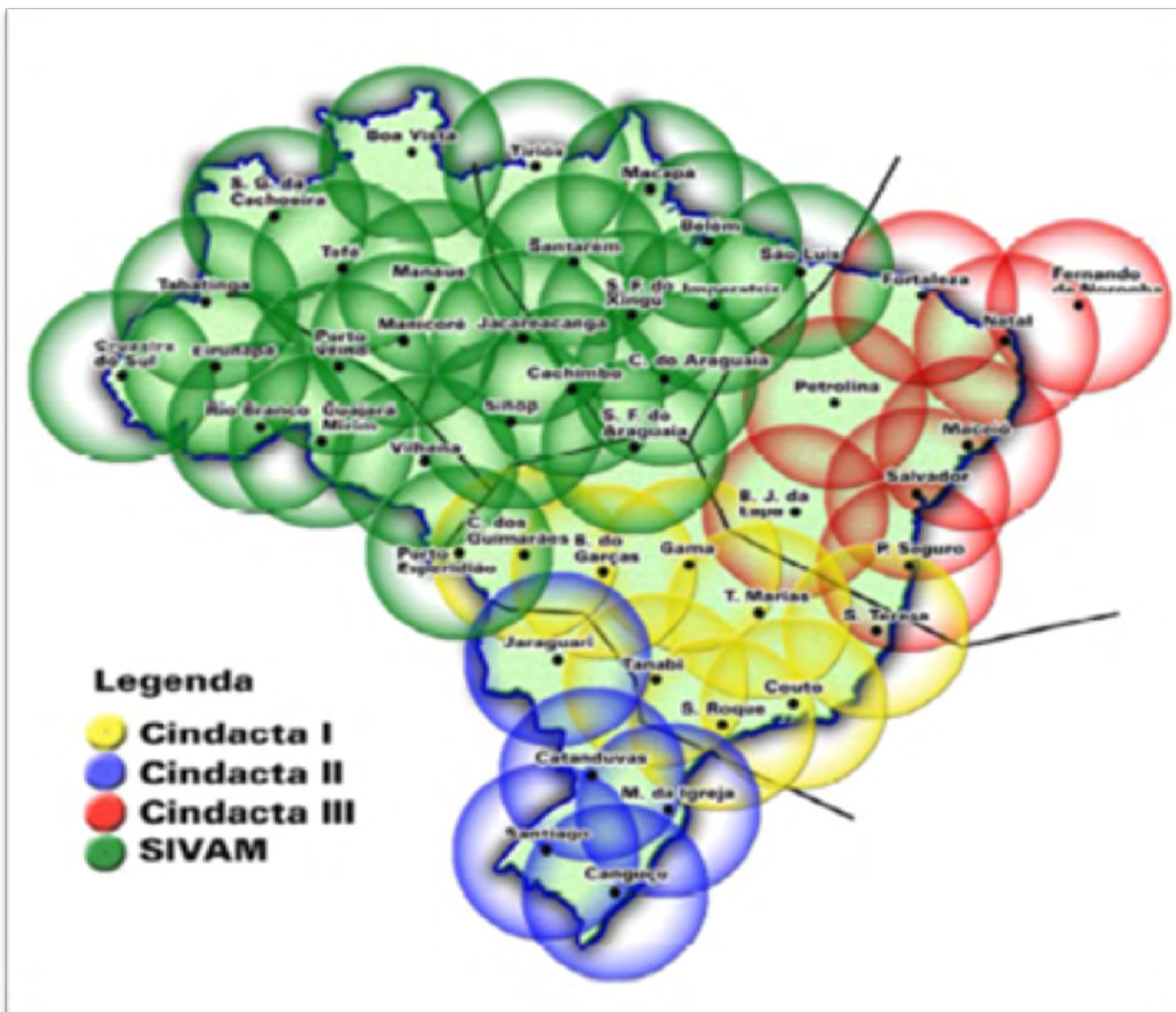


Today's Oceanic / Remote Reality





The Legacy Terrestrial Solution



Automatic Dependent Surveillance – ADS-B (out)

- An innovative and proven surveillance concept through ground based stations
- Significant development in replacing or augmenting radar surveillance
- Upcoming transponder mandate for all aircraft in Europe and US
- Almost all new aircraft by default are ADS-B equipped

A quantum leap in aircraft surveillance — except...

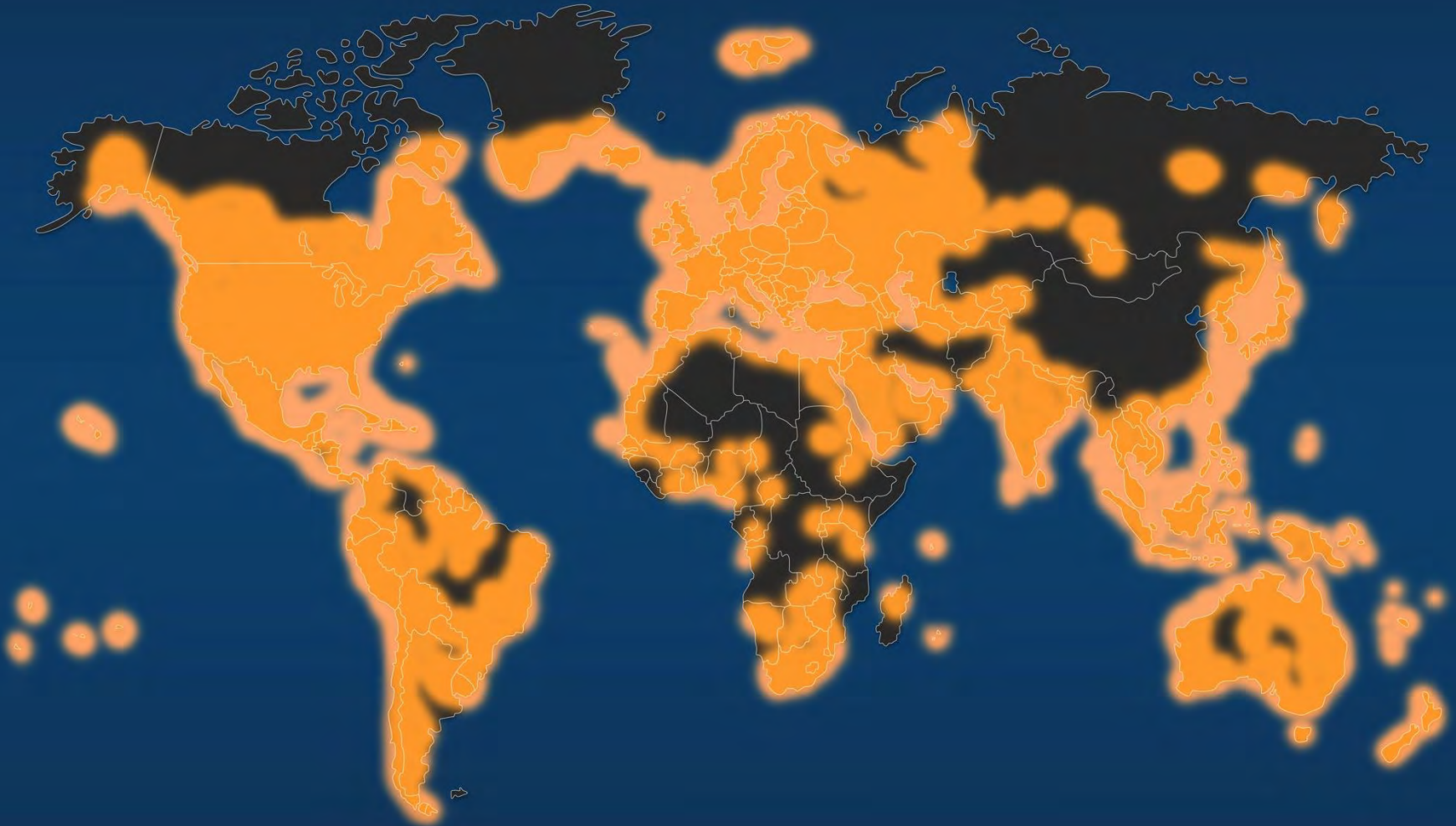


Current surveillance is limited to line of sight





Over 70% of the world remains un-surveilled





Today's airline surveillance challenges

Oceanic / Remote

- Restricted speeds, routes and altitude
- Limited operational and weather flexibility
- Restricted flow / metering delays
- “Harmonica” separation
- Complexity / no harmonized system
- Converging avionics requirements
- Safety risk of being in un-surveilled airspace

Terrestrial:

- High costs of surveillance signal duplication
- High costs of telecom / O&M
- Lack of cross-border signal sharing (flow restrictions)
- Contingency requires a full duplicate surveillance layer
- Significant time to implement large scale changes



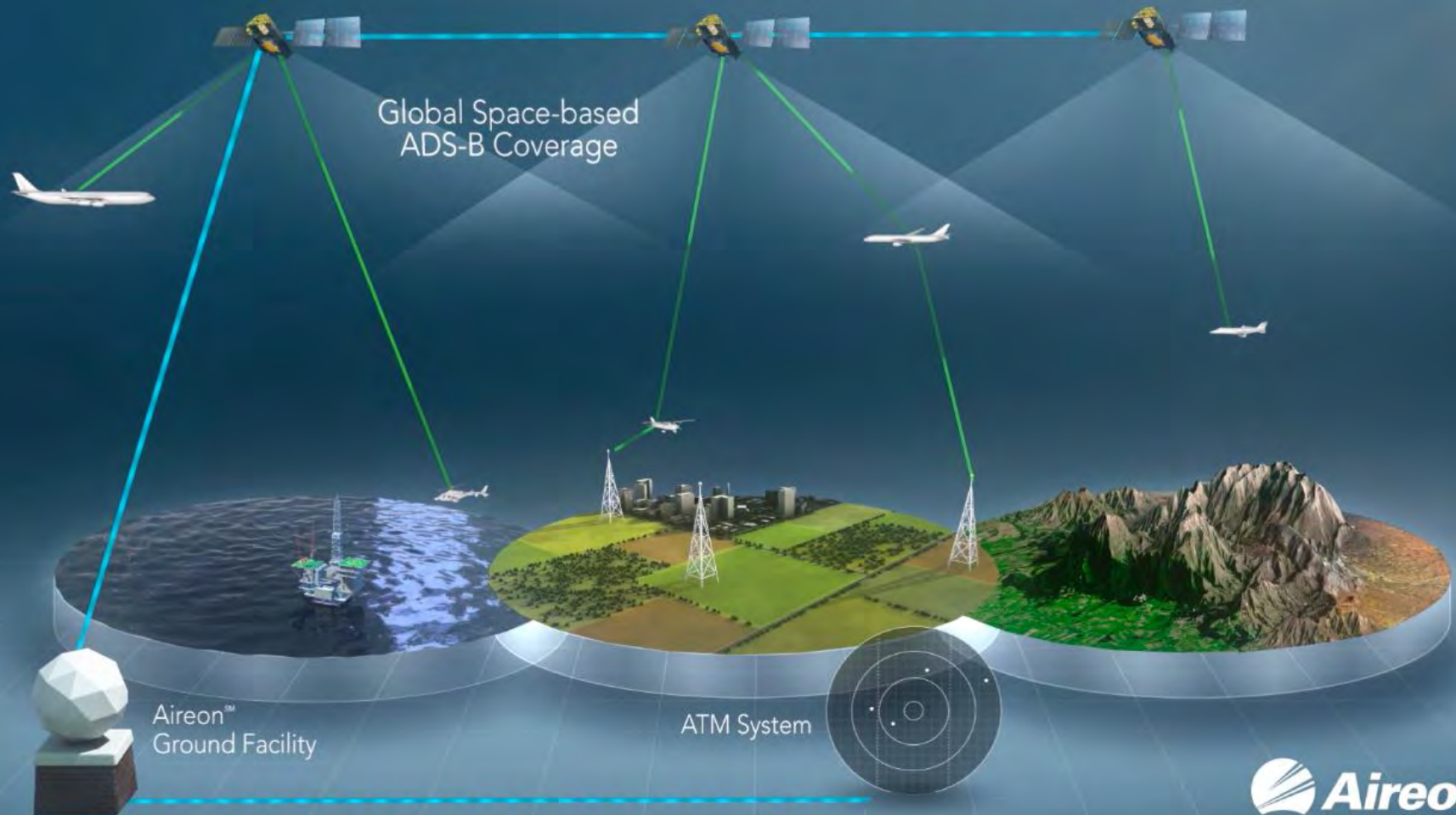


Unlocking ATM performance





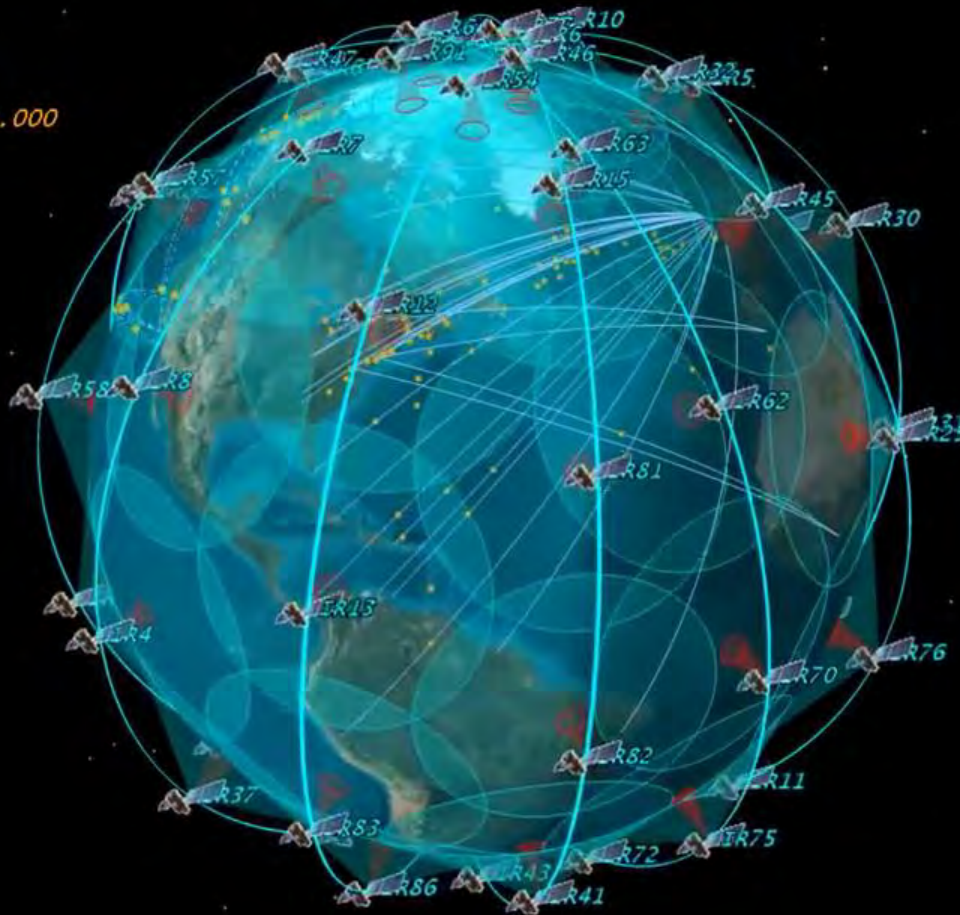
Unlocking ATM Performance





Transforming The Way You See The Sky

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Earth Inertial Axes





Aireon System

Investors, Innovators and Customers





Investors, Customers and Innovators





Launch in 2015, Global Coverage in 2017

- A \$3 Billion US/Canadian/European satellite project, commissioned by Iridium, built by ThalesAlenia Space in France

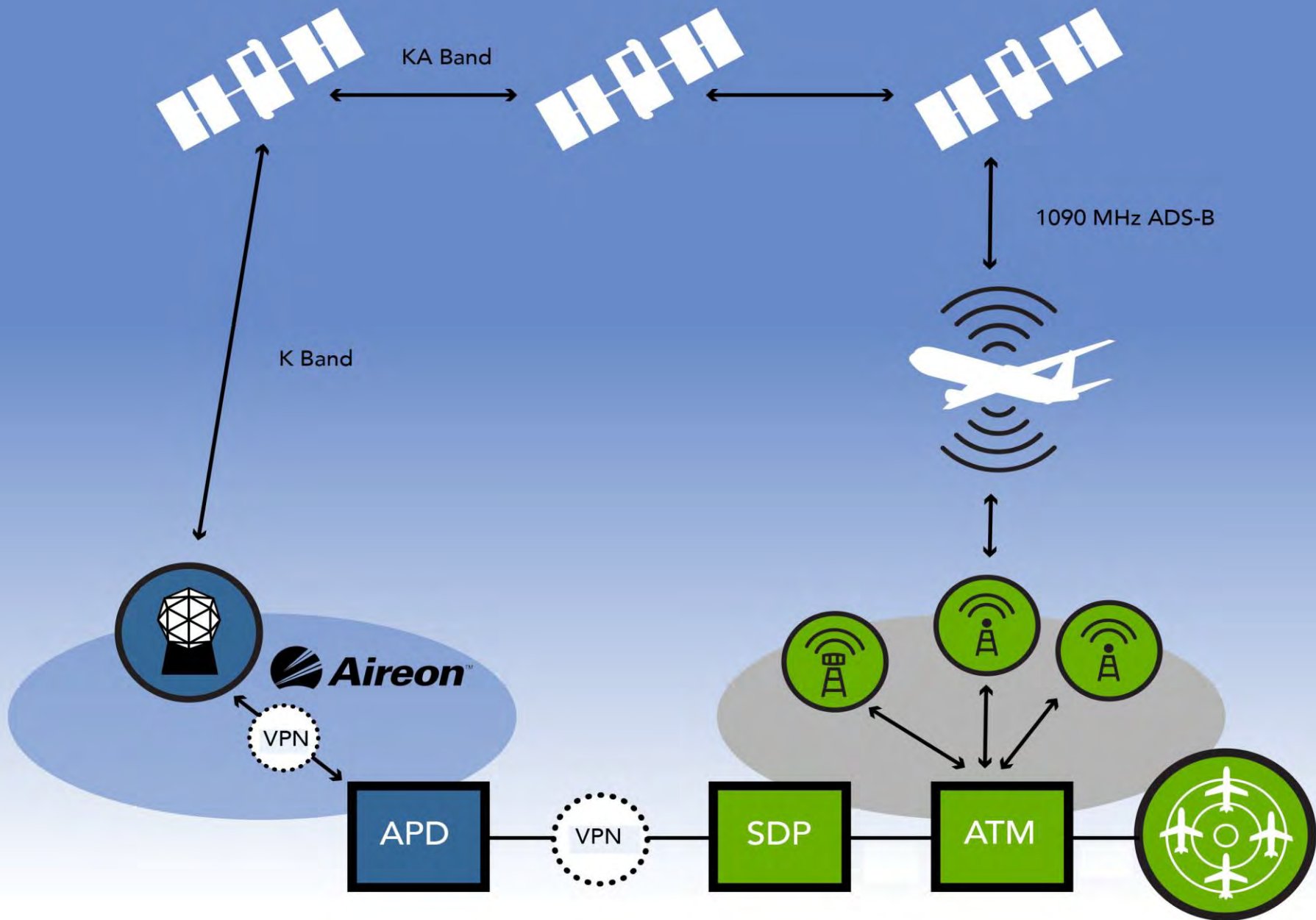


- Space-qualified ADS-B receiver payload being developed by Harris Corporation will fly in a 72 LEO satellite constellation with 9 ground spares



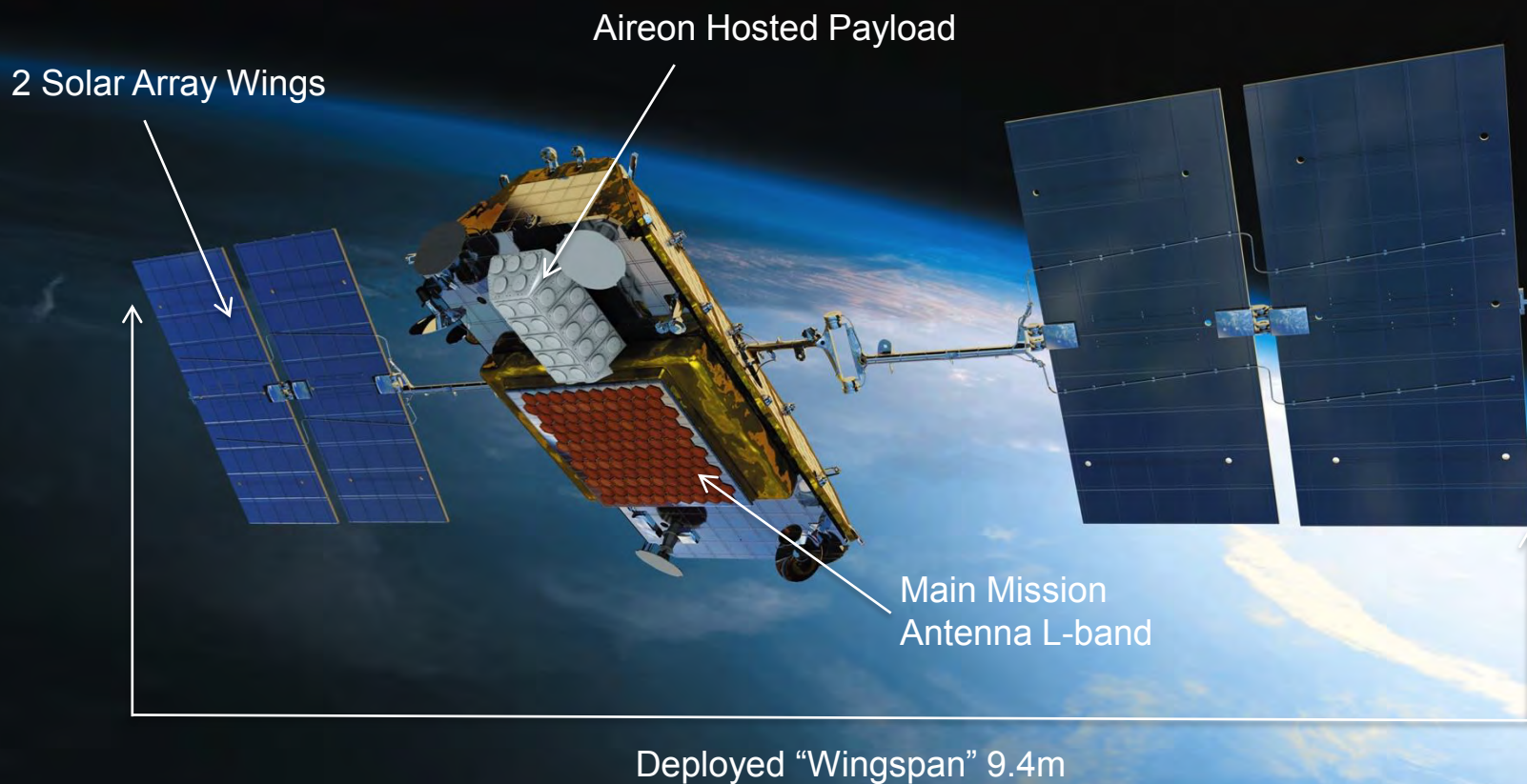
- Systems engineering and ground data processing system by Exelis with significant expertise and existing ground based ADS-B infrastructure



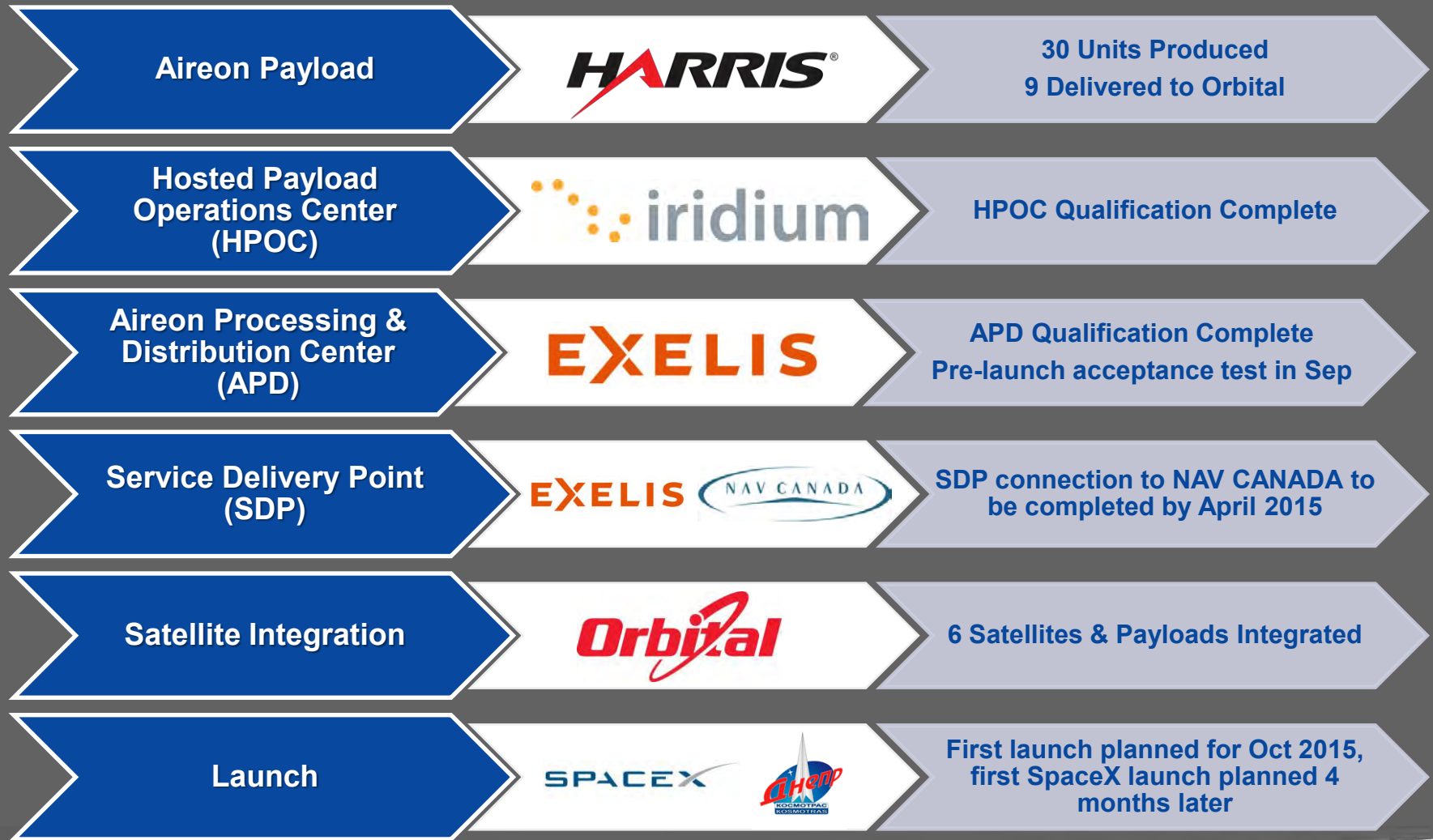




Iridium NEXT Satellite Configuration

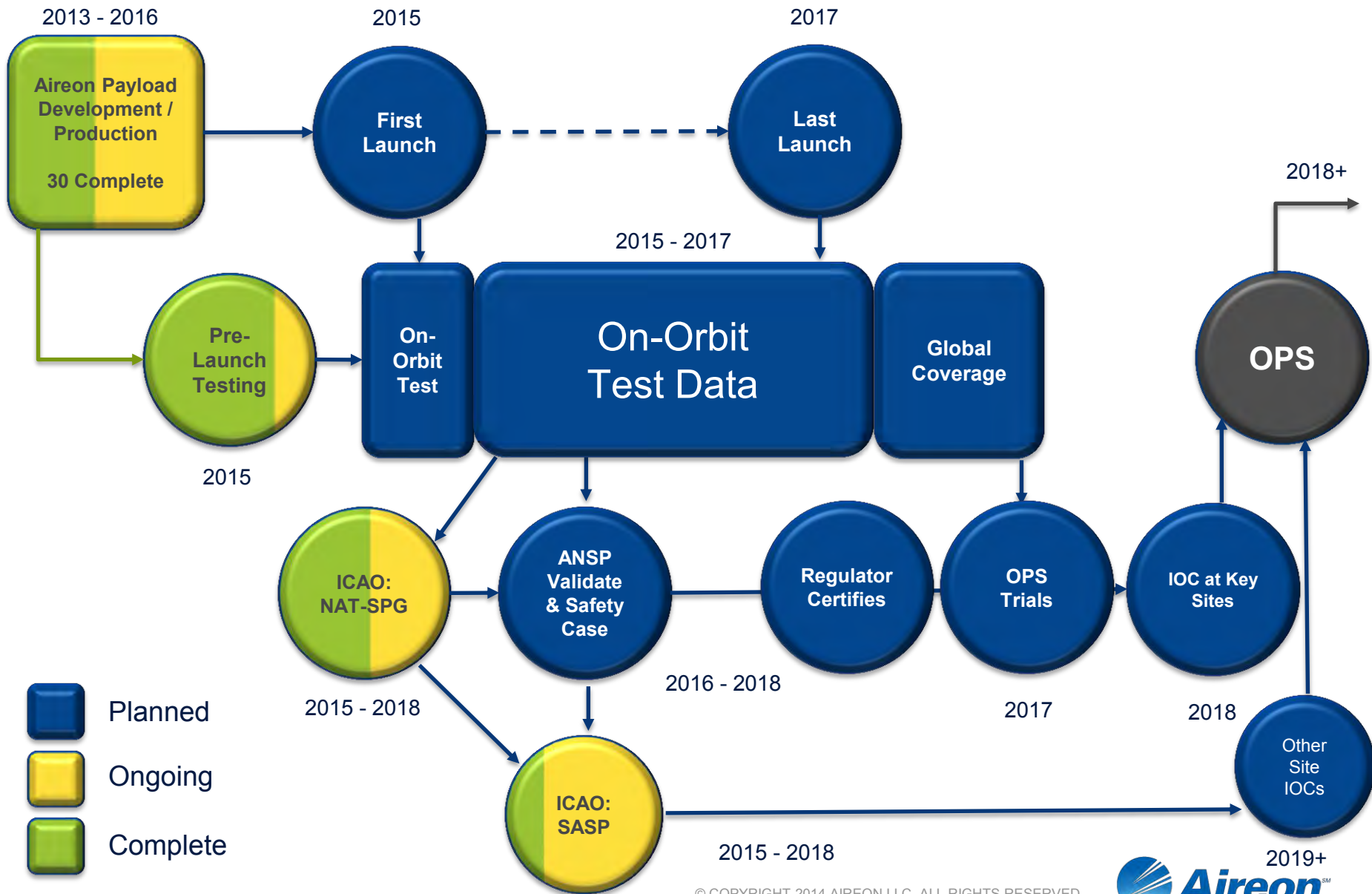


Aireon System Development Status





Roadmap to Initial Operating Capability

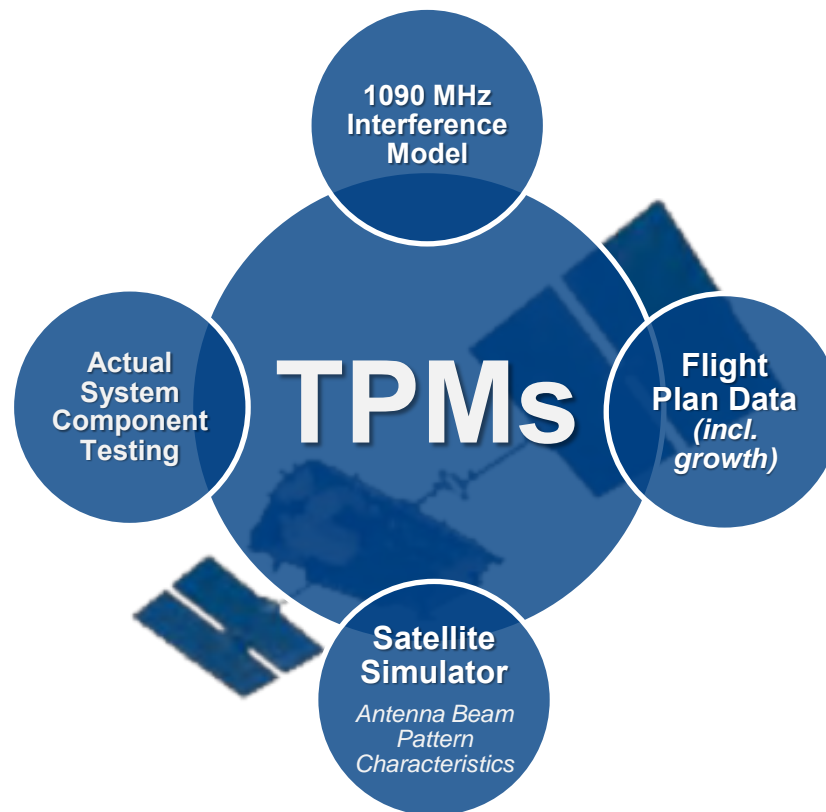




Aireon Performance Simulation

Aireon has created a global performance simulation tool called ASIM to calculate critical Technical Performance Metrics (TPM):

- Update Interval
- Latency
- Availability





It's Just ADS-B!

ATS Surveillance Requirements (EUROCAE)



	ATS Surveillance Requirements (EUROCAE)	Aireon™
Surveillance Data-link Requirements	Variable Per Region <i>(DO-260 Version 0, 1, 2)</i>	Accepts all 1090ES ADS-B <i>(DO-260 Versions 0, 1, 2)</i>
Aircraft Transmitter Classes Supported	A1 or Higher <i>(125 Watt minimum)</i>	A1 or Higher <i>(125 Watt minimum, with a top-mount antenna (TCAS))</i>
Data Format to ANSP	ASTERIX CAT021, CAT023, CAT025 and FAA CAT033 and CAT023	ASTERIX CAT021, CAT023, CAT025 and FAA CAT033 and CAT023
Capacity	Minimum 250 within a high density service volume	≥10,000 simultaneous aircraft globally
System Coverage	Enroute Service Volume (200 NM)	Continuous Global Coverage
Availability	≥ 99.9%	≥ 99.9%
Latency	≤ 1.5s to the ATM Automation Platform	≤ 1.5s to the ATM Automation Platform
Update Interval	≤ 8s at 95%	Simulation and testing shows that targets will be delivered at an UI of ≤ 8s* at 95%

* ASIM Simulation & Component Testing





Broad support among major ANSP's

- **Launch Customers:**

- Nav Canada, ENAV, NAVIAIR, Irish Aviation Authority
- UK-NATS

- **MOA in place with:**

- FAA, Nav Portugal
- Singapore, India
- ASECNA, South Africa
- Blue Med Fab

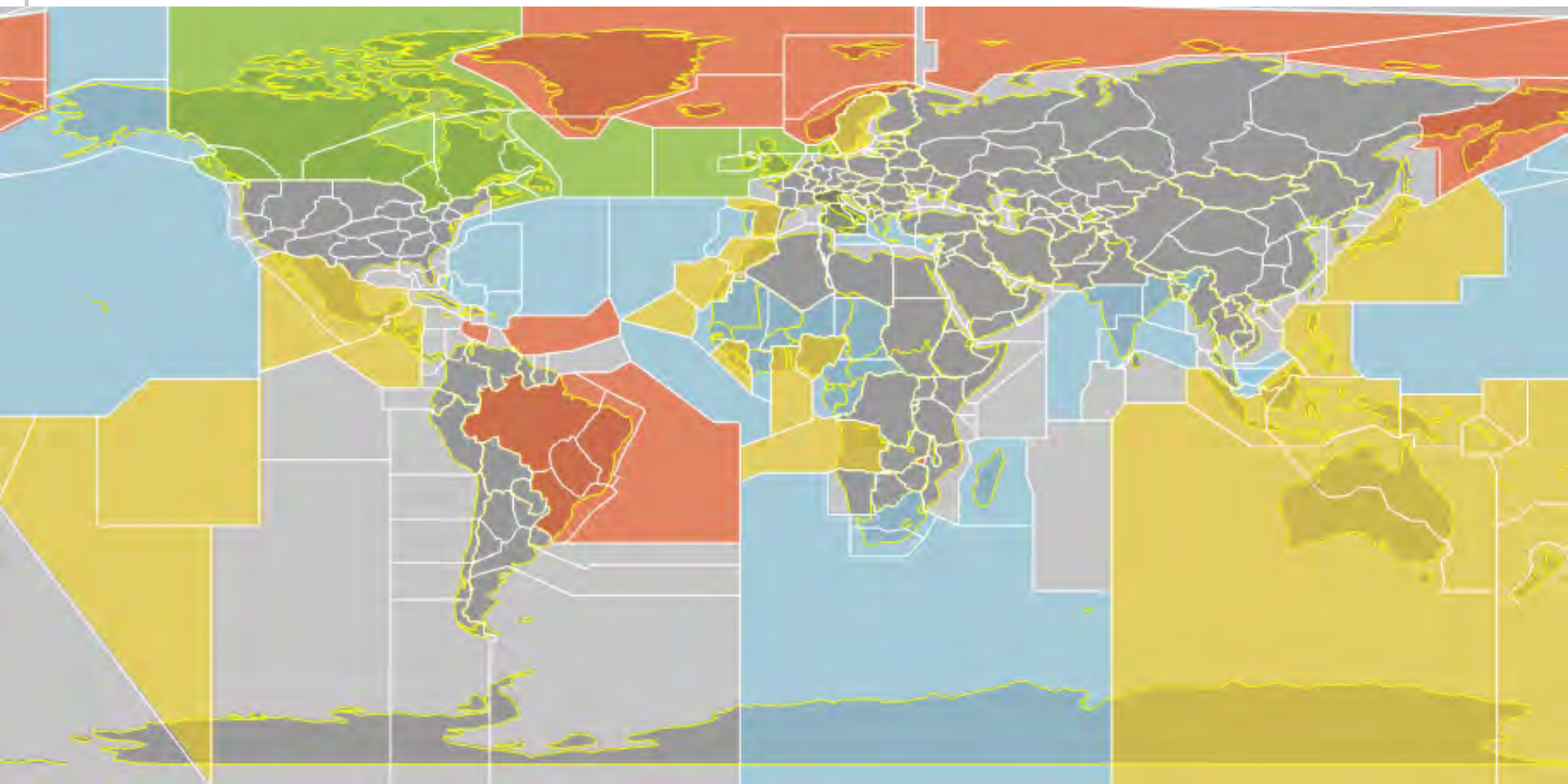
- **MOA in development for:**

- Trinidad, Brazil, Curacao
- Iceland, Russia, Australia, New Zealand





Next phase is securing strategic traffic corridors to deliver seamless operational benefits for airlines



DSA
MOA to DSA
MOA Development
(Pre)-engaged




Space-Based ADS-B Integration Into ATM Systems

- **Sole Source Surveillance**
 - Provide a signal, suitable for surveillance, to an ATM system where it currently does not exist to enhance safety, efficiency and operational performance
- **Augmented surveillance**
 - Augment existing ADS-B or radar surveillance to fill gaps, improve performance, lower infrastructure costs, improve safety, share surveillance data and provide seamless contingency
- **Contingency surveillance**




Oceanic Comparison (no DCPC)

	ADS-C	SSR	ADS-B Ground Station	 Aireon
Avionics	SatCom	Mode S or ATRCBS Transponder	1090ES ADS-B (DO-260 versions 0, 1, 2)	1090ES ADS-B (DO-260 versions 0, 1, 2)
Single Receiver Footprint / Range	1300 NM	200 NM <i>(varies with altitude)</i>	200 NM <i>(varies with altitude)</i>	1100 NM
System Coverage	No Polar / Subscribed Only	Line of Sight Limitation	Line of Sight Limitation	Continuous Global Coverage
Availability	≥ 99.9%	≥ 99.9%	≥ 99.9%	≥ 99.9%
Latency (RSP / 95%)	180s	≤ 1.5s to the ATM Automation Platform	≤ 1.5s to the ATM Automation Platform	≤ 1.5s to the ATM Automation Platform
Update Interval (95%)	~14 minutes	< 8 – 12s	< 6 – 8s	< 8s*
Possible Separation	≥ 30NM	≤15NM	≤15NM	≤15NM

* ASIM Simulation & Component Testing



5NM Surveillance Comparison (DCPC)

	ADS-C	SSR	ADS-B Ground Station	 Aireon
Avionics	n/a	Mode S or ATRCBS Transponder	1090ES ADS-B (DO-260 versions 0, 1, 2)	1090ES ADS-B (DO-260 versions 0, 1, 2)
Single Receiver Footprint / Range	n/a	200 NM (varies with altitude)	200 NM (varies with altitude)	1100 NM
System Coverage	n/a	Line of Sight Limitation	Line of Sight Limitation	Continuously Global Coverage
Availability	n/a	≥ 99.9%	≥ 99.9%	≥ 99.9%
Latency (RSP / 95%)	n/a	≤ 1.5s to the ATM Automation Platform	≤ 1.5s to the ATM Automation Platform	≤ 1.5s to the ATM Automation Platform
Update Interval (95%)	n/a	< 8 – 12s	< 6s	< 8s*
Possible Separation	n/a	5NM	5NM	5NM

* ASIM Simulation & Component Testing

Initial Oceanic Assessment

- High level assessment of 8 oceanic areas
- Based on 1,000' climb fuel savings
- Up to 3 climbs per flight
- Vetted with IATA airline member familiar with oceanic operations
- Considered conservative and achievable

Oceanic Assessment Benefits

Estimated \$439 million in 2018

Major Oceanic FIRs	Commercial IFR Flights (000s)	Total Fuel Climb Savings (000s)	GHGs (000s Tonnes CO ₂ Equivalent)
Pacific	131	\$169,776	446.4
Shanwick / Gander	390	\$127,000	332.8
New York-Santa Maria	138	\$64,584	169.8
US Coastal	109	\$7,358	19.3
Tasman Sea	48	\$3,240	8.5
Mumbai	22	\$1,337	3.5
North Atlantic above 65°	46	\$21,528	56.6
South Pacific	20	\$43,920	115.5
	904	\$438,742	1,152.4



Phased Implementation in the North Atlantic



- Phase 1 (2016) Conformance Monitoring of space based signal
- Phase 2 15NM longitudinal / $\frac{1}{2}$ degree separation, on tracks between surveillance identified a/c
- Phase 3: 15NM Longitudinal off tracks between surveillance identified aircraft
- Phase 4: Allow surveillance identified aircraft to operate on all tracks which do not intersect
- Phase 5: 15 NM lateral separation between the tracks of surveillance-identified aircraft operating on non-intersecting tracks
- Phase 6: Application of 15 NM separation between surveillance-identified aircraft
- Evolving thereafter...



Aireon ALERT & Aircraft Flight Tracking



Aireon ADS_B Flight Tracking

- Aireon will have global ADS-B visibility
- Enables real time flight tracking without new avionics
- Position update available every 8 seconds or less

Aireon ALERT

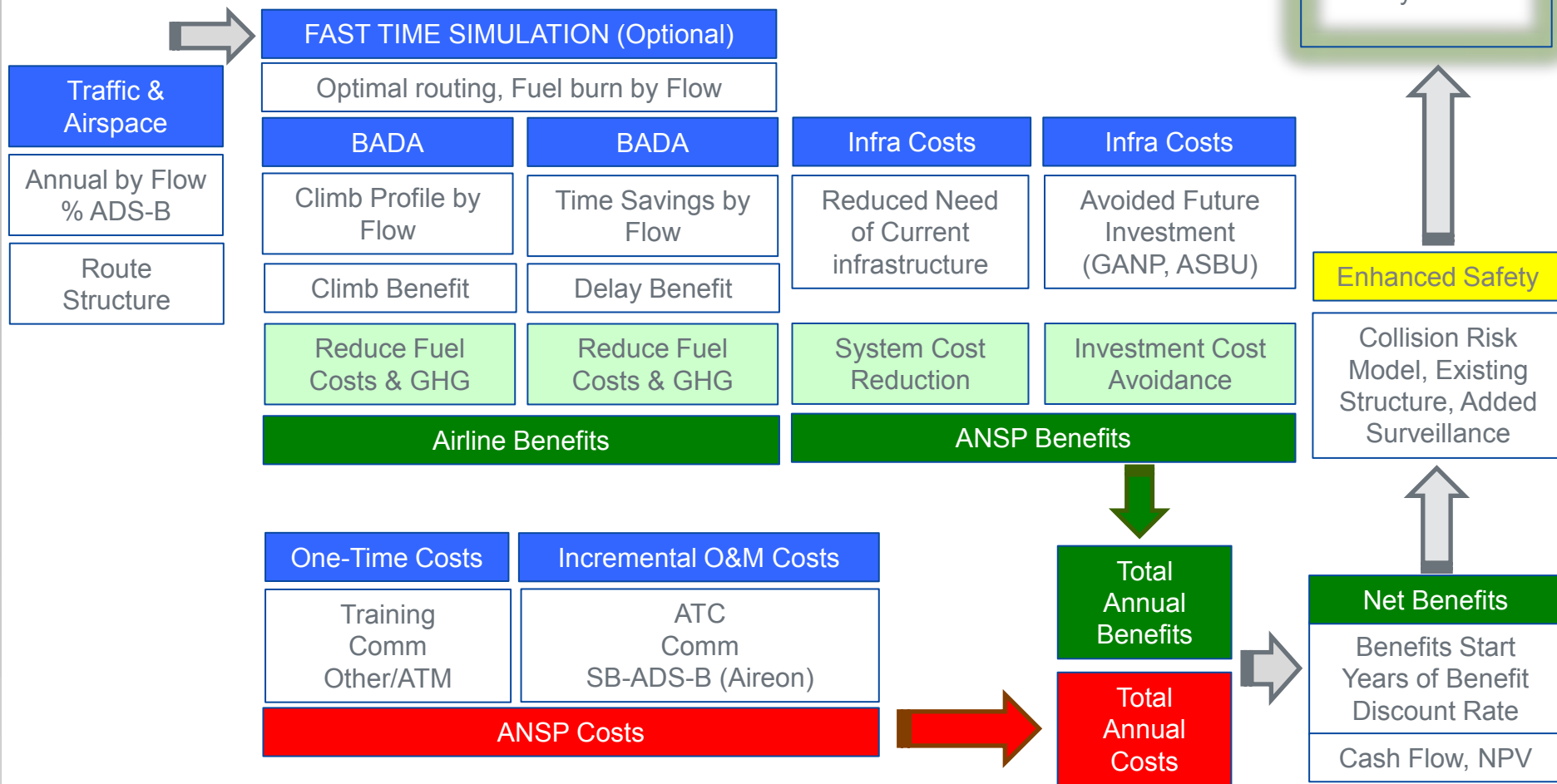
- A 24/7 call center will be available through IAA's COM facility
- A free of charge alert system will be made available as a public service
- All airlines, States and Rescue Coordination Centers can pre-register
- In the event of a distress or alert phase where there is no known aircraft position, Aireon will make the last known position or track available.



Aireon ALERT will globally satisfy the ICAO 15 minute flight tracking recommendation at every 8 seconds without avionics costs.



The Cost Benefit Analysis Model





Identified Benefits Areas far Outweigh Costs





Primary Airline Benefits



Fuel / Time savings:

- Increased access to optimal altitudes
- Use of cost index air speeds
- Decreased flight distance from improved routing
- Minimize impact from operational and weather disruptions
- Reduced disruption from legacy surveillance system outages
- Reduced metering delay / improved flow
- More predictable airline operations

Cost Reduction:

- Avoided avionics investment
- Reduced training costs through harmonization of operating environment
- Reduced infrastructure costs / avoided costs



Primary ANSP Benefits



Cost Reduction:

- Reduced disruption from legacy surveillance system outages
- Decreased radar system replacement or maintenance costs
- Decreased ground based ADS-B replacement or maintenance costs
- Decreased WAM replacement or maintenance costs
- Avoided surveillance system expansion investment
- Avoided signal duplication and associated telecom costs
- Decreased infrastructure and signal costs through cross border contingency
- Reduced training costs through harmonization of operating environment
- Improved data for flight billing and airspace route design purposes



Safety & Societal Benefits



Safety Benefits:

- Reduced loss of separation
- Improved search and rescue services
- Reduction of gross navigation errors
- Reduced complexity through harmonization of operating environment
- Early detection of emergency transponder codes
- Improved airspace integration of UAS
- Improved data for flight billing and airspace route design purposes

Societal Benefits:

- Reduced Greenhouse Gas Emissions (carbon credit)
- Safety Gains



Value Added Data (to be determined)

Currently no global movement data set exists

- Airline Operations Control
- Actual movement data (real time)
- Flight Plan / Operational Analysis
- Data feed for airline / airport systems
- Historical Analysis
- Fleet Tracking
- Low cost situational awareness in towers / operational centers
- Airport surface movement
- Remote towers
- Insurance
- UAV integration
- Space vehicle tracking
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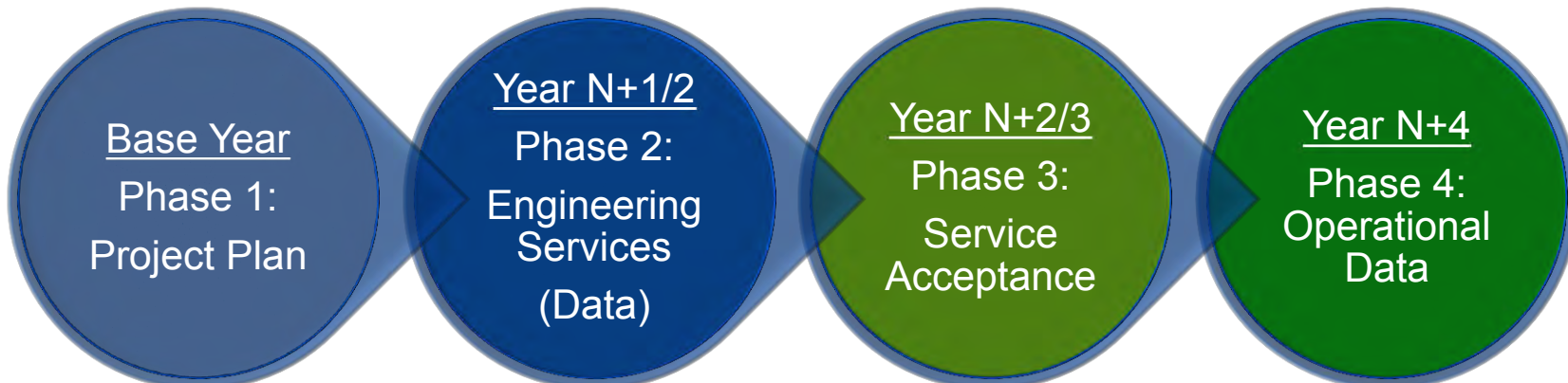


Operational Transition Scenarios

CONOPS Scenarios	Capability	Communication	Surveillance	Separation
No surveillance with limited COM	Base Case	Limited	Procedural	Long 10 min (80 nm) Lat: 80nm to 120nm
		Limited	SB-ADSB Surveillance	Long 10 min (80 nm) Lat: 60nm or better
ADS-C without DCPC	Base Case	HF/CPDLC	ADS-C	80, 40 or 30 nm
		HF/CPDLC	SB-ADSB Surveillance	<15 nm
ADS-C with DCPC	Base Case	DCPC	ADS-C	30 nm
		DCPC	SB-ADSB Surveillance	5 nm
Existing Surveillance	Base Case	DCPC	Radar, WAM, or Ground Based ADS-B	5 nm
		DCPC	SB-ADSB Surveillance	5 nm



Structured Approach to New Data Services Agreements



- **ANSP Pays Unique Costs**
- Program Management Plan
- Aireon System Description Document
- Interface Control Document
- Site Survey
- Concept of Operations Survey
- Service Acceptance Data Package

- **ANSP Pays Unique Costs**
- Aireon pays signal delivery to demarcation point
- ANSP pays the telco to SDP
- Time and Material
- Support as needed by customer
- Support Safety Case
- Support Testing & Validation

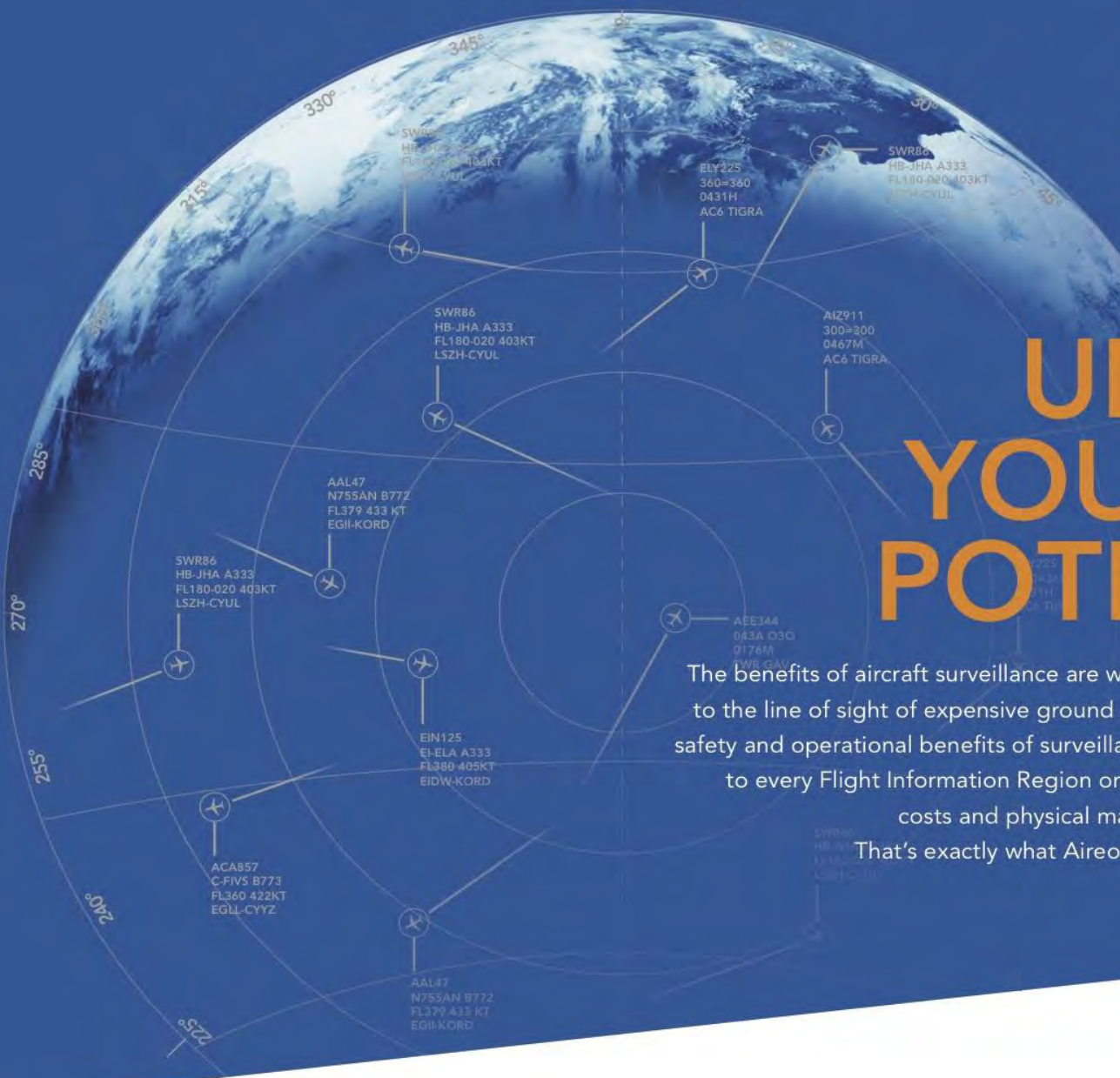
- **ANSP Pays Unique Costs (as in phase 2)**
- SDP in place
- Test Plan
- Test Procedures
- Test Reports
- Service Acceptance Data Package
- Regulatory Approval
- **Operational Trail (3 month)**

- **Start Service Fee**
- Data Service Agreement
- Service Level Agreement
- Operational Integration of Aireon
- Delivery of service

SPACE BASED ADS-B UNLOCK YOUR ATM POTENTIAL

The benefits of aircraft surveillance are well known but surveillance is limited to the line of sight of expensive ground installations. Imagine extending the safety and operational benefits of surveillance and the cost benefits of ADS-B to every Flight Information Region on the planet, without the investment costs and physical maintenance of ground infrastructure. That's exactly what Aireon global ADS-B surveillance can do.

Globally operational in 2018.



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