IP-XX

Space-based ADS-B Progress Update

ICAO ANI/WG4 Meeting

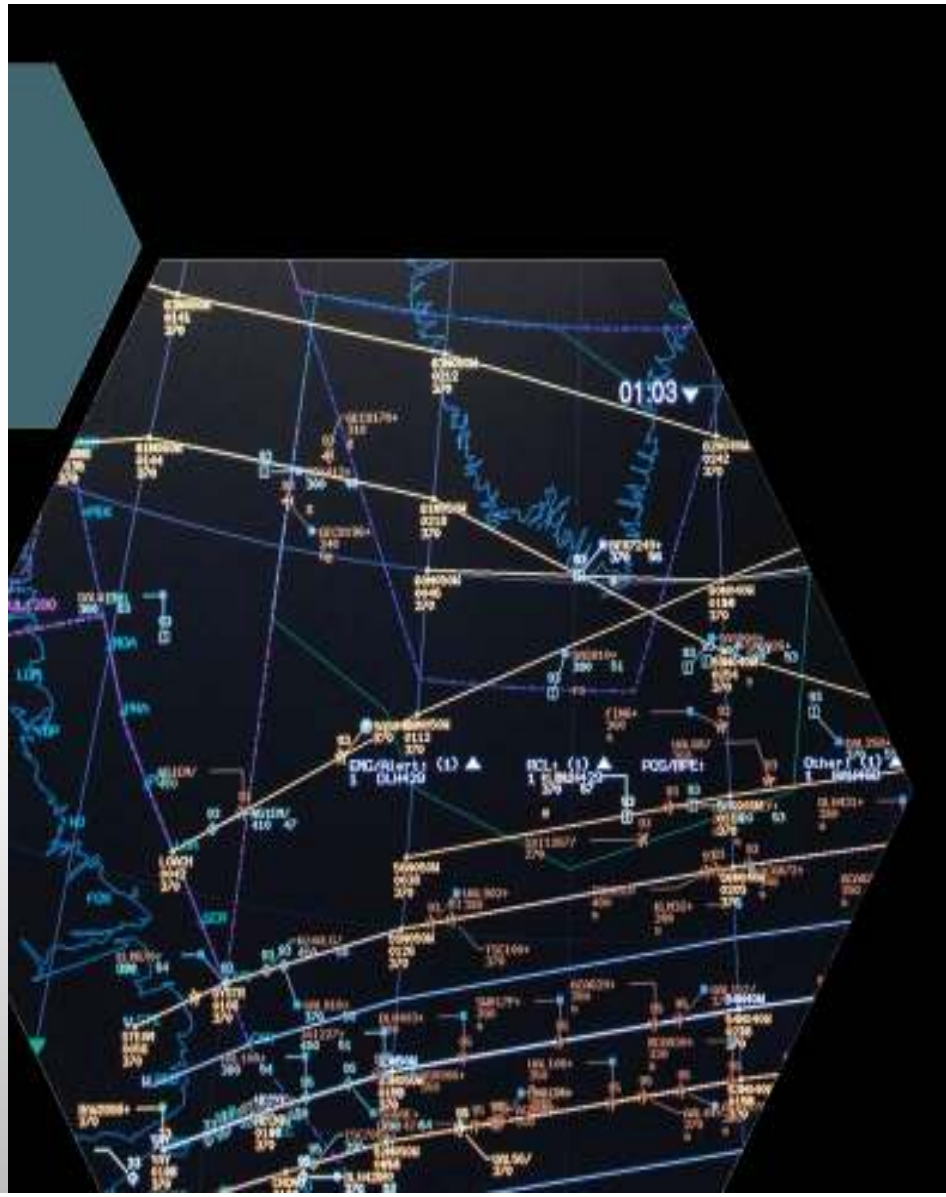
21-24 August, 2018

*"El tiempo y el espacio son **modos** por los cuales **pensamos** ... y no las condiciones en las que vivimos"* - *Albert Einstein*

*"Time and space are **modes** by which we **think** ....and not conditions in which we live"*

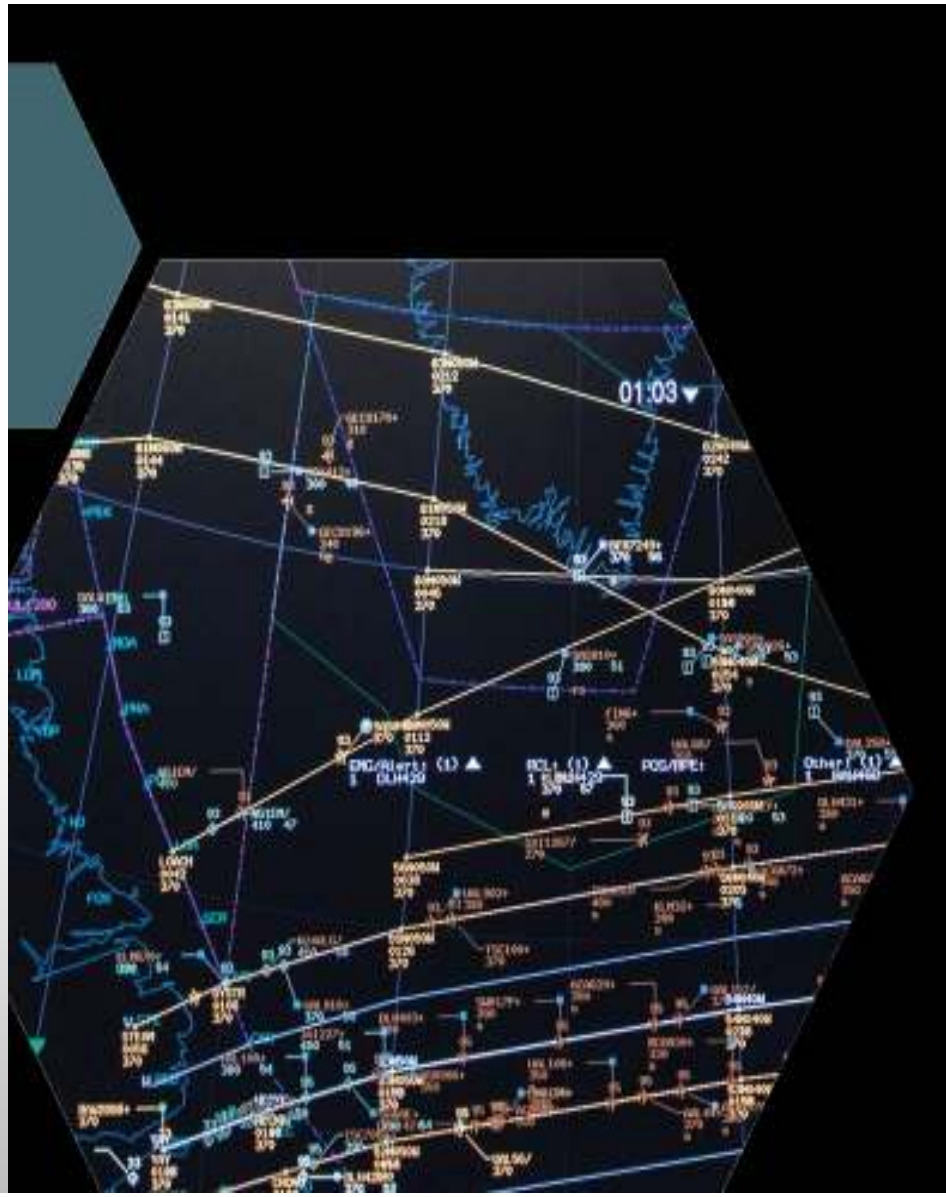
Albert Einstein

1. Introduction
2. The Maturity Process
3. ICAO Global Surveillance Planning Methodology
4. Implementation Planning
5. Safety Certification
6. Deployment
8. Industry Studies



1. Introduction

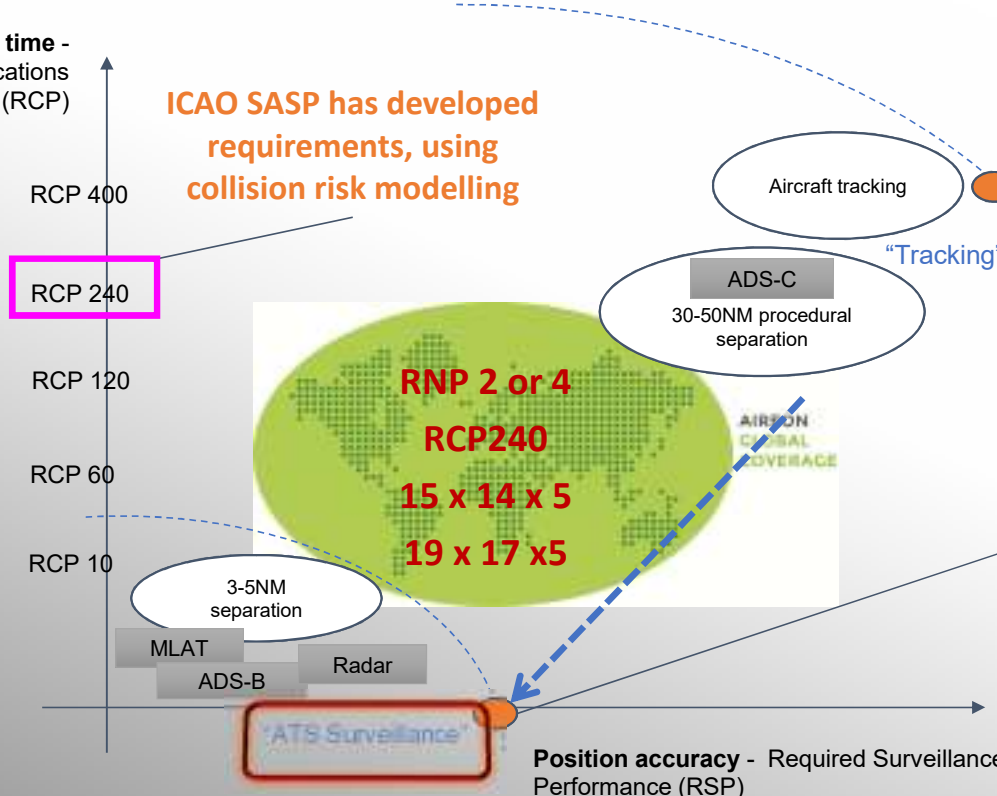
ICAO Perspective



The **type** of Air Traffic Service depends principally on the performance of the surveillance system (to provide position) and communications system (to control aircraft)

Better **surveillance** and **communications** performance means lower separation minima (to accommodate more traffic)

Theoretically an ANSP will
- Set RSP and RCP according to the airspace density
- Determine a separation minima needed
- Ensure system performance is fixed



Position reporting every **15mins** or less
(ICAO 2018 mandate)

"The operator obtains four dimensional (latitude, longitude, altitude, time) aircraft position information at 15 minutes intervals or less" [1]

ICAO Annex 6

ED-129B minimum standards		
	Update rate	8 seconds
	Latency	2 seconds
	Probability of update rate within 8 seconds	95%

Systems for which, "*It has been demonstrated, by comparative assessment of other methodology, to have a level of safety and performance equal to or better than monopulse SSR*" [2]

ICAO PANS-ATM

Why - Real-Time Surveillance?

- Providing safe separation is the primary function of Air Traffic Control
- To provide efficient and effective separation the ability to accurately **determine** the aircraft position (Surveillance) and to "**communicate**" resolutions to the pilot (Clearance).
- Collision Risk Modeling is aimed at keeping an aircraft "At Risk Period" (ARP) within a target level of safety
- Historically oceanic and remote areas have not been able to meet the Target Level of Safety due to the limited performance & availability of both SUR and Clearance Delivery
- Reducing the time it takes to detects an aircraft (PRI) increases the available safety buffer using existing COM performance (CRD)
- This can be used to reduce punitive oceanic separation standards and/or to improve the ability to detect and resolve conflicts

Surveillance

Position Reporting Interval (PRI)

Position Reporting Interval:

- The time between aircraft position updates
- Longer intervals mean less accurate aircraft position information for the controller
- Longer intervals result in a longer time to detect a problem that requires intervention

Communications

Conflict Resolution Delay (CRD)

Conflict Resolution Delay:

- The time between detecting a problem and resolution of the conflict
- This time includes communication (COM) to the pilot, pilot reaction and aircraft inertia

	PSR	SSR	MLAT	Ground-based ADS-B	Space-based ADS-B
Cooperative	No	Yes	Yes	Yes	Yes
Passive	No	No	Possible	Yes	Yes
Automatic correlation possible	No	Yes	Yes	Yes	Yes
Aircraft height	No	Yes	Yes, using Mode C or independently if at least 4 sensors	Yes	Yes
Typical effective detection range	Terminal 111 km (60 NM) --- En-route 185-463 km (100-250 NM)	463 km (250 NM)	Varies with number of sensors and their placement	463 km (250 NM)	Global (with a low earth orbiting constellation)
Range affected by terrain or other obstacles	Yes	Yes	Yes	Yes	Minimal
Aircraft position determined independently	Yes	Yes	Yes	No (GNSS position transmitted by aircraft)	No (GNSS position transmitted by aircraft)

2. The Maturity Process

Evolution of Satellite based ADS-B

Evolution of Satellite-based CNS

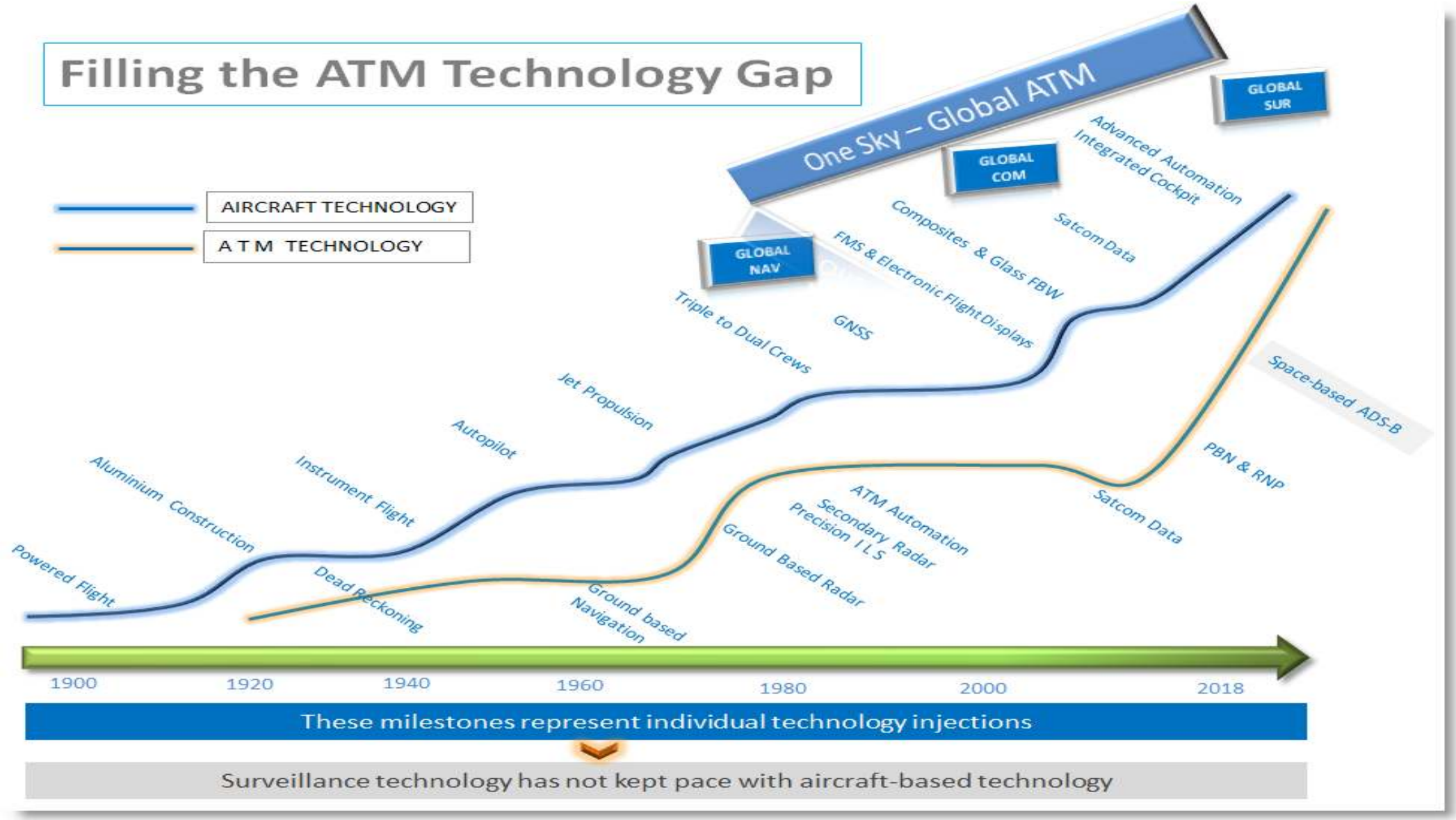
- 1983 FANS Committee
- 1991 10th ANC. Satellite based – overcome terrestrial limitations
- 1992 Global Coordinated Plan for SB CNS Systems – take advantage of available Sat. technologies (GNSS & Satcom)
- 1996 CNS/ATM systems mature. Spearhead global technical solutions, focus regional development
- **1998** Global Plan for CNS-ATM released
- **2003** 11th ANC recognizes ADS-B as the Surv. Technology of the Future
- 2004 35th Assembly introduces GATMOC to guide planning & implementation
- 2006 GANP
- **2007** Doc 4444 incorporated updated references to "ATS surveillance" rather than "radar"
- 2012 Endorsed "**One Sky**" - 12th ANC, GANP + ASBU + Roadmap

12th ANC Recommendation 1/9

Support the **inclusion** in the Global Air Navigation Plan, **development** and **adoption** of space-based automatic dependent surveillance - broadcast surveillance as a surveillance enabler; Develop **Standards** and Recommended Practices and **guidance material** to support space-based automatic dependent surveillance - broadcast as appropriate; and **Facilitate** needed interactions among stakeholders, if necessary, to support this technology

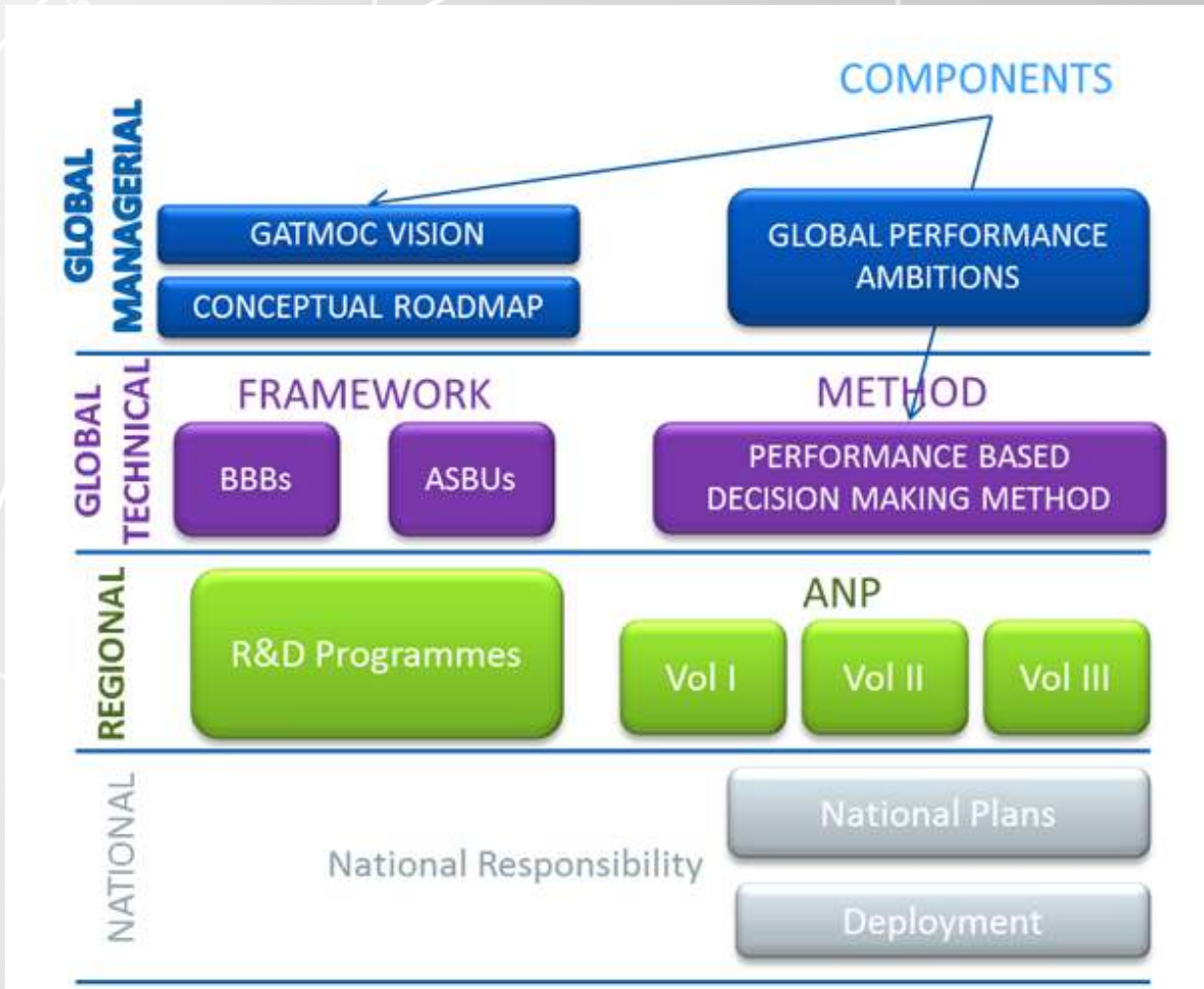
B0 – ASUR – Minimum Path, Cost advantages, deployment in remote/non-radar areas

Filling the ATM Technology Gap



3. ICAO Global Surveillance Planning Methodology

Recognition of ADS-B



Global Approach to Planning & Implementation

Doubling of air traffic growth rates every 15 years since the 1970s

"Unmanaged air traffic growth can also lead to increased safety risks in those circumstances when it outpaces the regulatory and infrastructure developments needed to support it"

ADS-B seen as the opportunity in

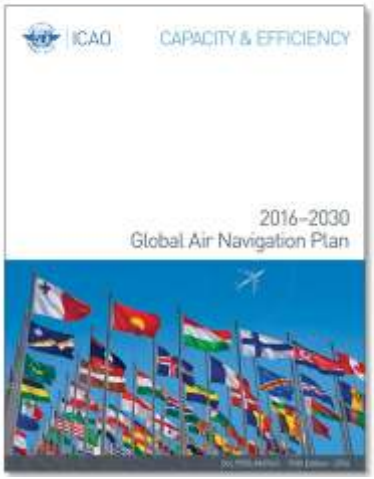
- bridging surveillance gaps
- supporting future trajectory-based ATM concepts, RPAS, TBO
- support business decisions to expand radar-equivalent service volumes
- exploit & leverage full potential for State cooperation, improving flight efficiency, enhancing safety
- use of 'radar like' separations into remote or 'non-radar' areas

Global Approach to Planning & Implementation

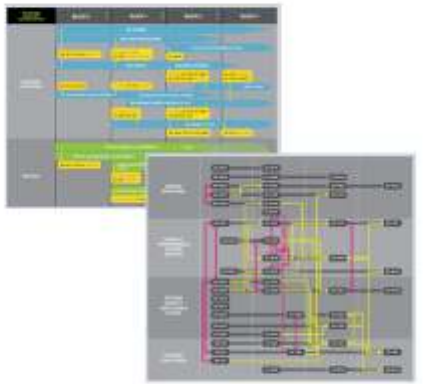
ADS-B seen as the opportunity in

- the **single** choice in non-radar airspace and where traffic could benefit from ATC surveillance
- **fused** ground systems baselined on cooperative surveillance will provide the sophistication for separation, surface operations and safety net functions
- the **twin** demands of increased traffic levels and reduced separation will require an improved form of ADS-B
- Priority & Minimum Path **strategy**
- Positive impact on technology **life-cycle**

Contents of the 2016-2030 GANP



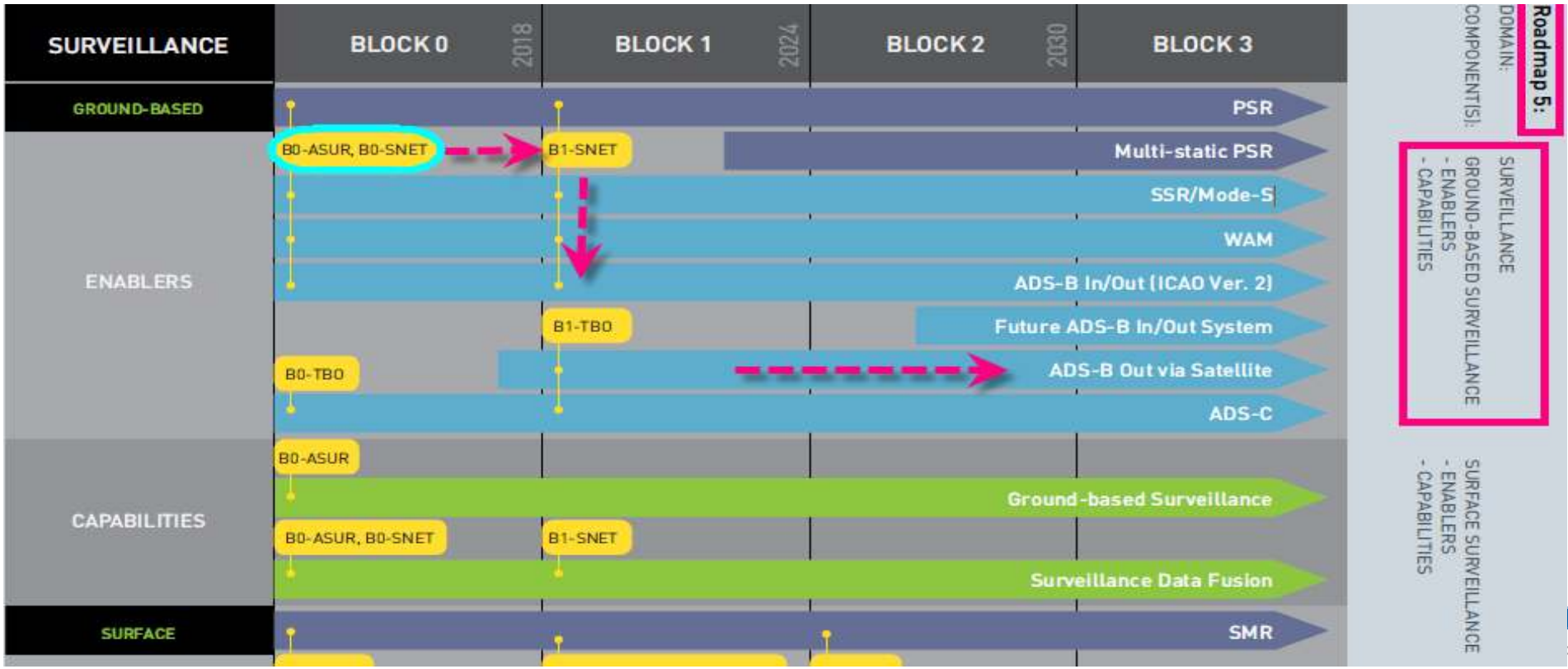
Aviation System Block Upgrades (ASBU) Methodology



Technology Roadmaps and Module Dependencies

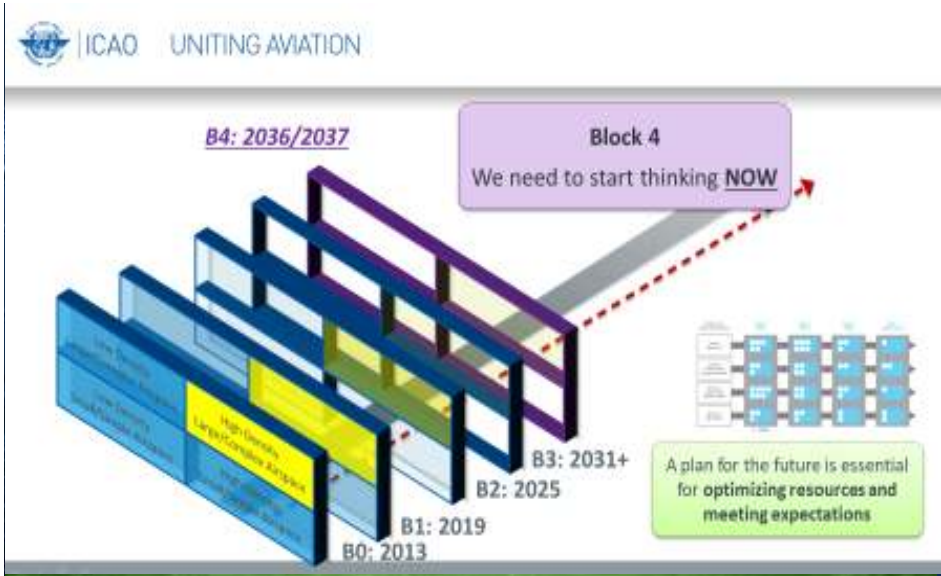
Global Approach to Planning & Implementation

"B0-ASUR - operationally, the lower costs of dependent surveillance infrastructure in comparison to conventional radars support business decisions to expand radar-equivalent service volumes and the use of radar-like separation procedures into remote or non-radar areas".



4. Implementation Planning

Developments since 2016



ANS Implementation Planning

CANSO: ANSP Guidelines for Implementing ATS Surveillance Services Using Space-Based ADS-B

- ubiquitous global ATS Surveillance coverage
- achieving global ATM
- reception of ADS-B signals will use existing technologies- satellites, transponders, receivers
- leverage current capabilities and knowledge to provide global coverage

IATA: User Requirements for Air Traffic Services

"ADS-B is the next generation surveillance technology capable of replacing radar.

Space-based ADS-B is a technology where ADS-B receivers are placed on satellites

If the satellites provide global coverage, then ADS-B surveillance can be provided globally."

5. Safety Certification

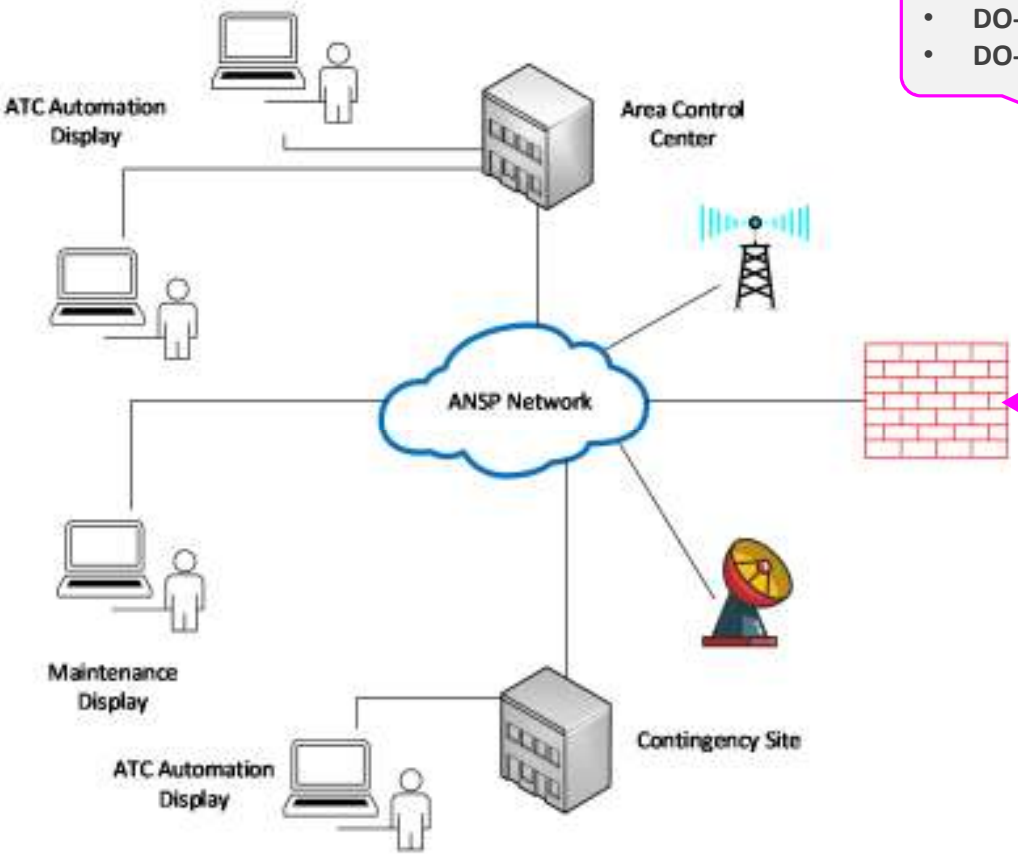
EASA
ISO
RTCA
EUROCAE

Technical Performance Measures

Parameter	Source (Standard)	Required Value
Service Volume Availability	ICAO Global Operational Data Link Document (GOLD); April 26, 2013	≥ 0.999
Latency (Message Receipt to Customer SDP)	Eurocontrol GEN SUR, Section 3.7.3.1.5 (ATC SUR Sensor + SUR Distribute)	≤ 2.0s (99th percentile)
Probability of Update	EUROCAE Technical Specification for an 1090 MHz Extended Squitter ADS-B Ground System, ED-129B	≥ 96% for an Update Interval of 8 seconds (for low density en route airspace)

Key safety requirements enabling reduced separation

New Technology Insertion Through Safety Standards

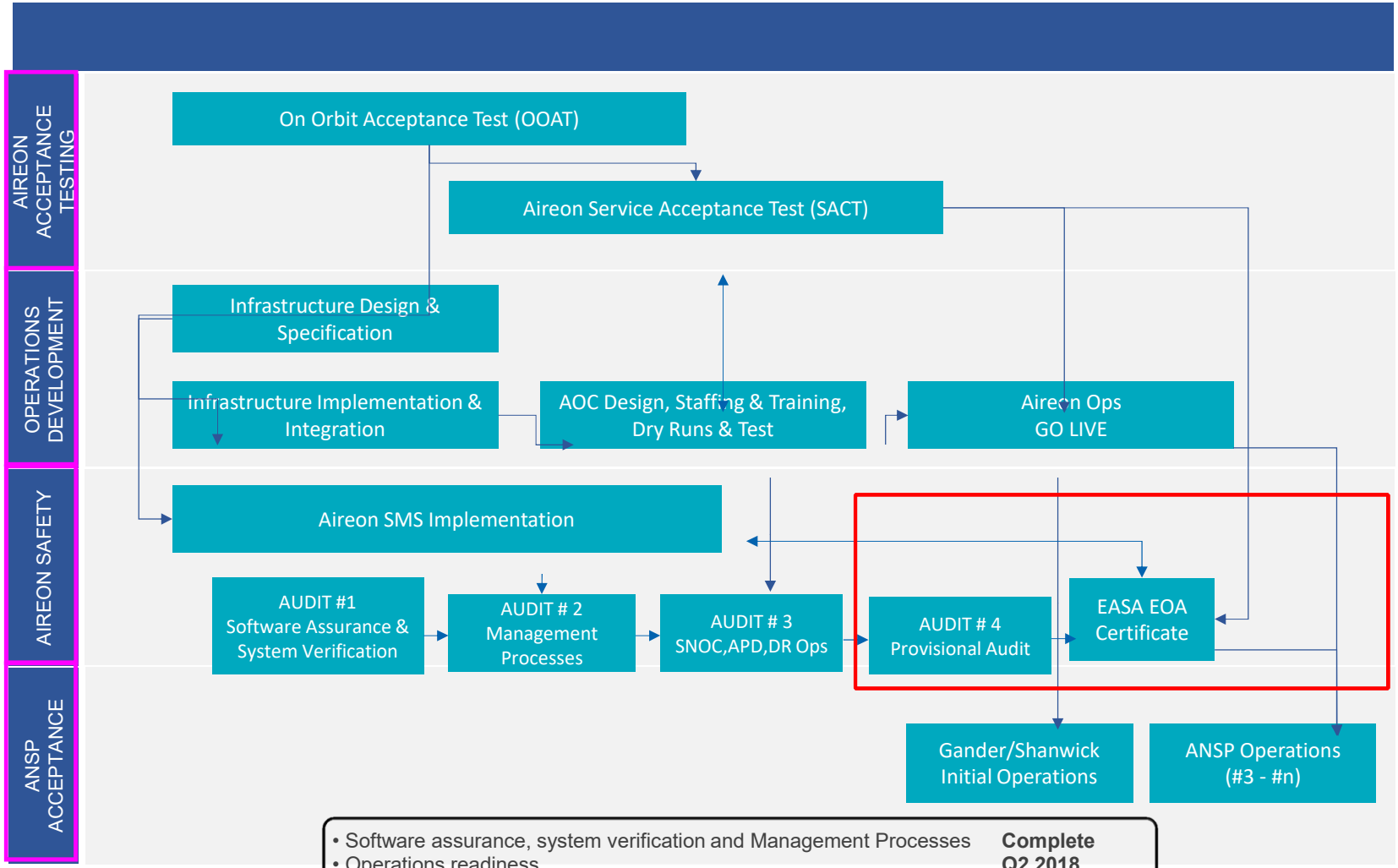


- DO-260, 260A, 260B / ED-109, ED-109A
- DO-178C / ED-12C

Aireon is working with EASA for certification approval as an ATM/ANS Surveillance Service Provider Organization

* DO-278A / ED-109A / ED-129B / ASTERIX

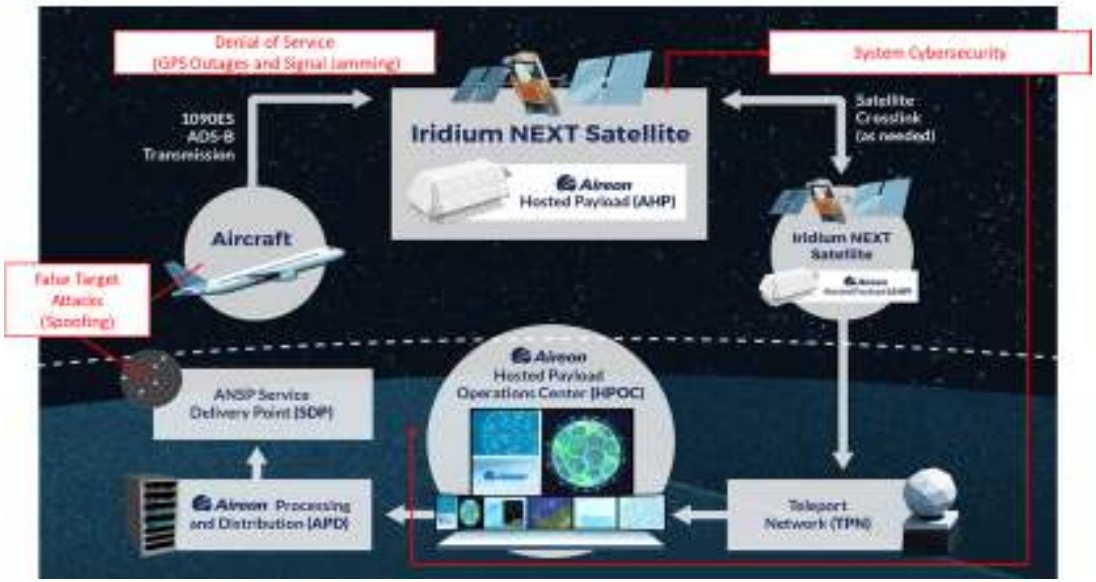
Pathway to EASA Certification & Operations



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

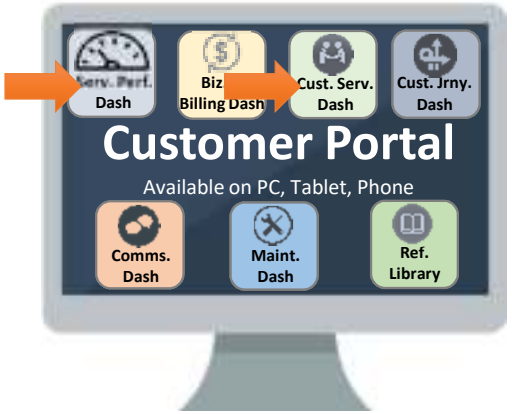
• Software assurance, system verification and Management Processes	**Complete**
• Operations readiness	**Q2 2018**
• Provisional Certification	**Q3 2018**

Cybersecurity



- Aireon is committed to reducing vulnerabilities to security related incidents, GPS jamming and spoofing, and cybersecurity management techniques throughout the system and service offering.
- Aireon treats security as an evolving threat that will be intentionally addressed over the lifecycle of the service through *governance, design assurance, standards and regulations.*
  - Involvement within RTCA, EUROCAE, EUROCONTROL, ICAO, AIA and ATCA ensures alignment with industry “best practices”
  - Following guidance contained in NIST Standards
  - EASA audits address software assurance, integrity of management processes, and validation of operational continuity of services
- ANSP customers provide specific security requirements that Aireon addresses in operational service deliverables.

Tools to support operations and maintenance – Service Performance and Customer Service Dashboards



6. Deployment

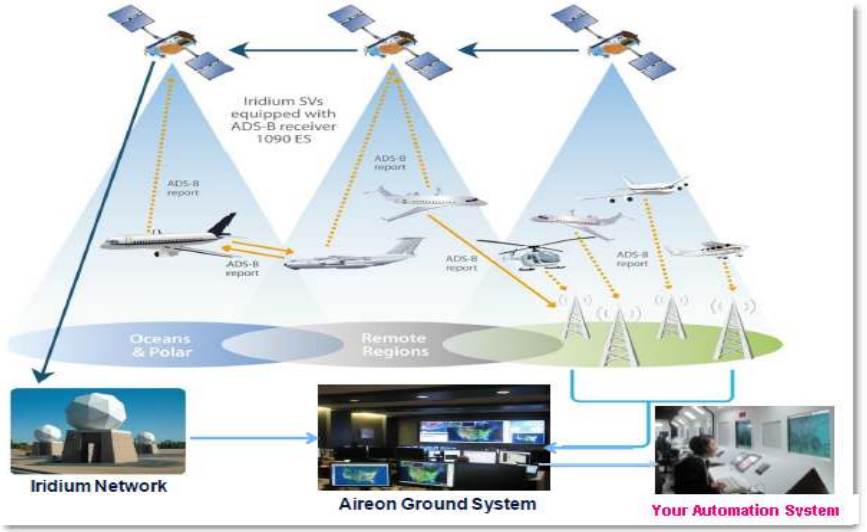
Space-based ADS-B via ICAO Standards

Deployment closely tied to COM

Scenario 1 – VHF DCPC exists

Apply current PANS ATM – 5NM ATS Surveillance Minima

Use VHF Comms



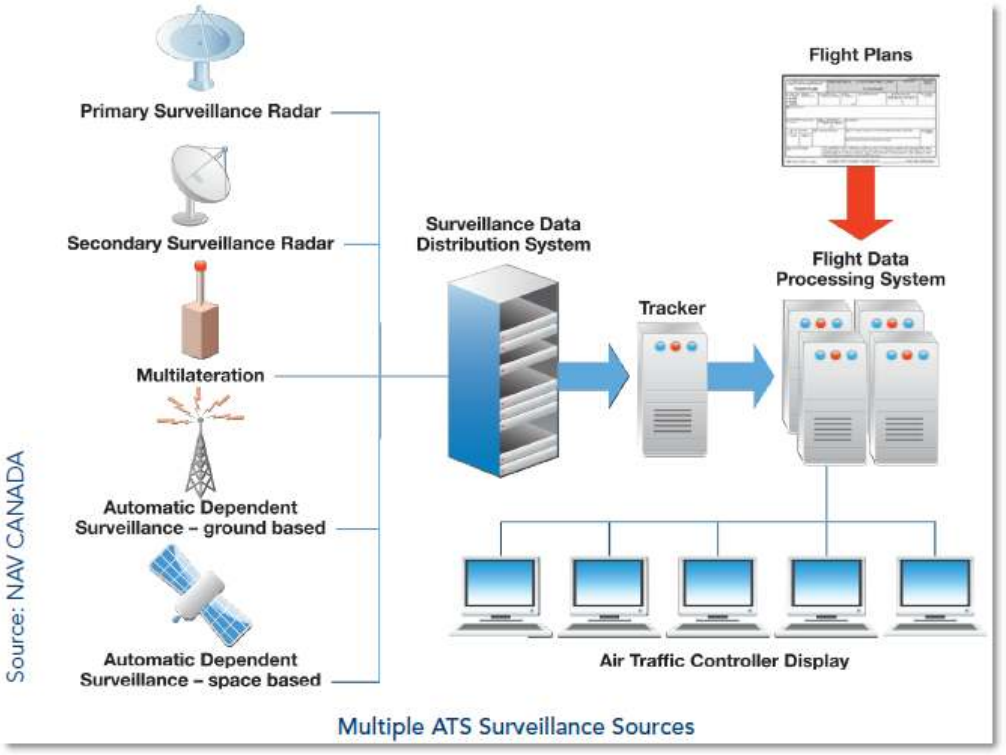
Scenario 2 – No VHF Coverage

Apply SASP Minima
"Separation Minima using ATS Surveillance systems where VHF voice communications are not available"

Use CPDLC DCPC Comms

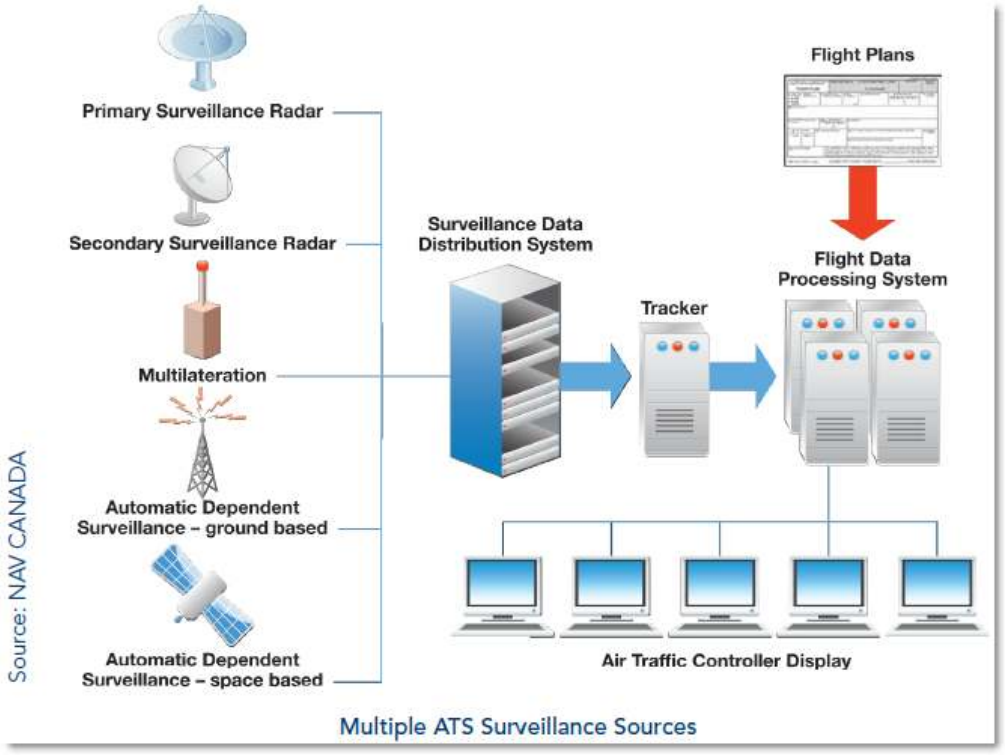
1. Deploying SB ADS-B into an existing SUR System

- Co-located with VHF Communications
- Analogous to source from a new 'manufacturer' of ADS-B receivers
- Validation on data quality, interfaces and displays
- Fast track for regulatory approvals -EASA ANS Service Provider Certification
- Guarantees for SB ADS-B data signal meets the key minimum success criteria
- A short period of operational observation to establish parity of the ground-based and space-based data quality
- Evidence to demonstrate to Regulator - conforms to the technical standards for a ground based ADS-B surveillance system.
- Apply current ICAO PANS ATM minima
- Work with State regulators to support mandates to upgrade all aircraft operating in certain parts of their airspace with ADS-B equipment



1. Deploying SB ADS-B into an existing SUR System

- Regulations
  - ATS surveillance versus radar
  - Avionics certification
- Exclusion lists
  - Sharing
  - Internal reporting and actions
- Technical and maintenance personnel
  - Training
  - Different monitoring and performance requirements

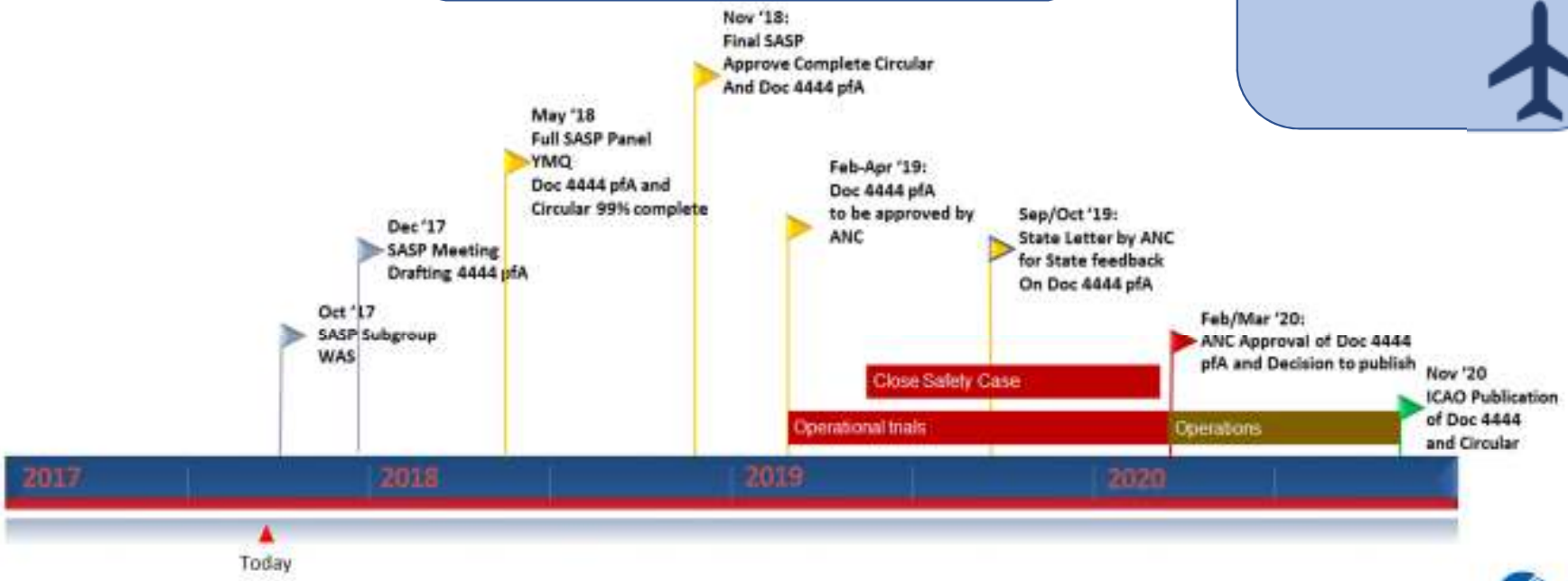


2. Deploying SB ADS-B into a Procedural System

Collision Risk Modeling

Operational Trials

Operations



Doc 4444 pfA: Proposal for Amendment of Doc 4444 with new separation minima and conditions.
Circular: Supporting Documentation providing States with information and guidance to plan and apply new separation
Doc 4444: Published document

2. Deploying SB ADS-B into a Procedural System

C, N and ATM Requirements	
NAV requirements	RNP4 or an applicable RNP2
COM Requirements	RCP 240
Contingency Requirements … should normal COM fail	Alternative means of COM: Recognize, Intervene, Resolve conflict – Total Time 9 mins*.
ATM: Lateral Conformance	Lateral warning threshold set: 3NM
Vectoring Restrictions using CPDLC	CPDLC shall not be used for vectoring in application of separation

Standard: 15 x 14 x 5		
Dimension	**Minima**	**Conditions**
Parallel or Non-intersecting Tracks	15 NM Lateral	» the number of aircraft deviating 7 NM or more off the cleared track shall be less than 3×10^{-5} per flight hour; and » the number of aircraft deviating 11 NM or more off the cleared track shall be less than 1.9×10^{-5} per flight hour; **or** » the density of traffic in the airspace as measured by occupancy is less than 0.6.
Same or Crossing Tracks	14 NM Longitudinal	provided: » relative angle less than 45 degrees
Opposite Direction on reciprocal	5 NM Climb or Descend	SUR reports from both aircraft demonstrate passing each other by this minima

Expanded Standard: 19 x 17 x 5	
Parallel or Non-intersecting Tracks	19 NM Lateral
Intersecting Tracks (5.4.1.2.1.7)	19 NM Lateral
Same or Crossing Tracks (less than 90deg)	17 NM Longitudinal
Opposite Direction on reciprocal	5 NM Climb or Descend – SUR reports from both aircraft demonstrate passing each other by this minima

Note
For implementation guidance, use ICAO Manual *"Guidelines for Separation Minima Using ATS Surveillance Systems Where VHF Voice Communications are not Available (Manual xxx)".*

8. Benefit Statement

ICAO – One Sky

Benefits of Global Surveillance

- **Improved safety**
  - Automated safety alerts for ATC
  - Situational awareness for ATC
  - Improved Search & Rescue
  - Less transactional work for ATC/Pilots
- **Improved System Capacity**
  - Reduced separation between aircraft
  - Tactical Control, FRA
  - Flexible Use of Airspace
- **Improved efficiency for users**
  - Reduced & more flexible separation standards
  - More clearances to requested route/level
  - Reduced stepped climb/descent
  - Increased flexibility in poor weather
  - Less delay
  - Lower pilot workload
  - Reduced fuel burn & operating time
- **Reduced environmental impact**

AviationDaily — The Business Daily of the Scheduled Airline Industry Since 1939

ICAO Council President Endorses Space-Based ADS-B

Bill Carey | *Aviation Daily* — Mar 6, 2018

EMAIL | SHARE | Tweet | G+ | Recommend 0 | COMMENTS 0

Bill Carey

MADRID--Space-based tracking of aircraft is a technology equalizer that offers nations that lack radar infrastructure a way to quickly improve their surveillance capability, International Civil Aviation Organization (ICAO) council president Olumuyiwa Benard Aliu said. In a keynote address at the World ATM Congress here, Aliu gave a ringing endorsement to space-based automatic dependent surveillance-broadcast (ADS-B), a system that uses receiver payloads on satellites to route aircraft ...

- **Seamlessness**
  - Filling in Gaps
  - Redundancy
  - No FIR boundary limitations

REDUCING NAT VERTICAL CRE

SB ADS-B is expected to reduce the vertical Collision Risk Estimate well below the Target Level of Safety

Comparison of Vertical Collision Risks with and without Surveillance
Gander-Shanwick OCAs

Current Operations (ADS-C conformance monitoring)	12.1 fatal accidents in one billion flight hours
SB ADS-B	3.1 fatal accidents in one billion flight hours
% Reduction	**-74%**

With Strategic Lateral Offset Procedure (SLOP)
Sources: 2015 NAT ANSP Flight and NAT Central Monitoring Agency (CMA) Data, NAT MWG and Scrutiny Group 2015 data

Safety Net Benefits

- RAM Route Adherence Monitoring (RAM)
- ARCW11 ADS Route conformance warning
- CLAM Cleared Level Adherence Monitoring (CLAM)
- STCA Short term Conflict Alerts (STCA)
- Safety “buffer” zone beyond airspace boundary provides early identification of coordination errors.
- Improve on pre-emptive benefits by design to avoid Coordination Time errors,
- Awareness (including ‘missing’ flight plans) to detect aircraft ‘not expected’ on
  - boundary point
  - on expected route
  - at expected Time
  - expected Flight Level.

Increasing Sector and Cross-Boundary Safety

- Lowered risk of data loss between airspace sectors through continuous surveillance
- Enabling availability of surveillance data on both sides of the sector boundary
- Reduce hand-off errors, early detection of altitude / position errors
- Early detection of emergency transponder codes
- Reduced complexity through harmonization of operating environment between ANSPs

Normal Tracking & ADT

Aireon ALERT & Aircraft Flight Tracking

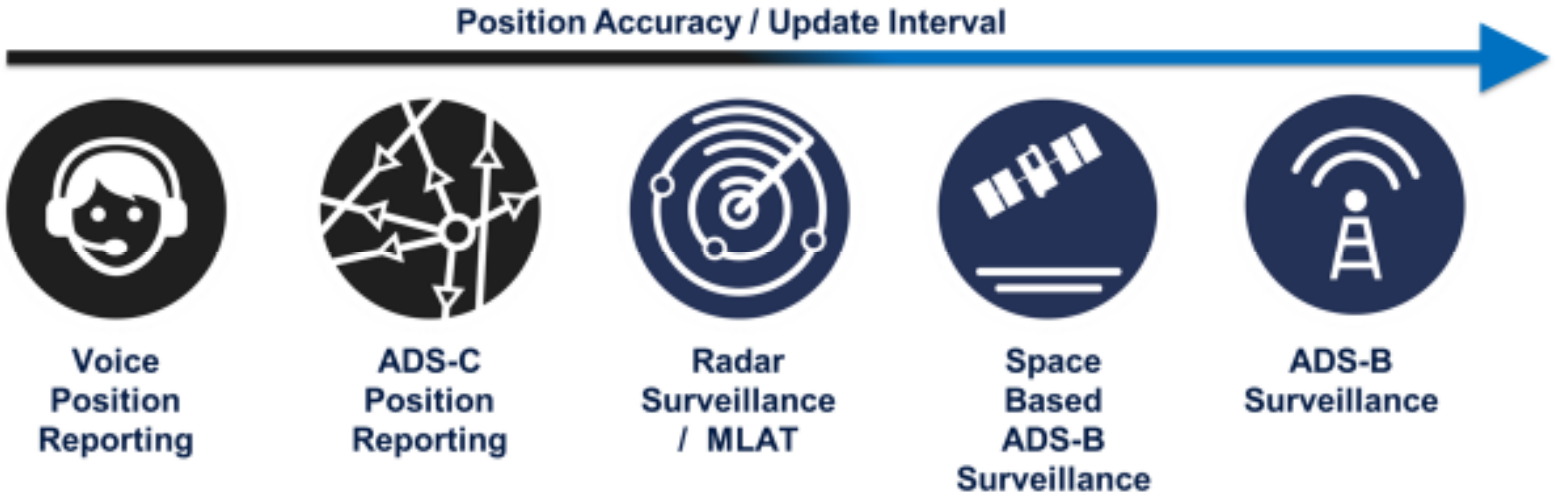
- Aireon ADS-B Flight Tracking
  - Aireon will have global ADS-B visibility
  - Enables real time flight tracking without new avionics
  - Position update available every 8 seconds or less
- Aireon ALERT
  - A 24/7 call center will be available through IAA's COM facility
  - A free of charge alert system 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

IAA

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

SAR: Less Time on Search & Faster Rescue



		Area of uncertainty during a trigger event			
		A320	A330	A340/B77W	A380
	Cruise speed (kts)	427	475	482	488
Operational Radius Between Position Reports (sq./ km)	PIREP (30min)	491,165	607,798	625,844	641,522
	ADS-C (15min)	122,791	151,949	156,461	160,380
	ADS-B (8sec)	**9.7**	**12.0**	**12.4**	**12.7**

- **Aireon Aircraft Locating and Emergency Response Tracking (Aireon ALERT)- Available Wednesday, 22 August 2018**

- **ALERT** is the aviation industry's first and only…..
- Free, Global, Real-time Alert & Locating service for:
  - Pre-registered aircraft operators (airlines)
  - ANSPs, search and rescue organizations and aviation regulators
- A one-time, per event aircraft location service
- Registration open… 24/7 service will be operated by the IAA
- Global ADS-B tracking data, provided by Aireon

What Information is Available to me from Aireon ALERT

- Once the emergency request has been received by Aireon ALERT the operator will execute a search query (uncertainty, alert or distress).
- If the aircraft is found, a 4-dimensional report will be verbally provided:
  - Latitude
  - Longitude
  - Altitude
  - Time
- A package will then be produced that goes to the Aireon ALERT technical support team and the requester.
  - It will include a map of the last 15 minutes of flight, with one plot per minute and the 4-dimensional report information.

How Do Organizations Register?

1. Pre-registration is required to use Aireon ALERT.
2. The requestor logs in to their Aireon ALERT dashboard, where they can view their unique identification and "PIN" number and dial-in number enabling them to speak directly with an Aireon ALERT operator. This begins the formal request process.
3. The requestor should be ready to provide either the Flight ID or ICAO HEX address.
4. The Aireon ALERT operator will then execute a search query, and if the aircraft is found, a 4-dimensional report will be verbally provided – Latitude, Longitude, Altitude and Time.
5. A package is also sent to the registered Aireon ALERT email address. It will include a map of the last 15 minutes of flight, with one plot per minute and the 4-dimensional report information.
6. At this point, the request is considered fulfilled.

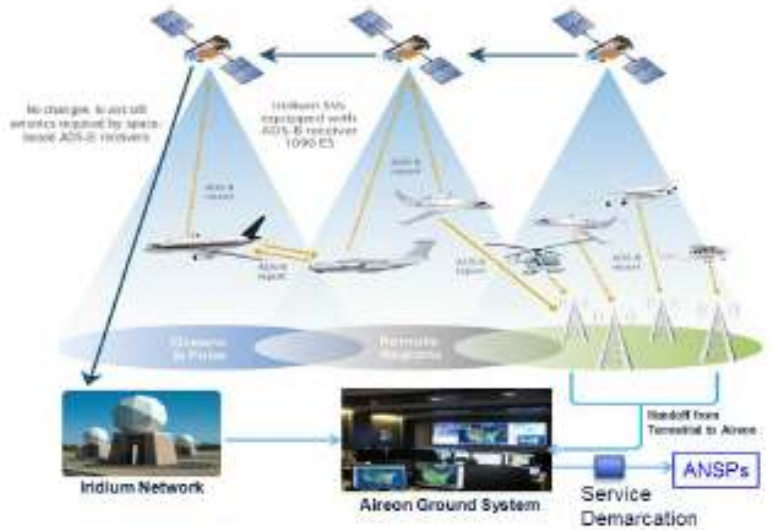
https://aireonalert.com/

It's Live! How does it work?

- The Aireon ALERT service will be live in Q1 2019.
  - Once registered and cleared, an authorized contact from the designated organization calls in to Aireon ALERT desk with an location request.
  - The caller is verified by an Aireon ALERT desk operator.
  - Caller provides aircraft identifying information – at least 1 of 3 (tail #, etc.).
  - Desk operator looks up aircraft using specially design Aireon ALERT interface.
  - If aircraft is located THEN the operator provides the last known location coordinates by phone to the caller.
    - If located an Aireon ALERT Event Report will be produced and sent to authorized contact's email address on file.
  - The operator will follow up to ensure Event Report was received.

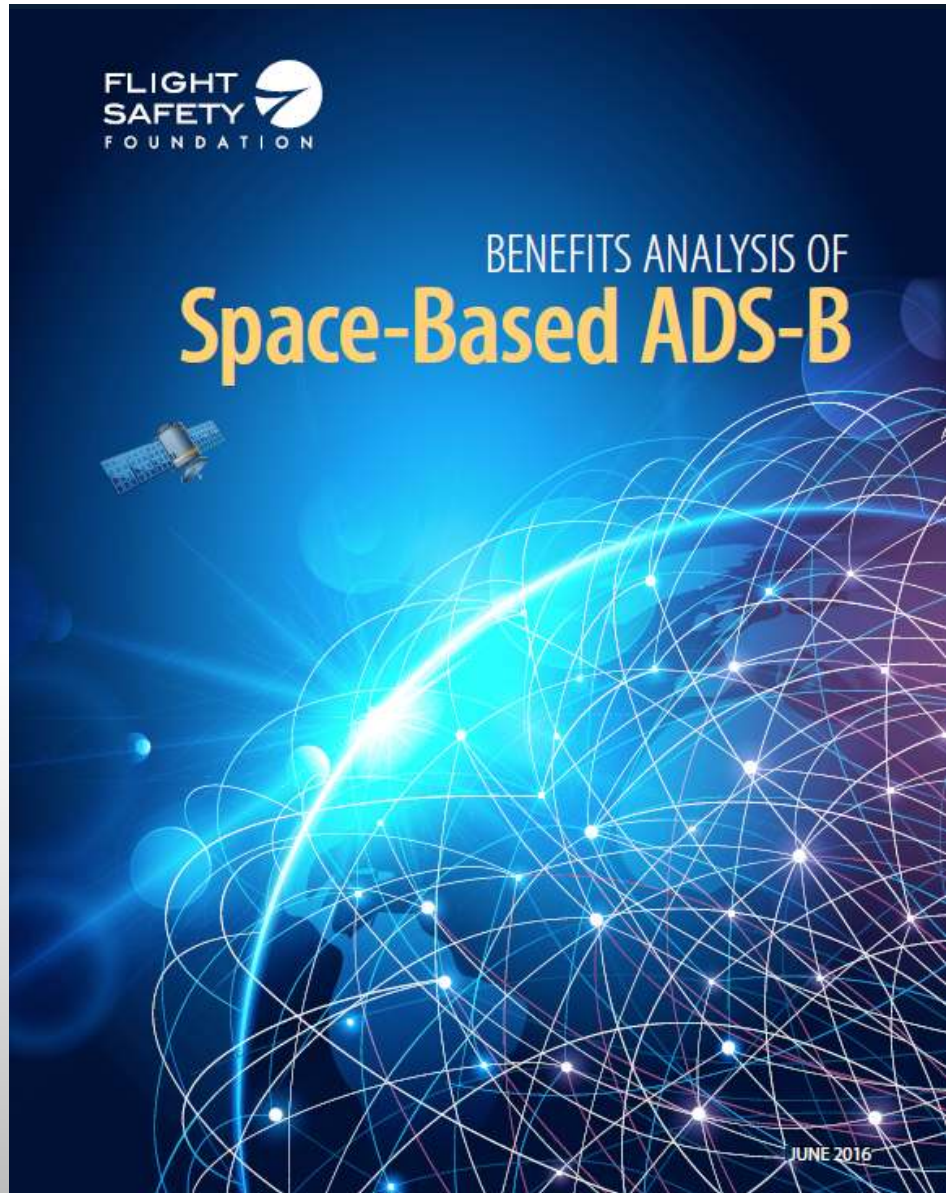
Technical Simplicity

- “Surveillance as a service” – “plug and play” ASTERIX 21 data
- Ground infrastructure limited to a connection (service Delivery Point (SDP) set-up – the only hardware on ANSP premises
- Managed Data delivery & Security up to the demarcation point through MPLS or direct data feed
- Equipment data specifications available thru Aireon
- 50nm additional coverage included



8. Industry Studies

Improving
- Safety
- Flight Efficiency
- Cost Efficiency



Flight Safety Foundation Study: Immediate Benefits

- A single global surveillance system
- Reduced oceanic separation standards
- Enhanced situational awareness
- Enhanced search and rescue
- Reduction in ATC and pilot workload
- Improved cross-flight information boundary error and detection
- Improved and early detection of off-track errors
- Enhance safety alerting
- Improved weather avoidance
- Enhanced height monitoring in reduced vertical separation minima (RVSM) airspace
- Increased surveillance system augmentation and elimination of surveillance gaps
- Enhanced safety for offshore helicopter operations
- Reduced reliance on legacy infrastructure
- More efficient flight trajectory
- Availability of preferred altitudes
- Route efficiency
- Speed management
- Increased system integrity
- Enhanced incident and accident investigations
- Reduced emissions and fuel burn

FLIGHT SAFETY FOUNDATION

Aireon

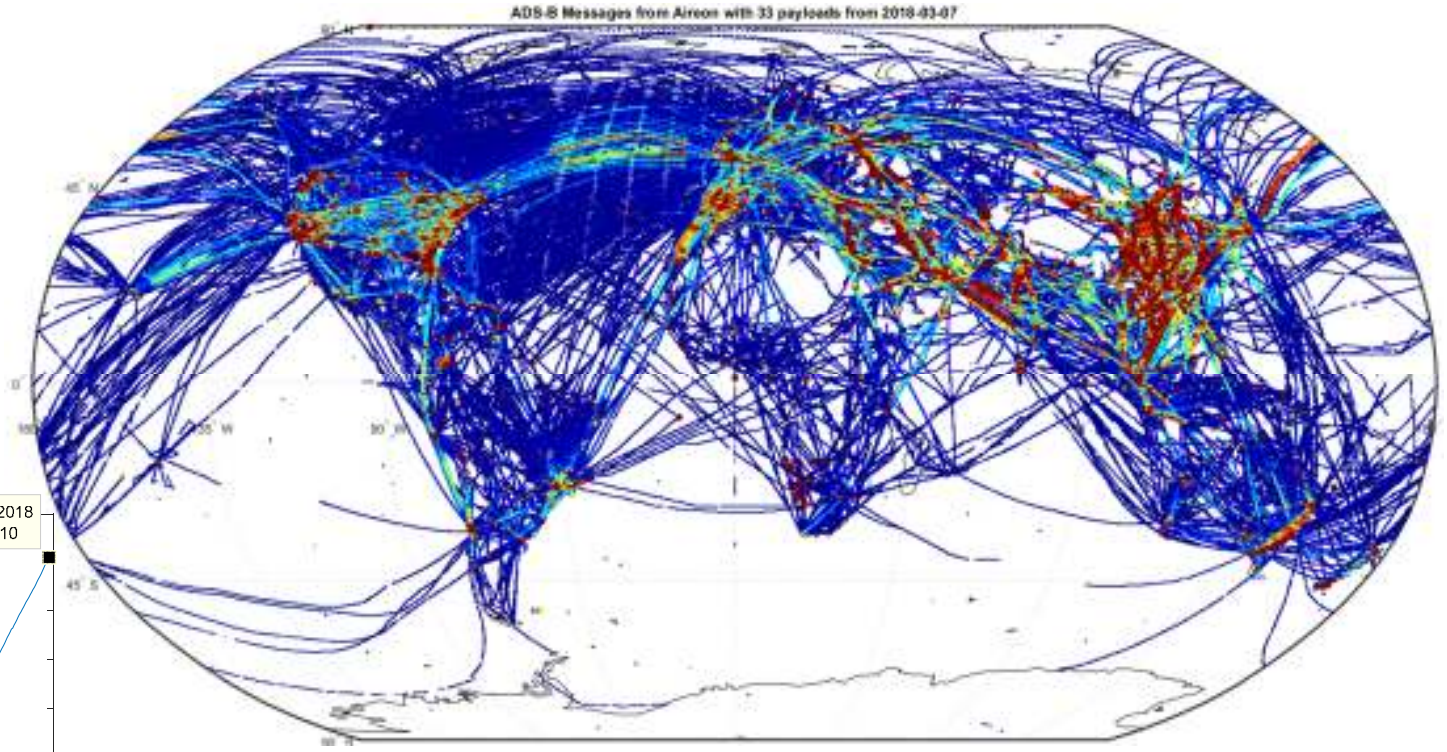
Flight Safety Foundation Study: Mid-Term Benefits

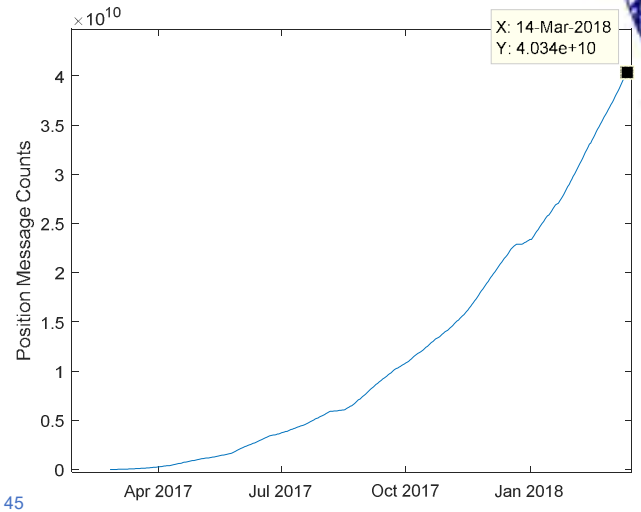
- Jumping a generation of surveillance technology and improving service in remote and difficult-terrain regions
- Facilitating improved cooperation in contingency management
- Greater interoperability (an ICAO harmonization enabler)
- Enabler or more regional and local data sharing
- Support for conflict zone and volcanic ash cloud management
- Reduced risk of controlled flight into terrain
- Improved services to visual flight rules (VFR) aircraft

Flight Safety Foundation Study: Longer-Term Benefits

- Enabler for global safety performance monitoring and analysis
- Enhanced global air traffic flow management
- Supporting unmanned aircraft systems/remotely piloted aircraft systems
- Future capacity enabler
- Enhancing airport terminal airspace operations
- Enhancing airport ground handling
- Challenging existing CNS and FANS requirements
- Downstream economic and social benefits
- Security

Aireon Aircraft Surveillance Coverage – 65 Payloads





As of now, Aireon receives over 9 billion ADS-B position messages received per month!

“El tiempo y el espacio son modos por los cuales pensamos ... y no las condiciones en las que vivimos” - Albert Einstein

Muchas Gracias ! Thank you!

Bernard Gonsalves

ATM Support

bernard.gonsalves@fliteplan.net

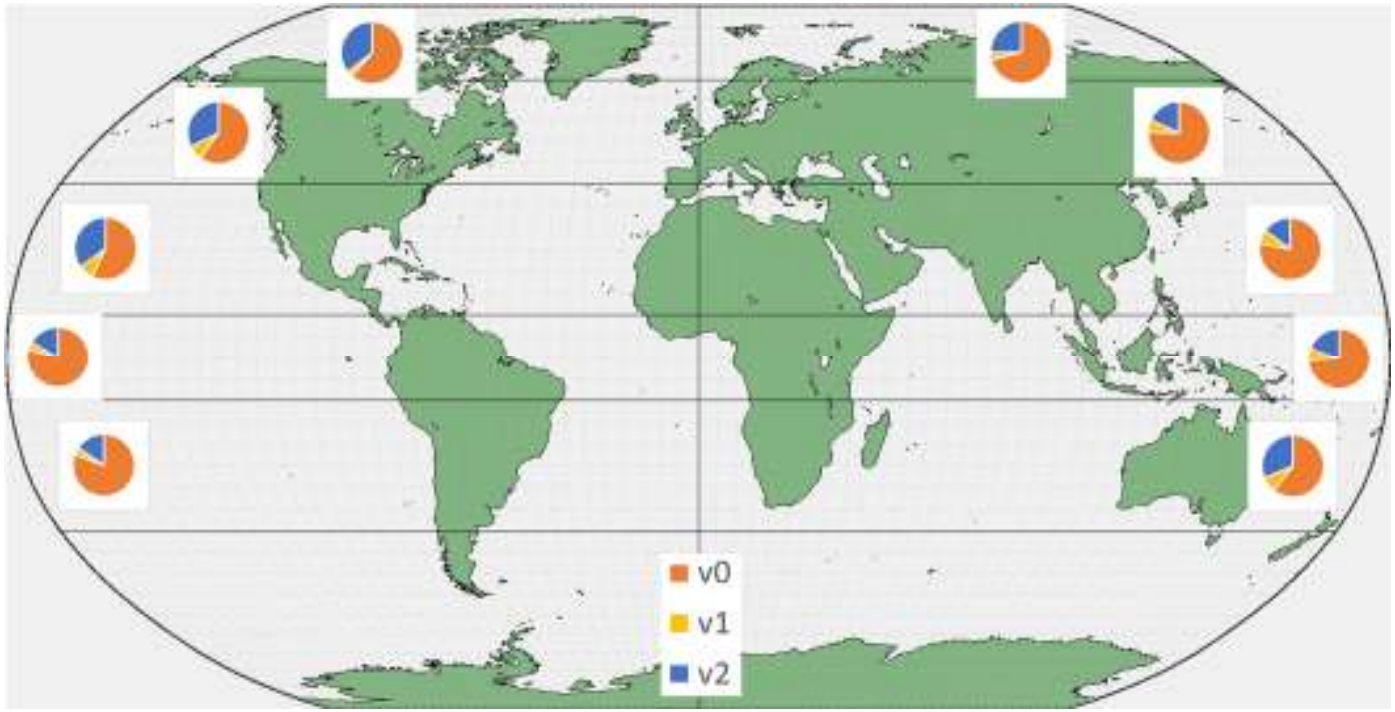
“Time and space are modes by which we think ….and not conditions in which we live” Albert Einstein

NAV CANADA iridium Everywhere enav NATS IAA NAVIAIR Aireon

Regulation - Global ADS-B Out Rulemaking

State	What	When Effective	Standard
Australia	At or above FL290 All IFR levels	December 2013 February 2017	DO-260 Looking at TSO199 for GA
USA	Most aircraft in controlled airspace	January 2020	DO-260B
Europe	Aircraft operating IFR>5,700KG or >250K TAS	June 2020	DO-260B
UAE	All IFR	January 2020	DO-260B
Singapore	At or above FL290 on specified routes	December 2013	DO-260
Vietnam	At or above FL290 on specified routes	December 2013	DO-260
Hong Kong	At or above FL290 on airways HK FIR	December 2016	DO-260
Indonesia	Class A FL290 - FL460	January 2018	DO-260
Taiwan	At or above FL290 on two routes All flights at or above FL290	September 2016 December 2019	DO-260
Colombia	All airspace	January 2020	DO-260B
China	Proposed and currently under consultation	July 2019 December 2022	DO-260 DO-260B
New Zealand	NPRM released – All aircraft above FL245 Proposed – All aircraft in controlled airspace	1 January 2019 1 January 2022	DO260 (with forward fit for DO260B)
Canada	No mandate proposed; preferential service in Hudson Bay		DO-260
Sri Lanka	All ATS Routes within Colombo TMA	31 December 2020	DO-260
Fiji Islands		December 2013	DO-260
Malaysia	Kuala Lumpur FIR	End 2022	DO-260

Current State of ADS-B Out Version Distribution



47,552 Unique ICAO Addresses Observed

ICAO UNITING AVIATION

13th Air Navigation Conference (AN-Conf/13)

9 – 19 October 2018, Montréal, Canada

Air Navigation Committee (Committee A)	Aviation Safety Committee (Committee B)
1: Air navigation global strategy	6: Organizational safety issues
2: Enabling the global air navigation system	
3: Enhancing the global air navigation system	7: Operational safety risks
4: Implementing the global air navigation system and the role of planning and implementation regional groups (PIRGs)	8: Emerging safety issues
5: Emerging issues	

Safety

Aircraft Movements → LHD GNE → CRM

300m -1000ft
> 25nm

TLS

5 x 10 -9
pfh

- » **GNE**: Lateral errors of 25 nautical miles (NM) or more from the aircraft's cleared route
- » **LHD**: Errors of 300 feet or more from a clearance altitude
- » **TIME**: Occurs when an aircraft's reported actual time of arrival (ATA) is more than 3 minutes before or after the estimated time of arrival (ETA)
- » **INTERVENTION**: Occurs when an aircraft reports an incorrect routing and ATC intervenes to correct the error before the aircraft actually executes the incorrect routing

1. Altimetry or Auto. Alt. Control
2. Turbulence & WX
3. Emerg. Descent (w/o/ Cont.procedures)
4. TCAS RA
5. Not following ATC Clr.
6. Incorrect ATC Clr.
7. Coord. Errors G-G