



ICAO

Building from the Aireon Safety Case and Certification to Support an ANSP Safety Case

Vincent Capezzuto

Mexico City, 29-November-2018





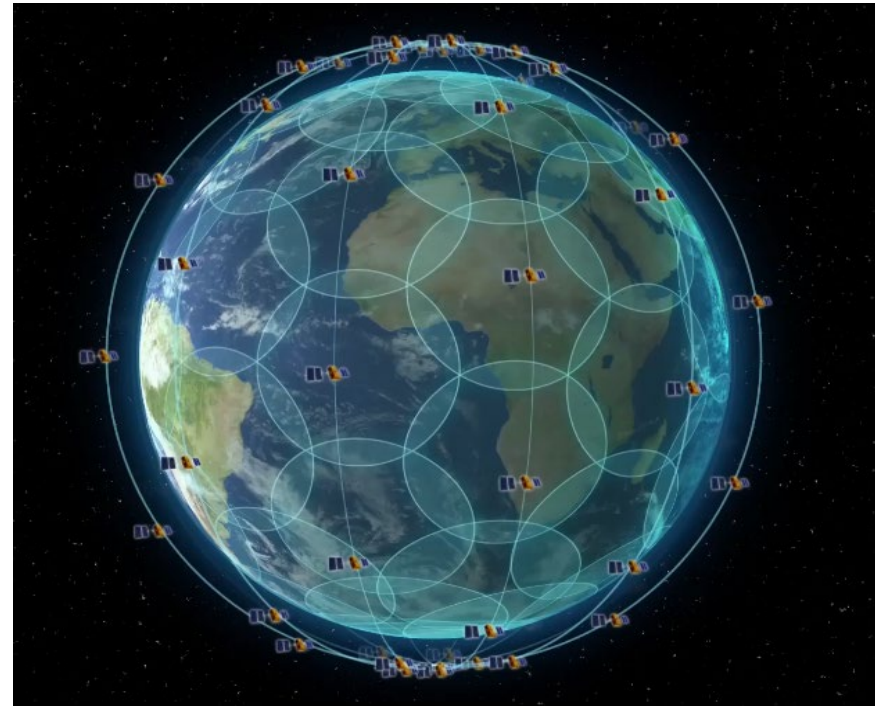
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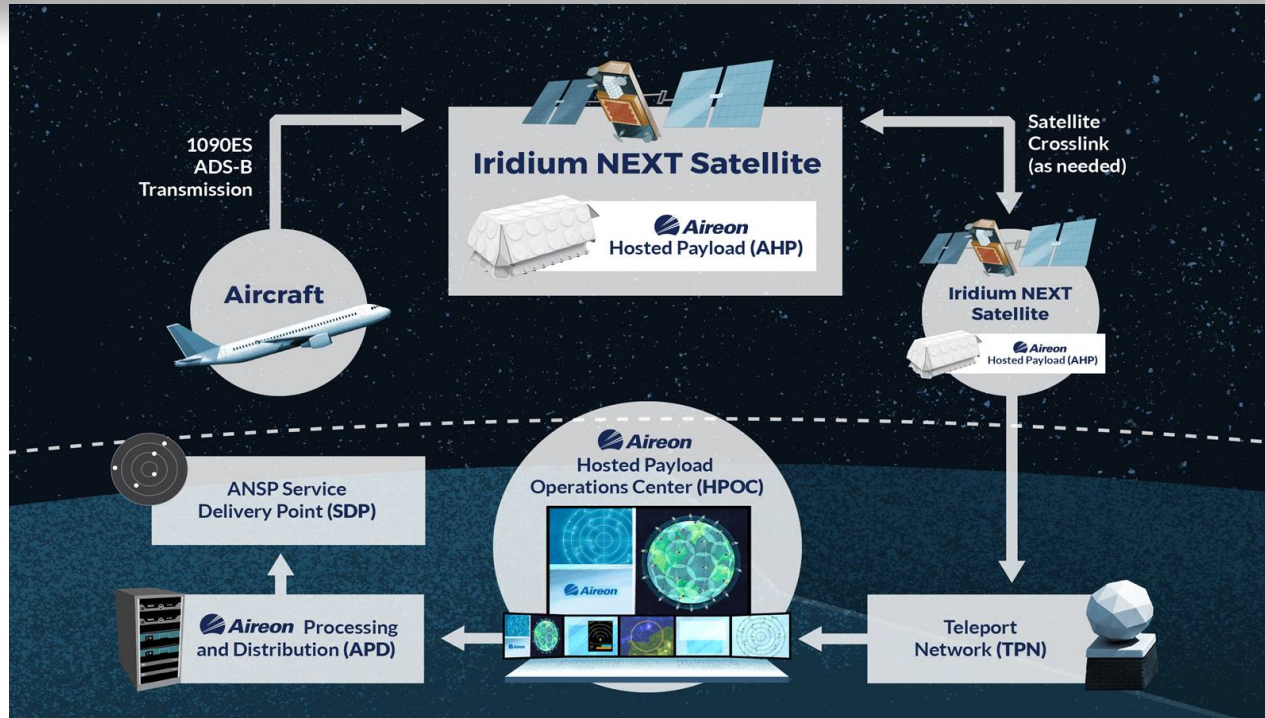
CAPACITY & EFFICIENCY

Aireon Overview and Status



Surveillance For All ADS-B Equipped Aircraft EVERYWHERE





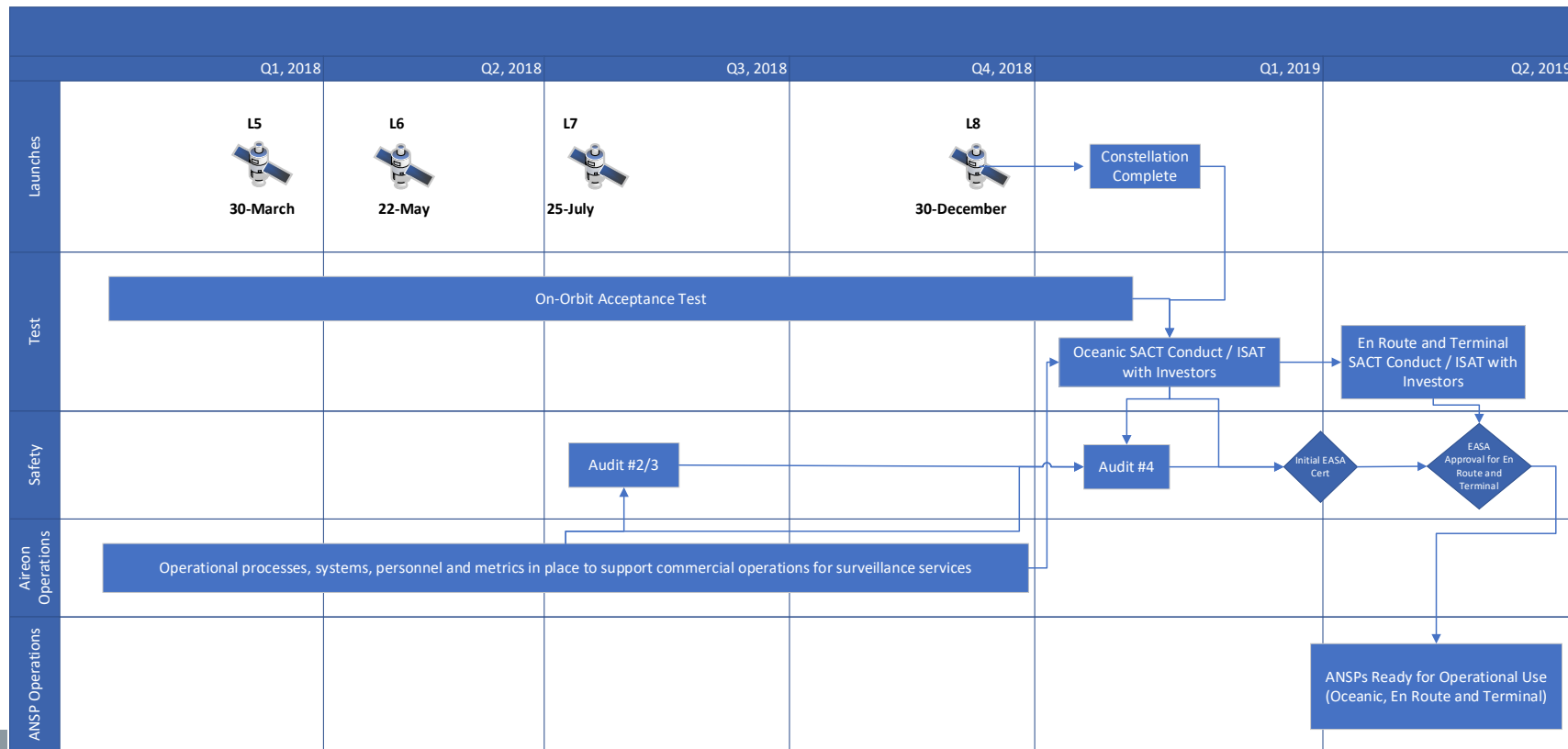
Highly Adaptable Technology Capable of Uploading New Receiver Design to Accommodate DO-260 Updates Ensuring Future Proofing

Space-Based ADS-B Operational Use Cases

| Environment | Type of services | Horizontal Separation Minima | Reference |
|-------------------------------|--|------------------------------|--|
| Oceanic - Advanced | AREA control service in Oceanic sector | 15 NM | SASP May 2018 Meeting Report; Appendix A |
| En-Route Non-Radar (NRA) | AREA control service in En-Route sector | 5 NM | PANS-ATM Doc. 4444; Section 8.7.3.1 |
| En-Route Radar (RAD) | | | |
| Terminal Area Non-Radar (NRA) | APPROACH control service in a TMA sector | 3 NM | PANS-ATM Doc. 4444; Section 8.7.3.2 (a) |
| Terminal Radar (RAD) | | | |



Objectives



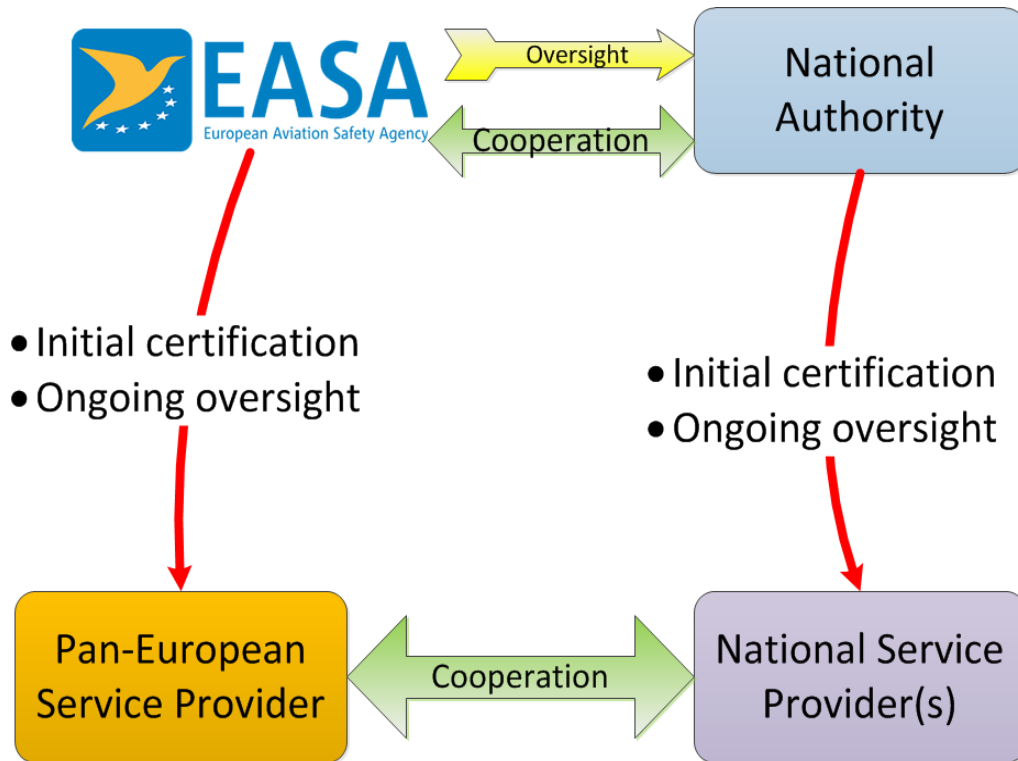


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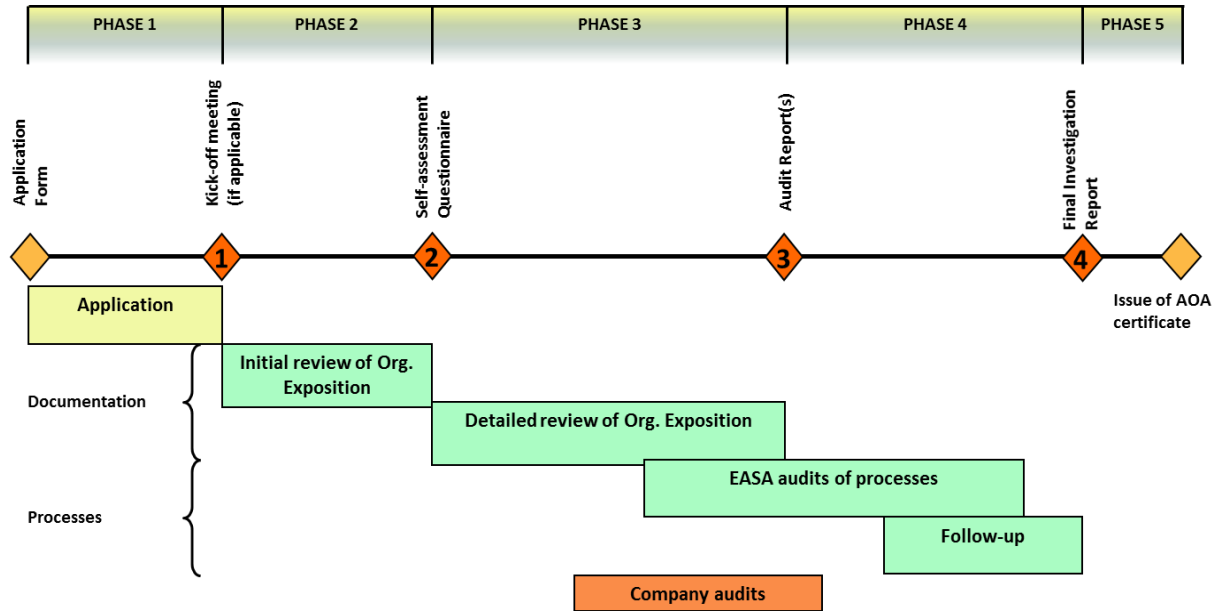
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EASA Initial Certification





Initial Certification Process



Initial Aireon Certification

Certification scope:

- From the receiving antenna at the Iridium-NEXT satellite
- To the entry point of the ADS-B reports at the user Air Navigation Service Provider (ANSP), output of the Service Delivery Point (SDP)

Geographical scope of the EASA certificate:

- Established consistently with the applicability of the EASA Basic Regulation
- Limited to the ATM/ANS services provided in the airspace of the territory to which the Treaty applies, as well as in any other airspace where Member States apply Regulation (EC) No 551/2004 in accordance with Article 1(3) of that Regulation

Initial Aireon Certification

Aireon surveillance service will be described in a dedicated Service Definition Document (SDD), including (as examples):

- Performance Requirements (e.g. Probability of Update, Latency)
- Notification requirements (e.g. in case of underperformance or contingency situations)

The EASA certification (and continuous oversight) process aims to confirm the compliance of the service:

- with respect to the applicable EU regulation and
- with respect to the service characteristics presented in the SDD

Continuous Oversight

Once a certificate is granted to an organization, the continuous oversight process starts. Two main processes can be identified:

- Evaluation of the continuous compliance with the applicable regulation
 - Desktop reviews and on-site audits
 - Confirm compliance with all the applicable requirements in a cycle of 2 years
 - May also be applied for changes to the organization structure
- Changes to Functional System
 - Safety-related changes to the functional system must be notified
 - EASA, as Competent Authority, will decide the need of a safety review of each change
 - When “no review” is decided, the organization can proceed with the implementation
 - Upon EASA review and acceptance, the change can be implemented



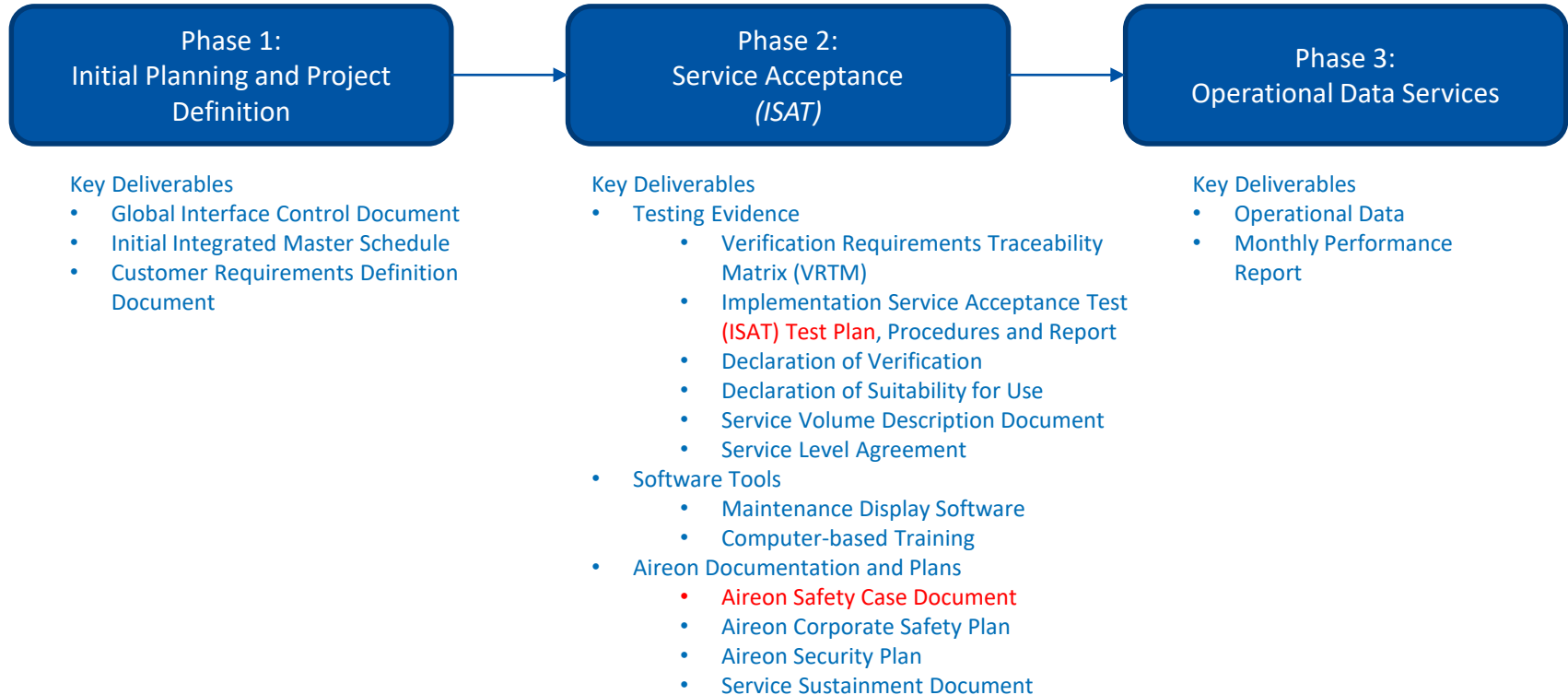
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CAPACITY & EFFICIENCY

ANSP Safety Case Development Approach



Contracts: Three Phase Approach



Aireon Deliverables as Input to ANSP Safety Case



Contents:

- EASA ATM / ANS Org Cert
- Declaration of Verification
- Declaration of Suitability
- Environment Description
- Service Definition Doc
- Safety Arguments
- Safety Requirements
- Hazards Analysis

Contents:

- Installation Test Cases
- ICD / TELCO
- Security Test Cases
- Operations Test Cases
- Local Maintenance Display
- Redundancy Test Cases
- Performance Test Cases
- Aireon Dashboard
- Customer Test Cases

Contents:

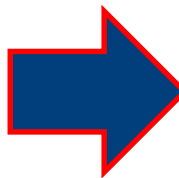
- Concept of Use
- Separation Minima
- Routes
- Holding Areas
- Airspace Structure
- ATC Sectorization
- Air Traffic Management
- ATC Training

ANSP Safety Case Implementation for Space-based ADS-B

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AN/188



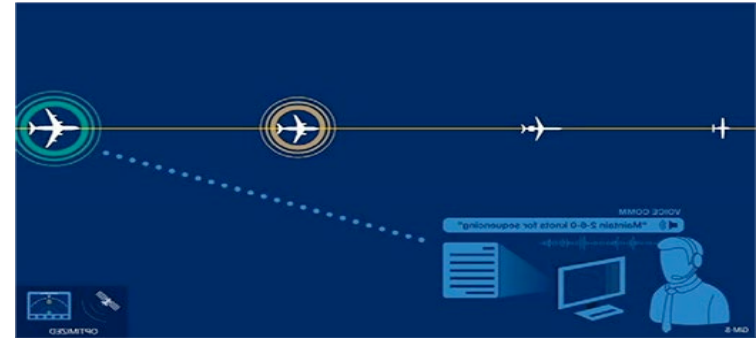
**Assessment of ADS-B and
Multilateration Surveillance
to Support Air Traffic Services
and Guidelines for Implementation**



- Definition of an Airspace Concept
- Identification of ADS-B Performance Requirements
- Safety Assessment
- Preparation for Implementation

Definition of Airspace Concept

- The ANSP should develop the concept of operation unique to their objectives
- This will assist in formulating the needed operational changes to integrate Space-based ADS-B into their operational environment because introducing a new surveillance source could affect:
 - Separation Minima
 - Routes
 - Holding Areas
 - Airspace Structure
 - ATC Sectorization
 - Air Traffic Management
 - ATC Training



Oceanic 15NM Separation Performance Requirements



International Civil Aviation Organization

SEPARATION AND AIRSPACE SAFETY PANEL (SASP)

SECOND MEETING

Montreal, 7 to 18 May 2018

The material in this report has not been considered by the Air Navigation Commission. The views expressed therein should be taken as advice of a panel of experts to the Air Navigation Commission but not as representing the views of the Organization. After the Air Navigation Commission has reviewed this report, a supplement setting forth the action taken by the Air Navigation Commission thereon will be issued to this report.

| CNS-ATM Requirements | |
|--|--|
| SUR requirements | ATS surveillance system (Radar, ADS-B or MLAT) |
| NAV requirements | Aircraft capable of RNP4 or RNP2 |
| COM Requirements | RCP 240 (Performance based, could be CPDLC but not defined as ADS-C) |
| Contingency Requirements ... should normal COM fail | Alternative means of COM: Recognize, Intervene, Resolve conflict – Total Time 9 mins*. <u>Note: No ADS-C contingency requirement</u> <u>Note: No Next & Next + 1 requirement</u> |
| ATS System: Lateral Conformance- Reduced Separation | Lateral warning threshold set: 3NM |
| ATM System: Lateral Conformance- Basic | Lateral warning threshold set: 3NM |

Next Steps:

- November 2020 Publish Revision in PANS / ATM Doc 4444

En-Route/TMA Radar Environment Performance Requirements



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

SAFETY, PERFORMANCE AND INTEROPERABILITY REQUIREMENTS DOCUMENT FOR ADS-B-RAD APPLICATION

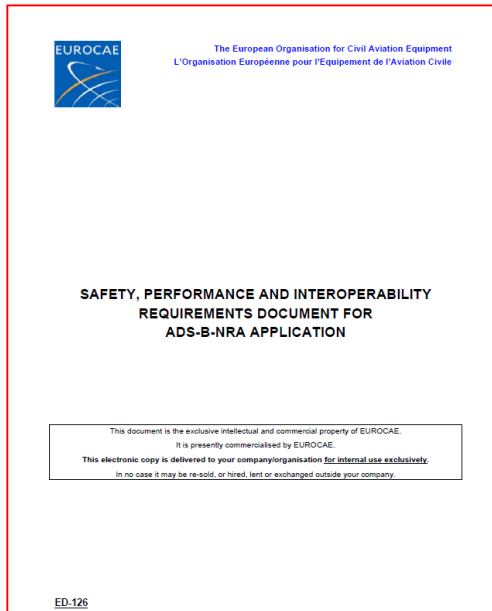
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| | | | |
|---------------|--|------------------------------|-----------------|
| RAD 1 | A Single Primary Surveillance Radar (PSR) with ADS-B surveillance in medium-density TMA, applying 3 nautical mile (NM) separation | ADS-B + PSR | TMA |
| RAD 2a | Single Monopulse Secondary Surveillance Radar (SSR) with ADSB surveillance in high-density En Route airspace, applying 5 NM separation | ADS-B + Monopulse SSR | En Route |
| RAD 2b | Single Mode S Radar with ADS-B surveillance in high-density En Route airspace, applying 5 NM separation | ADS-B + Mode S | En Route |
| RAD 3 | Single Primary Surveillance Radar (PSR) with a collocated single SSR together with ADS-B surveillance in high-density TMA, applying 3 NM separation as well as 2 NM/2.5 NM separation as applicable to dependent and independent parallel runway operations | PSR + SSR + ADS-B | TMA |

Comparative Analysis: Safety, Performance & Interoperability Requirements

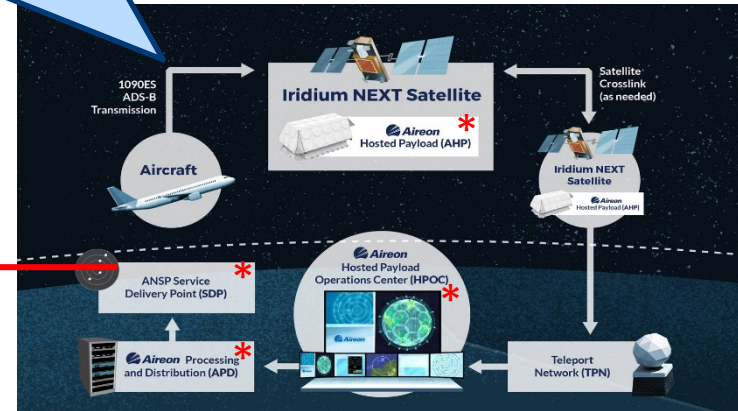
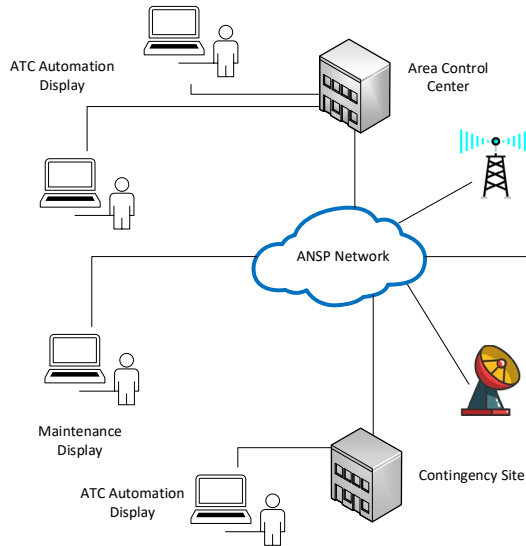
En-Route/TMA Non Radar Environment Performance Requirements



- Operational services and environment definition - services, intended functions, and associated procedures of the ADS-B-NRA application and the assumptions about the environment in which the application is operating
- Safety and Performance Requirements
 - requirements by comparing ADS-B with a reference SSR radar, thereby establishing minimum requirements under nominal conditions
 - derived safety requirements by considering potential hazards with ADS-B based separation services
 - derived requirements in order to control the likelihood of the hazards and their effects
- Interoperability Requirements - assure that the elements of the CNS/ATM system employed for ADS-B-NRA will correctly work together to carry out their intended function in a safe manner

Aireon Technology Insertion Based on Existing 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



Identification of ADS-B Performance Requirements: Service Level Agreement (SLA) Metrics

- **[ANSP]_Aireon001: Service Volume Availability of $\geq 99.9\%$**

Note - in accordance with the ICAO Global Operational Data Link Document (GOLD) as set forth in the RSP Specification, Appendix C, Table C-3

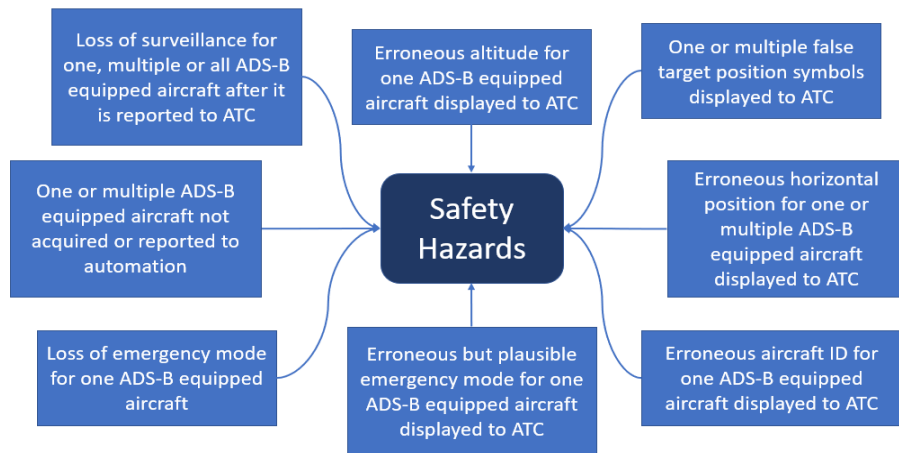
- **[ANSP]_Aireon002: Latency $\leq 2.0s$ (99th percentile)**

Note - in accordance with the EUROCONTROL Safety & Performance Requirements Document for a Generic Surveillance System Support Air Traffic Control Services (GEN-SUR SPR VOLUME 1) as set forth in Section 3.7.3.1.5 (SUR Sensor + SUR Distribute) SPR 9 and Table 33

- **[ANSP]_Aireon003: Probability of Update $\geq 96\%$ for an Update Interval of 8 seconds**

Note - in accordance with the EUROCAE Technical Specification for an 1090 MHz Extended Squitter ADS-B Ground System, ED-129B; as set forth in Section 3.3.1.1

Safety Assessment



| Risk probability | | Risk severity | | | | |
|----------------------|---|-------------------|----------------|------------|------------|-----------------|
| | | Catastrophic A | Hazardous B | Major C | Minor D | Negligible E |
| Frequent | 5 | 5A | 5B | 5C | 5D | 5E |
| Occasional | 4 | 4A | 4B | 4C | 4D | 4E |
| Remote | 3 | 3A | 3B | 3C | 3D | 3E |
| Improbable | 2 | 2A | 2B | 2C | 2D | 2E |
| Extremely improbable | 1 | 1A | 1B | 1C | 1D | 1E |

Risk-based decision making

Preparation for Implementation

- As the safety case defines the change to the ANSP operational environment, an implementation plan defines the actions to be taken to implement the capability.
- Depending on the safety hazards and the associated mitigations there may be changes made to the ANSP systems, policy and procedures. Examples of areas that may require change proposals would be:
 - ATC Automation modifications to accept additional surveillance sensors
 - ATC modifications to display ADS-B aircraft indicators
 - ATC Training revisions
 - ATC procedure changes/amendments
 - ATC airspace boundaries definition
 - Best equip – best served route changes
 - Performance monitoring equipment
 - Technician training

Sample ANSP Safety Case Outline

1. Introduction
 - a. Purpose and scope of the Safety Case Document (SCD)
 - b. Applied Method
 - c. Document Content
 - d. Applicable Documents
 - e. Definition of terms
 2. Description of the Service and environment
 - a. ATC Service ICAO Definition
 - b. Operational Environments and ATC services
 - c. Operational Surveillance Information provided to the ATC
 - d. Functional Architecture of the Surveillance System
 - e. Architecture and Functional Description of the Surveillance System
 - f. External Systems supporting the ATC Service
 - g. System Human Interface
 3. Scope of the Safety Case
 - a. In-Scope of the Safety Case
 - b. Out of Safety Case Scope
 4. Safety Arguments
 5. Assessment for airspace where ADS-B ground stations could be used
 - a. Overview of the Process
 - b. Identification of Safety and Performance requirements and assumptions
 - c. Evidence for the design of the Surveillance System
 - d. Evidence for the implementation of the Surveillance System
 6. Assessment for airspace where ground-based surveillance is not possible
 - a. Overview of the process
 - b. Specifications of the Surveillance Service
 - c. Evidence for the design of the Surveillance System
 - d. Evidence for the implementation of the Surveillance System
 7. Safe operations of the Surveillance Service
 - a. Roles, responsibilities, interfaces and agreements with suppliers and customers
 - b. Procedures for operations and maintenance
 - c. Procedures regarding transition to a new build
 - d. Safety assurance and monitoring procedures
 - e. Safety promotion activities
 - f. Quality Management
 8. Synthesis of Requirements and Assumptions
 - a. Safety Case Requirements and Assumptions
 - b. ADS-B-NRA Requirements
 - c. ADS-B-RAD Requirements and Assumptions
 - d. ICAO Annex 10 Requirements
 - e. OSED Requirements and Assumptions
 - f. Safety Requirements and Assumptions
- Conclusions and recommendations
 - Appendix A: OSED
 - Appendix B: OSED comparison to ADS-B RAD and NRA Standards
 - Appendix C: Fault Tree analysis

Safety Summary

- Discussions should take place between the ANSP and their safety regulator
 - inform of the proposed change
 - positively demonstrate relevant safety regulations are satisfied
- The ANSP is responsible for demonstrating that acceptable levels of safety are and continue to be achieved
- The ANSP's safety case acts as a vehicle to gain regulatory approval for the new service

The ANSP's regulator may also acquire support from EASA regarding Aireon company processes, policies, procedures, personnel competency and design assurance approach

Space-Based ADS-B Will Be Operational Soon!

- Global ADS-B coverage over oceans, remote and terrestrial airspace will be available to all ANSPs
- Remaining launch on track to complete system deployment, testing and certification
- 11 launch customers representing 28 nations are planning to use the service operationally
- Significant work is being done by the FAA in preparation for the use of space-based ADS-B
- Ongoing EASA oversight post-certification throughout the service lifecycle



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Central American
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(SAM) Office
Lima

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Central African
(WACAF) Office
Dakar

European and
North Atlantic
(EUR/NAT) Office
Paris

Middle East
(MID) Office
Cairo

Eastern and
Southern African
(ESAF) Office
Nairobi

Asia and Pacific
(APAC) Sub-office
Beijing

Asia and Pacific
(APAC) Office
Bangkok



THANK YOU

Audit Scope

- The following audits are identified in the context of the Aireon initial certification:

| Audit | Scope | Place |
|----------|---|--------------------------|
| Audit #1 | Compliance with Reg. 482/2008 (Software Assurance) System Verification Activities | Aireon HQs |
| Audit #2 | Aireon management processes | Aireon HQs |
| Audit #3 | SNOC Operation APD Operation Contingency/Disaster Recovery Site operation | SNOC Contingency Site |
| Audit #4 | Findings closure, On-Orbit (SACT) testing | Aireon HQs |

EASA Certification: Audit 2/3 Results



Results of the audit: positive aspects

- Clear company vision and goals
- Highly professional staff met
- Positive attitude towards the audit
- Transparent and open minded
- Good collaboration between Aireon and its partners



Results of the audit

- Observations
 - A way to communicate and draw third parties and future audit teams attention on specific matters that deserve scrutiny
- Level II findings
 - non-compliance with applicable requirements or organisation's procedures and manuals
- Level I findings
 - Significant non-compliance with applicable requirements or organisation's procedures and manuals
 - Lowers safety or seriously endangers safety

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ANSP Planned Usage

| ANSP | Airspace | Environment |
|------------------------|---|--------------------|
| NAV CANADA (Canada) | Canadian Domestic | En Route |
| | Gander OCA | Oceanic |
| NATS (United Kingdom) | Southeast Corner of Shanwick FIR | Oceanic |
| | Shanwick FIR | Oceanic |
| Enav (Italy) | Brindisi FIR | En Route |
| | Roma FIR | En Route |
| Naviar (Denmark) | Kobenhavn FIR | En Route |
| | Airspace in Adjacent FIR with Delegation of Air Traffic Services to Denmark | En Route |
| IAA (Ireland) | Shannon FIR | En Route |
| | Shannon Oceanic Transition Area (SOTA) | En Route |
| | Northern Oceanic Transition Area (NOTA) | En Route |
| | Dublin | Terminal Test Case |

ANSP Planned Usage

| ANSP | Airspace | Environment |
|------------------------|---------------------------------|----------------------|
| DC-ANSP (Curacao) | Oceanic West | Oceanic |
| | Oceanic & Terrestrial East | Oceanic and En Route |
| ATNS (South Africa) | Johannesburg Oceanic | Oceanic |
| | Johannesburg Terrestrial | En Route |
| | Capetown FIR | En Route |
| CAAS (Singapore) | Singapore FIR | En Route |
| SCAA (Seychelles) | Seychelles FIR | Oceanic and En Route |
| Isavia (Iceland) | Reykjavik Control Area | En Route |
| | Sondrestrom FIR | En Route |
| ASECNA | Dakar FIR Oceanic & Terrestrial | Oceanic and En Route |
| | Antananarivo FIR | Oceanic and En Route |
| | Niamey FIR | En Route |
| | N'Djamena FIR | En Route |
| | Brazzaville FIR | En Route |

SLA: Technical Support Performance Metrics

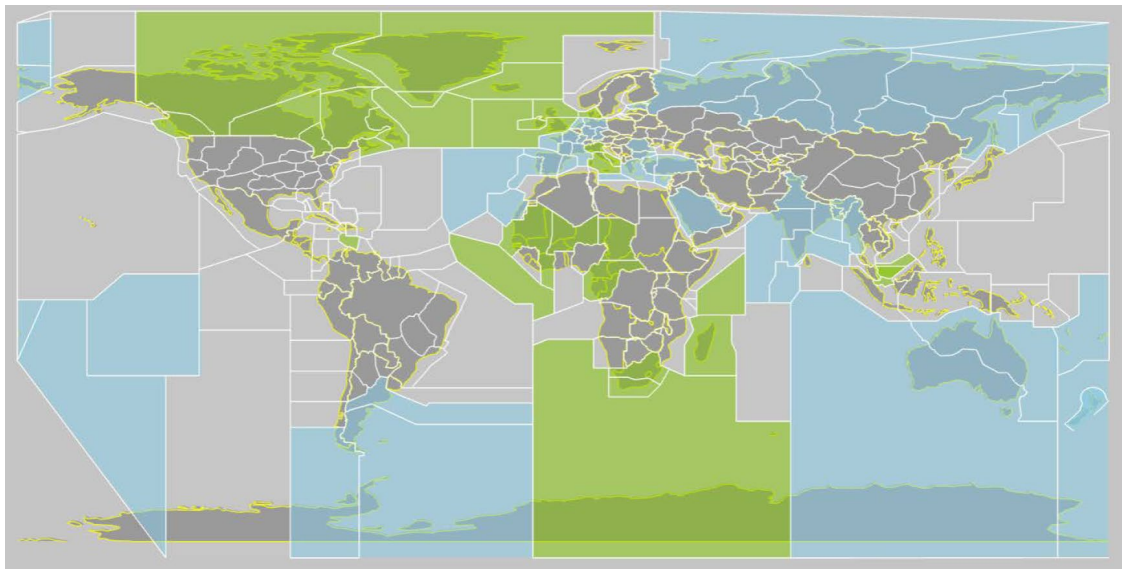
- **[ANSP]_Aireon004:** The response time for technical support shall be two hours, to be measured from the time that the incident was reported to the Aireon technical support desk being requested to respond (i.e. not from the actual time of the failure) to the time when [ANSP] is advised of the action being taking to restore the Service and an estimated restoration time.
- **[ANSP]_Aireon005:** Problem Trouble Report (“PTR”) adjudication time from reporting to fix:
 - Category 1 – Critical: Response time from reporting to fix is a maximum of 24 hours
 - Category 2 – Major: Response time from reporting to fix is a maximum of 7 days
 - Category 3 – Minor: Response time from reporting to fix will be coordinated with [ANSP] scheduled Service updates



Global Equipage Mandates

| State/Adm. | 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 cruise | 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 | | DO-260 |
| Hong Kong | At or above FL290 on airways L642 and M771 | February 2016 | DO-260 |
| Indonesia | At or above FL290 | January 2018 | DO-260 |
| Taipei FIR | 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 | 31 December 2018 31 December 2021 | DO260 (with forward fit for DO260B) Looking at TSO 199 for GA |
| Canada | No mandate proposed; preferential service in Hudson Bay | | DO-260 |

Global ANSP Launch Customers Supporting Rollout



■ = Signed Contract
■ = MOU

Data Services Agreements in Place

- NAV CANADA
- NATS (United Kingdom)
- ENAV (Italy)
- IAA (Ireland)
- Naviar (Denmark)
- DC-ANSP (Curacao)
- Air Traffic Navigational Services Co. Ltd (South Africa)
- Civil Aviation Authority of Singapore
- Seychelles
- ISAVIA (Iceland)
- Aerial Navigation Safety in Africa and Madagascar (ASECNA)

Safety Assessment: Sample Hazard

| Operational Hazard | Description | ANSP Mitigation Strategy(ies) |
|--|---|---|
| <u>Corruption</u> of altitude information for a <u>single</u> aircraft | <p>The altitude of a single aircraft provided to the controller is incorrect.</p> <p>The incorrect altitude is detected by the controller if the error is not plausible. When it is detected, the controller continues providing vertical separation without using the erroneous displayed altitude information.</p> <p>If it is not detected, the controller could potentially make decisions which would bring the aircraft into proximity to another aircraft believing it to be vertically separated therefore creating a conflict.</p> | ANSP procedures exist to manage this scenario for a single aircraft (i.e. alternative separation) |