



ADS-B 1090 MHz Ext. Squitter Ground Station Specification - Iteration 3

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Abstract

The ADS-B 1090 MHz Extended Squitter Ground Station (1090 GS) is part of a ground based surveillance system that provides airspace and airport surface situational awareness to air traffic controllers. The 1090 GS receives and decodes ADS-B data broadcasted in the form of 1090 MHz extended squitters (1090 ES) from appropriately equipped aircraft (and airport vehicles), compiles corresponding target reports in ASTERIX Category 021 (ATX021) format, and forwards these ATX021 reports to client systems or functions (typically Surveillance Data Processing Systems).

This specification addresses the requirements for ADS-B 1090 GS within the functional ADS-B Ground Surveillance Domain as defined in the P15.04.05.a deliverable D20: ADS-B Surveillance System Specifications for Iteration 3.

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Executive Summary

The ADS-B 1090 MHz Extended Squitter Ground Station (**1090 GS**) is part of a ground surveillance system that provides airspace and airport surface situational awareness to air traffic controllers (and potentially other users within ATM). The 1090 GS provides target surveillance reports in ASTERIX Category 021 format (**ATX021**) to client systems or functions, such as Surveillance Data Processing. It generates these reports on the basis of data extracted from aircraft broadcasted 1090 MHz extended squitters (**1090 ES**). These squitters contain data (such as position, velocity, status etc.) obtained from onboard systems and sensors.

Additionally the 1090 GS generates status reports (ASTERIX Category 023 and 247 formats) to inform client systems of changes in the station status, the services available, and the ATX021 and ATX023 versions used.

This Technical Specification presents the third iteration of the functional, non functional and interface requirements applying to the 1090 GS as derived from the requirements stated in the Project 15.04.05.a ADS-B Surveillance System Specification for Iteration 3, ref. [1], and is intended to be used by Project 15.04.05.b for the development of a third iteration 1090 GS prototype.

Project 15.04.05.a covers the following ADS-B enhancements:

a. Iterations 1 (ref. [23]) and 2 (ref. [3])

- Initial ADS-B applications
- Applications defined in SESAR projects (including future separation modes such as spacing, separation etc.)
- Integration of ADS-B with WAM
- Security and Civil-Military Interoperability
- 1090 ES MHz datalink technology enhancements

b. Iteration 3 (enhancements added in this specification)

- Advanced enhancements from integration with WAM
 - ADS-B target report update by WAM system
- Advanced security enhancements
 - Range measurement from active interrogation

This third iteration specification supports all the enhancements that were specified in Iterations 1, 2 and 3. All the applicable requirements and material developed in Iterations 1 and 2 of the 1090 GS specification have been included in this third iteration specification.

This specification is not intended to dictate the physical architecture of the 1090 GS. Allowance is made for distributed architectures such as those consisting of multiple 1090 ES receivers (possibly remotely located) with a centrally hosted report assembly function via a common server, or the provision of the ADS-B Ground Station function by WAM systems.

Furthermore while this specification covers only ADS-B requirements it does not exclude physical implementations where SDPD functionality is implemented within the ADS-B Ground Station. No requirements are however specified for any such integrated SDPD functionality.

1 Introduction

The Technical Specification contains the functional, non functional and interface requirements applying to the ADS-B 1090 MHz Extended Squitter Ground Station (**1090 GS**) as derived from the requirements stated in the ADS-B Surveillance System Specification for Third Iteration, ref. [1].

1.1 Purpose of the document

This document constitutes the third iteration¹ of the requirements specification for the 1090 GS developed by Project 15.04.05a and is intended to be used by Project 15.04.05.b, which is tasked to develop a corresponding 1090 GS prototype in support of SESAR validation activities.

1.2 Intended readership

The audience of this document includes:

- Projects 15.04.05.a and b;
- Any other SJU projects that may require 1090 GS for their validation activities.

1.3 Inputs from other projects

ADS-B surveillance standards have been developed by RTCA and EUROCAE (see ref. [4], [5], [6], [7], [8] for avionics equipment and [9], [10] for ATC surveillance of Non Radar and Radar airspaces). Furthermore EUROCAE has published a standard for 1090 GS (ED-129, ref. [11]) which would meet the requirements of ADS-B surveillance in Non Radar Airspaces (ED-126, ref. [9]), and is interoperable with DO-260, ref. [6], or DO-260A, ref. [7], compliant aircraft.

Additionally EUROCONTROL has developed ASTERIX standards (Category 021, ref. [12], and Category 023, ref. [13]) for ADS-B data and station status reporting between ground systems. The EUROCAE 1090 GS specification, ED-129, ref. [11], is compliant with these ASTERIX standards.

SJU Project 15.04.05a has developed ground station specifications for Iteration 1 (ref. [23]) and Iteration 2 (ref. [3]), meeting the requirements specified in ref. [19] and [2], respectively. These specifications are baselined on the above EUROCAE/RTCA/ASTERIX standards adding a number of enhancements (see Sec. 2.3).

1.4 Structure of the document

This document is organised as follows:

- Chapter 1: Introduction, document structure, and high level overview.
- Chapter 2: General 1090 GS description.
- Chapter 3: 1090 GS Functional and Non-Functional Requirements.
- Chapter 4: Assumptions.
- Chapter 5: Referenced documents.
- Appendix A: Traceability to the Iteration 3 requirements from ref. [1].
- Appendix B: Applicable baseline requirements from Iteration 2 (ref. [3])
- Appendix C: Applicable baseline requirements from Iteration 1 (ref. [23]).
- Appendix D: Summary of differences between DO-260A and DO-260B.
- Appendix E: Applicable ED-129 requirements.

¹ A first iteration 1090 GS has been specified in ref. [23] and a second iteration in ref. [3].

- Appendix F: 1090 MHz Interference Environment to be used for the verification of performance requirements.

1.5 Requirement Definitions – General Guidance

Requirements have been developed according to the SESAR Requirements and V&V Guidelines, ref. [15]. They are broken down as follows (per ref. [16])

- General;
- Message Processing and Report Assembly;
- Equipment Control and Status;
- Receiver Characteristics;
- Adaptability;
- Performance;
- Safety and Security;
- Maintainability and Reliability;
- Component Internal Data;
- Design and Construction Constraints;
- Interface.

Requirement identifiers are specified as **REQ-15.04.05.a-D13-0xxx.yyyy**, where **xxx** may take the values shown in Table 1. Requirements retained from Iteration 1 (ref. [23]), and Iteration 2 (ref. [3]) keep their original identifiers (namely REQ-15.04.05.a-D05-0xxx.yyyy and REQ-15.04.05.a-D09-0xxx.yyyy, respectively).

| xxx | Meaning |
|-----|--|
| 010 | ADS-B RAD requirement, Appendix C.1 |
| 020 | DO-260B requirement, Appendix C.2 |
| 030 | WAM integration requirement, Appendices A.1, B.2 and C.3.1 |
| 040 | TOA versus distance check requirement, Appendix C.3.2 |
| 050 | Power versus distance check requirement, Appendix C.3.3 |
| 060 | Angle of Arrival check requirement, Appendix C.3.4 |
| 070 | Track Consistency check requirement, Appendix C.3.5 |
| 080 | ADS-B APT requirement, Appendix B.1 |
| 090 | Network Bandwidth Optimisation, Appendix B.6 |
| 100 | Behavioural Analysis, Appendix B.3 |
| 110 | Civil/Military interoperability, Appendix B.5 |
| 120 | Time Differential of Arrival, Appendix B.4 |
| 130 | Range measurement from active interrogation |
| 000 | Other, Sec. 3.1.1 |

Table 1 Requirement Identifier Allocation

1.6 Scope

The term '**1090 GS**' refers to an ADS-B 1090 MHz Mode S Extended Squitter Ground Station, whose primary function is to receive 1090 MHz Mode S Extended Squitter (**1090 ES**) messages broadcasted by ADS-B equipped aircraft (and possibly airport surface vehicles), extract the data contained therein, assemble appropriate ATX021 target reports, ATX023 status reports, and optionally ATX247 version reports, and forward these reports to client systems over a data network.

The 1090 GS is the component "ADS-B Ground Station" of the ADS-B Ground Surveillance Domain shown in blue lines in Figure 1 (ref. [1]) below .

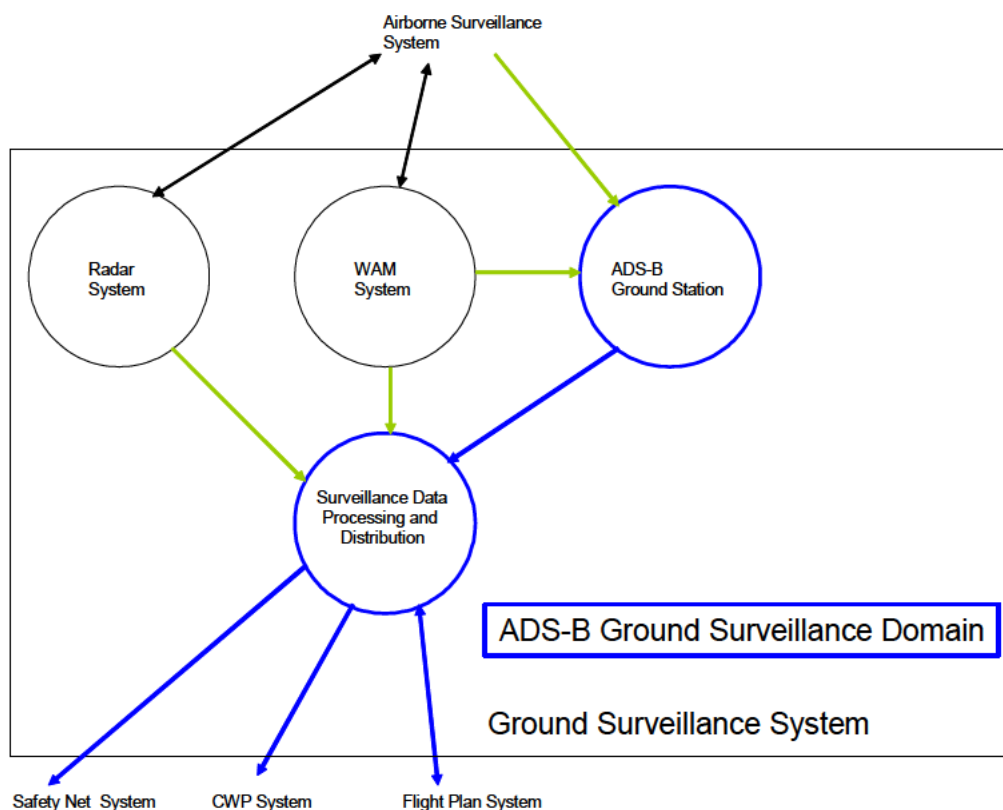


Figure 1 ADS-B Ground Surveillance Domain

- = Existing standardised interfaces, **already processed** by Baseline, **not modified** by P15.4.5.a
- = Existing standardised interfaces, **already processed** by Baseline, **modified** by P15.4.5.a
- = Existing standardised interfaces, **out of scope** of P15.4.5.a

It should be noted that the inclusion of Radar Systems and/or WAM systems depends on the operational environment and associated ADS-B applications which are to be deployed. In case of ADS-B NRA or ADS-B APT deployment, ADS-B may be the only surveillance source.

Notes:

- This specification does not seek to dictate the physical architecture of the 1090 GS equipment, and allows for distributed architectures including the provision of the 1090 GS function by WAM systems.
- SDPD requirements are considered out of this specification’s scope, although 1090 GS implementations incorporating SDPD requirements are feasible.

1.7 1090 GS Overview

The 1090 GS is part of a ground surveillance system (see Figure 1) that provides airspace and/or airport surface situational awareness information to client systems (typically SDPD or FDPS) that typically serve air traffic controllers (and potentially other users in ATM).

The 1090 GS receives and decodes ADS-B messages broadcasted over 1090 MHz via Extended Squitters by aircraft (and possibly surface vehicles), from which it extracts position, velocity and status information, which it then validates and assembles into ATX021 target reports to be forwarded to client systems over a data network.



The reported targets are typically located within a pre-configured Service Volume².

Target Validation may be based on correlations of the different data received from the target and/or comparisons with data received from other surveillance systems (WAM, SSR, and 1090 GS) or FDPS.

Additionally, the 1090 GS may provide periodically Ground Station Status reports and ASTERIX Version reports in ATX023 and ATX247 format, respectively. Ground Station Status reports indicate to the client system the status of the Ground Station and the characteristics of the ADS-B service provided. ASTERIX Version reports indicate the ASTERIX message format version used for ADS-B reports.

1.8 Acronyms and Terminology

| Term | Definition |
|----------------|--|
| 1090 ES | 1090 MHz Mode S Extended Squitter |
| 1090 GS | ADS-B 1090 MHz Extended Squitter Ground Station |
| ADD | Aircraft Derived Data |
| ADS-B | Automatic Dependent Surveillance - Broadcast |
| ADS-R | Enhanced ADS in Radar Areas |
| AF | Application Field |
| APT | Airport |
| ASR | Airport Surveillance Radar |
| ATC | Air Traffic Control |
| ATCO | Air Traffic Controller |
| ATM | Air Traffic Management |
| ATS | Air Traffic Services |
| ATXnnn | ASTERIX Category nnn, e.g. ATX021, ATX023, ATX247 |
| BAQ | Barometric Altitude Quality |
| BITE | Built In Test Equipment |
| CASCADE | Cooperative ADS through Surveillance and Communication Applications Deployed in ECAC (EUROCONTROL project) |
| CE | European Conformity |
| CDTI | Cockpit Display of Traffic Information |
| CF | Control Field |

² The definition of the Service Volume depends on local operational needs, environmental conditions and geographical constraints.

| Term | Definition |
|----------------|--|
| CFMU | Central Flow Management Unit (EUROCONTROL) |
| CL | Confidence Level |
| CMI | Control and Monitoring Interface |
| CWP | Controller Working Position |
| DF | Downlink Format |
| DoA | Direction of Arrival |
| DOD | Detailed Operational Description |
| E-ATMS | European Air Traffic Management System |
| ECAC | European Civil Aviation Conference |
| ES | Extended Squitter |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| EUROCAE | European Organisation for Civil aviation Equipment |
| FDPS | Flight Data Processing System |
| FMS | Flight Management System |
| FRUIT | False Replies Uncorrelated In Time |
| FTC | Format Type Code (ADS-B) |
| GPS | Global Positioning System |
| GS | Ground Station |
| GVA | Geometric Vertical Accuracy |
| HRD | Horizontal Reference Direction |
| IAP | Increment of Average Power |
| IRF | Interrogation Repetition Frequency |
| IFR | Instrument Flight Rules |
| LRU | Line Replaceable Unit |
| LSB | Least Significant Bit |
| MHz | MegaHertz |

| Term | Definition |
|---------------------------|---|
| MICA | Mode S Interrogator Code Allocation cell (EUROCONTROL) |
| MOPS | Minimum Operational Performance Standards |
| MTL | Minimum Trigger Level |
| NACp | Navigation Accuracy Category for Position |
| NACv | Navigation Accuracy Category for Velocity |
| NIC | Navigation Integrity Category |
| NUCp | Navigation Uncertainty Category for Position |
| NUCr | Navigation Uncertainty Category for Velocity |
| OM | Operational Mode |
| OSED | Operational Service and Environment Definition |
| POA | Position Offset Applied |
| RA | Resolution Advisory |
| RAD | Radar |
| RF | Radio Frequency |
| RTCA | Radio Technical Commission for Aeronautics |
| RTD | Return Trip Delay |
| SAC | System Area Code |
| SAF | Single Antenna Flag |
| SDA | System Design Assurance |
| SDPD | Surveillance Data Processing and Distribution |
| SESAR | Single European Sky ATM Research Programme |
| SIC | System Identification Code |
| SIL | Surveillance Integrity Level |
| SJU | SESAR Joint Undertaking (Agency of the European Commission) |
| SJU Work Programme | The programme which addresses all activities of the SESAR Joint Undertaking Agency. |
| SESAR Programme | The programme which defines the Research and Development activities and Projects for the SJU. |

| Term | Definition |
|----------------|--|
| SMR | Successful Message Reception |
| SNMP | Simple Network Management Protocol |
| SPI | Special Position Identification |
| SPIR | Safety, Performance and Interoperability Requirements |
| SPR | Safety and Performance Requirements |
| STATFOR | Air Traffic Statistics and Forecast (EUROCONTROL Agency Service) |
| TCAS | Traffic Alert and Collision Avoidance System |
| TDOA | Time Differential of Arrival |
| TMA | Terminal Manoeuvring Area |
| TOA | Time of Arrival |
| TOI | Time of Interrogation |
| UAT | Universal Access Transceiver |
| UTC | Coordinated Universal Time |
| VNS | Version Not Supported |
| VPL | Vertical Protection Limit |
| WAM | Wide Area Multilateration |

2 General 1090 GS Description

2.1 Context

The 1090 GS provides ADS-B Services to one or more client systems connected to it via a data communications network. An ADS-B Service consists of the provision of ATX021 reports for 1090 ES equipped targets (aircraft and/or surface vehicles) located within some pre-configured Service Volume, with a given reporting mode (data driven or periodic³). Additionally, each ADS-B Service includes the periodic provision of ATX023 and ATX247 reports indicating the status of the 1090 GS, the characteristics of the ADS-B service, and the ATX021/023 versions used.

Optionally a 1090 GS may provide distinct ADS-B Services to separate groups of client systems. In that case each ADS-B Service should be configurable independently of the other ADS-B Services and would provide its specific ATX023 and ATX247 reports.

The present specification considers only the minimum case of a 1090 GS providing a single ADS-B Service [ASSUMPTION_2] .

The context diagram for the 1090 GS per ED-129 is shown in Figure 2 below.

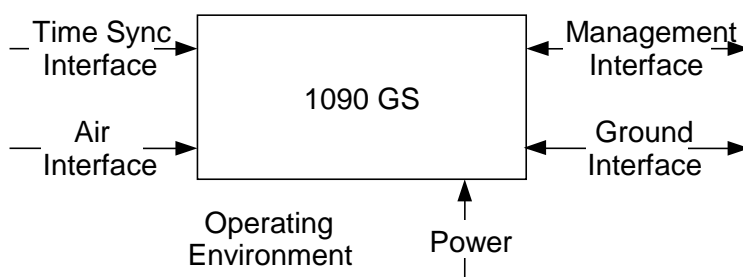


Figure 2: 1090 GS Context Diagram

The 1090 GS interfaces are:

- Time Synchronisation Interface – This interface provides time reference signals that are used to synchronise the Ground Station’s internal timekeeping functions with Coordinated Universal Time (UTC). UTC time is used to express the time of applicability and/or time of message reception in ADS-B reports and may also be used in other functions.
- Air Interface – 1090 MHz RF input is received via the Air Interface. The third iteration of the 1090 GS adds the capability to issue Mode S interrogations to support range measurement from active interrogations (see App. A.2).
- Management Interface – The Management Interface is used to control, configure and monitor the 1090 GS.
- Ground Interface – ADS-B reports derived from 1090 ES messages are sent to other ground equipment via the Ground Interface. In addition to the ED-129 requirements (generation of ATX021, ATX023, and ATX247 reports), this specification requires for the 1090 GS the capability to receive over the ground interface:
 - WAM position and status reports (ATX020 and ATX019, respectively) for WAM Integration, and/or
 - ADS-B position and station status reports (possibly in ATX021 and ATX023 format, respectively) from other 1090 GS for ADS-B data validation tests.
- Power Interface – The 1090 GS receives electrical power via the Power Interface.

The operating environment consists of physical interfaces and constraints, heat sources and sinks, electromagnetic interference sources and other entities that are not signal interfaces.

³ In periodic mode the 1090 GS provides target reports at a preconfigured fixed rate. In data driven mode the 1090 GS provides target reports when new data are available.

2.2 1090 GS Modes and States

The 1090 GS has various modes and states. Modes are commanded by an operator, while a state is a property of the Ground Station which the Ground Station will determine automatically based on BITE results.

2.2.1 1090 GS Modes

In accordance with ED-129, ref. [11], two modes are considered for the Ground Station⁴: **Operational** and **Maintenance**.

Maintenance mode is used for changing the configuration of the Ground Station. **Configuration** changes are not permitted in Operational mode.

2.2.2 1090 GS States

In accordance with ED-129, ref. [11], three states are defined for the 1090 ES Ground Station: *Initialisation*, *On-Line* and *Failed*.

These states are meant to facilitate the description of the external behaviour of the 1090 GS. However the method of implementing such behaviour, with or without the state machine, is for the 1090 GS manufacturer to decide.

The *Initialisation* state is entered on power up. Following completion of the power-on self-test, the 1090 GS enters either the *On-Line* state or the *Failed* state depending on the result of BITE.

The *On-Line* state is the normal operating state of the 1090 GS. It indicates that it is either providing an operational service meeting the minimum performance requirements, or is capable of doing so.

The *Failed* state is entered when an error condition is detected that means that the minimum operational performance requirements cannot be met.

The 1090 GS does not enter the *Failed* state as a result of warning conditions.

2.2.3 1090 GS Time Source States

In addition to the states defined in the previous section, the 1090 GS can be described in terms of the state of its UTC synchronisation. ED-129, ref. [11], defines this time source state machine which has three states: *Not Coupled*, *UTC Coupled* and *Coasting*. It is again meant to facilitate description of the external behaviour of the 1090 GS and not to prescribe the method of implementing this behaviour.

The *Not Coupled* state indicates that the Ground Station is not synchronised to a UTC time source and is not providing valid UTC time.

The *UTC Coupled* state indicates that the Ground Station is synchronised to a UTC time source and is providing valid UTC time.

The *Coasting* state indicates that the Ground Station is no longer synchronised to a UTC time source but is able to maintain UTC time internally with the required accuracy. When this accuracy can no longer be maintained the Time Source state will change to *Not Coupled*.

When power is first applied to the system or when there is a system reset, the UTC Time State is "*Not Coupled*." After a valid UTC time has been obtained, the UTC Time State becomes "*UTC Coupled*". If the UTC time reference degrades or is lost while in the "*UTC Coupled*" state, the state changes to "*Coasting*"⁵. The Ground Station remains in the *Coasting* state until it is no longer able to assure the required UTC time accuracy.

⁴ Additional modes may be introduced by 1090 GS manufacturers (for example a **Test Mode**).

⁵ For the transition from *Coasting* to *Not Coupled* the manufacturer must ensure that the transition occurs before the required UTC performance is lost.

2.3 Major 1090 GS Capabilities

SJU Project 15.04.05a has developed 1090 GS specifications in three successive iterations supporting the capabilities listed in Table 2 below. Each iteration supports the enhancements introduced in the previous iterations and adds the indicated capabilities.

Table 2 1090 GS Capabilities per Iteration

| Iteration | Capabilities |
|----------------|---|
| 1 ref. [23] | <ul style="list-style-type: none"> • Compliance with EUROCAE/RTCA/ASTERIX standards ref. [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], and [14]; • Use of WAM data for ADS-B position validation; • Time of Arrival versus distance check for ADS-B report validation; • Power versus distance check for ADS-B report validation; • Angle of arrival check for ADS-B report validation; • Consistency Check (Position versus Velocity). |
| 2 ref. [3] | <p>All Iteration 1 capabilities plus</p> <ul style="list-style-type: none"> • Compliance with the EUROCAE APT standard, ref. [20]; • Advanced integration with WAM <ul style="list-style-type: none"> ○ Enhanced ADS-B target report validation; • Civil/military interoperability <ul style="list-style-type: none"> ○ Reception and decoding of DF19 messages; • Advanced security enhancements <ul style="list-style-type: none"> ○ Use of TDOA Techniques, ○ Behavioural analysis of targets; • Other enhancements <ul style="list-style-type: none"> ➤ Automatic network bandwidth optimisation techniques (to adapt the data transmission content and rate according to the capacity of the network). |
| 3 ref. [1] | <p>All Iteration 2 capabilities plus</p> <ul style="list-style-type: none"> • Integration of ADS-B with WAM <ul style="list-style-type: none"> ○ ADS-B Target Report update by WAM system • Security enhancements <ul style="list-style-type: none"> ○ Range measurement from active interrogation |

2.4 User Characteristics

The 1090 GS users are defined in ref. [1].

2.5 Operational Scenarios

The operational uses of 1090 GS are described in ref. [1].

2.6 Functional

2.6.1 Functional decomposition

A functional block diagram of the 1090 GS is shown in Figure 3. The primary function of the 1090 GS is to receive 1090 MHz RF input on the Air Interface, extract data from the 1090 MHz ES messages, assemble the data into ATX021 reports, ref. [12], and send these reports to client systems over the Ground Interface. Other functions support this primary function.

The partitioning shown in Figure 3 describes the high level behaviour of the 1090 GS. It is not intended to convey any implementation requirements or the physical architecture of the equipment.

The functional blocks and lines shown in green colour in Figure 3 are additional to those foreseen in ED-129, ref. [11]. The ADS-B Data Validation functional block has been added to perform the security enhancements listed in Sec. 3.4.3. The 1090 Interrogator has been added to support range measurement from active interrogations (see App. A.1). The ground interface provides inputs to the ADS-B data validation block from other surveillance sources and also provides WAM target position reports (ATX020) to the Report Assembly function to enable ADS-B target report updates using WAM data (see App. A.1).

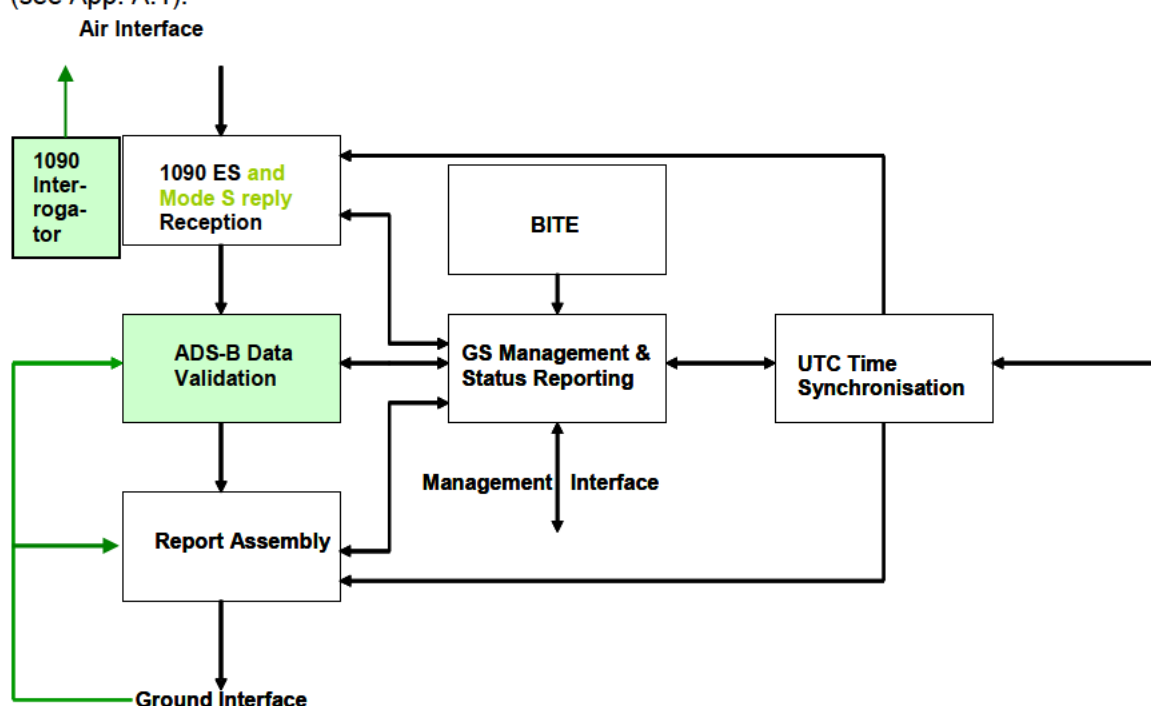


Figure 3: 1090 GS Component Overview

2.6.2 Functional analysis

The 1090 GS provides the following functions:

- **1090 Reception and Decoding:** Reception of 1090 MHz RF and decoding of extended and short squitter messages;
- **1090 Interrogation:** Active interrogation of ADS-B targets in order to validate their range;
- **Report Assembly:** Compilation of ADS-B reports to be forwarded to third party client ground systems (e.g. ADS-B servers, SDPD, etc.);
- **UTC Time Synchronisation:** UTC time synchronisation of the 1090 ES Ground Station for output report time stamping;

- **Ground Station Management and Status Reporting:** Station management, monitoring and control functions, and service status, including Built In Test Equipment (BITE);
- **ADS-B Data Validation:** Performs ADS-B data validation using own 1090 ES data and/or data received over the air and/or ground interface (e.g. WAM reports, or ADS-B reports from other 1090 GS, or implementation specific messages from external 1090 ES reception functions).

The characteristics of each of the above functions are detailed below.

2.6.2.1 1090 Reception and Decoding Function

This function handles the reception and decoding of extended and short squitter messages transmitted over the 1090 MHz channel in accordance with the provisions in the Mode S standards and ED-129, ref. [6], [7], [8], and [11]. It typically consists of a reception and demodulation sub-function and a decoder sub-function.

The reception and demodulation sub-function is designed to receive, and process in real time 1090 RF signals from appropriately equipped aircraft and vehicles. The decoding sub-function must include the capability to process and decode Extended Squitter messages of Downlink Format (DF) 5⁶, 17, 18 (with CF = 0, or 1, or 6) and 19 (with AF = 0) including at least the types listed in Sec 3.1.2, where all the requirements for the processing of ADS-B messages are specified.

2.6.2.2 1090 Interrogator Function

This function handles the transmission of Mode S interrogations in accordance with ref. [5], which will serve to trigger Mode S replies from ADS-B targets that can be used by the ADS-B Data Validation function to calculate target ranges (range measurement from active interrogations enhancement).

2.6.2.3 Report Assembly Function

This function processes the information extracted from received 1090 ES messages and assembles ATX021 reports in real time. Each report refers to a single target and contains the latest information available. ASTERIX reports are transmitted over a ground network to client systems.

ATX021 reports may include information extracted from multiple 1090 ES messages. The ADS-B Report Assembly function performs all the necessary correlation, data age tracking and data conversion operations which are required to assemble and translate squitter information to ATX021 format, using the mapping specified in ED-129 with the additional requirements specified in Sec. 3.1.2.

The ADS-B Report Assembly function can be configured to produce ATX021 reports in Data Driven (Real Time) mode as described in ED-129 with the additional requirements specified in Sec. 3.1.2.

When operating in periodic mode the ADS-B Report Assembly function may also use WAM ATX020 target reports to cover gaps in the reception of 1090 ES position data (ADS-B target report update by WAM system enhancement).

2.6.2.4 UTC Time Synchronisation Function

The 1090 GS should ensure autonomous, reliable and accurate UTC time stamping of the generated ASTERIX reports. For this purpose the 1090 GS needs a sufficiently reliable and accurate UTC time reference source, or alternatively an interface to an external standard UTC time source of equivalent quality. The internal or external time source supplies all the data necessary for the establishment of the UTC times of reception of position and velocity information.

2.6.2.5 Ground Station Management and Status Reporting Function

The 1090 GS is intended to operate unattended and autonomously. It must however provide a monitoring, maintenance and control function allowing an operator to:

- Monitor the Ground Station status, and the status of each subsystem and service, including BITE and end-to-end system checks;

⁶ Needed to support the Range Measurement from Active Interrogations enhancement, see App. A.2.

- Perform maintenance, configuration, and control actions, including changes of mode for the Ground Station.

The 1090 GS should provide protection against unauthorised access to the system maintenance and control functions.

2.6.2.5.1 Status Reports

The 1090 GS includes a status reporting function, which reports the status of the Ground Station and its services to client systems over a ground network. These status reports will use the ATX023 message format.

Status reports are generated periodically, with a configurable reporting period.

Reports are also generated immediately following any change in the status of a 1090 GS function or subsystem.

2.6.2.5.2 BITE Function

The 1090 GS includes a Built In Test Equipment (BITE) capability, such that there is a continuous monitoring of the operating status of the equipment, which is achieved by the monitoring and analysis of critical system parameters at all relevant system levels.

The 1090 GS BITE is able to detect faults affecting the performance of the Ground Station. BITE should register the faulty equipment (at LRU level) locally at the system and notify the monitoring, logging, and control subsystems accordingly.

The BITE tests include an end-to-end system check including the RF input to the antenna. This check may make use of a Site Monitor, which is an external 1090 ES ADS-B emitter, allowing an overall integrity check of the system including the antenna.

The 1090 GS executes BITE tests both at start-up and periodically. The tests should be summarised in the form of an overall BITE status signal to be used for failure indications to the operator and to client systems.

The behaviour of the Ground Station when a failure is detected is described in ED-129 with the additional requirements specified in Sec. 3.1.3.

In addition to BITE the 1090 GS may also support diagnostics and other relevant tests, including manual runs of built-in tests.

2.6.2.6 ADS-B Data Validation

This function implements the security enhancements indicated in Table 2. These enhancements foresee the application of a series of tests to validate the ADS-B data received via 1090 ES. Some validation tests are performed using exclusively 1090 ES data (see for example “Velocity versus Position Information” in Sec. 3.4.3.6). Others also use target data obtained over the Ground Interface from external sources (WAM, other 1090 GS, other 1090 ES reception functions) or even Mode S replies (see App. A.2).

The ADS-B Data Validation function operates on the data provided by the 1090 Reception and Decoding function after the target identity and position has been established and validated per ED-129 provisions. The validation check results are fed to the Report Assembly function for inclusion in the corresponding ATX021 reports.

2.7 Service View

N/A

3 1090 GS Functional and non-Functional Requirements

This section lists the Iteration 3 functional and non functional requirements for the 1090 GS. Since the baseline for Iteration 3 is the Iteration 2 1090 GS specification in ref. [3] ([ASSUMPTION_1]), this section includes all applicable requirements from Iterations 1 and 2 as well as the additional requirements introduced in Iteration 3 (see Table 2).

Traceability to the Iteration 3 surveillance system enhancements from ref. [1] is provided in Appendix A. Traceability to Iteration 2 enhancements, ref. [3], is provided in Appendix B, and traceability to Iteration 1 enhancements (ref. [23]) is provided in Appendix C.

In this requirement specification the word:

- "shall" indicates a statement of requirement which is essential (= mandatory).
- "should" indicates a statement of requirement which is desirable (= optional).

3.1 Capabilities

This Section specifies requirements concerning the following 1090 GS capabilities:

- General Sec. 3.1.1
- Message Processing and Report Assembly Sec. 3.1.2
- Equipment Control and Status Sec. 3.1.3
- Receiver Characteristics Sec. 3.1.4

3.1.1 General

Conformance to ED-129, ref. [11], is a baseline assumption (see [ASSUMPTION_1]) under all three iterations of the 1090 GS specification, in order to ensure support for ADS-B NRA, ref. [9], and interoperability with DO-260/A equipped aircraft, ref. [6],[7].

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0000.0010 |
| Requirement | The 1090 GS shall be compliant with the ED-129 requirements listed in Appendix E which are marked as "applicable". All the requirements listed in this Section are additional to those listed in Appendix E. |
| Title | ED-129 |
| Status | <In Progress> |
| Rationale | Part of the baseline assumptions [ASSUMPTION_1] |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | D20/D18/D05 Assumption | <Full> |

3.1.2 Message Processing and Report Assembly

This Subsection specifies message processing and report assembly requirements for the following enhancements :

- ADS-B RAD (ED-161) Compliance Sec. 3.1.2.1
- ADS-B APT (ED-163) Compliance Sec. 3.1.2.2

- DO-260B Compliance

Sec. 3.1.2.3

3.1.2.1 ADS-B RAD (ED-161) Compliance

The following 1090 GS requirements have been extracted (as shown in App. C.1) from ADS-B RAD ref. [10] requirements as specified in ref. [19].

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0010 |
| Requirement | The 1090 GS shall be able to receive ADS-B messages over 1090 ES in accordance with the ED-129 provisions listed in Appendix E augmented with the DO-260B compliance requirements stated in this specification. |
| Title | GS_Receive |
| Status | <In Progress> |
| Rationale | ED-161 requirement augmented with DO-260B compliance per D18. |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0001 | <Partial> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0060 | <Full> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0020 |
| Requirement | The 1090 GS shall decode data from 1090 ES ADS-B messages in accordance with the provisions in ED-129 augmented with the enhancements for DO-260B compliance stated in this specification. |
| Title | GS_Decode |
| Status | <In Progress> |
| Rationale | Same as for REQ-15.04.05.a-D05-0010.0010. |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0001 | <Partial> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0030 |
| Requirement | The 1090 GS shall associate the 1090 ES data with a target per the provisions in ED-129 and the enhancements specified in this document. |
| Title | GS_Associate |
| Status | <In Progress> |
| Rationale | ED-129 covers the baseline target association requirements. |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0001 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0040 |
| Requirement | The 1090 GS shall apply mandatory squitter decoding validation checks according to ED-129 and the additional validation checks specified in this document. |
| Title | GS_Validation |
| Status | <In Progress> |
| Rationale | D18 enhancements compliance |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0001 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0050 |
| Requirement | If the validation tests are passed, the 1090 GS shall package and timestamp the decoded data into a target report in ATX021 form in accordance with ED-129 provisions and the enhancements specified in this document |
| Title | GS_Report |
| Status | <In Progress> |
| Importance | <Essential> |
| Rationale | D18 enhancements compliance |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0001 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0070 |
| Requirement | <p>The 1090 GS shall report the following minimum data set per target report to the ATC Processing system:</p> <ul style="list-style-type: none"> ▪ Aircraft Horizontal Position – Latitude and Longitude); ▪ Pressure altitude; ▪ Quality Indications of Horizontal Position; ▪ Aircraft Identity (a/c identification and Mode A code); ▪ Emergency Indicators; ▪ Special Position Identification (SPI); ▪ Time of Applicability. <p>NOTES: Emergency Indicators and SPI are provided only when selected by the flight crew. 24 bit address is included as mandatory ATX021 field</p> |
| Title | Cat21_Data |
| Status | <In Progress> |
| Rationale | ED-161 (iteration 1) and also ED-163 compliance (Iteration 2) |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0002 | <Full> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0012.0004 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0080 |
| Requirement | The 1090 GS shall provide in each target report a time of applicability of the position information. |
| Title | GS_TOA |
| Status | <In Progress> |
| Rationale | ED-161 compliance, see also ED129_REQ_171, ED129_REQ_172, and ED129_REQ_173 |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0004 | <Full> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0090 |
| Requirement | The 1090 GS shall provide separate times of applicability for any specific data items, who's TOA differs from that of the position. |
| Title | GS_Other_TOA |
| Status | <In Progress> |
| Rationale | ED-161 requirement |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0005 | <Full> |

3.1.2.2 ADS-B APT (ED-163) Compliance

The following 1090 GS requirements have been extracted (as shown in App. B.1) from ADS-B APT [20] requirements as specified in ref. [2].

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D09-0080.0010 |
| Requirement | The 1090 GS shall be able to process and decode 1090 ES Surface Position Messages (FTC=5-8) emitted from DO-260/260A/260B equipped targets and report the extracted information in the relevant ATX021 fields. |
| Title | Surface Mobile Position and Velocity |
| Status | <In Progress> |
| Rationale | ED-163 compliance |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0012.0002 | <Partial> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0012.0004 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D09-0080.0020 |
| Requirement | The 1090 GS shall be able to process and decode 1090 ES Aircraft Operational Status (FTC=31) messages emitted from DO-260A targets and report the “Aircraft Length and Width” and “Position Offset Applied” data in the relevant ATX021 fields. |
| Title | Target Length |
| Status | <In Progress> |
| Rationale | ED-163 compliance for DO-260A aircraft, which provide POA instead of GPS antenna offset. DO-260B aircraft are covered by REQ-15.04.05.a-D05-0020.0060 and 0020.0140. DO-260 aircraft do not provide the required information. |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0012.0002 | <Partial> |
| Identifier | REQ-15.04.05.a-D09-0080.0030 | | |
| Requirement | The 1090 GS shall be able to process and decode 1090 ES Aircraft Identification and Type messages (FTC=1-4) emitted from DO-260/260A/260B targets and report the Emitter Category in the appropriate ATX021 field. | | |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0012.0002 | |
|--|------------------------------|--|

3.1.2.3 DO-260B Compliance

Ref. [23] states that the 1090 GS must be able to interoperate with ED102A/DO-260B equipped aircraft in addition to DO-260 and DO-260A ones foreseen in ED-129.

The requirements listed below have been extracted from the DO-260B requirements identified in App. C.2 and further explained in Appendix D of this specification.

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0010 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall ignore the “OPERATIONAL MODE (OM)” Subfield in Aircraft Operational Status Messages. NOTE: Subfield reserved for Receiving ATC Services |
| Title | DO260B_OM |
| Status | <In Progress> |
| Rationale | DO-260B conformance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0030 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “Reserved Bit-A” subfield. |

| | |
|---------------------|---|
| | NOTE: Based on Proposed RTCA DO-260B/EUROCAE ED-102A Provisions for Backward Compatibility. |
| Title | DO260B_IFR |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0040 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “TCAS Operational” subfield. NOTE: Replaces POA = “Position Offset Applied” In DO-260A |
| Title | DO260B TCAS OP |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0050 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “Geometric Vertical Accuracy (GVA)” subfield. NOTE: Replaces the Barometric Altitude Quality (BAQ) in DO-260A |
| Title | DO260B BAQ |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0060 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the “GPS Antenna Offset” OM Code. |
| Title | DO260B_OM_CODE |
| Status | <In Progress> |
| Rationale | ED-163 and DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0012.0002 | <Partial> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0070 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Source Integrity Level (SIL) Data. |
| Title | DO260B SIL DATA |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0080 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Source Integrity Level (SIL) Supplement Data. |
| Title | DO260B SIL SUP DATA |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0090 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report System Design Assurance. |
| Title | DO260B SDA |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0100 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Capability Class 1090ES IN. NOTE: Replaces the “CDTI Traffic Display Capability” in DO-260A. |
| Title | DO260B_CC_1090ES_IN |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0110 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Capability Class UAT IN. |
| Title | DO260B_CC_UAT_IN |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0120 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “NIC Supplement-B” subfield. NOTE: replaces “Single Antenna Flag (SAF)” in DO-260A. |
| Title | DO260B NIC SUP B |
| Status | <In Progress> |
| Rationale | DO-260B compliance |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0130 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “NIC Supplement-C” subfield.. |
| Title | DO260B NIC SUP C |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0140 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Aircraft/Vehicle Length and Width Code. NOTE: Different from DO-260/DO-260A. |
| Title | DO260B_AC_Length |
| Status | <In Progress> |
| Rationale | ED-163 and DO-260B compliance |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0012.002 | <Partial> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0160 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Navigation Integrity Category (NIC). NOTE: Difference from DO-260/DO-260A is the added radius (0,3NM) and that the Vertical Protection Limit (VPL) is not taken into account. |
| Title | DO260B_NIC_RADIUS |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0180 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Navigation Accuracy Category for Position (NACP). NOTE: Difference from DO-260A is that the Vertical Protection Limit (VPL) is not taken into account. |
| Title | DO260B_NACP |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------|------------|
|--------------|---------------------|------------|------------|

| | | | |
|-------------|--------------------|------------------------------|-----------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |
|-------------|--------------------|------------------------------|-----------|

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0190 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report "Navigation Accuracy Category - Velocity" (NACV). NOTE: Difference from DO-260A is that the Vertical Protection Limit (VPL) is not taken into account. |
| Title | DO260B_NACV |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0200 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the "Target State Data" message. NOTES: Differences from DO-260/DO-260A: a. Elimination of "Target Heading/Track Angle" and "Target Heading/Track Indicator" which are replaced with "Selected Heading Status", "Selected Heading Sign" and "Selected Heading". b. Elimination of "Target Altitude Type", "Target Altitude Capability" and "Target Altitude" which are replaced with "Selected Altitude Type" and "MCP/FCU Selected Altitude or FMS Selected Altitude". c. Addition of "Barometric Pressure Setting (Minus 800 millibars)". d. Addition of MCP / FCU Mode Bits Data: <ul style="list-style-type: none"> o "Status of MCP/FCU Mode Bits", o "Autopilot Engaged", o "VNAV (Managed) Mode Engaged", o "Altitude Hold Mode", o "Approach Mode", and o "LNAV (Managed) Mode Engaged". |
| Title | DO260B_target_state |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0210 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Emergency/Priority message. |

| | |
|---------------------|---|
| | NOTE: Difference from DO-260/DO-260A is the addition of Mode A Code as a part of the message. |
| Title | DO260B_Emergency |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0020.0220 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Surface Position Message. NOTE: Difference from DO-260/DO-260A is the quantization of lower values of Surface Movement field in Surface Position Message which are changed to add value denoting "stopped" with the speed of 0 knots. |
| Title | DO260B Surface Position |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D, and ED-163 requirement |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0012.0004 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0230 |
| Requirement | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Target State and Status message. NOTES: Differences from DO-260/DO-260A: <ul style="list-style-type: none"> ▪ New "Subtype" Code for the Target State and Status Message due to the modified format (for backward compatibility). ▪ Elimination of Emergency/Priority and incorporation of new field reserved for ADS-R Flag bits. |
| Title | DO260B_Target_State_ADR |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0061 | <Partial> |

[REQ]

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0020.0240 |
| Requirement | The 1090 GS shall be able to assemble the DO-260B data items in the corre- |

| | |
|---------------------|------------------------------------|
| | sponding ATX021 target report. |
| Title | DO260B_Cat21_Report |
| Status | <In Progress> |
| Rationale | DO-260B compliance, see Appendix D |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0060.0063 | <Partial> |

3.1.3 Equipment Control and Status

This subsection consolidates the equipment control and status related requirements derived from all the enhancements considered in this specification , namely:

- WAM Integration Sec. 3.1.3.1
- Time of Arrival versus Distance Validation Sec. 3.1.3.2
- Power versus Distance Validation Sec. 3.1.3.3
- Angle of Arrival Validation Sec. 3.1.3.4
- Track Consistency Validation Sec. 3.1.3.5
- Behavioural Analysis Sec. 3.1.3.6
- Network Bandwidth Optimisation Sec. 3.1.3.7
- Time Differential of Arrival Techniques Sec. 3.1.3.8
- Range Measurement from active interrogation Sec. 3.1.3.9

3.1.3.1 WAM Integration

3.1.3.1.1 Iteration 1

The following Iteration 1 equipment control and status requirements have been extracted from the WAM Integration requirements identified in Appendix C.3.1.

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0010 |
| Requirement | The ADS – B/WAM Integration functionality in the 1090 GS should be activated/ deactivated via a configurable parameter. |
| Title | WAM_CFG |
| Status | <In Progress> |
| Rationale | WAM Integration Requirement |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0001 | <Partial> |

[REQ]

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0020 |
| Requirement | The reception of ATX020 reports by the 1090 GS WAM integration function should be activated/ deactivated via a configurable parameter. |
| Title | ATX020_CFG |

| | |
|---------------------|-----------------------------|
| Status | <In Progress> |
| Rationale | WAM Integration Requirement |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0001 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0040 |
| Requirement | The reception of ATX019 messages in the 1090 GS should be activated/ deactivated via a configurable system parameter. |
| Title | ATX019 CFG |
| Status | <In Progress> |
| Rationale | Activation of WAM integration |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0003 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0050 |
| Requirement | The reception of ATX019 messages in the 1090 GS shall be managed via a configurable Time out system parameter. |
| Title | ATX019 CFG Timeout |
| Status | <In Progress> |
| Rationale | WAM Integration requirement |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0003 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0155 |
| Requirement | The threshold used for comparison of the Pre-validated and Reference positions shall be a configurable parameter. |
| Title | WAM Deviation Margin |
| Status | <In Progress> |
| Rationale | See App. C.3.1 |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0007 | <Partial> |

3.1.3.1.2 Iteration 2

The following Iteration 2 equipment control and status requirements have been extracted from the WAM Integration requirements identified in Appendix B.2.

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0030.0240 |
| Requirement | The threshold values used for comparison described in requirements D09-0030.0230 and 0030.0235 should be configurable. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0030.0003 | |
|--|------------------------------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0030.0295 |
| Requirement | All the thresholds used for the comparisons specified in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 should be configurable offline. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0030.0007 | |
|--|------------------------------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0030.0315 |
| Requirement | The threshold used for the comparisons specified in requirements D09-0030.0305 and 0310 should be configurable offline. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0030.0011 | |
|--|------------------------------|--|

3.1.3.1.3 Iteration 3

The following Iteration 3 configuration requirements have been extracted from the WAM Integration requirements identified in Appendix A.1.

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0030.0015 |
| Requirement | The 1090 GS "WAM Target Report Substitution" function shall be activated/deactivated via a configurable parameter. |
| | A.1 |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0030.0040 |
| Requirement | It shall be possible to configure a maximum duration during which the 1090 GS may apply WAM Target Report substitution. |
| | A.1 |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0030.0100 |
| Requirement | The 1090 GS shall use WAM target reports in substitution of missing 1090ES data only if their accuracy is better than a user configurable threshold. |
| | A.1 |

3.1.3.2 Time of Arrival versus Distance Validation

The following Iteration 1 equipment control and status requirements have been extracted from the Time of Arrival versus Distance Validation requirements identified in Appendix C.3.2.

[REQ]

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0010 |
| Requirement | The TOA/Distance validation function should be activated/ deactivated via a configurable parameter. |
| Title | TOA_Activation |

| | |
|---------------------|-----------------|
| Status | <In Progress> |
| Rationale | D18 requirement |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0050 |
| Requirement | The association of external sensors to the 1090 GS TOA/Distance validation function should be configurable. |
| Title | GS SF ACT DEACT |
| Status | <In Progress> |
| Rationale | D18 requirement |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0070 |
| Requirement | The reception of each of the n external sensor Operational Status Data streams should be managed via a configurable Time out parameter. Refer to REQ-15.04.05a-D05-0040.0060. |
| Title | REC_S_OP_S_D |
| Status | <In Progress> |
| Rationale | See C.3.2 |
| Category | <Functional> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

3.1.3.3 Power versus Distance Validation

The following Iteration 1 equipment control and status requirements have been extracted from the Power versus Distance Validation requirements identified in Appendix C.3.3.

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0030 |
| Requirement | The signal level metric measurement parameters of the 1090 GS Power versus Distance validation function shall be configurable. |
| Title | PVD_Metric_Config |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0040 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0106 |
| Requirement | The signal level metric calculation parameters and the preset threshold used for comparing theoretical and monitored signal levels shall be configurable parameters. |
| Title | PVD_Threshold |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0040 | <Partial> |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0050.0005 |
| Requirement | The 1090 GS Power versus Distance validation function should be activated/deactivated via a configurable parameter. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0040.0040 | |
|--|------------------------------|--|

3.1.3.4 Angle of Arrival Validation

The following Iteration 1 equipment control and status requirements have been extracted from the Angle of Arrival Validation requirements identified in Appendix C.3.4.

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0060.0015 |
| Requirement | The 1090 GS Angle of Arrival validation function should be activated/deactivated via a configurable parameter. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0040.0001 | |
|--|------------------------------|--|

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0020 |
| Requirement | The resolution of the direction of arrival for the Angle of Arrival validation function shall be configurable |
| Title | MIN_RDA_CFG |
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0003 | <Partial> |

[REQ]

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0030 |
| Requirement | The resolution of the direction of arrival for the Angle of Arrival validation function shall define a sector of arrival. |
| Title | MIN_RDA_SA |

| | |
|---------------------|---------------|
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0003 | <Partial> |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0072 |
| Requirement | The parameter " n " (minimum number of consecutive "not matching" position messages for the Angle of Arrival Validation function) shall be configurable. |
| | See C.3.4 |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0040.0006 | |
|--|------------------------------|--|

3.1.3.5 Track Consistency Validation

The following Iteration 1 equipment control and status requirements have been extracted from the Track Consistency Validation requirements identified in Appendix C.3.5.

| | | | |
|-------------|---|------------------------------|-----------|
| Identifier | REQ-15.04.05.a-D05-0070.0010 | | |
| Requirement | The 1090 GS Track Consistency verification function should be activated/ deactivated via a configurable parameter. | | |
| | App. C.3.5 | | |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0050 | <Partial> |
| Identifier | REQ-15.04.05.a-D05-0070.0026 | | |
| Requirement | The preset threshold used by the 1090 GS Track Consistency verification function shall be configurable. | | |
| | App. C.3.5 | | |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0050 | <Partial> |

3.1.3.6 Behavioural Analysis

The following Iteration 2 equipment control and status requirements have been extracted from the Behavioural Analysis requirements identified in Appendix B.3.

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0010 |
| Requirement | The 1090 GS Track Velocity Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | | |
|--|-----------|--|
| | 0040.0080 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0040 |
| Requirement | The 1090 GS Track Acceleration Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | | |
|--|-----------|--|
| | 0040.0080 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0070 |
| Requirement | The 1090 GS Track Acceleration Change Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | | |
|--|-----------|--|
| | 0040.0080 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0100 |
| Requirement | The 1090 GS Track Heading Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | | |
|--|-----------|--|
| | 0040.0080 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0130 |
| Requirement | The 1090 GS Track Heading Change Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | |
|-------------|--|
| | 0040.0080 |
| Identifier | REQ-15.04.05.a-D09-0100.0160 |
| Requirement | The 1090 GS Track Altitude Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | |
|-------------|---|
| | 0040.0080 |
| Identifier | REQ-15.04.05.a-D09-0100.0190 |
| Requirement | The 1090 GS Track Altitude Change Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | |
|-------------|---|
| | 0040.0080 |
| Identifier | REQ-15.04.05.a-D09-0100.0220 |
| Requirement | The 1090 GS Track Vertical Rate Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | |
|-------------|--|
| | 0040.0080 |
| Identifier | REQ-15.04.05.a-D09-0100.0250 |
| Requirement | The 1090 GS Track Vertical Rate Change Consistency verification function should be activated/ deactivated via a configurable parameter. |

| | |
|-------------|--|
| | 0040.0080 |
| Identifier | REQ-15.04.05.a-D09-0100.0370 |
| Requirement | The preset velocity range used by the 1090 GS Track Velocity Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|-------------|--|
| | 0040.0084 |
| Identifier | REQ-15.04.05.a-D09-0100.0380 |
| Requirement | The preset Acceleration range used by the 1090 GS Track Acceleration Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|-------------|--|
| | 0040.0084 |
| Identifier | REQ-15.04.05.a-D09-0100.0390 |
| Requirement | The preset Acceleration Change range used by the 1090 GS Track Acceleration Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|-------------|--|
| | 0040.0084 |
| Identifier | REQ-15.04.05.a-D09-0100.0400 |
| Requirement | The preset Heading range used by the 1090 GS Track Heading Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|-------------|--|
| | 0040.0084 |
| Identifier | REQ-15.04.05.a-D09-0100.0410 |
| Requirement | The preset Heading Change range used by the 1090 GS Track Heading Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|--|-----------|
| | 0040.0084 |
|--|-----------|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0420 |
| Requirement | The preset Altitude range used by the 1090 GS Track Altitude Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|-------------|--|
| | 0040.0084 |
| Identifier | REQ-15.04.05.a-D09-0100.0430 |
| Requirement | The preset Altitude Change range used by the 1090 GS Track Altitude Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|--|-----------|
| | 0040.0084 |
|--|-----------|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0440 |
| Requirement | The preset Vertical Rate range used by the 1090 GS Track Vertical Rate Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|--|-----------|
| | 0040.0084 |
|--|-----------|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0450 |
| Requirement | The preset Vertical Rate Change range used by the 1090 GS Track Vertical Rate Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. |

| | |
|--|-----------|
| | 0040.0084 |
|--|-----------|

3.1.3.7 Network Bandwidth Optimisation

The following Iteration 2 equipment control and status requirements have been extracted from the Network Bandwidth Optimisation requirements identified in Appendix B.6.

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0010 |
| Requirement | The 1090 GS should include a Network Bandwidth Optimization function that is activated / deactivated via a configurable parameter over the 1090 GS external CMI |

| | |
|--|-----------|
| | 0000.0030 |
|--|-----------|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0710 |
| Requirement | The 1090 GS should be able to indicate its current Degradation Level on its external CMI, using the value "0" for normal operation (=no degradation), and otherwise a positive integer corresponding to the current Degradation Level. |

| | |
|--|-----------|
| | 0000.0042 |
|--|-----------|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0420 |
| Requirement | The Omission of Optional Items Mitigation function should be activated and deactivated via configurable parameter over the external 1090 GS CMI. |

| | |
|--|-----------|
| | 0000.0038 |
|--|-----------|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0090.0440 |
| Requirement | The Reduced Data Update Rate Mitigation should be activated / deactivated via a configurable parameter over the 1090 GS external CMI |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0450 |
| Requirement | The Geographical Filtering Mitigation should be activated / deactivated via a parameter configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0470 |
| Requirement | The Coverage Volume Filter should be activated/deactivated via a parameter configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

Additional configuration parameters for network bandwidth optimization are specified in REQ-15.04.05.a-D09-0090.0020, 0090.0120, 0090.0430, 0090.0447, 0090.0460, 0090.0510, 0090.0520, 0090.0540, 0090.0560, 0090.0580, and 0090.0610.

3.1.3.8 Time Differential of Arrival Techniques

The TDOA Techniques enhancement [specified in Sec. 3.4.3.7] has the following equipment control and status requirements:

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0120.0010 |
| Requirement | The 1090 GS TDOA validation function should be activated/ deactivated via a configurable parameter. |
| | B.4 |

| | | |
|--|-----------|--|
| | 0040.0040 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0120.0070 |
| Requirement | The TDOA validation threshold should be configurable. |
| | B.4 |

| | | |
|--|-----------|--|
| | 0040.0042 | |
|--|-----------|--|

3.1.3.9 Range Measurement from active interrogation

The security enhancement (see App.) to compare the ADS-B reported target range from the 1090 GS with the corresponding distance derived through active interrogation of the target includes the following 1090 GS configuration requirements:

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0030 |
| Requirement | The 1090 GS interrogator transmission power shall be configurable according to the requested surveillance coverage. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0040 |
| Requirement | The interrogation rate of the 1090 GS interrogator shall be configurable. |

| | |
|------------|------------------------------|
| Identifier | REQ-15.04.05.a-D13-0130.0120 |
|------------|------------------------------|

| | |
|-------------|--|
| Requirement | The RTD maximum validity period shall be a configurable parameter. |
| Identifier | REQ-15.04.05.a-D13-0130.0180 |
| Requirement | The threshold of the Range Measurement from Active Interrogation in REQ-15.04.05.a-D13-0130.0170 shall be a configurable parameter. |
| Identifier | REQ-15.04.05.a-D13-0130.0220 |
| Requirement | The 1090 GS Range Measurement from Active Interrogation function shall be activated/ deactivated via a configurable parameter. |

3.1.4 Receiver Characteristics

The applicable receiver characteristics (extracted from ED-129) are listed in Appendix E.

3.2 Adaptability

Adaptability requirements have been identified in Iteration 2 with regard to Network Bandwidth Optimisation and they are presented in the following subsection.

3.2.1 Network Bandwidth Optimisation

Ref. [2] specifies Iteration 2 requirements for adaptability of the ADS-B report transmission rate and data content to data network capacity, as a means of avoiding potential network saturation. The following 1090 GS requirements have been identified per the analysis in Appendix B.6:

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0020 |
| Requirement | If the Network Bandwidth Optimization function is activated, the 1090 GS shall be able to determine its actual network load, possibly through indications supplied via SNMP by an external provider (e.g. router, switch, etc.), at a frequency configurable over the 1090 GS external CMI |

| | | |
|-------------|--|--|
| | 0000.0030 | |
| Identifier | REQ-15.04.05.a-D09-0090.0110 | |
| Requirement | The 1090 GS Network Bandwidth Optimization function should support multiple Degradation Levels in increasing order of severity (ranging from normal condition to most severe degradation), where each Degradation Level is associated with a distinct Mitigation Strategy | |

| | | |
|--|-----------|--|
| | 0000.0032 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0120 |
| Requirement | Each 1090 GS Degradation Level shall be associated with a parameter indicating the Threshold to consider as overload of the current network level, and configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0032 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0130 |
| Requirement | If the Network Bandwidth Optimization function is activated, the 1090 GS shall compare the actual network load with the Threshold specified in D09-0090.0120 to detect network overloads. |

| | | |
|--|-----------|--|
| | 0000.0032 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0140 |
| Requirement | The 1090 GS should have a mechanism to prevent switching up and down its current Degradation Level due to transient network load peaks. |

| | | |
|--|-----------|--|
| | 0000.0032 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0210 |
| Requirement | If the Network Bandwidth Optimization function is activated, and an overload is detected, then the 1090 GS shall switch to the next more severe Degradation Level. |

| | | |
|--|-----------|--|
| | 0000.0034 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0310 |
| Requirement | If the Network Bandwidth Optimization function is activated, and a recovery from an overload is detected, then the 1090 GS shall switch to the next less severe Degradation Level. |

| | | |
|--|-----------|--|
| | 0000.0036 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0410 |
| Requirement | The 1090 GS shall be able to support one or more of the following Mitigation functions: <ul style="list-style-type: none"> ▪ Omission of Optional Items ▪ Reduced Data Update Rate ▪ Geographical Filtering |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0430 |
| Requirement | Each optional item in ATX021 reports should be selectable as a separate Mitigation via a parameter configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0435 |
| Requirement | If an optional ATX021 item has been enabled as a Mitigation, the 1090 GS shall not include it in ATX021 reports |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0447 |
| Requirement | If the Reduced Data Update Rate Mitigation is enabled, the 1090 GS shall transmit ATX021 reports with a period of x+0.5 seconds, where x is value within the range 0 to 14.5 seconds (in 0.5 steps) configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|------------|------------------------------|
| Identifier | REQ-15.04.05.a-D09-0090.0460 |
|------------|------------------------------|

| | |
|-------------|--|
| Requirement | If the Geographical Filtering Mitigation is enabled, then the 1090 GS shall implement a Coverage Volume filter (possibly separate per ADS-B Service) consisting of one or more of the following parameters (all configurable over the 1090 GS external CMI): <ul style="list-style-type: none"> ▪ Maximum Flight Level ▪ Minimum Flight Level ▪ Maximum Range ▪ Minimum Range |
|-------------|--|

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0480 |
| Requirement | If the target flight level is greater than the Maximum Flight Level, then the 1090 GS shall not transmit ATX021 reports for this target. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0485 |
| Requirement | If the target flight level is less than the Minimum Flight Level, then the 1090 GS shall not transmit ATX021 reports for this target. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0490 |
| Requirement | If the target range is greater than the Maximum Range, then the 1090 GS shall not transmit ATX021 reports for this target. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0495 |
| Requirement | If the target range is less than the Minimum Range, then the 1090 GS shall not transmit ATX021 reports for this target. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0510 |
| Requirement | If the Geographic Filtering Mitigation function is enabled, the 1090 GS shall be able to support the following additional Mitigations (activated/deactivated via the external 1090 GS CMI) <ul style="list-style-type: none"> - Increase Minimum Flight Level (D09-0090.0540) - Decrease Maximum Flight Level (D09-0090.0520) - Increase Minimum Range (D09-0090.0580) - Decrease Minimum Range (D09-0090.0560) |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0520 |
| Requirement | If the Decrease Maximum Flight Level Mitigation is enabled, then the 1090 GS shall decrease the configured Maximum Flight Level by a parameter |

| | |
|--|---|
| | configurable over the 1090 GS external CMI. |
|--|---|

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0540 |
| Requirement | If the Increase Minimum Flight Level Mitigation is enabled, then the 1090 GS shall increase the configured Minimum Flight Level by a parameter configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0560 |
| Requirement | If the Decrease Maximum Range Mitigation is enabled, then the 1090 GS shall decrease the configured Maximum Range by a parameter configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0580 |
| Requirement | If the Increase Minimum Range Mitigation is enabled, then the 1090 GS shall increase the configured Minimum Range by a parameter configurable over the 1090 GS external CMI. |

| | | |
|--|-----------|--|
| | 0000.0038 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0610 |
| Requirement | The 1090 GS should support configurable Mitigation Strategies per degradation level and ADS-B Service |

| | | |
|--|-----------|--|
| | 0000.0040 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0615 |
| Requirement | 1090 GS Mitigation Strategies shall consist of one or more of the Mitigations specified in requirements D09-0090.0410, 0090.0460 and 0090.0510 |

| | | |
|--|-----------|--|
| | 0000.0040 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0090.0620 |
| Requirement | If the Network Bandwidth Optimization function is activated, the 1090 GS shall apply all the configured Mitigation Strategies up to and including the one assigned to the current Degradation Level (i.e. If Degradation Level=3, then Mitigation Strategies 1, 2 & 3 will apply). |

| | | |
|--|-----------|--|
| | 0000.0040 | |
|--|-----------|--|

3.3 Performance Characteristics

1090 GS performance characteristics have been identified with regard to

- Coverage and Detection Sec. 3.3.1
- Capacity Sec. 3.3.2
- Latency Sec. 3.3.3

- Accuracy Sec. 3.3.4

3.3.1 Coverage and Detection

Coverage and detection requirements have been identified with regard to

- ADS-B RAD Compliance Sec. 3.3.1.1
- ADS-B APT Compliance Sec. 3.3.1.2

3.3.1.1 ADS-B RAD Compliance

The following Coverage and Detection related requirements are derived from ADS-B RAD requirements stated in ED-161, see App. C.1.

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0160 |
| Requirement | The 1090 GS shall be able to provide a target report containing ADS-B Position data associated with any aircraft in En Route airspace and received from the a/c within the last 8 seconds with a probability of 97% |
| Title | GS_Coverage |
| Status | <In Progress> |
| Rationale | ED-161 requirement |
| Category | <Performance> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0017 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0170 |
| Requirement | The 1090 GS shall be able to detect a change of Mode A code provided by the ADS-B aircraft domain, and include it in a target report within no longer than 8 seconds, with a probability of 95% En Route ¹⁹ . |
| Title | GS Mode A |
| Status | <In Progress> |
| Rationale | ED-161 requirement |
| Category | <Performance> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0018 | <Full> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0190 |
| Requirement | The 1090 GS shall be able to provide a target report containing ADS-B Position data associated with any aircraft in TMA airspace and received from the a/c within the last 5 seconds and with probability 97% ¹⁹ . |
| Title | GS_TMA |
| Status | <In Progress> |
| Rationale | ED-161 Requirement |
| Category | <Performance> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0021 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0200 |
| Requirement | The 1090 GS shall detect a change of Mode A within a time interval of 5 seconds with probability 95% in TMA. |
| Title | ModeA TMA |
| Status | <In Progress> |
| Rationale | ED-161 requirement |
| Category | <Performance> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0022 | <Partial> |

3.3.1.2 ADS-B APT Compliance

The following Coverage and Detection related requirements are derived from ADS-B APT requirements stated in ED-163, see Appendix B.1.

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0080.0050 |
| Requirement | The 1090 GS shall be able to provide ATX021 target report updates for any moving Mobile on the airport surface within 1 sec from the last report with probability of at least 90%. |

| | | |
|-------------|---|--|
| | REQ-15.04.05.a-D19-0022.0001 | |
| Identifier | REQ-15.04.05.a-D09-0080.0060 | |
| Requirement | The 1090 GS shall be able to provide ATX021 target report updates including emergency mode items for any Mobile on the airport surface within 2 sec from the last report with probability of at least 90%. | |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0022.0002 | |
|--|------------------------------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0080.0070 |
| Requirement | The 1090 GS shall be able to report non changing ADS-B items for Mobiles on the airport surface within 20 sec with a probability of at least 90%. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0022.0003 | |
|--|------------------------------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0080.0080 |
| Requirement | The 1090 GS shall be able to report Identity changes of Mobiles on the airport surface within 20 sec with a probability of at least 90%. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0022.0004 | |
|--|------------------------------|--|

3.3.2 Capacity

The following Capacity related requirements are derived from ADS-B RAD requirements stated in ED-161, see App. C.1.

[REQ]

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0140 |
| Requirement | The 1090 GS shall have the capacity to handle the reports from all ADS-B tar- |

| | |
|---------------------|--|
| | gets in the worst case environment as described in Appendix F without degradation. |
| Title | GS_Capacity |
| Status | <In Progress> |
| Rationale | D18 requirement |
| Category | <Capacity> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0007 | <Full> |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0080.0040 |
| Requirement | The 1090 GS shall have the capacity to acquire and maintain all ADS-B surface targets in the worst case airport environment reported in Appendix F. |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D19-0012.0003 | |
|--|------------------------------|--|

3.3.3 Latency

ED-129 specifies a maximum 1090 GS latency of 0.5 sec, see ED129_REQ_9, for NRA airspaces. ED-161 specifies a 95% latency requirement for “Ground ADS-B Receive” function in a RAD airspace leading to the following requirement for the 1090 GS:

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0120 |
| Requirement | The 95% latency for ADS-B surveillance reports at the output of the 1090 GS in a RAD airspace shall be no greater than 0.5 seconds, measured from 1090 ES message reception to the transmission of the corresponding target report by the 1090 GS. |
| Title | GS_Latency |
| Status | <In Progress> |
| Rationale | ED-161 requirement |
| Category | <Performance> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0003 | <Full> |

3.3.4 Accuracy

ED-129 specifies a Time of Applicability accuracy of less than ± 0.2 sec, see ED129_REQ_12. ED-161 introduces the following accuracy requirement for the 1090 GS:

[REQ]

| | |
|-------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0130 |
| Requirement | The time of applicability conveyed in the 1090 GS reports shall have an absolute accuracy relative to UTC of ± 0.1 seconds or less. |
| Title | TOA_Accuracy |
| Status | <In Progress> |
| Rationale | ED-161 requirement |
| Category | <Performance> |
| Validation Method | |

| | |
|---------------------|--------|
| Verification Method | <Test> |
|---------------------|--------|

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0004 | <Full> |

3.4 Safety & Security

Safety requirements have been identified with regard to

- Duplicate Addresses Sec. 3.4.1
- Emergency Indications Sec. 3.4.2

Security requirements are presented in Sec. 3.4.3.

3.4.1 Duplicate Addresses

The following Duplicate Address handling requirements are derived from ADS-B RAD requirements stated in ED-161, see App. C.1.

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0150 |
| Requirement | The 1090 GS shall be able to detect and report duplicate 24-bit addresses within the same reception coverage area with a probability of 99%. |
| Title | GS_Duplicate |
| Status | <In Progress> |
| Rationale | ED-161 (and ED-129) requirement |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0013 | <Partial> |

3.4.2 Emergency Indications

The following requirements on Emergency Indications are derived from ADS-B RAD requirements stated in ED-161, see App. C.1.

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0180 |
| Requirement | The 1090 GS shall be able to detect a change of emergency and SPI information provided by the ADS-B aircraft domain, and include it in a target report within no longer than 8 seconds, with a probability of 95% En Route ¹⁹ . |
| Title | GS_Emergency |
| Status | <In Progress> |
| Rationale | ED-161 requirement |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0019 | <Full> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0210 |
| Requirement | The 1090 GS shall detect a change of Emergency and SPI information within a time interval of 5 seconds with a probability of 95% in TMA ¹⁹ . |
| Title | GS_Emergency_TMA |
| Status | <In Progress> |
| Rationale | ED-161 Requirement |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0023 | <Full> |

3.4.3 Security Enhancements

Security enhancements are listed separately for

- Enhanced Target report validation via WAM Integration Sec. 3.4.3.1
- TOA versus Distance Validation Sec. 3.4.3.2
- Power versus Distance Validation Sec. 3.4.3.3
- Angle of Arrival Validation Sec. 3.4.3.4
- Track Consistency Verification Sec. 3.4.3.5
- Behavioural analysis of targets Sec. 3.4.3.6
- Time Differential of Arrival Techniques Sec. 3.4.3.7
- ADS-B target report update by WAM system Sec. 3.4.3.8
- Range Measurement from active interrogation Sec. 3.4.3.9

It is noted that

- equipment control and status requirements are listed in Sec. 3.1.3;
- external interface requirements are listed in Sec. 3.9.

3.4.3.1 Enhanced Target report validation via WAM Integration

The following WAM Integration requirements are derived from the Iteration 1 requirements stated in ref. [19] and [1], and analysed in App. C.3.1.

[REQ]

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0030 |
| Requirement | The 1090 GS WAM Integration function shall extract at least the following items from each ATX020 report received: <ul style="list-style-type: none"> ▪ I020/041 ▪ I020/042 ▪ I020/100 ▪ I020/070 ▪ I020/220 ▪ I020/245 ▪ I020/140 |
| Title | WAM_Atx20_Items |
| Status | <In Progress> |
| Rationale | Decoding of WAM target reports for the EAM integration function, see |

| | |
|---------------------|--------------------|
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0002 | <Full> |
| <SATISFIES> | <Enabler> | REQ-15.04.05.a-D20-0030.0001 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0060 |
| Requirement | If ATX019 message reception is activated and no ATX019 message has been received during a preconfigured timeout period, the 1090 GS shall issue an appropriate ATX023 status report. |
| Title | WAM Timeout |
| Status | <In Progress> |
| Rationale | WAM Integration requirement, see App. C.3.1 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0003 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0080 |
| Requirement | The 1090 GS WAM Integration function shall extract at least the following items from the received ATX019 reports: <ul style="list-style-type: none"> ▪ I019/140 ▪ I019/550 |
| Title | GS_I_ATX019 |
| Status | <In Progress> |
| Rationale | WAM Integration requirement, |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0004 | <Full> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0090 |
| Requirement | The ADS - B/WAM Validity check (see REQ-15.04.05.a-D05-0030.0140 and 0030.0150) shall be performed only in case the information reported in I019/550 respects the following condition: NOGO = 00. |
| Title | ADS B WAM V CHECK1 |
| Status | <In Progress> |
| Rationale | WAM Integration requirement, see App. C.3.1 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0005 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0100 |
| Requirement | The ADS-B/WAM Validity check (see REQ-15.04.05.a-D05-0030.0140 and 0030.0150) shall not be performed when the I019/550 subfield in incoming ATX019 reports indicates the following condition: NOGO = 10 or =11 or =01. |
| Title | ADS_B_WAM_V_CHECK2 |
| Status | <In Progress> |
| Rationale | WAM Integration requirement, see App. C.3.1 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0005 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0110 |
| Requirement | For each target position update (Pre-validated Position) assembled from 1090 ES data, the 1090 GS shall identify a relevant WAM target report (Reference Report) in order to perform the ADS – B/WAM Validity check (REQ-15.04.05.a-D05-0030.0140 and 0030.0150). |
| Title | 1090ES WAM Association |
| Status | <In Progress> |
| Rationale | WAM position association with 1090 ES, see App. C.3.1 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0006 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0120 |
| Requirement | The Pre Validated Position and Reference Report shall refer to the same time of applicability within a preset tolerance |
| Title | WAM time tolerance |
| Status | <In Progress> |
| Rationale | Timestamp tolerance of associated WAM position, see App. C.3.1 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0006 | <Partial> |

[REQ]

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0130 |
| Requirement | The Reference Report shall be determined using only those ATX020 Reports referring to the same aircraft 24 bit Address as the Pre-validated Position. |

| | |
|---------------------|--|
| | NOTE: The case of duplicate addresses is to be considered at a later stage |
| Title | REF_REPORT |
| Status | <In Progress> |
| Rationale | 1090 ES and WAM alignment by address, see App. C.3.1 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0006 | <Partial> |

Ref. [2] has added further target report validation requirements, which result in the following additional 1090 GS requirements for Iteration 2 (see Appendix B.2):

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0030.0200 |
| Requirement | The 1090 GS WAM Integration function shall be able to extract at least the following items from each received ATX020 report: <ul style="list-style-type: none"> - I020/110 Measured Height (Local Cartesian Coordinates) - I020/202 Calculated Track Velocity in Cartesian Coordinates -I020/250 Mode S MB Data |
| | <In Progress> |
| | <Security> |
| | <Test> |

| | | | |
|-------------|---|-----------|-----------|
| <SATISFIES> | <ATMS Requirement> | 0030.0001 | <Partial> |
| Identifier | REQ-15.04.05.a-D09-0030.0205 | | |
| Requirement | In addition to the process described in D05-0030.0110 (identification of related WAM report), the 1090 GS shall be able to identify a relevant WAM target report (called Reference Report) each time one of the following messages is received: <ul style="list-style-type: none"> -Airborne Velocity Message (called Pre-validated Velocity) -Target State and Status Message (called Pre-validated Status) -Surface Position Message (called Pre-validated Surface) | | |
| | <In Progress> | | |
| | <Security> | | |
| | <Test> | | |

| | | | |
|-------------|--|-----------|-----------|
| <SATISFIES> | <ATMS Requirement> | 0030.0001 | <Partial> |
| Identifier | REQ-15.04.05.a-D09-0030.0210 | | |
| Requirement | The Pre-validated Velocity, the Pre-validated Status and the Pre-validated Surface Position shall refer to the same time of applicability of the Reference Report within a configurable tolerance | | |
| | <In Progress> | | |
| | <Security> | | |
| | <Test> | | |

| | | | |
|-------------|--|-----------|-----------|
| <SATISFIES> | <ATMS Requirement> | 0030.0001 | <Partial> |
| Identifier | REQ-15.04.05.a-D09-0030.0215 | | |
| Requirement | The reference report shall be determined using only those ATX020 Reports referring to the same Mode S 24-bit address reported in the 1090 ES Message. | | |
| | <In Progress> | | |
| | <Security> | | |
| | <Test> | | |

| | | | |
|-------------|--------------------|-----------|-----------|
| <SATISFIES> | <ATMS Requirement> | 0030.0002 | <Partial> |
|-------------|--------------------|-----------|-----------|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0030.0220 |
| Requirement | In case of WAM target reports with duplicate Mode S addresses, the 1090 GS WAM Integration function shall be able to resolve the ambiguity in order to correctly perform the validation of the report. |
| | <In Progress> |
| | <Security> |
| | <Test> |

| | | | |
|-------------|---|-----------|--------|
| <SATISFIES> | <ATMS Requirement> | 0030.0002 | <Full> |
| Identifier | REQ-15.04.05.a-D09-0030.0225 | | |
| Requirement | If an Airborne Position Message is received, the 1090 GS WAM Integration function shall be able to compare the Measured Height indicated in the Reference Report with the altitude reported in the Pre-validated Position. | | |
| | <In Progress> | | |
| | <Security> | | |
| | <Test> | | |

| | | | |
|-------------|---|-----------|-----------|
| <SATISFIES> | <ATMS Requirement> | 0030.0003 | <Partial> |
| Identifier | REQ-15.04.05.a-D09-0030.0230 | | |
| Requirement | If the difference between the Measured Height indicated in the Reference Report and the altitude reported in the Pre-validated Position is greater than a configurable threshold, the ADS-B report shall be marked as "Suspicious for Altitude". | | |
| | <In Progress> | | |
| | <Security> | | |
| | <Test> | | |

| | | | |
|-------------|--|--|-----------|
| <SATISFIES> | <ATMS Requirement> | | <Partial> |
| Identifier | REQ-15.04.05.a-D09-0030.0235 | | |
| Requirement | If the difference between the Measured Height indicated in the Reference Report and the altitude reported in the Pre-validated Position is less than a configured threshold, the ADS-B report shall be marked as "Consistent for Altitude". | | |
| | <In Progress> | | |
| | <Security> | | |
| | <Test> | | |

| | | | |
|-------------|--------------------|--|-----------|
| <SATISFIES> | <ATMS Requirement> | | <Partial> |
|-------------|--------------------|--|-----------|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0030.0250 |
| Requirement | If a Target State and Status Message is received, the 1090 GS WAM Integration function shall be able to perform the following checks: <ul style="list-style-type: none"> - Selected Altitude in the Pre-validated Status against the Selected Altitude in the Mode S MB Data in the Reference Report; - Barometric Pressure Settings in the Pre-validated Status against Barometric Pressure Settings in the Mode S MB Data in the Reference Report. |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0255 |
| Requirement | If a Velocity Message with information about Airspeed and Heading (subtypes 3 and 4) is received, the 1090 GS WAM Integration function shall be able to perform the following comparisons: <ul style="list-style-type: none"> - True Airspeed in the Pre-validated Velocity Message against the True Airspeed in the Reference Report; - Indicated airspeed in the Velocity Message against the Indicated Airspeed in the Reference Report; |

| | |
|--|---|
| | <ul style="list-style-type: none"> - Magnetic Heading in the Pre-validated Velocity Message against the Magnetic Heading in the Reference Report; - Barometric Vertical Rate in the Pre-validated Velocity Message against the Barometric Altitude Rate in the Reference Report |
|--|---|

| | |
|-------------|---|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0260 |
| Requirement | <p>If a Velocity Message with information about Velocity Over Ground (subtypes 1 and 2) is received, the 1090 GS WAM Integration function shall be able to perform the following comparisons:</p> <ul style="list-style-type: none"> -E/W Direction Bit, E/W Velocity, N/S Direction Bit, N/S Velocity in the Pre-validated velocity against True Track Angle and Ground Speed in the Reference Report; -Vertical Rate in the Pre-validated velocity Message against the Barometric Altitude Rate in the Reference Report. |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0265 |
| Requirement | <p>If a Surface Position Message is received, the 1090 GS WAM Integration function shall be able to perform the following comparisons:</p> <ul style="list-style-type: none"> -Heading/Ground Track and Movement in the Pre-validated Surface against True Track Angle and Ground Speed in the Reference Report; -Heading/Ground Track in the Pre-validated Surface against Magnetic Heading in the Reference Report. |

| | |
|-------------|---|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0270 |
| Requirement | The validation checks described in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 shall be performed only if the relevant Mode S Enhanced data are available in the WAM report. |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0275 |
| Requirement | The validation checks described in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 shall be performed verifying that the difference between the current parameter value included in the Reference Report and the equivalent one reported in the Pre-validated Report is less than a configurable threshold. |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0280 |
| Requirement | If at least one of the validation sub-checks reported in the requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 fails, the ADS-B report shall be marked as "Suspicious for Mode S Data". |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0285 |
| Requirement | If all validation sub-checks described in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 are positive, the ADS-B report shall be marked as "Consistent for Mode S Data". |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0290 |
| Requirement | If the 1090 GS WAM Integration function cannot perform any of the tests specified in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 due to the unavailability of Mode S Enhanced Data in the Refer- |

| | |
|--|--|
| | ence Report, the ADS-B report shall be marked as “Suspicious for Mode S Data” |
|--|--|

| | |
|-------------|---|
| | REQ-15.04.05.a-D19-0030.0007 |
| Identifier | REQ-15.04.05.a-D09-0030.0300 |
| Requirement | If a Velocity Message with information about Velocity Over Ground (subtypes 1 and 2) is received, the 1090 GS WAM Integration function shall be able to compare the Calculated Track Velocity in Cartesian Coordinates indicated in the Reference Report with the velocity reported in the Pre-validated Velocity. |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0011 |
| Identifier | REQ-15.04.05.a-D09-0030.0305 |
| Requirement | If the difference between the Track Velocity indicated in the Reference Report and the Airspeed reported in the Pre-validated Position is greater than a configurable threshold, the ADS-B report shall be marked as “Suspicious for Velocity”. |

| | |
|-------------|--|
| | REQ-15.04.05.a-D19-0030.0011 |
| Identifier | REQ-15.04.05.a-D09-0030.0310 |
| Requirement | If the difference between the Calculated Track Velocity indicated in the Reference Report and the Airspeed reported in the Pre-validated Position is less than a configured threshold, the ADS-B report shall be marked as “Consistent for Velocity”. |

| | |
|--|------------------------------|
| | REQ-15.04.05.a-D19-0030.0011 |
|--|------------------------------|

3.4.3.2 TOA versus Distance Validation

The following Time of Arrival versus Distance validation requirements are derived from the Iteration 1 requirements stated in ref. [19], and analysed in App. C.3.2:

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0020 |
| Requirement | The 1090 GS TOA/Distance validation function shall be able to manage simultaneously n (with $n \geq 2$) different Target Data streams coming from different 1090 ES receive functions (=external sensors) NOTE: External sensors may be 1090 GS or 1090 ES receivers. Then data streams would be in ATX021 or in raw 1090 ES format, respectively. |
| Title | TOA Server |
| Status | <In Progress> |
| Rationale | D18 requirement |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0060 |
| Requirement | The 1090 GS TOA/Distance validation function shall be able to manage simultaneously n (with $n \geq 2$) different System Operational Status Data streams, one per associated external sensor. NOTE: External sensors may be 1090 GS or 1090 ES receivers. Then operational status data streams would be in ATX023 or in custom format, respectively. |
| Title | GS_SF_M |
| Status | <In Progress> |
| Rationale | See C.3.2 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0080 |
| Requirement | If REQ-15.04.05.a-D05-0040.0070 is implemented and Time out expires [i.e. no System Operational Status Data information has been received during the timeout period], a relevant ATX023 notification shall be issued. |
| Title | TOA Remote Status Timeout |
| Status | <In Progress> |
| Rationale | See C.3.2 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0040.0090 |
| Requirement | In case one of the n external sensor Operational Status time outs expires, the 1090 GS TOA/Distance validation function shall exclude the corresponding target data stream from the TOA/Distance Validity check. |
| Title | SR_OP_STATUS |
| Status | <In Progress> |
| Rationale | See C.3.2 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

[REQ]

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0100 |
| Requirement | The TOA/Distance validation function shall be able to calculate the distance of each target from the associated sensor per target report received from that sensor. |
| Title | GS_CD_T |
| Status | <In Progress> |

| | |
|---------------------|------------|
| Rationale | See C.3.2 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0030 | <Partial> |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0040.0110 |
| Requirement | The TOA/Distance validation function shall exclude from the TOA/Distance Validity check the target data streams coming from external sensors whose Operational status is not declared healthy. |
| | See C.3.2 |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0040.0031 | |
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[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0040.0120 |
| Requirement | The TOA/Distance validation function shall verify, for each 1090 ES position message received by n (n>=2) different receive functions, that the following conditions are true: “Time of Reception of position message in the nearest ADS – B sensor <= Time of reception of position message – in the second nearest ADS – B sensor. AND “Target Distance from nearest ADS – B sensor <= Target Distance second nearest ADS – B sensor |
| Title | GS_SF_V_PM |
| Status | <In Progress> |
| Rationale | See C.3.2 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0031 | <Partial> |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0040.0124 |
| Requirement | If a 1090 ES position message has been received by n < 2 external sensors, the 1090 GS TOA/Distance validation function shall mark it as “TOA/Distance Not Validated”. |
| | See C.3.2 |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0040.0031 | |
|--|------------------------------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0128 |
| Requirement | If a 1090 ES position message fails the TOA/Distance validity check per REQ-15.04.05.a-0040.0120, then the 1090 GS TOA/Distance validation function shall mark it as “TOA/Distance Inconsistent”. |
| | See C.3.2 |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0040.0031 | |
|--|------------------------------|--|

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0040.0130 |
| Requirement | If a 1090 ES position message passes the TOA/Distance validity check per REQ-15.04.05.a-0040.0120, then the 1090 GS TOA/Distance validation function shall mark it as "TOA/Distance Consistent". |
| Title | TOA_Dist_Pass |
| Status | <In Progress> |
| Rationale | See C.3.2 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0031 | <Partial> |

3.4.3.3 Power versus Distance Validation

The following Power versus Distance validation requirements are derived from the Iteration 1 requirements stated in ref. [19], and analysed in App. C.3.3:

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0010 |
| Requirement | The 1090 GS Power versus Distance validation function shall measure an appropriate metric of the signal level of incoming 1090 ES position messages received for targets in "target data maintenance" mode (see ED-129 chapter 3). |
| Title | PVD Measurement |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0040 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0040 |
| Requirement | The 1090 GS Power versus Distance validation function shall calculate (per ED-129 App. F) the theoretical value of the chosen signal level metric for incoming 1090 ES position messages received for targets in "target data maintenance" mode. |
| Title | PvD Calculation |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0042 | <Full> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0043 | <Full> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0044 | <Full> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0080 |
| Requirement | For each generated target position report, the Power versus Distance validation function shall compare the measured signal level metric with the calculated theoretical value. |
| Title | PvD_Comparison |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0045 | <Full> |

3.4.3.4 Angle of Arrival Validation

The following Angle of Arrival validation requirements are derived from the requirements stated in ref. [19], and analysed in App. C.3.4:

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0010 |
| Requirement | The 1090 GS Angle of Arrival validation function shall register the real direction of arrival of each 1090 ES position message received for targets in "target data maintenance" mode. |
| Title | AoA Register |
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0002 | <Full> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0060.0040 |
| Requirement | The 1090 GS Angle of Arrival validation function shall calculate the theoretical direction of arrival of each of the received 1090 ES position messages for targets in "target data maintenance" mode using the reported position and the known 1090 GS receiver location. |
| Title | AoA Direction |
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0004 | <Full> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0050 |
| Requirement | When the theoretical direction of arrival of a 1090 ES position message is contained within the real sector of arrival, the Angle of Arrival Validation function shall mark the message as "valid". |
| Title | C_DA_M |
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0005 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0060 |
| Requirement | When a calculated direction of arrival is not contained inside the real sector of arrival, the Angle of Arrival Validation function shall mark the message as "not matching". |
| Title | C DA NM |
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0005 | <Partial> |

3.4.3.5 Track Consistency Verification

The following Track Consistency verification requirements are derived from the requirements stated in D18, ref. [19], Sec 3.4.2, as analysed in App. C.3.5 of this specification.

| | | | |
|-------------|---|------------------------------|-----------|
| Identifier | REQ-15.04.05.a-D05-0070.0020 | | |
| Requirement | For each incoming 1090 ES position message from any target in "data maintenance mode", the 1090 GS Track Consistency verification function shall verify track consistency by comparing the velocity values reported by that target against the velocity calculated using the reported target lat/long positions. | | |
| | App. C.3.5 | | |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0050 | <Partial> |
| Identifier | REQ-15.04.05.a-D05-0070.0022 | | |
| Requirement | The 1090 GS Track Consistency verification function shall mark position messages as "Velocity Inconsistent", if the calculated velocity deviates from the reported one by a preset threshold (or more). | | |
| | App. C.3.5 | | |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0050 | <Partial> |
| Identifier | REQ-15.04.05.a-D05-0070.0024 | | |
| Requirement | The 1090 GS Track Consistency verification function shall mark position messages as "Velocity Consistent", if the calculated velocity deviates from the reported one by less than the preset threshold. | | |
| | App. C.3.5 | | |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0050 | <Partial> |

3.4.3.6 Behavioural analysis of targets

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0020 |
| Requirement | The 1090 GS Track Velocity Consistency verification function shall mark target messages as “Velocity Inconsistent”, if the received velocity deviates from the valid range. |

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| | 0040.0080 | |
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|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0030 |
| Requirement | The 1090 GS Track Consistency verification function shall mark target messages as “Velocity Consistent”, if the received velocity is within the valid range. |

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| | 0040.0080 | |
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| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0050 |
| Requirement | The 1090 GS Track Acceleration Consistency verification function shall mark target messages as “Acceleration Inconsistent”, if the received acceleration deviates from the valid range. |

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| | 0040.0080 | |
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| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0060 |
| Requirement | The 1090 GS Track Acceleration Consistency verification function shall mark target messages as “Acceleration Consistent”, if the received acceleration is within the valid range. |

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| | 0040.0080 | |
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|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0080 |
| Requirement | The 1090 GS Track Acceleration Change Consistency verification function shall mark target messages as “Acceleration Change Inconsistent”, if the received acceleration change deviates from the valid range. |

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| | 0040.0080 | |
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| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0090 |
| Requirement | The 1090 GS Track Acceleration Change Consistency verification function shall mark target messages as “Acceleration Change Consistent”, if the received acceleration change is within the valid range. |

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| | 0040.0080 | |
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| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0110 |
| Requirement | The 1090 GS Track Heading Consistency verification function shall mark target messages as “Heading Inconsistent”, if the received Heading deviates from the calculated value (out of predefined configurable range). |

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| | 0040.0080 | |
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| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0120 |
| Requirement | The 1090 GS Track Heading Consistency verification function shall mark target messages as “Heading Consistent”, if the received Heading is within the valid range around calculated heading. |

| | | | |
|-------------|--|-----------|--|
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0140 | | |
| Requirement | The 1090 GS Track Heading Change Consistency verification function shall mark target messages as “Heading Change Inconsistent”, if the received Heading change deviates from the valid range. | | |
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0150 | | |
| Requirement | The 1090 GS Track Heading Change Consistency verification function shall mark target messages as “Heading Change Consistent”, if the received Heading change is within the valid range. | | |
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0170 | | |
| Requirement | The 1090 GS Track Altitude Consistency verification function shall mark target messages as “Altitude Inconsistent”, if the received Altitude deviates from the valid value (out of predefined configurable range). | | |
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0180 | | |
| Requirement | The 1090 GS Track Altitude Consistency verification function shall mark target messages as “Altitude Consistent”, if the received Altitude is within the valid range of Altitude. | | |
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0200 | | |
| Requirement | The 1090 GS Track Altitude Change Consistency verification function shall mark target messages as “Altitude Change Inconsistent”, if the received Altitude change deviates from the valid range. | | |
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0210 | | |
| Requirement | The 1090 GS Track Altitude Change Consistency verification function shall mark target messages as “Altitude Change Consistent”, if the received Altitude change is within the valid range. | | |
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0230 | | |
| Requirement | The 1090 GS Track Vertical Rate Consistency verification function shall mark target messages as “Vertical Rate Inconsistent”, if the received Vertical Rate deviates from the valid value (out of predefined configurable range). | | |
| | | 0040.0080 | |
| Identifier | REQ-15.04.05.a-D09-0100.0240 | | |
| Requirement | The 1090 GS Track Vertical Rate Consistency verification function shall mark target messages as “Vertical Rate Consistent”, if the received Vertical Rate is within the valid range of Vertical Rate. | | |
| | | 0040.0080 | |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0260 |
| Requirement | The 1090 GS Track Vertical Rate Change Consistency verification function shall mark target messages as “Vertical Rate Change Inconsistent”, if the received Vertical Rate change deviates from the valid range. |

0040.0080

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0270 |
| Requirement | The 1090 GS Track Vertical Rate Change Consistency verification function shall mark target messages as “Vertical Rate Change Consistent”, if the received Vertical Rate change is within the valid range. |

0040.0080

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0280 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Velocity Consistency verification function shall verify track velocity consistency by comparing the velocity value reported by that target against the valid velocity range for each “ADS-B Emitter Category SET” Code independently. |

0040.0082

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0290 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Acceleration Consistency verification function shall verify track Acceleration consistency by comparing the acceleration value (calculated from the last two velocity values) against the valid acceleration range for each “ADS-B Emitter Category SET” Code independently. |

0040.0082

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|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0300 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Acceleration Change Consistency verification function shall verify track Acceleration Change consistency by comparing the acceleration change (calculated from the last two calculated acceleration values) against the valid acceleration change range for each “ADS-B Emitter Category SET” Code independently. |

0040.0082

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0310 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Heading Consistency verification function shall verify track Heading consistency by comparing the Heading value (received from a/c) against the calculated Heading (calculated from the last two position values) for each “ADS-B Emitter Category SET” Code independently. |

0040.0082

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0320 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Heading Change Consistency verification function shall verify track Heading Change consistency by comparing the Heading change (calculated from the last two calculated Heading values) against the valid Heading change range for each “ADS-B Emitter Category SET” Code independently. |

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| | 0040.0082 | |
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|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0330 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Altitude Consistency verification function shall verify track Altitude consistency by comparing the Altitude value (received from a/c) against the valid Altitude range for each “ADS-B Emitter Category SET” Code independently. |

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| | 0040.0082 | |
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|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0340 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Altitude Change Consistency verification function shall verify track Altitude Change consistency by comparing the Altitude change (calculated from the last two Altitude values) against the valid Altitude change range for each “ADS-B Emitter Category SET” Code independently. |

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| | 0040.0082 | |
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|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0350 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Vertical Rate Consistency verification function shall verify track Vertical Rate consistency by comparing the Vertical Rate value (received from a/c) against the valid Vertical Rate range for each “ADS-B Emitter Category SET” Code independently. |

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| | 0040.0082 | |
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|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0360 |
| Requirement | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Vertical Rate Change Consistency verification function shall verify track Vertical Rate Change consistency by comparing the Vertical Rate change (calculated from the last two Vertical Rate values) against the valid Vertical Rate change range for each “ADS-B Emitter Category SET” Code independently. |

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| | 0040.0082 | |
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|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0460 |
| Requirement | While the Track Velocity Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Velocity internal indicator to 10 (=not validated for velocity value). |

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| | 0040.0086 | |
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| Identifier | REQ-15.04.05.a-D09-0100.0470 |
| Requirement | For each target marked by the Track Velocity Consistency verification function as “Velocity Inconsistent”, the 1090 GS system shall set the specific BAR Velocity internal indicator to 01. |

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| | 0040.0086 | |
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|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0480 |
| Requirement | For each target marked by the Track Velocity Consistency verification function as “Velocity Consistent”, the 1090 GS system shall set the specific BAR |

| | |
|-------------|---|
| | Velocity internal indicator to 00. |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0490 |
| Requirement | While the Track Acceleration Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Acceleration internal indicator to 10 (=not validated for Acceleration value). |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0500 |
| Requirement | For each target marked by the Track Acceleration Consistency verification function as “Acceleration Inconsistent”, the 1090 GS system shall set the specific BAR Acceleration internal indicator to 01. |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0510 |
| Requirement | For each target marked by the Track Acceleration Consistency verification function as “Acceleration Consistent”, the 1090 GS system shall set the specific BAR Acceleration internal indicator to 00. |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0520 |
| Requirement | While the Track Acceleration Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Acceleration Change internal indicator to 10 (=not validated for Acceleration Change value). |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0530 |
| Requirement | For each target marked by the Track Acceleration Change Consistency verification function as “Acceleration Change Inconsistent”, the 1090 GS system shall set the specific BAR Acceleration Change internal indicator to 01. |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0540 |
| Requirement | For each target marked by the Track Acceleration Change Consistency verification function as “Acceleration Change Consistent”, the 1090 GS system shall set the specific BAR Acceleration Change internal indicator to 00. |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0550 |
| Requirement | While the Track Heading Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Heading internal indicator to 10 (=not validated for Track Heading value). |
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0560 |
| Requirement | For each target marked by the Track Heading Consistency verification function as “Heading Inconsistent”, the 1090 GS system shall set the specific BAR Heading internal indicator to 01. |
| | 0040.0086 |

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|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0570 |
| Requirement | For each target marked by the Track Heading Consistency verification function as "Heading Consistent", the 1090 GS system shall set the specific BAR Heading internal indicator to 00. |

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| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0580 |
| Requirement | While the Track Heading Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Heading Change internal indicator to 10 (=not validated for Heading Change value). |

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| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0590 |
| Requirement | For each target marked by the Track Heading Change Consistency verification function as "Heading Change Inconsistent", the 1090 GS system shall set the specific BAR Heading Change internal indicator to 01. |

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| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0600 |
| Requirement | For each target marked by the Track Heading Change Consistency verification function as "Heading Change Consistent", the 1090 GS system shall set the specific BAR Heading Change internal indicator to 00. |

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|-------------|---|
| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0610 |
| Requirement | While the Track Altitude Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Altitude internal indicator to 10 (=not validated for Altitude value). |

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| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0620 |
| Requirement | For each target marked by the Track Altitude Consistency verification function as "Altitude Inconsistent", the 1090 GS system shall set the specific BAR Altitude internal indicator to 01. |

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| | 0040.0086 |
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| Identifier | REQ-15.04.05.a-D09-0100.0630 |
| Requirement | For each target marked by the Track Altitude Consistency verification function as "Altitude Consistent", the 1090 GS system shall set the specific BAR Altitude internal indicator to 00. |

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| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0640 |
| Requirement | While the Track Altitude Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Altitude Change internal indicator to 10 (=not validated for Altitude Change value). |

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| | 0040.0086 |
| Identifier | REQ-15.04.05.a-D09-0100.0650 |
| Requirement | For each target marked by the Track Altitude Change Consistency verification function as "Altitude Change Inconsistent", the 1090 GS system shall set the specific BAR Altitude Change internal indicator to 01. |

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| | 0040.0086 |
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|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0660 |
| Requirement | For each target marked by the Track Altitude Change Consistency verification function as "Altitude Change Consistent", the 1090 GS system shall set the specific BAR Altitude Change internal indicator to 00. |

| | | |
|--|-----------|--|
| | 0040.0086 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0670 |
| Requirement | While the Track Vertical Rate Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Vertical Rate internal indicator to 10 (=not validated for Vertical Rate value). |

| | | |
|--|-----------|--|
| | 0040.0086 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0680 |
| Requirement | For each target marked by the Track Vertical Rate Consistency verification function as "Vertical Rate Inconsistent", the 1090 GS system shall set the specific BAR Vertical Rate internal indicator to 01. |

| | | |
|--|-----------|--|
| | 0040.0086 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0690 |
| Requirement | For each target marked by the Track Vertical Rate Consistency verification function as "Vertical Rate Consistent", the 1090 GS system shall set the specific BAR Vertical Rate internal indicator to 00. |

| | | |
|--|-----------|--|
| | 0040.0086 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0100.0700 |
| Requirement | While the Track Vertical Rate Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Vertical Rate Change internal indicator to 10 (=not validated for Vertical Rate Change value). |

| | | |
|--|-----------|--|
| | 0040.0086 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0710 |
| Requirement | For each target marked by the Track Vertical Rate Change Consistency verification function as "Vertical Rate Change Inconsistent", the 1090 GS system shall set the specific BAR Vertical Rate Change internal indicator to 01. |

| | | |
|--|-----------|--|
| | 0040.0086 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0720 |
| Requirement | For each target marked by the Track Vertical Rate Change Consistency verification function as "Vertical Rate Change Consistent", the 1090 GS system shall set the specific BAR Vertical Rate Change internal indicator to 00. |

| | | |
|--|-----------|--|
| | 0040.0086 | |
|--|-----------|--|

3.4.3.7 Time Differential of Arrival Techniques

In accordance with D19, ref. [2], the TDOA technique will allow verification of the integrity of the ADS-B position extracted from 1090 ES messages by checking its conformance to the hyperboloid reconstructed inside the 1090 GS via the TDOA technique. This hyperboloid is elaborated taking as input

the Times of Arrival of the same 1090 ES message at multiple 1090 GS or receiver function locations. Therefore for this enhancement there are two possible 1090 GS configurations:

- Multiple Ground Stations with overlapping coverage connected to a central processing system.
- receiver functions

The TDOA requirements specified in D19, ref. [2], have been elaborated into the following 1090 GS requirements, see Appendix B.4

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0120.0030 |
| Requirement | The 1090 GS TDOA validation function shall be able to process a number ($n \geq 2$) of TOA (one TOA per 1090 GS in the cluster or 1090 GS receiving function) for each 1090 ES position message received from the same target. |
| | B.4 |

| | | |
|--|-----------|--|
| | 0040.0040 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0120.0040 |
| Requirement | The 1090 GS TDOA validation function shall be able to generate the Time Differential Of Arrival (TDOA) hyperboloid from the TOAs associated with the same 1090 ES position message per req. D09-0120.0030. |
| | B.4 |

| | | |
|--|-----------|--|
| | 0040.0040 | |
|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0120.0050 |
| Requirement | The 1090 GS TDOA validation function shall validate the ADS-B 3D position information derived from each 1090 ES message using as reference the TDOA hyperboloid generated per req. D09-0120.0040. |
| | B.4 |

| | | |
|--|-----------|--|
| | 0040.0042 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0120.0060 |
| Requirement | The ADS-B position shall be considered "VALID" if the distance between the ADS-B 3D position and the corresponding TDOA hyperboloid is below a threshold. |
| | B.4 |

| | | |
|--|-----------|--|
| | 0040.0042 | |
|--|-----------|--|

3.4.3.8 ADS-B target report update by WAM system

The objective of this Iteration 3 enhancement is to increase the robustness and integrity of ADS-B system output by using WAM system target reports (ATX020 format) when 1090ES data are not available. It assumes that the 1090 GS has the capability to receive and decode ATX020 reports per REQ-15.04.05.a-D05-0030.0030 from Iteration 1.

The following 1090 GS requirements have been identified in App. A.1⁷:

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0030.0010 |
| Requirement | The 1090 GS shall include a "WAM system target report update" function permitting the use of WAM ATX020 target reports as input for the generation of ATX021 reports when 1090ES data are not available |
| | WAM Target Report Substitution Function |

⁷ Configuration related 1090 GS requirements have been placed in Sec. 3.1.3.1.3, while 1090 GS output requirements have been placed Sec. 3.9.

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0030.0020 |
| Requirement | WAM Target Report substitution shall only apply when the 1090 GS operates in periodic reporting mode. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0030.0030 |
| Requirement | WAM Target Report substitution shall start with the first missing periodic ADS-B target report. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0030.0050 |
| Requirement | WAM Target Report substitution shall be applicable only when the track status (ATX020: I020/170 Track Status, CNF subfield) of the candidate WAM target report shows "Confirmed Track". |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0030.0060 |
| Requirement | The 1090 GS shall use the following information from WAM target report updates in case of WAM Target Report substitution: <ul style="list-style-type: none"> • Time of Applicability for position ; • Target position in WGS 84 latitude and longitude ; • Target barometric altitude (Flight Level) ; • Ground Bit Set (GBS) information, if available. |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0030.0080 |
| Requirement | In case of WAM Target Report substitution the 1090 GS shall use in the ADS-B report WAM target position data as is, i.e. without any extrapolation or smoothing. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0030.0110 |
| Requirement | The 1090 GS shall set the position quality indicators (NIC, NUCp and NACp - item I021/090) in ATX021 reports generated with WAM target position information to their lowest possible level, i.e. to the value "invalid" or "not applicable" as appropriate. |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0030.0120 |
| Requirement | ATX021 fields, which are not replaced by data from WAM system updates, shall be reported according to their validity times per ED-129. |

3.4.3.9 Range Measurement from active interrogation

This Iteration 3 enhancement proposes to increase the security of ADS-B reports by validating the target range derived from the ADS-B reported position with the range that can be calculated from the round trip delay of replies to active interrogations from the 1090 GS. It requires that the 1090 GS possesses active interrogation capability and can receive Mode S replies.

The following 1090 GS requirements have been determined from the analysis in App. A.2⁸:

⁸ Configuration related 1090 GS requirements have been placed in Sec. 3.1.3.9, while interface requirements have been placed in Sec. 3.9.

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0015 |
| Requirement | The 1090 GS shall be able to interrogate ADS-B targets using at least selective UF5 interrogations. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0050 |
| Requirement | The 1090 GS shall be able to time stamp and record the Time Of Interrogation (TOI) of each transmitted interrogation. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0070 |
| Requirement | The 1090 GS shall be able to receive Mode S replies and time stamp and record their Time Of Arrival (TOA) |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0080 |
| Requirement | For each pair interrogation/reply, the 1090 GS (intended to be equipped with a single receiving station) shall be able to calculate the Round Trip Delay (RTD). |
| | |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0130.0090 |
| Requirement | The 1090 GS shall be able to associate each calculated RTD to an ADS-B target in coverage. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0110 |
| Requirement | The 1090 GS shall discard any RTD higher than a preset maximum validity period. |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0130.0140 |
| Requirement | The 1090 GS shall mark as "NOT VALIDATED" any ADS-B target position update for which the validity of the associated RTD has expired, or if there is no associated RTD. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0150 |
| Requirement | At each ADS-B target position update, if the RTD of the corresponding target is valid, the 1090 GS shall calculate the sphere of radius R , centered on the 1090 GS; where $R=c*RTD/2$ |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0130.0170 |
| Requirement | The 1090 GS shall mark the ADS-B position as : <ul style="list-style-type: none"> • "VALID" if the distance between the ADS-B 3D position and the RTD sphere generated per REQ-15.04.05.a-D13-0130.0150 is lower than a preset threshold; • "NOT VALID" otherwise. |

3.4.4 Integrity

In addition to the integrity related ED129_REQ_11 requirement for NRA airspaces, two additional integrity requirements have been identified:

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0100 |
| Requirement | The probability of a 1090 GS integrity failure in a RAD airspace shall be 1E-05 or less per hour. |
| Title | GS_RAD_Integrity |
| Status | <In Progress> |
| Rationale | E-161 requirement |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0001 | <Full> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0080.0090 |
| Requirement | The probability of a 1090 GS integrity failure is an APT environment shall be 5.00E-04 or less per hour. |
| Title | GS APT Integrity |
| Status | <In Progress> |
| Rationale | E-163 requirement |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0022.0005 | <Full> |

3.5 Maintainability

No maintainability requirements have been identified.

3.6 Reliability

3.6.1 Availability

The availability provisions in ED-129 apply (see ED129_REQ_16).

3.6.2 Continuity

ED-129 does not set continuity requirements as it considers them an issue for local implementation. ED-161 and 163 specify continuity requirements for the « Ground ADS-B receive function », which lead to the following consolidated 1090 GS requirement :

[REQ]

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0010.0110 |
| Requirement | The probability of a 1090 GS continuity failure shall be 1E-05 or less per hour |
| Title | GS_Continuity |
| Status | <In Progress> |

| | |
|---------------------|---|
| Rationale | ED-161 requirement covering also ED-163 |
| Category | <Reliability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0020.0002 | <Full> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D19-0022.0006 | <Full> |

3.7 Component Internal Data Requirements

This specification does not prescribe any particular internal 1090 GS component architecture.

3.8 Design and Construction Constraints

No design or construction constraints have been identified.

3.9 1090 GS Interface Requirements

In accordance with the traceability analysis presented in Appendix A to Appendix C the 1090 GS has the interface requirements listed in the subsections below:

| <u>Subsection</u> | <u>Page</u> |
|---|-------------|
| 1. Baseline | 72 |
| 2. WAM Integration | 73 |
| 3. Network Bandwidth Optimisation | 75 |
| 4. TOA versus Distance | 75 |
| 5. Power versus Distance | 76 |
| 6. Angle of Arrival | 77 |
| 7. Behavioural Analysis | 78 |
| 8. Track Consistency Verification | 78 |
| 9. Time Differential of Arrival | 78 |
| 10. Range Measurement from active interrogation | 79 |

The interface specification of the 1090 GS is provided in ref. [17] on the basis of the requirements identified in this document.

1. Baseline

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0010.0060 |
| Requirement | The 1090 GS shall compile ATX021 reports (per the provisions in ref. [17]) for targets within its (configurable) coverage volume and forward them to client systems over a data network. |
| Title | GS_Forward |
| Status | <In Progress> |
| Rationale | Basic D18 assumption and ED-129 requirement |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------|------------|
|--------------|---------------------|------------|------------|

| | | | |
|-------------|--------------------|------------------------------|-----------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0010.0001 | <Partial> |
|-------------|--------------------|------------------------------|-----------|

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0000-0020 |
| Requirement | The 1090 GS shall compile ATX023 status reports and forward them to client systems over a data network in accordance with the applicable ED-129 provisions per Appendix E and including the ATX023 additions specified in Sec. 3.4 of this document. |
| Title | ATX023 Compliance |
| Status | <In Progress> |
| Rationale | ATX023 reporting is required by for ED-129 compliance and also by the enhancements listed in Sec. 3.4. |
| Category | <Interoperability> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------|------------|
| <SATISFIES> | <Enabler> | ED-129 | <Full> |

2. WAM Integration

a. Iteration 1 requirements

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0015 |
| Requirement | The 1090 GS WAM integration function shall be able to receive and decode ATX020 v1.7 target reports from WAM systems. |

| | | |
|--|-----------|--|
| | 0030.0001 | |
|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0035 |
| Requirement | The 1090 GS WAM integration function shall be able to receive and decode WAM system status messages in ATX019 v1.2 format. |
| Status | <In Progress> |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0030.0003 | |
|--|------------------------------|--|

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0070 |
| Requirement | If ATX019 reception is activated and the Time out specified in 0030.0060 expires, then the WAI bits in ATX021 target reports shall be set to the value 10 (= not validated by the WAM function) while this condition persists. |
| Title | WAM Nonvalidated reports |
| Status | <In Progress> |
| Rationale | WAM Integration requirement, see App. C.3.1 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0003 | <Partial> |

[REQ]

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0102 |
| Requirement | If the ADS-B/WAM Validity check is not performed because of the conditions stated in REQ-15.04.05.a-0030.0100, the 1090 GS shall issue ATX021 reports with the WAI bits set to the value 10 (=not validated by the WAM integration function), ref. [17]. |

| | |
|---------------------|---|
| Title | WAM_ATX019_NOGO_ATX021 |
| Status | <In Progress> |
| Rationale | WAM Integration requirement, see App. C.3.1 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0005 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0104 |
| Requirement | If the ADS-B/WAM Validity check is not performed because of the conditions stated in REQ-15.04.05.a-0030.0100, the 1090 GS shall issue an appropriate ATX023 message. |
| Title | ADS ATX019 NOGO ATX023 |
| Status | <In Progress> |
| Rationale | WAM Integration requirement, see App. C.3.1 |
| Category | <Safety> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0005 | <Partial> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0030.0140 |
| Requirement | If the distance between the Pre Validated Position and the position indicated in the associated WAM Reference Report is less than a preset threshold, the Pre Validated Position shall be reported in ATX021 with the WAI bits set to 00 (= consistent with WAM), ref. [17]. |
| Title | ADSB_and_WAM_Valid |
| Status | <In Progress> |
| Rationale | Positive result of validity check with WAM position, see App. C.3.1 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0007 | <Partial> |

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0030.0150 |
| Requirement | If the distance between the Pre Validated Position and the position indicated in the associated WAM Reference Report is greater than the preset threshold The Pre Validated Position shall be reported in ATX021 with the WAI bits set to 01 (=inconsistent with WAM), ref. [17]. |
| Title | ADSB and WAM NotValid |
| Status | <In Progress> |
| Rationale | Negative result of validity check with WAM position, see App. C.3.1 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0030.0007 | <Partial> |

| Identifier | REQ-15.04.05.a-D09-0030.0320 | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------------------|---|----------------------|----------------------|----------------------|--------------------|-----------------|------------|------------|------------|------------|----|---------------|---------------|---------------|---------------|----|------------|------------|------------|------------|----|---------------------------------|--|--|--|----|
| Requirement | <p>The 1090 GS WAM Integration function shall be able to report the results of the checks specified in D09-0030.0300, 0305, and 0310 checks by means of the ATX021 report WAI bits as follows:</p> <table border="1"> <thead> <tr> <th>Position test result</th> <th>Velocity Test result</th> <th>Altitude test result</th> <th>Mode S test result</th> <th>ATX021 WAI bits</th> </tr> </thead> <tbody> <tr> <td>Consistent</td> <td>Consistent</td> <td>Consistent</td> <td>Consistent</td> <td>00</td> </tr> <tr> <td>Not performed</td> <td>Not performed</td> <td>Not performed</td> <td>Not performed</td> <td>10</td> </tr> <tr> <td>Consistent</td> <td>Consistent</td> <td>Consistent</td> <td>Suspicious</td> <td>11</td> </tr> <tr> <td colspan="4">All other possible combinations</td> <td>01</td> </tr> </tbody> </table> <p>Note: the meaning of the WAI bits is the following: -00 the report is VALID -01 the report is NOT VALID -10 the report is NOT VALIDATED -11 the report is VALID EXCLUDING MODE S DATA</p> | Position test result | Velocity Test result | Altitude test result | Mode S test result | ATX021 WAI bits | Consistent | Consistent | Consistent | Consistent | 00 | Not performed | Not performed | Not performed | Not performed | 10 | Consistent | Consistent | Consistent | Suspicious | 11 | All other possible combinations | | | | 01 |
| Position test result | Velocity Test result | Altitude test result | Mode S test result | ATX021 WAI bits | | | | | | | | | | | | | | | | | | | | | | |
| Consistent | Consistent | Consistent | Consistent | 00 | | | | | | | | | | | | | | | | | | | | | | |
| Not performed | Not performed | Not performed | Not performed | 10 | | | | | | | | | | | | | | | | | | | | | | |
| Consistent | Consistent | Consistent | Suspicious | 11 | | | | | | | | | | | | | | | | | | | | | | |
| All other possible combinations | | | | 01 | | | | | | | | | | | | | | | | | | | | | | |

| | | | |
|--|--|------------------------------|--|
| | | REQ-15.04.05.a-D19-0030.0012 | |
| | | REQ-15.04.05.a-D19-0030.0004 | |
| | | REQ-15.04.05.a-D19-0030.0008 | |

c. Requirements added in Iteration 3

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0030.0130 |
| Requirement | The 1090 GS shall indicate WAM target report substitutions through an appropriate error condition field to be added in I021/040. |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0030.0140 |
| Requirement | The 1090 GS shall report the activations and deactivations of the WAM Target Report update function in an appropriate ATX023 status report. |

3. Network Bandwidth Optimisation

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0090.0720 |
| Requirement | The 1090 GS shall indicate periodically (and on an event driven basis in case of change) its currently applied Degradation Level on ATX023 reports, with a period configurable over its external CMI. |

| | | | |
|--|--|-----------|--|
| | | 0000.0042 | |
|--|--|-----------|--|

4. TOA/Distance

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0040.0025 |
| Requirement | If the 1090 GS TOA/Distance Validation function uses data from external 1090 GS, then it shall be able to receive and decode ATX021 target reports from these systems. |

| | | | |
|--|--|-----------|--|
| | | 0040.0030 | |
|--|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0065 |
| Requirement | If the 1090 GS TOA/Distance Validation function uses 1090 GS as external sensors, then it should be able to receive and decode ATX023 status messages from these systems. |

| | | | |
|--|--|-----------|--|
| | | 0040.0030 | |
|--|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D05-0040.0140 |
| Requirement | For each 1090 ES position message marked as "TOA/Distance Not Validat- |

| | |
|--|---|
| | ed”, the 1090 GS shall issue the corresponding ATX021 report with the TOA bits set to the value 10, ref. [17]. |
| | See C.3.2 |

| | | | |
|-------------|---|------------------------------|--|
| | | REQ-15.04.05.a-D18-0040.0031 | |
| Identifier | REQ-15.04.05.a-D05-0040.0150 | | |
| Requirement | For each 1090 ES position message marked as “TOA/Distance Consistent”, the 1090 GS shall issue the corresponding ATX021 report with the TOA bits set to the value 00, ref. [17]. | | |
| | See C.3.2 | | |

| | | | |
|-------------|---|------------------------------|--|
| | | REQ-15.04.05.a-D18-0040.0031 | |
| Identifier | REQ-15.04.05.a-D05-0040.0160 | | |
| Requirement | For each 1090 ES position message marked as “TOA/Distance Inconsistent”, the 1090 GS shall issue the corresponding ATX021 report with the TOA bits set to the value 01, ref. [17]. | | |
| | See C.3.2 | | |

| | | | |
|--|--|------------------------------|--|
| | | REQ-15.04.05.a-D18-0040.0031 | |
|--|--|------------------------------|--|

5. Power versus Distance

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0100 |
| Requirement | If the difference between theoretical and measured signal level metric values exceeds a preset threshold, then the 1090 GS shall issue the resulting ATX021 report with the PRV bits set to 01 (= power/distance inconsistent), ref. [17]. |
| Title | Distance_Power_NOK |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0046 | <Full> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0047 | <Full> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0104 |
| Requirement | If the difference between theoretical and measured signal level metric values does not exceed the preset threshold, then the 1090 GS shall issue the resulting ATX021 report with the PRV bits set to 00 (= power/distance consistent), ref. [17]. |
| Title | Distance Power OK |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0046 | <Full> |

[REQ]

| | |
|---------------------|---|
| Identifier | REQ-15.04.05.a-D05-0050.0108 |
| Requirement | While the power versus distance validation function is deactivated, the 1090 GS shall issue ATX021 report with the PRV bits set to 10 (=power versus distance not validated), ref. [17]. |
| Title | Distance_Power_Not_Available |
| Status | <In Progress> |
| Rationale | See C.3.3 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0046 | <Full> |

6. Angle of Arrival

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0060.0018 |
| Requirement | While the Angle of Arrival validation function is not activated, the 1090 GS shall issue all ATX021 reports with the AoA bits set to 10 (=not validated by the AoA function), ref. [17]. |
| | See C.3.4 and ref. [17] |

| | | |
|--|------------------------------|--|
| | REQ-15.04.05.a-D18-0040.0001 | |
|--|------------------------------|--|

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0070 |
| Requirement | When a received 1090 ES position message is marked by the Angle of Arrival validation function as "not matching", and the n - 1 previous consecutive position messages for the same target were also marked as "not matching", the 1090 GS shall set the AoA bits in the resulting ATX021 report to the value 01 (=direction of arrival inconsistency), ref. [17]. |
| Title | AoA Inconsistency |
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0006 | <Partial> |
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0007 | <Full> |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D05-0060.0074 |
| Requirement | When a 1090 ES position message is received and marked by the Angle of Arrival validation function as "not matching", and the m previously received consecutive position messages were also marked "not matching" but m is less than n - 1, then the 1090 GS shall issue the corresponding ATX021 report with the AoA bits set to 00 (=consistent direction of arrival), ref. [17]. |
| | See C.3.4 |

| | | |
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| | -0040.0006 | |
|--|------------|--|

[REQ]

| | |
|---------------------|--|
| Identifier | REQ-15.04.05.a-D05-0060.0076 |
| Requirement | When a 1090 ES position message is received and marked by the Angle of Arrival validation function as “valid”, the 1090 GS shall issue the corresponding ATX021 report with the AoA bits set to 00 (=consistent direction of arrival), ref. [17]. |
| Title | Angle Discrepancy |
| Status | <In Progress> |
| Rationale | See C.3.4 |
| Category | <Security> |
| Validation Method | |
| Verification Method | <Test> |

[REQ Trace]

| Relationship | Linked Element Type | Identifier | Compliance |
|--------------|---------------------|------------------------------|------------|
| <SATISFIES> | <ATMS Requirement> | REQ-15.04.05.a-D18-0040.0006 | <Partial> |

7. Behavioural Analysis

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0100.0730 |
| Requirement | Behavioural Analysis results shall be reported in the corresponding ATX021 report through a consolidated BAR indicator whose value is derived from the values of the specific BAR internal indicators plus the PVC internal indicator (“Position Change versus Velocity” from Iteration 1, see req. D05-0070.0020) as follows: <ul style="list-style-type: none"> ▪ BAR=10 (“Behaviour Not Validated”), if all the specific internal BAR and PVC indicators have been set to 10; ▪ BAR=01 (“Behaviour Not Valid”), if any of the specific internal BAR or PVC indicators has been set to 01; ▪ BAR=00 (“Behaviour Valid”), if all of the specific internal BAR and PVC indicators have been set to 00; ▪ BAR=11 (“Behaviour Valid only for a test subset”), in all other cases. |

| | | | |
|--|--|-----------|--|
| | | 0040.0086 | |
| | | 0040.0050 | |

8. Track Consistency Verification

See REQ-15.04.05.a-D09-0100.0730.

9. Time Differential of Arrival

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0120.0080 |
| Requirement | In case the TDOA validation provides a positive result the 1090 GS shall mark the corresponding ATX021 report as “TDOA Valid”. |
| | B.4 |

| | | | |
|--|--|-----------|--|
| | | 0040.0044 | |
|--|--|-----------|--|

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D09-0120.0090 |
| Requirement | In case the TDOA validation provides a negative result the 1090 GS shall mark the corresponding ATX021 report as “TDOA Not Valid”. |
| | B.4 |

| | | | |
|--|--|-----------|--|
| | | 0040.0044 | |
|--|--|-----------|--|

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D09-0120.0100 |
| Requirement | While the TDOA validation function is deactivated, the 1090 GS shall mark |

| | |
|--|--|
| | any issued ATX021 reports as "TDOA Not Validated". |
| | B.4 |

| | | |
|--|-----------|--|
| | 0040.0044 | |
|--|-----------|--|

10. Range Measurement from active interrogation

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0060 |
| Requirement | The 1090 GS shall be able to receive and decode the Mode S replies to its own interrogations. |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0130.0190 |
| Requirement | If the ADS-B position is considered "VALID" per REQ-15.04.05.a-D13-0130.0170, the 1090 GS shall mark the corresponding ATX021 report as "Range Measurement from Active Interrogation Valid". |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0130.0200 |
| Requirement | If the ADS-B position is considered "NOT VALID" per REQ-15.04.05.a-D13-0130.0170, the 1090 GS shall mark the corresponding ATX021 report as "Range Measurement from Active Interrogation Not Valid". |

| | |
|-------------|--|
| Identifier | REQ-15.04.05.a-D13-0130.0210 |
| Requirement | If the ADS-B position is considered "NOT Validated" per REQ-15.04.05.a-D13-0130.0140, the 1090 GS shall mark the ATX021 reports as "Range Measurement from Active Interrogation Not Validated". |

| | |
|-------------|---|
| Identifier | REQ-15.04.05.a-D13-0130.0230 |
| Requirement | The 1090 GS shall report the activations and deactivations of the Range Measurement from Active Interrogation function in an appropriate ATX023 status report |

4 Assumptions

[ASSUMPTION_1] The baseline for this specification will be ref. [3].

[ASSUMPTION_2] This specification will consider only the minimum case of a 1090 GS providing a single ADS-B Service.

[ASSUMPTION_3] This specification will consider only data driven mode operations for the 1090 GS.

[ASSUMPTION_4] RF performance specifications will assume that the Ground Station equipment is connected to a Reference Antenna having the characteristics listed below⁹ (see justification in ED-129 [11], Appendix G):

- a. Horizontal Pattern: The antenna pattern is nominally omni-directional in the horizontal plane.
- b. Gain: The antenna gain is 0 dB with respect to isotropic.
- c. Frequency: The antenna receives signals on the nominal operating frequency of 1090 MHz.

⁹ The gain characteristics chosen for the Reference Antenna are not significant, as they are being defined purely to support theoretical analysis. The actual antenna gain does however affect figures such as MTL that are specified in ED-129 [11].

5 References

- [1] SJU 15.04.05a ADS-B Surveillance System Specifications for Third Iteration, D20, Ed. 00.01.00, Aug 2012
- [2] SJU 15.04.05a ADS-B Surveillance System Specifications for Second Iteration, D19, Ed. 00.03.00, Sept 2011
- [3] SJU 15.04.05a ADS-B 1090 MHz Ext Squitter Ground Station Specification – Iteration 2, D09, Ed. 00.01.02, Sept 2011
- [4] RTCA DO-242A: Minimum Aviation System Performance Standards for ADS-B, June 2002
- [5] EUROCAE/RTCA MOPS for SSR Mode S Transponders, ED-73B/DO-181C, Oct 2002
- [6] EUROCAE/RTCA MOPS for 1090 MHz ADS-B, ED-102/DO-260, Sept 2000
- [7] RTCA MOPS for 1090 ES ADS-B and TIS-B, DO-260A, Dec. 2006 (includes Changes 1 and 2)
- [8] EUROCAE/RTCA MOPS for 1090 ES ADS-B and TIS-B, ED-102A/DO-260B, Dec 2009
- [9] EUROCAE/RTCA SPIR Document for ADS-B NRA Application, ED-126/DO-303, Dec 2006
- [10] EUROCAE/RTCA SPIR Document for ADS-B RAD Application, ED-161/DO-318, Sept 2009
- [11] EUROCAE ED-129: Technical Specification for a 1090 MHz Extended Squitter ADS-B Ground Station, June 2010
- [12] EUROCONTROL ASTERIX Standards CAT 21, Ed 1.8, Jan 2011,
- [13] EUROCONTROL ASTERIX Standards CAT 23, Ed 1.2, March 2009
- [14] EUROCONTROL ASTERIX Standards CAT 247, Ed.1.2, Feb 2008
- [15] SESAR Requirements and V&V Guidelines, Latest Version
- [16] SESAR Toolbox User Manual, Latest Version
- [17] SJU 15.04.05.a , Interface Specifications for Iteration 3, D15, Ed. 00.00.02, Aug 2012
- [18] EUROCONTROL, 1090 MHz RAD FRUIT Study, V1.0, July 2010
- [19] SJU 15.04.05a, ADS-B Surveillance System Specifications for First Iteration, D18, Ed. 00.01.00, Feb 2011
- [20] EUROCAE/RTCA, SPIR Document for ADS-B APT Application, ED-163/DO-321, Nov 2010
- [21] SJU 15.01.06, Comparison of SESAR and CASCADE Scenarios, Oct 2010
- [22] SJU 15.01.06, 1030/1090 Scenario Description Deliverable, D12, Ed. 00.01.01, Nov 2010
- [23] SJU 15.04.05a ADS-B 1090 MHz Ext Squitter Ground Station Specification – Iteration 1, D05, Ed. 00.02.00, March 2010

5.1 Use of copyright/patent material /classified material

No copyright or patent material is included in this specification.

5.1.1 Classified Material

N/A

Appendix A Traceability of Iteration 3 Requirements

This appendix specifies the traceability of the 1090 GS Iteration 3 requirements to the ADS-B Ground Surveillance enhancements specified in ref. [1].

As indicated in Sec. 3 of ref. [1] the Iteration 3 enhancements which have an impact on the 1090 GS are:

- Integration of ADS-B with WAM: ADS-B target report data update by WAM system;
- Security Enhancements: Range measurement from active interrogation.

The following subsections list the 1090 GS requirements corresponding to each of the requirements for the above enhancements which have been allocated in ref. [1] to the 1090 GS system.

A.1 ADS-B target report update by WAM system

This enhancement makes use of WAM target reports (ATX020) by the 1090 GS (see Figure 4 below) to generate ADS-B target reports (ATX021) when 1090ES data are not available. It is expected that this enhancement will increase the robustness and integrity of ADS – B System output.

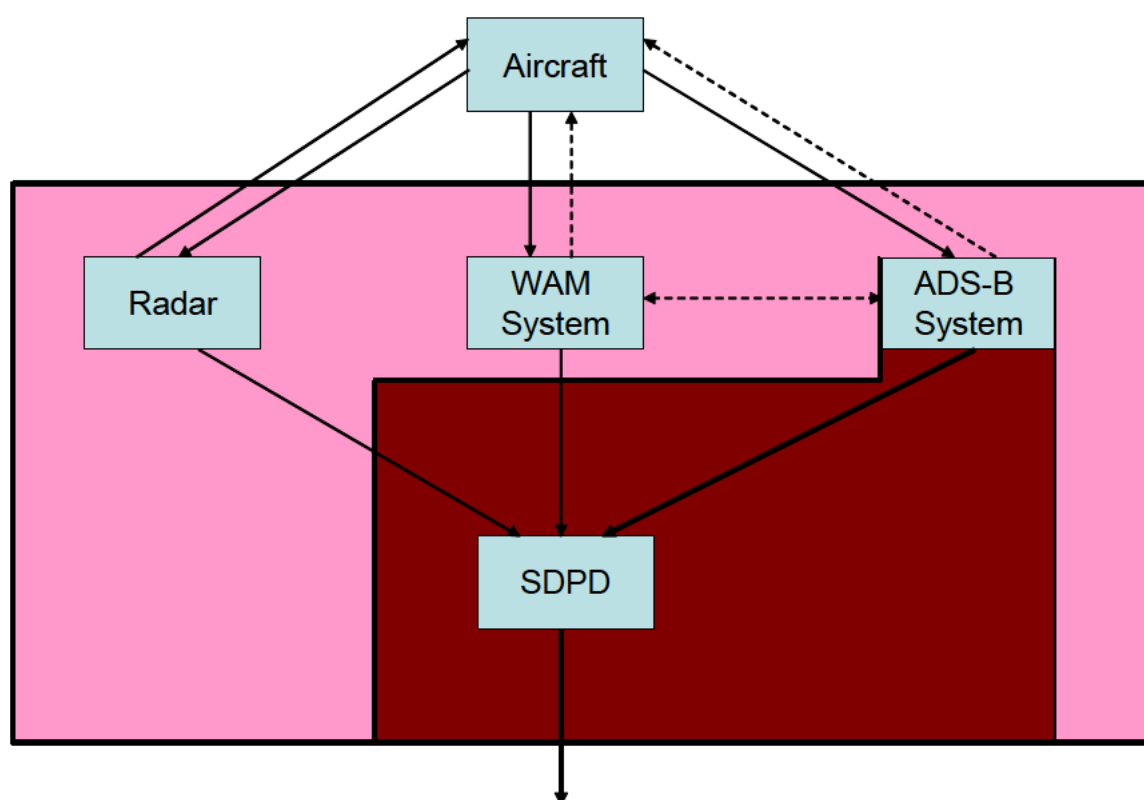


Figure 4 Target report integration by WAM system

| REQ-15.04.05.a-D20- Req. ID | D20 Requirement | REQ-15.04.05.a-D13- Req. ID | GS Requirement for 3 rd Iteration | Notes |
|-----------------------------|--|-----------------------------|---|-----------------------------|
| 0030.0001 | In case of missing ADS-B target report updates, the ADS-B system shall use available WAM system target report updates (position) as target position report. | 0030.0010 | The 1090 GS shall include a “WAM Target Report Substitution” function permitting the use of WAM ATX020 target reports as input for the generation of ATX021 reports when 1090ES data are not available. | Implies req. D05-0030.0030. |
| | | 0030.0015 | The 1090 GS “WAM Target Report Substitution” function shall be activated/deactivated via a configurable parameter. | Configuration |
| | | 0030.0020 | WAM Target Report substitution shall only apply when the 1090 GS operates in periodic reporting mode. | |
| | | 0030.0030 | WAM Target Report substitution shall start with the first missing periodic ADS-B target report. | |
| | | 0030.0040 | It shall be possible to configure a maximum duration during which the 1090 GS may apply WAM Target Report substitution. | Configuration |
| | | 0030.0050 | WAM Target Report substitution shall be applicable only when the track status (ATX020: I020/170 Track Status, CNF subfield) of the candidate WAM target report shows “Confirmed Track”. | |
| | | 0030.0060 | The 1090 GS shall use the following information from WAM target report updates in case of WAM Target Report substitution: <ul style="list-style-type: none"> • Time of Applicability for position ; • Target position in WGS 84 latitude and longitude ; • Target barometric altitude (Flight Level) ; • Ground Bit Set (GBS) information, if available. | |

| REQ-15.04.05.a-D20- Req. ID | D20 Requirement | REQ-15.04.05.a-D13- Req. ID | GS Requirement for 3 rd Iteration | Notes |
|-----------------------------|-----------------|-----------------------------|--|--|
| | | 0030.0080 | In case of WAM Target Report substitution the 1090 GS shall use in the ADS-B report WAM target position data as is, i.e. without any extrapolation or smoothing. | |
| | | 0030.0100 | The 1090 GS shall use WAM target reports in substitution of missing 1090ES data only if their accuracy is better than a user configurable threshold. | Configuration |
| | | 0030.0110 | The 1090 GS shall set the position quality indicators (NIC, NUCp and NACp - item I021/090) in ATX021 reports generated with WAM target position information to their lowest possible level, i.e. to the value "invalid" or "not applicable" as appropriate. | Ideally they should be set according to the data in I020/0500 (DOP, SDP,...), but that is an open issue. |
| | | 0030.0120 | ATX021 fields, which are not replaced by data from WAM system updates, shall be reported according to their validity times per ED-129. | |
| | | 0030.0130 | The 1090 GS shall indicate WAM target report substitutions through an appropriate error condition field to be added in I021/040. | Output |
| | | 0030.0140 | The 1090 GS shall report the activations and deactivations of the WAM Target Report update function in an appropriate ATX023 status report | Output |

A.2 Range Measurement from active interrogation

ADS-B report security can be enhanced by comparing the range of a target from the 1090 GS as calculated from its reported ADS-B position with the distance derived from the round trip delay of its replies to active interrogation from the 1090 GS.

| REQ-15.04.05.a-D20- Req. ID | D20 Requirement | REQ-15.04.05.a-D13- Req. ID | GS Requirement for 3 rd Iteration | Notes |
|-----------------------------|---|-----------------------------|--|--------------------------------|
| 0040.0001 | The ADS-B Ground Surveillance Domain should be equipped with a 1030 MHz interrogator, capable of interrogating ADS-B targets according to all relevant ICAO Annex 10 requirements. | 0130.0015 | The 1090 GS shall be able to interrogate ADS-B targets using at least selective UF5 interrogations. | |
| | | 0130.0030 | The 1090 GS interrogator transmission power shall be configurable according to the requested surveillance coverage. | Configuration |
| | | 0130.0040 | The interrogation rate of the 1090 GS interrogator shall be configurable. | Configuration |
| 0040.0002 | If REQ-15.04.05.a-D20-0040.0001 is implemented, the ADS-B Ground Surveillance Domain shall have the capability to determine the Round Trip Delay (RTD) of every received 1090 MHz reply elicited by its own interrogations (registered as <i>Real RTD</i>). | 0130.0050 | The 1090 GS shall be able to time stamp and record the Time Of Interrogation (TOI) of each transmitted interrogation. | |
| | | 0130.0060 | The 1090 GS shall be able to receive and decode the Mode S replies to its own interrogations. | Input |
| | | 0130.0070 | The 1090 GS shall be able to receive Mode S replies and time stamp and record their Time Of Arrival (TOA). | |
| | | 0130.0080 | For each pair interrogation/reply, the 1090 GS (intended to be equipped with a single receiving station) shall be able to calculate the Round Trip Delay (RTD). | |
| 0040.0003 | If REQ-15.04.05.a-D20-0040.0002 is implemented, the ADS-B Ground Surveillance Domain shall register the last RTD of each of the received ES and its time stamp. | 0130.0090 | The 1090 GS shall be able to associate each calculated RTD to an ADS-B target in coverage. | |
| 0040.0004 | If REQ-15.04.05.a-D20-0040.0003 is implemented, each calculated RTD shall be con- | 0130.0110 | The 1090 GS shall discard any RTD higher than a preset maximum validity period. | The maximum validity period is |

| REQ-15.04.05.a-D20- Req. ID | D20 Requirement | REQ-15.04.05.a-D13- Req. ID | GS Requirement for 3 rd Iteration | Notes |
|-----------------------------|---|-----------------------------|---|--|
| | sidered applicable to RTD Validation for a configurable time period. | | | defined in D13-0130.0120 |
| | | 0130.0120 | The RTD maximum validity period shall be a configurable parameter. | Configuration |
| 0040.0005 | If REQ-15.04.05.a-D20-0040.0003 and REQ-15.04.05.a-D20-0040.0004 are implemented, each time a valid position message is received for a target in "target data maintenance" mode (see ED-129 chapter 3) and the associated RTD applicability is elapsed, the ADS-B position report shall be marked as NOT VALIDATED. | 0130.0140 | The 1090 GS shall mark as "NOT VALIDATED" any ADS-B target position update for which the validity of the associated RTD has expired, or if there is no associated RTD. | |
| 0040.0006 | If REQ-15.04.05.a-D20-0040.0003 and REQ-15.04.05.a-D20-0040.0004 are implemented, each time a valid position message is received for a target in "target data maintenance" mode (see ED-129 chapter 3), the ADS-B Ground Surveillance Domain shall validate the ADS-B report comparing the ADS-B position data with the computed applicable RTD. | 0130.0150 | At each ADS-B target position update, if the RTD of the corresponding target is valid, the 1090 GS shall calculate the sphere of radius R , centered on the 1090 GS; where $R=c*RTD/2$ | |
| | | 0130.0170 | The 1090 GS shall mark the ADS-B position as : <ul style="list-style-type: none"> • "VALID" if the distance between the ADS-B 3D position and the RTD sphere generated per REQ-15.04.05.a-D13-0130.0150 is lower than a preset threshold; • "NOT VALID" otherwise. | The threshold is defined in req. D13-0130.0180 |
| | | 0130.0180 | The threshold of the Range Measurement from Active Interrogation in REQ-15.04.05.a-D13-0130.0170 shall be a configurable parameter. | Configuration |

| REQ-15.04.05.a-D20- Req. ID | D20 Requirement | REQ-15.04.05.a-D13- Req. ID | GS Requirement for 3 rd Iteration | Notes |
|-----------------------------|---|-----------------------------|---|---------------|
| 0040.0007 | If REQ-15.04.05.a-D20-0040.0006 is implemented, the ADS-B Ground Surveillance Domain shall be able to report the validation result in the ASTERIX CAT021 ADS-B report. | 0130.0190 | If the ADS-B position is considered "VALID" per REQ-15.04.05.a-D13-0130.0170, the 1090 GS shall mark the corresponding ATX021 report as "Range Measurement from Active Interrogation Valid". | Output |
| | | 0130.0200 | If the ADS-B position is considered "NOT VALID" per REQ-15.04.05.a-D13-0130.0170, the 1090 GS shall mark the corresponding ATX021 report as "Range Measurement from Active Interrogation Not Valid". | Output |
| | | 0130.0210 | If the ADS-B position is considered "NOT Validated" per REQ-15.04.05.a-D13-0130.0140, the 1090 GS shall mark the ATX021 reports as "Range Measurement from Active Interrogation Not Validated". | Output |
| 0040.0008 | If REQ-15.04.05.a-D20-0040.0007 is implemented, the SDPD shall be able to use the validation result | | NOT APPLICABLE. | REQ for SDPD |
| 0040.0009 | If REQ-15.04.05.a-D20-0040.0008 is implemented, the validation result (positive/negative) should be reported to the end user of the surveillance data | | NOT APPLICABLE. | REQ for SDPD |
| 0040.0010 | It shall be possible to activate/deactivate the function of range measurement from active interrogation | 0130.0220 | The 1090 GS Range Measurement from Active Interrogation function shall be activated/ deactivated via a configurable parameter. | Configuration |
| | | 0130.0230 | The 1090 GS shall report the activations and deactivations of the Range Measurement from Active Interrogation function in an appropriate ATX023 status report. | Output |

Appendix B Traceability of Iteration 2 Requirements

Iteration 2 ref. [2] added a set of requirements on the ADS-B surveillance system on top of those already specified in the Iteration 1 baseline document [19]. The requirements added in ref. [2] that have been allocated to the 1090 GS are listed in this Appendix and expanded into more detailed 1090 GS requirements.

Only those Iteration 2 requirements marked as applicable to Iteration 3 have been included in Sec. 3.

B.1 ADS-B APT Compliance

Ref. [2] requires for Iteration 2 support of ADS-B APT [20] leading to the following 1090 GS requirements:

| REQ-15.04.05.a-D19- Req. ID | D19 Requirement | REQ-15.04.05.a-D09- Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|-----------------------------|---|-----------------------------|--|---|
| 0012.0002 | For all mobiles on the Manoeuvring Area, the Ground Domain should be capable of receiving and processing the following list of ADS-B surveillance parameters: <ul style="list-style-type: none"> ▪ Emitter Category ▪ Geometric Altitude ▪ Velocity Vector (heading/track and ground speed) ▪ Mobile Size (length/width codes) ▪ GPS antenna offset information | 0080.0010 | The 1090 GS shall be able to process and decode 1090 ES Surface Position Messages (FTC=5-8) emitted from DO-260/260A/260B equipped targets and report the extracted information in the relevant ATX021 fields. | Y |
| | | 0080.0020 | The 1090 GS shall be able to process and decode 1090 ES Aircraft Operational Status (FTC=31) messages emitted from DO-260A targets and report the "Aircraft Length and Width" and "Position Offset Applied" data in the relevant ATX021 fields. | Y |
| | | 0080.0030 | The 1090 GS shall be able to process and decode 1090 ES Aircraft Identification and Type messages (FTC=1-4) emitted from DO-260/260A/260B targets and report the Emitter Category in the appropriate ATX021 field. | Y |
| | | | Altitude information is not broadcasted by targets on the airport surface. | Y |
| 0012.0003 | The Ground Domain shall have the capacity to acquire and maintain all Mobiles in the Manoeuvring Area. | 0080.0040 | The 1090 GS shall have the capacity to acquire and maintain all ADS-B surface targets in the worst case airport environment reported in Appendix F. | Y |
| 0012.0004 | For all Mobiles on the Manoeuvring Area, the Ground Domain shall be capable of receiving, processing and displaying to | | Covered by D09-0080.0010, D05-0010.0070, and for DO-260B aircraft D05-0020.0220. | Y |

| REQ-15.04.05.a-D19- Req. ID | D19 Requirement | REQ-15.04.05.a-D09- Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|-----------------------------|---|-----------------------------|---|---|
| | the controller the following list of ADS-B surveillance parameters: <input type="checkbox"/> Horizontal Position <input type="checkbox"/> Identity Information <input type="checkbox"/> Pressure Altitude (for airborne aircraft) <input type="checkbox"/> Discrete Emergency Code(s) (not required for vehicles) - as a minimum: general emergency, communications failure, unlawful interference. | | | |
| 0022.0001 | The update interval for ADS-B position reports for Mobiles on the airport surface Manoeuvring Area shall be 1 second at a probability of at least 90% (at interface E2) | 0080.0050 | The 1090 GS shall be able to provide ATX021 target report updates for any moving Mobile on the airport surface within 1 sec from the last report with probability of at least 90%. | Y |
| 0022.0002 | The update interval for ADS-B emergency mode items for aircraft on the airport surface Manoeuvring Area shall be 2 seconds at a probability of at least 90% (at interface E2) | 0080.0060 | The 1090 GS shall be able to provide ATX021 target report updates including emergency mode items for any Mobile on the airport surface within 2 sec from the last report with probability of at least 90%. | Y |
| 0022.0003 | The update interval for non-changing ADS-B items for Mobiles on the airport surface Manoeuvring Area shall be 20 seconds at a probability of at least 90% (at interface E2) | 0080.0070 | The 1090 GS shall be able to report non changing ADS-B items for Mobiles on the airport surface within 20 sec with a probability of at least 90%. | Y |
| 0022.0004 | The update interval for changing Identity Information on the airport surface Manoeuvring Area shall be 20 seconds at a probability of at least 90% (at interface E2) | 0080.0080 | The 1090 GS shall be able to report Identity changes of Mobiles on the airport surface within 20 sec with a probability of at least 90%. | Y |
| 0022.0005 | The probability of the Ground Domain system integrity failure shall be 1.00E-03 or less per hour | 0080.0090 | The probability of a 1090 GS integrity failure is an APT environment shall be 5.00E-04 or less per hour. | Y ¹⁰ |
| 0022.0006 | The probability of the Ground Domain system continuity failure shall be 1.00E- | | Covered by D05-0010.0110 | Y |

¹⁰ See also RAD requirement D05-0010.0100.

| REQ-15.04.05.a-D19- Req. ID | D19 Requirement | REQ-15.04.05.a-D09- Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|-----------------------------|---------------------|-----------------------------|--|---|
| | 03 or less per hour | | | |

B.2 Enhanced ADS-B target report validation via WAM integration

Iteration 1 [23] introduced a number of 1090 GS requirements for ADS-B target report validation using WAM data. These requirements are listed in Appendix C.3.1. Iteration 2 [1] adds further ADS-B target report validation requirements which are analysed in this section.

Assumption 1

The main objective of the WAM integration function is to perform a check between ADS-B data and WAM data for the following information:

- Position check
- Velocity check
- Altitude check
- Mode S data check

The position check has already been specified in Iteration 1, see Appendix C.3.1.

Assumption 2

The Mode S data check is performed considering the information coming from the Mode S – Enhanced Data (i.e. ITEM I020/250 Mode S MB Data).

Due to the multiple information items contained in I020/250, the check is composed of several “sub-checks”. Not all sub-checks can always be performed due to the fact that Mode S enhanced data may not always be available in the WAM reports.

For this reason, the Mode S data checks will be performed only on those data available in the WAM report.

Assumption 3

The WAM Integration function shall report the result of the tests in the corresponding ATX021 report through the WAI flag values:

- 00 = VALID
- 01 = NOT VALID
- 10 = NOT VALIDATED
- 11 = VALID EXCLUDING MODE S DATA

The last classification has been included in order to take into account the possibility that the Position check, the Velocity check and the Altitude check might be positive, while the Mode S data check is negative or has not been performed (per Assumption 2). This is done in order to avoid loss of information about velocity, position and altitude validations, in case only one (or a sub-set) of the sub-checks of the Mode S data check is negative.

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|---|---|
| 0030.0001 | <p>The ADS-B Ground Surveillance Domain processes and decodes received WAM data in ASTERIX CAT020. In addition to data specified in Iteration 1, the following minimum data item should be decoded:</p> <ul style="list-style-type: none"> ▪ Measured Height ▪ Mode-S MB Data ▪ Calculated Track Velocity | 0030.0200 | <p>The 1090 GS WAM Integration function shall be able to extract at least the following items from each received ATX020 report:</p> <ul style="list-style-type: none"> - I020/110 Measured Height (Local Cartesian Coordinates) - I020/202 Calculated Track Velocity in Cartesian Coordinates - I020/250 Mode S MB Data | Y |
| | | 0030.0205 | <p>In addition to the process described in D05-0030.0110 (identification of related WAM report), the 1090 GS shall be able to identify a relevant WAM target report (called Reference Report) each time one of the following messages is received:</p> <ul style="list-style-type: none"> - Airborne Velocity Message (called Pre-validated Velocity) - Target State and Status Message (called Pre-validated Status) - Surface Position Message (called Pre-validated Surface) | Y |
| | | 0030.0210 | <p>The Pre-validated Velocity, the Pre-validated Status and the Pre-validated Surface Position shall refer to the same time of applicability of the Reference Report within a configurable tolerance.</p> | Y |
| | | 0030.0215 | <p>The reference report shall be determined using only those ATX020 Reports referring to the same Mode S 24-bit address reported in the 1090 ES Message.</p> | Y |
| 0030.0002 | <p>The ADS-B Ground Surveillance Domain should be able to manage the case of WAM reports with duplicated Mode S addresses during the phase of correlation of ADS-B reports with WAM reports.</p> | 0030.0220 | <p>In case of WAM target reports with duplicate Mode S addresses, the 1090 GS WAM Integration function shall be able to resolve the ambiguity in order to correctly perform the validation of the report.</p> | Y |
| 0030.0003 | <p>The ADS-B Ground Surveillance Domain should be able to check the integrity of</p> | 0030.0225 | <p>If an Airborne Position Message is received, the 1090 GS WAM Integration function shall be able to compare the</p> | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|--|---|
| | the barometric altitude reported in ADS-B reports through the WAM data. | | Measured Height indicated in the Reference Report with the altitude reported in the Pre-validated Position. | |
| | | 0030.0230 | If the difference between the Measured Height indicated in the Reference Report and the altitude reported in the Pre-validated Position is greater than a configurable threshold, the ADS-B report shall be marked as "Suspicious for Altitude". | Y |
| | | 0030.0235 | If the difference between the Measured Height indicated in the Reference Report and the altitude reported in the Pre-validated Position is less than a configured threshold, the ADS-B report shall be marked as "Consistent for Altitude". | Y |
| | | 0030.0240 | The threshold values used for comparison described in requirements D09-0030.0230 and 0030.0235 should be configurable. | Y |
| 0030.0004 | If D19-0030.0003 is implemented, the ADS-B Ground Surveillance Domain shall be able to report the validation result in the ASTERIX CAT021 ADS-B report. | | Covered by requirement D09-0030.0320 | Y |
| 0030.0007 | The ADS-B Ground Surveillance Domain should be able to perform a cross check between data in ADS-B report received through 1090 ES and Mode S enhanced data in WAM reports. | 0030.0250 | If a Target State and Status Message is received, the 1090 GS WAM Integration function shall be able to perform the following checks: <ul style="list-style-type: none"> -Selected Altitude in the Pre-validated Status against the Selected Altitude in the Mode S MB Data in the Reference Report; -Barometric Pressure Settings in the Pre-validated Status against Barometric Pressure Settings in the Mode S MB Data in the Reference Report. | Y |
| | | 0030.0255 | If a Velocity Message with information about Airspeed and Heading (subtypes 3 and 4) is received, the 1090 GS WAM Integration function shall be able to perform the following comparisons: <ul style="list-style-type: none"> - True Airspeed in the Pre-validated Velocity Message | Y |

| REQ-15.04.05.a-D19- Req. ID | D19 Requirement | REQ-15.04.05.a-D09- Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|-----------------------------|-----------------|-----------------------------|---|---|
| | | | against the True Airspeed in the Reference Report; - Indicated airspeed in the Velocity Message against the Indicated Airspeed in the Reference Report; - Magnetic Heading in the Pre-validated Velocity Message against the Magnetic Heading in the Reference Report; - Barometric Vertical Rate in the Pre-validated Velocity Message against the Barometric Altitude Rate in the Reference Report. | |
| | | 0030.0260 | If a Velocity Message with information about Velocity Over Ground (subtypes 1 and 2) is received, the 1090 GS WAM Integration function shall be able to perform the following comparisons: -E/W Direction Bit, E/W Velocity, N/S Direction Bit, N/S Velocity in the Pre-validated velocity against True Track Angle and Ground Speed in the Reference Report; -Vertical Rate in the Pre-validated velocity Message against the Barometric Altitude Rate in the Reference Report. | Y |
| | | 0030.0265 | If a Surface Position Message is received, the 1090 GS WAM Integration function shall be able to perform the following comparisons: -Heading/Ground Track and Movement in the Pre-validated Surface against True Track Angle and Ground Speed in the Reference Report; -Heading/Ground Track in the Pre-validated Surface against Magnetic Heading in the Reference Report. | Y |
| | | 0030.0270 | The validation checks described in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 shall be performed only if the relevant Mode S Enhanced data | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|--|---|
| | | | are available in the WAM report. | |
| | | 0030.0275 | The validation checks described in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 shall be performed verifying that the difference between the current parameter value included in the Reference Report and the equivalent one reported in the Pre-validated Report is less than a configurable threshold. | Y |
| | | 0030.0280 | If at least one of the validation sub-checks reported in the requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 fails, the ADS-B report shall be marked as “Suspicious for Mode S Data”. | Y |
| | | 0030.0285 | If all validation sub-checks described in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 are positive, the ADS-B report shall be marked as “Consistent for Mode S Data”. | Y |
| | | 0030.0290 | If the 1090 GS WAM Integration function cannot perform any of the tests specified in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 due to the unavailability of Mode S Enhanced Data in the Reference Report, the ADS-B report shall be marked as “Suspicious for Mode S Data”. | Y |
| | | 0030.0295 | All the thresholds used for the comparisons specified in requirements D09-0030.0250, 0030.0255, 0030.0260, and 0030.0265 should be configurable offline. | Y |
| 0030.0008 | If D19-0030.0007 is implemented, the ADS-B Ground Surveillance Domain shall be able to report the validation result in the ASTERIX CAT021 ADS-B report | | Covered by requirement D09-0030.0320. | Y |
| 0030.0011 | The ADS-B Ground Surveillance Domain should be able to check the integrity of the velocity reported in ADS-B reports through the WAM data. | 0030.0300 | If a Velocity Message with information about Velocity Over Ground (subtypes 1 and 2) is received, the 1090 GS WAM Integration function shall be able to compare the Calculated Track Velocity in Cartesian Coordinates indicated in | Y |

| REQ-15.04.05.a-D19- Req. ID | D19 Requirement | REQ-15.04.05.a-D09- Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------------------|--|-----------------------------|--|---|----------------------|----------------------|--------------------|-----------------|------------|------------|------------|------------|----|---------------|---------------|---------------|---------------|----|------------|------------|------------|------------|----|---------------------------------|--|--|--|----|---|
| | | | the Reference Report with the velocity reported in the Pre-validated Velocity. | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 0030.0305 | If the difference between the Track Velocity indicated in the Reference Report and the Airspeed reported in the Pre-validated Position is greater than a configurable threshold, the ADS-B report shall be marked as “Suspicious for Velocity”. | Y | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 0030.0310 | If the difference between the Calculated Track Velocity indicated in the Reference Report and the Airspeed reported in the Pre-validated Position is less than a configured threshold, the ADS-B report shall be marked as “Consistent for Velocity”. | Y | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 0030.0315 | The threshold used for the comparisons specified in requirements D09-0030.0305 and 0310 should be configurable offline. | Y | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0030.0012 | If D19-0030.0011 is implemented, the ADS-B Ground Surveillance Domain shall be able to report the validation result in the ASTERIX CAT021 ADS-B report. | 0030.0320 | <p>The 1090 GS WAM Integration function shall be able to report the results of the checks specified in D09-0030.0300, 0305, and 0310 checks by means of the ATX021 report WAI bits as follows:</p> <table border="1" data-bbox="1032 938 1675 1121"> <thead> <tr> <th>Position test result</th> <th>Velocity Test result</th> <th>Altitude test result</th> <th>Mode S test result</th> <th>ATX021 WAI bits</th> </tr> </thead> <tbody> <tr> <td>Consistent</td> <td>Consistent</td> <td>Consistent</td> <td>Consistent</td> <td>00</td> </tr> <tr> <td>Not performed</td> <td>Not performed</td> <td>Not performed</td> <td>Not performed</td> <td>10</td> </tr> <tr> <td>Consistent</td> <td>Consistent</td> <td>Consistent</td> <td>Suspicious</td> <td>11</td> </tr> <tr> <td colspan="4">All other possible combinations</td> <td>01</td> </tr> </tbody> </table> <p>Note: the meaning of the WAI bits is the following: -00 the report is VALID -01 the report is NOT VALID -10 the report is NOT VALIDATED -11 the report is VALID EXCLUDING MODE S DATA</p> | Position test result | Velocity Test result | Altitude test result | Mode S test result | ATX021 WAI bits | Consistent | Consistent | Consistent | Consistent | 00 | Not performed | Not performed | Not performed | Not performed | 10 | Consistent | Consistent | Consistent | Suspicious | 11 | All other possible combinations | | | | 01 | Y |
| Position test result | Velocity Test result | Altitude test result | Mode S test result | ATX021 WAI bits | | | | | | | | | | | | | | | | | | | | | | | | | |
| Consistent | Consistent | Consistent | Consistent | 00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Not performed | Not performed | Not performed | Not performed | 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Consistent | Consistent | Consistent | Suspicious | 11 | | | | | | | | | | | | | | | | | | | | | | | | | |
| All other possible combinations | | | | 01 | | | | | | | | | | | | | | | | | | | | | | | | | |

B.3 Behavioural Analysis of Targets

The aim of this Iteration 2 enhancement [1] is to increase the robustness and integrity of 1090 GS target reports by introducing a number of consistency checks on different information items supplied by the ADS-B target. The consolidated result of these checks will be indicated in ATX021 reports through an indicator called BAR for "Behavioural Analysis Result", which shall replace the PVC indicator used in Iteration 1.

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|--|---|
| 0040.0080 | The ADS-B Ground Surveillance system should validate the track consistency evaluating track behaviour (values and changes of specific a/c attributes). <i>Note: Those specific attributes are: velocity, acceleration, heading, altitude, and vertical rate.</i> | | Velocity | |
| | | 0100.0010 | The 1090 GS Track Velocity Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0100.0020 | The 1090 GS Track Velocity Consistency verification function shall mark target messages as "Velocity Inconsistent", if the received velocity deviates from the valid range. | Y |
| | | 0100.0030 | The 1090 GS Track Consistency verification function shall mark target messages as "Velocity Consistent", if the received velocity is within the valid range. | Y |
| | | | Acceleration | |
| | | 0100.0040 | The 1090 GS Track Acceleration Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0100.0050 | The 1090 GS Track Acceleration Consistency verification function shall mark target messages as "Acceleration Inconsistent", if the received acceleration deviates from the valid range. | Y |
| | | 0100.0060 | The 1090 GS Track Acceleration Consistency verification function shall mark target messages as "Acceleration Consistent", if the received acceleration is within the valid range. | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|---|---|
| | | | Acceleration Change | |
| | | 0100.0070 | The 1090 GS Track Acceleration Change Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0100.0080 | The 1090 GS Track Acceleration Change Consistency verification function shall mark target messages as “Acceleration Change Inconsistent”, if the received acceleration change deviates from the valid range. | Y |
| | | 0100.0090 | The 1090 GS Track Acceleration Change Consistency verification function shall mark target messages as “Acceleration Change Consistent”, if the received acceleration change is within the valid range. | Y |
| | | | Heading | |
| | | 0100.0100 | The 1090 GS Track Heading Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0100.0110 | The 1090 GS Track Heading Consistency verification function shall mark target messages as “Heading Inconsistent”, if the received Heading deviates from the calculated value (out of predefined configurable range). | Y |
| | | 0100.0120 | The 1090 GS Track Heading Consistency verification function shall mark target messages as “Heading Consistent”, if the received Heading is within the valid range around calculated heading. | Y |
| | | | Heading Change | |
| | | 0100.0130 | The 1090 GS Track Heading Change Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0100.0140 | The 1090 GS Track Heading Change Consistency verification function shall mark target messages as “Heading Change Inconsistent”, if the received Heading change deviates from the valid range. | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|---|---|
| | | 0100.0150 | The 1090 GS Track Heading Change Consistency verification function shall mark target messages as “Heading Change Consistent”, if the received Heading change is within the valid range. | Y |
| | | | Altitude | |
| | | 0100.0160 | The 1090 GS Track Altitude Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0100.0170 | The 1090 GS Track Altitude Consistency verification function shall mark target messages as “Altitude Inconsistent”, if the received Altitude deviates from the valid value (out of predefined configurable range). | Y |
| | | 0100.0180 | The 1090 GS Track Altitude Consistency verification function shall mark target messages as “Altitude Consistent”, if the received Altitude is within the valid range of Altitude. | Y |
| | | | Altitude Change | |
| | | 0100.0190 | The 1090 GS Track Altitude Change Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0100.0200 | The 1090 GS Track Altitude Change Consistency verification function shall mark target messages as “Altitude Change Inconsistent”, if the received Altitude change deviates from the valid range. | Y |
| | | 0100.0210 | The 1090 GS Track Altitude Change Consistency verification function shall mark target messages as “Altitude Change Consistent”, if the received Altitude change is within the valid range. | Y |
| | | | Vertical Rate | |
| | | 0100.0220 | The 1090 GS Track Vertical Rate Consistency verification function should be activated/ deactivated via a configurable parameter. | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability | |
|----------------------------|---|-----------------------------|--|---|--|
| | | 0100.0230 | The 1090 GS Track Vertical Rate Consistency verification function shall mark target messages as “Vertical Rate Inconsistent”, if the received Vertical Rate deviates from the valid value (out of predefined configurable range). | Y | |
| | | 0100.0240 | The 1090 GS Track Vertical Rate Consistency verification function shall mark target messages as “Vertical Rate Consistent”, if the received Vertical Rate is within the valid range of Vertical Rate. | Y | |
| | | Vertical Rate Change | | | |
| | | 0100.0250 | The 1090 GS Track Vertical Rate Change Consistency verification function should be activated/ deactivated via a configurable parameter. | Y | |
| | | 0100.0260 | The 1090 GS Track Vertical Rate Change Consistency verification function shall mark target messages as “Vertical Rate Change Inconsistent”, if the received Vertical Rate change deviates from the valid range. | Y | |
| | | 0100.0270 | The 1090 GS Track Vertical Rate Change Consistency verification function shall mark target messages as “Vertical Rate Change Consistent”, if the received Vertical Rate change is within the valid range. | Y | |
| 0040.0082 | The ADS-B Ground Surveillance system should have a set of configurable ranges for each attribute behaviour to be verified based on “ADS-B Emitter Category SET” Code Definitions. <i>Note: Those specific attributes are: velocity, vertical rate, altitude, acceleration, and heading.</i> | Velocity | | | |
| | | 0100.0280 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Velocity Consistency verification function shall verify track velocity consistency by comparing the velocity value reported by that target against the valid velocity range for each “ADS-B Emitter Category SET” Code independently. | Y | |
| | | | Acceleration | | |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|---|
| | | 0100.0290 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Acceleration Consistency verification function shall verify track Acceleration consistency by comparing the acceleration value (calculated from the last two velocity values) against the valid acceleration range for each “ADS-B Emitter Category SET” Code independently. | Y |
| | | | Acceleration Change | |
| | | 0100.0300 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Acceleration Change Consistency verification function shall verify track Acceleration Change consistency by comparing the acceleration change (calculated from the last two calculated acceleration values) against the valid acceleration change range for each “ADS-B Emitter Category SET” Code independently. | Y |
| | | | Heading | |
| | | 0100.0310 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Heading Consistency verification function shall verify track Heading consistency by comparing the Heading value (received from a/c) against the calculated Heading (calculated from the last two position values) for each “ADS-B Emitter Category SET” Code independently. | Y |
| | | | Heading Change | |
| | | 0100.0320 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Heading Change Consistency verification function shall verify track Heading Change consistency by comparing the Heading change (calculated from the last two calculated Heading values) against the valid Heading change range for each “ADS-B Emitter Category SET” Code independently. | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|---|---|
| | | | Altitude | |
| | | 0100.0330 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Altitude Consistency verification function shall verify track Altitude consistency by comparing the Altitude value (received from a/c) against the valid Altitude range for each “ADS-B Emitter Category SET” Code independently. | Y |
| | | | Altitude Change | |
| | | 0100.0340 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Altitude Change Consistency verification function shall verify track Altitude Change consistency by comparing the Altitude change (calculated from the last two Altitude values) against the valid Altitude change range for each “ADS-B Emitter Category SET” Code independently. | Y |
| | | | Vertical Rate | |
| 0100.0350 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Vertical Rate Consistency verification function shall verify track Vertical Rate consistency by comparing the Vertical Rate value (received from a/c) against the valid Vertical Rate range for each “ADS-B Emitter Category SET” Code independently. | Y | | |
| | Vertical Rate Change | | | |
| 0100.0360 | For each incoming 1090 ES message from any target in “data maintenance mode”, the 1090 GS Track Vertical Rate Change Consistency verification function shall verify track Vertical Rate Change consistency by comparing the Vertical Rate change (calculated from the last two Vertical Rate values) against the valid Vertical Rate change range for each “ADS-B Emitter Category SET” Code independently. | Y | | |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|--|---|
| 0040.0084 | Based on received "ADS-B Emitter Category SET" Code Definitions, the ADS-B Ground Surveillance system should verify the track behaviour against predefined valid configurable attribute ranges for each item independently. <i>Note: Those specific attributes are: velocity, vertical rate, altitude, acceleration, and heading.</i> | | Velocity | |
| | | 0100.0370 | The preset velocity range used by the 1090 GS Track Velocity Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y |
| | | | Acceleration | |
| | | 0100.0380 | The preset Acceleration range used by the 1090 GS Track Acceleration Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y |
| | | | Acceleration Change | |
| | | 0100.0390 | The preset Acceleration Change range used by the 1090 GS Track Acceleration Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y |
| | | | Heading | |
| | | 0100.0400 | The preset Heading range used by the 1090 GS Track Heading Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y |
| | | | Heading Change | |
| 0100.0410 | The preset Heading Change range used by the 1090 GS Track Heading Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y | | |
| | Altitude | | | |
| 0100.0420 | The preset Altitude range used by the 1090 GS Track Altitude Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y | | |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|--|---|
| | | | Altitude Change | |
| | | 0100.0430 | The preset Altitude Change range used by the 1090 GS Track Altitude Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y |
| | | | Vertical Rate | |
| | | 0100.0440 | The preset Vertical Rate range used by the 1090 GS Track Vertical Rate Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y |
| | | | Vertical Rate Change | |
| | | 0100.0450 | The preset Vertical Rate Change range used by the 1090 GS Track Vertical Rate Change Consistency verification function shall be configurable for each Code independently based on received "ADS-B Emitter Category SET" Code Definitions. | Y |
| | | | Velocity | |
| 0040.0086 | The ADS-B Ground Surveillance system should issue the corresponding ATX021 report with the PVC bits set to adequate values based on the overall result of Track Consistency verification function. <i>Note: Track Consistency verification includes:</i> 1. <i>velocity versus position change (Iteration 1), and</i> 2. <i>track consistency evaluating track behaviour (velocity, vertical rate, altitude, acceleration, and heading) (Iteration 2)</i> | 0100.0460 | While the Track Velocity Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Velocity internal indicator to 10 (=not validated for velocity value). | Y |
| | | 0100.0470 | For each target marked by the Track Velocity Consistency verification function as "Velocity Inconsistent", the 1090 GS system shall set the specific BAR Velocity internal indicator to 01. | Y ¹¹ |
| | | 0100.0480 | For each target marked by the Track Velocity Consistency verification function as "Velocity Consistent", the 1090 GS system shall set the specific BAR Velocity internal indicator to 00. | Y |

¹¹ BAR, standing for "Behavioural Analysis Result", is a consolidated indication used in ATX021 reports for Iteration 2 and 3, replacing the PVC flag used in Iteration 1.

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|---|---|
| | | | Acceleration | |
| | | 0100.0490 | While the Track Acceleration Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Acceleration internal indicator to 10 (=not validated for Acceleration value). | Y |
| | | 0100.0500 | For each target marked by the Track Acceleration Consistency verification function as “Acceleration Inconsistent”, the 1090 GS system shall set the specific BAR Acceleration internal indicator to 01. | Y |
| | | 0100.0510 | For each target marked by the Track Acceleration Consistency verification function as “Acceleration Consistent”, the 1090 GS system shall set the specific BAR Acceleration internal indicator to 00. | Y |
| | | | Acceleration Change | |
| | | 0100.0520 | While the Track Acceleration Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Acceleration Change internal indicator to 10 (=not validated for Acceleration Change value). | Y |
| | | 0100.0530 | For each target marked by the Track Acceleration Change Consistency verification function as “Acceleration Change Inconsistent”, the 1090 GS system shall set the specific BAR Acceleration Change internal indicator to 01. | Y |
| | | 0100.0540 | For each target marked by the Track Acceleration Change Consistency verification function as “Acceleration Change Consistent”, the 1090 GS system shall set the specific BAR Acceleration Change internal indicator to 00. | Y |
| | | | Heading | |
| | | 0100.0550 | While the Track Heading Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Heading internal indicator to 10 (=not validated for Track Heading value). | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|---|
| | | 0100.0560 | For each target marked by the Track Heading Consistency verification function as "Heading Inconsistent", the 1090 GS system shall set the specific BAR Heading internal indicator to 01. | Y |
| | | 0100.0570 | For each target marked by the Track Heading Consistency verification function as "Heading Consistent", the 1090 GS system shall set the specific BAR Heading internal indicator to 00. | Y |
| | | Heading Change | | |
| | | 0100.0580 | While the Track Heading Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Heading Change internal indicator to 10 (=not validated for Heading Change value). | Y |
| | | 0100.0590 | For each target marked by the Track Heading Change Consistency verification function as "Heading Change Inconsistent", the 1090 GS system shall set the specific BAR Heading Change internal indicator to 01. | Y |
| | | 0100.0600 | For each target marked by the Track Heading Change Consistency verification function as "Heading Change Consistent", the 1090 GS system shall set the specific BAR Heading Change internal indicator to 00. | Y |
| | | Altitude | | |
| | | 0100.0610 | While the Track Altitude Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Altitude internal indicator to 10 (=not validated for Altitude value). | Y |
| | | 0100.0620 | For each target marked by the Track Altitude Consistency verification function as "Altitude Inconsistent", the 1090 GS system shall set the specific BAR Altitude internal indicator to 01. | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|---|---|
| | | 0100.0630 | For each target marked by the Track Altitude Consistency verification function as "Altitude Consistent", the 1090 GS system shall set the specific BAR Altitude internal indicator to 00. | Y |
| | | | Altitude Change | |
| | | 0100.0640 | While the Track Altitude Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Altitude Change internal indicator to 10 (=not validated for Altitude Change value). | Y |
| | | 0100.0650 | For each target marked by the Track Altitude Change Consistency verification function as "Altitude Change Inconsistent", the 1090 GS system shall set the specific BAR Altitude Change internal indicator to 01. | Y |
| | | 0100.0660 | For each target marked by the Track Altitude Change Consistency verification function as "Altitude Change Consistent", the 1090 GS system shall set the specific BAR Altitude Change internal indicator to 00. | Y |
| | | | Vertical Rate | |
| | | 0100.0670 | While the Track Vertical Rate Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Vertical Rate internal indicator to 10 (=not validated for Vertical Rate value). | Y |
| | | 0100.0680 | For each target marked by the Track Vertical Rate Consistency verification function as "Vertical Rate Inconsistent", the 1090 GS system shall set the specific BAR Vertical Rate internal indicator to 01. | Y |
| | | 0100.0690 | For each target marked by the Track Vertical Rate Consistency verification function as "Vertical Rate Consistent", the 1090 GS system shall set the specific BAR Vertical Rate internal indicator to 00. | Y |
| | | | Vertical Rate Change | |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|--|
| | | 0100.0700 | While the Track Vertical Rate Change Consistency verification function is deactivated, the 1090 GS shall set the specific BAR Vertical Rate Change internal indicator to 10 (=not validated for Vertical Rate Change value). | Y |
| | | 0100.0710 | For each target marked by the Track Vertical Rate Change Consistency verification function as “Vertical Rate Change Inconsistent”, the 1090 GS system shall set the specific BAR Vertical Rate Change internal indicator to 01. | Y |
| | | 0100.0720 | For each target marked by the Track Vertical Rate Change Consistency verification function as “Vertical Rate Change Consistent”, the 1090 GS system shall set the specific BAR Vertical Rate Change internal indicator to 00. | Y |
| | | | General / Consolidated BAR | |
| | | 0100.0730 | Behavioural Analysis results shall be reported in the corresponding ATX021 report through a consolidated BAR indicator whose value is derived from the values of the specific BAR internal indicators plus the PVC internal indicator (“Position Change versus Velocity” from Iteration 1, see req. D05-0070.0020) as follows: <ul style="list-style-type: none"> ▪ BAR=10 (“Behaviour Not Validated”), if all the specific internal BAR and PVC indicators have been set to 10; ▪ BAR=01 (“Behaviour Not Valid”), if any of the specific internal BAR or PVC indicators has been set to 01; ▪ BAR=00 (“Behaviour Valid”), if all of the specific internal BAR and PVC indicators have been set to 00; ▪ BAR=11 (“Behaviour Valid only for a test subset”), in all other cases. | a. No indication is provided about which tests have been performed when BAR=11. This issue should be investigated further in Iteration 3. b. Replaces req. D05-0070.0015, 0070.0030, and 0070.0040. |

B.4 Time Differential of Arrival

In accordance with D19 [1] the Time Differential of Arrival (TDOA) validation function will allow validation of the ADS-B (3D) position information derived by the 1090 GS from 1090 ES messages using a reference measurement based on a hyperboloid reconstructed from the arrival time differences of the same 1090 ES message at two receiving functions in different locations.

This TDOA validation function requires either multiple receiver functions per 1090 GS in separate locations, or multiple 1090 GS operating in cluster configuration.

The TDOA Validation function will declare the ADS-B position validated if the distance between the 3D ADS-B position and the Reference Measurement is below a configurable threshold.

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|---|---|
| 0040.0040 | The ADS-B Ground Surveillance Domain should be able to calculate for each received ADS-B position message the relative TDOA. | 0120.0010 | The 1090 GS TDOA validation function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0120.0030 | The 1090 GS TDOA validation function shall be able to process a number ($n \geq 2$) of TOA (one TOA per 1090 GS in the cluster or 1090 GS receiving function) for each 1090 ES position message received from the same target. | Y |
| | | 0120.0040 | The 1090 GS TDOA validation function shall be able to generate the Time Differential Of Arrival (TDOA) hyperboloid from the TOAs associated with the same 1090 ES position message per req. D09-0120.0030. | Y |
| 0040.0042 | The ADS-B Ground Surveillance Domain should be able to process the TDOA in order to validate the position information extracted from the position message | 0120.0050 | The 1090 GS TDOA validation function shall validate the ADS-B 3D position information derived from each 1090 ES message using as reference the TDOA hyperboloid generated per req. D09-0120.0040. | Y |
| | | 0120.0060 | The ADS-B position shall be considered "VALID" if the distance between the ADS-B 3D position and the corresponding TDOA hyperboloid is below a threshold. | Y |
| | | 0120.0070 | The TDOA validation threshold should be configurable. | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|---|---|
| 0040.0044 | The ADS-B Ground Surveillance Domain should be able to report the validation result in the ASTERIX CAT021 ADS-B report | 0120.0080 | In case the TDOA validation provides a positive result the 1090 GS shall mark the corresponding ATX021 report as "TDOA Valid". | Y |
| | | 0120.0090 | In case the TDOA validation provides a negative result the 1090 GS shall mark the corresponding ATX021 report as "TDOA Not Valid". | Y |
| | | 0120.0100 | While the TDOA validation function is deactivated, the 1090 GS shall mark any issued ATX021 reports as "TDOA Not Validated". | Y |

B.5 Civil/Military Interoperability

No specific civil/military interoperability requirements were identified in ref. [2]. It is noted that ED-129 includes the decoding of DF=19 squitters with AF=0 per ED129_REQ_79.

B.6 Network Bandwidth Optimisation

In accordance with ref [2] the Ground System Domain (and hence the 1090 GS) should be able to adapt its ADS-B report transmission rates and their data content in line with actual network capacity in order to prevent network overloads.

ASSUMPTIONS:

- The 1090 GS is considered a network host.
- The term **Mitigation** indicates a network overload mitigation function that can be applied in the 1090 GS (e.g. omission of optional ATX021 items, update rate reduction, geographical filtering etc).
- Each ADS-B Service is associated with a service volume (defined as the airspace volume enclosed by a maximum and minimum flight level and a maximum and a minimum range). The 1090 GS generates ATX021 reports only for targets within the service volume (per ADS-B service).
- A network overload **Mitigation Strategy** is defined as a set of configured **Mitigations**.

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|---|---|
| 0000.0030 | The ADS-B Ground Surveillance Domain should have the capability to monitor the load of the network. | 0090.0010 | The 1090 GS should include a Network Bandwidth Optimization function that is activated / deactivated via a configurable parameter over the 1090 GS external CMI | Y |
| | | 0090.0020 | If the Network Bandwidth Optimization function is activated, the 1090 GS shall be able to determine its actual network load, possibly through indications supplied via SNMP by an external provider (e.g. router, switch, etc.), at a frequency configurable over the 1090 GS external CMI | Y |
| 0000.0032 | The ADS-B Ground Surveillance Domain should have the capability to detect the overload of the network. | 0090.0110 | The 1090 GS Network Bandwidth Optimization function should support multiple Degradation Levels in increasing order of severity (ranging from normal condition to most severe degradation), where each Degradation Level is associated with a distinct Mitigation Strategy | Y |
| | | 0090.0120 | Each 1090 GS Degradation Level shall be associated with a parameter indicating the Threshold to consider as overload of the current network level, and configurable over the 1090 GS external CMI. | Y |
| | | 0090.0130 | If the Network Bandwidth Optimization function is activated, the 1090 GS shall compare the actual network load with the Threshold specified in D09-0090.0120 to detect network overloads. | Y |
| | | 0090.0140 | The 1090 GS should have a mechanism to prevent switching up and down its current Degradation Level due to transient network load peaks. | Y |
| 0000.0034 | The ADS-B Ground Surveillance Domain should have the capability to automatically reduce the load of the network in case of a detected overload, switching to | 0090.0210 | If the Network Bandwidth Optimization function is activated, and an overload is detected, then the 1090 GS shall switch to the next more severe Degradation Level | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|---|---|
| | the next level down of degraded data mode. | | | |
| 0000.0036 | The ADS-B Ground Surveillance Domain should have the capability to automatically switch back to the next level up of degraded mode or to the normal mode related to the load of the network in the case the detected network load has improved and passed a threshold over a configurable period of time. | 0090.0310 | If the Network Bandwidth Optimization function is activated, and a recovery from an overload is detected, then the 1090 GS shall switch to the next less severe Degradation Level. | Y |
| 0000.0038 | The ADS-B Ground Surveillance Domain should have degraded data mode that could imply: <ul style="list-style-type: none"> omission of optional items (several subsets could be configured); reduced data update rate; geographical filtering | 0090.0410 | The 1090 GS shall be able to support one or more of the following Mitigation functions: <ul style="list-style-type: none"> Omission of Optional Items Reduced Data Update Rate Geographical Filtering | Y |
| | | | Omission of Optional Items | |
| | | 0090.0420 | The Omission of Optional Items Mitigation function should be activated and deactivated via configurable parameter over the external 1090 GS CMI. | Y |
| | | 0090.0430 | Each optional item in ATX021 reports should be selectable as a separate Mitigation via a parameter configurable over the 1090 GS external CMI. | Y |
| | | 0090.0435 | If an optional ATX021 item has been enabled as a Mitigation, the 1090 GS shall not include it in ATX021 reports | Y |
| | | | Reduced Data Update Rate | |
| | | 0090.0440 | The Reduced Data Update Rate Mitigation should be activated / deactivated via a configurable parameter over the | Y |

| REQ-15.04.05.a-D19- Req. ID | D19 Requirement | REQ-15.04.05.a-D09- Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|-----------------------------|-----------------|-----------------------------|--|---|
| | | | 1090 GS external CMI | |
| | | 0090.0447 | If the Reduced Data Update Rate Mitigation is enabled, the 1090 GS shall transmit ATX021 reports with a period of x+0.5 seconds, where x is value within the range 0 to 14.5 seconds (in 0.5 steps) configurable over the 1090 GS external CMI. | Y ¹² |
| | | | Geographic Filtering | |
| | | 0090.0450 | The Geographical Filtering Mitigation should be activated / deactivated via a parameter configurable over the 1090 GS external CMI. | Y |
| | | 0090.0460 | If the Geographical Filtering Mitigation is enabled, then the 1090 GS shall implement a Coverage Volume filter (possibly separate per ADS-B Service) consisting of one or more of the following parameters (all configurable over the 1090 GS external CMI): <ul style="list-style-type: none"> ▪ Maximum Flight Level ▪ Minimum Flight Level ▪ Maximum Range ▪ Minimum Range | Y |
| | | 0090.0470 | The Coverage Volume Filter should be activated/deactivated via a parameter configurable over the 1090 GS external CMI. | Y |
| | | 0090.0480 | If the target flight level is greater than the Maximum Flight Level, then the 1090 GS shall not transmit ATX021 reports for this target. | Y |
| | | 0090.0485 | If the target flight level is less than the Minimum Flight | Y |

¹² See also ED129_REQ_100

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|---|
| | | | Level, then the 1090 GS shall not transmit ATX021 reports for this target. | |
| | | 0090.0490 | If the target range is greater than the Maximum Range, then the 1090 GS shall not transmit ATX021 reports for this target. | Y |
| | | 0090.0495 | If the target range is less than the Minimum Range, then the 1090 GS shall not transmit ATX021 reports for this target. | Y |
| | | 0090.0510 | If the Geographic Filtering Mitigation function is enabled, the 1090 GS shall be able to support the following additional Mitigations (activated/deactivated via the external 1090 GS CMI) <ul style="list-style-type: none"> - Increase Minimum Flight Level (D09-0090.0540) - Decrease Maximum Flight Level (D09-0090.0520) - Increase Minimum Range (D09-0090.0580) - Decrease Minimum Range (D09-0090.0560) | Y |
| | | 0090.0520 | If the Decrease Maximum Flight Level Mitigation is enabled, then the 1090 GS shall decrease the configured Maximum Flight Level by a parameter configurable over the 1090 GS external CMI. | Y |
| | | 0090.0540 | If the Increase Minimum Flight Level Mitigation is enabled, then the 1090 GS shall increase the configured Minimum Flight Level by a parameter configurable over the 1090 GS external CMI. | Y |
| | | 0090.0560 | If the Decrease Maximum Range Mitigation is enabled, then the 1090 GS shall decrease the configured Maximum Range by a parameter configurable over the 1090 GS external CMI. | Y |

| REQ-15.04.05.a-D19-Req. ID | D19 Requirement | REQ-15.04.05.a-D09-Req. ID | GS Requirement for 2 nd Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|---|---|
| | | 0090.0580 | If the Increase Minimum Range Mitigation is enabled, then the 1090 GS shall increase the configured Minimum Range by a parameter configurable over the 1090 GS external CMI. | Y |
| 0000.0040 | The ADS-B Ground Surveillance Domain should have a configurable adaptation strategy (including parameters and switching decisions). | 0090.0610 | The 1090 GS should support configurable Mitigation Strategies per degradation level and ADS-B Service. | Y |
| | | 0090.0615 | 1090 GS Mitigation Strategies shall consist of one or more of the Mitigations specified in requirements D09-0090.0410, 0090.0460 and 0090.0510. | Y |
| | | 0090.0620 | If the Network Bandwidth Optimization function is activated, the 1090 GS shall apply all the configured Mitigation Strategies up to and including the one assigned to the current Degradation Level (i.e. If Degradation Level=3, then Mitigation Strategies 1, 2 & 3 will apply). | Y |
| 0000.0042 | The ADS-B Ground Surveillance Domain should have means to indicate to external users the currently used mode level (normal, or level of degradation). | 0090.0710 | The 1090 GS should be able to indicate its current Degradation Level on its external CMI, using the value "0" for normal operation (=no degradation), and otherwise a positive integer corresponding to the current Degradation Level. | Y |
| | | 0090.0720 | The 1090 GS shall indicate periodically (and on an event driven basis in case of change) its currently applied Degradation Level on ATX023 reports, with a period configurable over its external CMI. | Y |

Appendix C Traceability of Iteration 1 Requirements

This Appendix lists the 1090 GS requirements from the Iteration 1 baseline documents [19] and [23] and indicates their applicability to Iteration 3.

Only those Iteration 1 requirements marked as applicable to Iteration 3 have been included in Sec. 3.

C.1 ADS-B RAD Compliance

| REQ-15.04.05.a -D18- Req. ID | D18 Requirement | REQ-15.04.05.a -D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|------------------------------------|--|------------------------------------|---|---|
| 0010.0001 | The "Ground ADS-B Receive" function shall receive ADS-B messages, decode, package and time-stamp the data, and send ADS-B Surveillance Reports to the ATC Processing System, i.e., the "Ground ADS-B Processing" function. | 0010.0010 | The 1090 GS shall be able to receive ADS-B messages over 1090 ES in accordance with the ED-129 provisions listed in Appendix E augmented with the DO-260B compliance requirements stated in this specification. | Y ¹³ |
| | | 0010.0020 | The 1090 GS shall decode data from 1090 ES ADS-B messages in accordance with the provisions in ED-129 augmented with the enhancements for DO-260B compliance stated in this specification. | Y ¹³ |
| | | 0010.0030 | The 1090 GS shall associate the 1090 ES data with a target per the provisions in ED-129 and the enhancements specified in this document. | Y |
| | | 0010.0040 | The 1090 GS shall apply mandatory squitter decoding validation checks according to ED-129 and the additional validation checks specified in this document. | Y |

¹³ Overlap with D09 requirements 0080.0010, 0080.0020, and 0080.0030.

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|--|---|
| | | 0010.0050 | If the validation tests are passed, the 1090 GS shall package and timestamp the decoded data into a target report in ATX021 form in accordance with ED-129 provisions and the enhancements specified in this document | Y |
| | | 0010.0060 | The 1090 GS shall compile ATX021 reports (per the provisions in ref. [17]) for targets within its (configurable) coverage volume and forward them to client systems over a data network. | Y ¹³ |
| 0010.0002 | <p>The “Ground ADS-B Receive” function shall provide the following minimum data set to the ATC Processing system:</p> <ul style="list-style-type: none"> • Aircraft Horizontal Position – Latitude and Longitude (OR 1 §A.7); • Pressure altitude (OR 1 §A.7); • Quality Indications of Horizontal Position (OR 4 §A.7); • Aircraft Identity (OR 1 §A.7); Emergency Indicators (OR 1 §A.7); • Special Position Identification (SPI) (OR 1 §A.7); • Time of Applicability (PR 30 §B.4.5.2). <p>NOTE: Emergency Indicators and SPI are provided only when selected by the flight crew.</p> | 0010.0070 | <p>The 1090 GS shall report the following minimum data set per target report to the ATC Processing system:</p> <ul style="list-style-type: none"> ▪ Aircraft Horizontal Position – Latitude and Longitude); ▪ Pressure altitude; ▪ Quality Indications of Horizontal Position; ▪ Aircraft Identity (a/c identification and Mode A code); ▪ Emergency Indicators; ▪ Special Position Identification (SPI); ▪ Time of Applicability. <p>NOTES: 1. Emergency Indicators and SPI are provided only when selected by the flight crew. 2. 24 bit address is included as mandatory ATX021 field</p> | Y ¹⁴ |
| 0010.0003 | When direct recognition procedures are used by the | | Covered by REQ-15.04.05.a-D05-0010.0070 | Y ¹⁵ |

¹⁴ Together with D09-0080.0010 satisfies also D19-0012.0004 for ED-163 compliance.

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|--|---|
| | ATCO for identification, the ADS-B Ground Domain shall contain a function to ensure the aircraft identity data that is broadcast is retained and correctly associated with the position information for display, (OR 5§A.5.6.2.4, §A.7). | | | |
| 0010.0004 | The "Ground ADS-B Receive" function shall provide in each ADS-B surveillance report a time of applicability (Interface E2) of the position information, (PR 30 §B.4.5). | 0010.0080 | The 1090 GS shall provide in each target report a time of applicability of the position information. | Y |
| 0010.0005 | If the time of applicability within each ADS-B surveillance report is not applicable for all data items of that report (interface E2), the "Ground ADS-B Receive" function shall provide separate times of applicability for the specific data items that differ, | 0010.0090 | The 1090 GS shall provide separate times of applicability for any specific data items, who's TOA differs from that of the position ¹⁶ . | Y |
| 0010.0006 | The "Ground ADS-B Surveillance Processing" function shall time-register the asynchronously received ADS-B position updates from ADS-B-equipped aircraft (OPA-ASSUMP.07 §B.2.2). | | Covered by REQ-15.04.05.a-D05-0010.0080 | Y |
| 0020.0001 | The likelihood of an ADS-B Ground Domain system integrity failure shall be 2E-05 or less per hour | 0010.0100 | The probability of a 1090 GS integrity failure in a RAD airspace shall be 1E-05 or less per hour. | Y |
| 0020.0002 | The likelihood of a "Ground ADS-B Receive" function continuity failure shall be 1E-05 or less per hour | 0010.0110 | The probability of a 1090 GS continuity failure shall be 1E-05 or less per hour. | Y |
| 0020.0003 | The 95% latency for ADS-B surveillance reports (measured between points D and E2 – output of the "Ground ADS-B Receive" function) shall be no greater than 0.5 seconds, excluding communication latency to the ATC processing system. Note: It is assumed that all latency on the "Ground ADS-B Receive" function is compensated. | 0010.0120 | The 95% latency for ADS-B surveillance reports at the output of the 1090 GS in a RAD airspace shall be no greater than 0.5 seconds, measured from 1090 ES message reception to the transmission of the corresponding target report by the 1090 GS | Y |
| 0020.0004 | The time of applicability conveyed in the ADS-B surveillance report shall have an absolute accuracy relative to | 0010.0130 | The time of applicability conveyed in the 1090 GS reports shall have an absolute ac- | Y |

¹⁵ Overlap also with D09-0080.0010.

¹⁶ ATX021 must provide appropriate fields.

| REQ-15.04.05.a -D18- Req. ID | D18 Requirement | REQ-15.04.05.a -D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|------------------------------------|--|------------------------------------|--|---|
| | UTC of ± 0.1 seconds or less | | accuracy relative to UTC of ± 0.1 seconds or less. | |
| 0020.0005 | The ADS-B Ground Domain shall not introduce any additional horizontal position error greater than that which might otherwise be introduced by a linear extrapolation using the instantaneous velocity for the target. Note: Linear extrapolation assumes uniform motion is continued along the latest velocity estimate to the time of synchronization. Consequently, additional errors will be introduced into the extrapolated position by uncertainties in the velocity estimate and aircraft accelerations that occur during the extrapolation period | | N/A ¹⁷ . | N/A |
| 0020.0006 | The ADS-B Ground Domain (including data link) shall not degrade altitude resolution to worse than 100 feet. | | N/A ¹⁸ | N/A |
| 0020.0007 | The ADS-B Ground Domain shall have capacity to handle the reports from the maximum load of aircraft in the environment as described in the OSED without degradation. | 0010.0140 | The 1090 GS shall have the capacity to handle the reports from all ADS-B targets in the worst case environment as described in Appendix F without degradation. | Y |
| 0020.0008 | The probability that the ADS-B Ground Domain detects a loss of ADS-B position, and provides an indication of such to the existing ATC Processing System shall be at least 99.99%. Notes: 1. Alternatively, the requirement might be fulfilled by the existing ATC Processing System, i.e., beyond interface F2*. 2. This requirement, taken together with ASSUMP 44, will ensure that the appropriate safety objectives are met. | | N/A for iteration 1 and 2 | N/A |
| 0020.0009 | The probability that the ADS-B Ground Domain detects a loss of ADS-B-reported altitude, and provides an indica- | | N/A for iteration 1 and 2 | N/A |

¹⁷ SDPS requirement.4¹⁸ requirement on ATX021

| REQ-15.04.05.a -D18- Req. ID | D18 Requirement | REQ-15.04.05.a -D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|------------------------------------|--|------------------------------------|--|---|
| | tion of such to the existing ATC Processing System shall be at least 99%. Notes: 1. Alternatively, the requirement might be fulfilled by the existing ATC Processing System, i.e., beyond interface F2*. 2. This requirement, taken together with ASSUMP 46, will ensure that the appropriate safety objectives are met | | | |
| 0020.0013 | The probability that the ADS-B Ground Domain detects duplicate ADS-B Aircraft Identities (i.e., discrete Mode A or aircraft identification) within the same sector), and provides an indication of such to the existing ATC Processing System shall be at least 99%. | 0010.0150 | The 1090 GS shall be able to detect and report duplicate 24-bit addresses within the same reception coverage area with a probability of 99%. | Y |
| 0020.0017 | The probability of providing a Surveillance Report containing newly received ADS-B Position data of sufficient quality associated with any aircraft in En Route airspace within 8 seconds shall be 97%. | 0010.0160 | The 1090 GS shall be able to provide a target report containing ADS-B Position data associated with any aircraft in En Route airspace and received from the a/c within the last 8 seconds with a probability of 97% | Y |
| 0020.0018 | The time interval between a change of Mode A code provided by the ADS-B aircraft domain and an ADS-B surveillance report containing the new Mode A code at interface E2 shall be no longer than 8 seconds (95%) En Route | 0010.0170 | The 1090 GS shall be able to detect a change of Mode A code provided by the ADS-B aircraft domain, and include it in a target report within no longer than 8 seconds, with a probability of 95% En Route ¹⁹ . | Y ¹⁹ |
| 0020.0019 | The time interval between a change of emergency and SPI information provided by the ADS-B aircraft domain and an ADS-B surveillance report containing the new emergency and SPI information at interface E2 shall be no longer than 8 seconds (95%) En Route. | 0010.0180 | The 1090 GS shall be able to detect a change of emergency and SPI information provided by the ADS-B aircraft domain, and include it in a target report within no longer than 8 seconds, with a probability of 95% En Route ¹⁹ . | Y ¹⁹ |
| 0020.0021 | The probability of providing a Surveillance Report containing newly received ADS-B Position data of sufficient quali- | 0010.0190 | The 1090 GS shall be able to provide a target report containing ADS-B Position data | Y ¹⁹ |

¹⁹ Data driven mode is assumed.

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| REQ-15.04.05.a -D18- Req. ID | D18 Requirement | REQ-15.04.05.a -D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|------------------------------------|--|------------------------------------|---|---|
| | ty associated with any aircraft in TMA airspace within 5 seconds shall be 97%. Notes: 1. Additional requirements are subject to local implementation. Other considerations may apply (see OSA: C.5.1.5 - "Loss of track information"). 2. Data continuity for a single aircraft is inherently encompassed by the requirements for position update, i.e. in terms of the number of consecutive misses of receiving a position update ultimately leading to a track drop. The required position update probability takes account of normal environmental factors that are experienced during this flight phase, such as coverage variations in received signals (including received satellite signals), that affect the production and receipt of ADS-B positions of sufficient quality on a single aircraft basis. Multiple aircraft data continuity is addressed in ASSUMP 24 | | associated with any aircraft in TMA airspace and received from the a/c within the last 5 seconds and with probability 97% ¹⁹ . | |
| 0020.0022 | The time interval between a change of Mode A code provided by the ADS-B aircraft domain and an ADS-B surveillance report containing the new Mode A code at point E2 shall be no longer than 5 seconds (95%) TMA. | 0010.0200 | The 1090 GS shall detect a change of Mode A within a time interval of 5 seconds with probability 95% in TMA. | Y |
| 0020.0023 | The time interval between a change of emergency and SPI information provided by the ADS-B aircraft domain and an ADS-B surveillance report containing the new emergency and SPI information at point E2 shall be no longer than 5 seconds (95%) TMA. | 0010.0210 | The 1090 GS shall detect a change of Emergency and SPI information within a time interval of 5 seconds with a probability of 95% in TMA ¹⁹ . | Y ¹⁹ |
| 0020.0024 | For TMA, if the position accuracy quality indicator (NACp) is not received within 15 seconds of a position message, then the ADS-B Ground Domain shall determine the position accuracy requirement has been met using a NIC encoding that corresponds to 513 meters (or less) as a sub- | | N/A ²⁰ | N/A |

²⁰ Allocated to SDPS

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|--|---|
| | stitute for the NACp requirement. Note: Alternatively, the requirement might be fulfilled by the existing ATC Processing System, i.e., beyond interface F2*. | | | |

C.2 1090 ES Technology

Compliance to DO-260B imposes the following requirements on the 1090 GS in addition to those defined in ED-129 [11] (which addresses only DO-260/DO-260A equipped airborne targets).

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|--|---|
| 0060.0060 | The ADS-B Surveillance System shall be capable to receive the message over 1090 ES in accordance with the introduced changes in the DO-260B standard. | | Covered by REQ-15.04.05.a-D05-0010.0010 | Y |
| 0060.0061 | The ADS-B Surveillance System shall be capable to decode the ADS-B message, in order to extract the available information, in accordance with the introduced changes in the DO-260B standard. | 0020.0010 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall ignore the "OPERATIONAL MODE (OM)" Subfield in Aircraft Operational Status Messages. NOTE: Subfield reserved for Receiving ATC Services | Y |

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|---|
| | | 0020.0030 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “Reserved Bit-A” subfield. NOTE: Based on Proposed RTCA DO-260B/EUROCAE ED-102A Provisions for Backward Compatibility. | Y |
| | | 0020.0040 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “TCAS Operational” subfield. NOTE: Replaces POA = “Position Offset Applied” In DO-260A | Y |
| | | 0020.0050 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the “Geometric Vertical Accuracy (GVA)” subfield. NOTE: Replaces the Barometric Altitude Quality (BAQ) in DO-260A | Y |
| | | 0020.0060 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the “GPS Antenna Offset” OM Code. | Y ²¹ |
| | | 0020.0070 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Source Integrity Level (SIL) Data. | Y |
| | | 0020.0080 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Source Integrity Level (SIL) Supplement Data. | Y |
| | | 0020.0090 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report System Design Assurance. | Y |

²¹ Supports also D19-0012.0002..



| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|---|
| | | 0020.0100 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Capability Class 1090ES IN. NOTE: Replaces the "CDTI Traffic Display Capability" in DO-260A. | Y |
| | | 0020.0110 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Capability Class UAT IN. | Y |
| | | 0020.0120 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the "NIC Supplement-B" subfield. NOTE: replaces "Single Antenna Flag (SAF)" in DO-260A. | Y |
| | | 0020.0130 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall process and report the "NIC Supplement-C" subfield. | Y |
| | | 0020.0140 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Aircraft/Vehicle Length and Width Code. NOTE: Different from DO-260/DO-260A. | Y |
| | | 0020.0160 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Navigation Integrity Category (NIC). NOTE: Difference from DO-260/DO-260A is the added radius (0,3NM) and that the Vertical Protection Limit (VPL) is not taken into account. | Y |
| | | 0020.0180 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report Navigation Accuracy Category for Position (NACP). NOTE: Difference from DO-260A is that the Vertical Protection Limit (VPL) is not taken into account | Y |

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|---|---|
| | | 0020.0190 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report "Navigation Accuracy Category - Velocity" (NACV). NOTE: Difference from DO-260A is that the Vertical Protection Limit (VPL) is not taken into account | Y |
| | | 0020.0200 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the "Target State Data" message. NOTES: Differences from DO-260/DO-260A: e. Elimination of "Target Heading/Track Angle" and "Target Heading/Track Indicator" which are replaced with "Selected Heading Status", "Selected Heading Sign" and "Selected Heading". f. Elimination of "Target Altitude Type", "Target Altitude Capability" and "Target Altitude" which are replaced with "Selected Altitude Type" and "MCP/FCU Selected Altitude or FMS Selected Altitude". g. Addition of "Barometric Pressure Setting (Minus 800 millibars)". h. Addition of MCP / FCU Mode Bits Data: <ul style="list-style-type: none"> o "Status of MCP/FCU Mode Bits", o "Autopilot Engaged", o "VNAV (Managed) Mode Engaged", o "Altitude Hold Mode", o "Approach Mode", and o "LNAV (Managed) Mode Engaged". | Y |
| | | 0020.0210 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Emergency/Priority message. NOTE: Difference from DO-260/DO-260A is the addition of Mode A Code as a part of the message. | Y |

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|---|---|
| | | 0020.0220 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Surface Position Message. NOTE: Difference from DO-260/DO-260A is the quantization of lower values of Surface Movement field in Surface Position Message which are changed to add value denoting "stopped" with the speed of 0 knots. | Y |
| | | 0020.0230 | If the ADS-B message is based on its announced DO-260B standard version, the 1090 GS shall be able to process and report the Target State and Status message. NOTES: Differences from DO-260/DO-260A: <ul style="list-style-type: none"> ▪ New "Subtype" Code for the Target State and Status Message due to the modified format (for backward compatibility). ▪ Elimination of Emergency/Priority and incorporation of new field reserved for ADS-R Flag bits. | Y |
| 0060.0062 | The ADS-B Surveillance System should be able to filter ADS-B messages based on their announced DO-260, DO-260A or DO-260B standard version. | | Covered by REQ-15.04.05.a-D05-0010.0010 | Y |
| 0060.0063 | The ADS-B System ground surveillance domain shall be able to transform the introduced DO-260B changes into Standard ATX021 data items. | 0020.0240 | The 1090 GS shall be able to assemble the DO-260B data items in the corresponding ATX021 target report. | Y |
| 0060.0064 | The ADS-B Ground Surveillance shall be able to output the DO-260B changes via Standard ATX021 data reports. | | Covered by REQ-15.04.05.a-D05-0010.0060 | Y |

C.3 Security Enhancements

C.3.1 Integration with WAM

ASSUMPTION 1: ADS – B/WAM System checks should be enabled in the 1090 GS via a configuration parameter and performed only if there is data reception over ATX019 and ATX020. The Data Reception over ATX019 and ATX020 should be enabled via a configuration parameter.

ASSUMPTION 2: the Check will be performed only in case the WAM System Operational Status is considered healthy. This information will be extracted from the ATX019 field I019/550.

ASSUMPTION 3: the WAM target reports will be used as reference for verifying the integrity of ADS – B Position Reports.

ASSUMPTION 4: taking into account ASSUMPTION 1, the 1090 GS shall be capable to send over the ATX021 the following information:

| ADS – B Report WAM Validation Status | Note |
|--------------------------------------|--|
| NOT VALIDATED | This information shall be provided in output when ATX020 or/and ATX019 are not available for the Test. Therefore the test cannot be performed and the report is marked as NOT VALIDATED. |
| VALID | This indication shall be provided in output when the ADS – B/WAM check passes. |
| NOT VALID | This indication shall be provided in output when the ADS – B/WAM check is fails. |

In the Table above it is not foreseen to report ADS – B Report Status indicating that the ATX019 and ATX020 are available, because the indication VALID/NOT VALID indicates already this information. If in fact the test has been performed then the ATX019 and ATX020 are available.

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|--|-----------------------------|---|---|
| 0030.0001 | The ADS-B Ground Surveillance Domain should be capable to receive output from a WAM system in ASTERIX CAT 020 version 1.7. | 0030.0010 | The ADS – B/WAM Integration functionality in the 1090 GS should be activated/ deactivated via a configurable parameter. | Y |
| | | 0030.0015 | The 1090 GS WAM integration function shall be able to receive and decode ATX020 v1.7 target reports from WAM systems. | Y |
| | | 0030.0020 | The reception of ATX020 reports by the 1090 GS WAM integration function should be activated/ deactivated via a configurable parameter. | Y |
| 0030.0002 | If REQ-15.04.05.a-D18-0030.0001 is implemented, the ADS-B Ground Surveillance Domain should process and decode received WAM data in ASTERIX CAT020 version 1.7. The following minimum set of data item should be decoded: <ul style="list-style-type: none"> • Aircraft Horizontal Position – Latitude and Longitude • Pressure altitude • Aircraft Identity (Mode 3A, Mode-S Address, Aircraft-Id) and Emergency Indicators • Time of Applicability | 0030.0030 | The 1090 GS WAM Integration function shall extract at least the following items from each ATX020 report received: <ul style="list-style-type: none"> ▪ I020/041 ▪ I020/042 ▪ I020/100 ▪ I020/070 ▪ I020/220 ▪ I020/245 ▪ I020/140 | Y ²² |
| 0030.0003 | The ADS-B Ground Surveillance Domain should be capable to receive WAM system status messages in ASTERIX CAT 019 ver- | 0030.0035 | The 1090 GS WAM integration function shall be able to receive and decode WAM system status messages in ATX019 v1.2 format. | Y |

²² Overlap with D09-0030.0200.

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|---|-----------------------------|---|---|
| | sion 1.2. | 0030.0040 | The reception of ATX019 messages in the 1090 GS should be activated/ deactivated via a configurable system parameter. | Y |
| | | 0030.0050 | The reception of ATX019 messages in the 1090 GS shall be managed via a configurable Time out system parameter. | Y |
| | | 0030.0060 | If ATX019 message reception is activated and no ATX019 message has been received during a preconfigured timeout period, the 1090 GS shall issue an appropriate ATX023 status report. | Y |
| | | 0030.0070 | If ATX019 reception is activated and the Time out specified in 0030.0060 expires, then the WAI bits in ATX021 target reports shall be set to the value 10 (= not validated by the WAM function) while this condition persists. | Y |
| 0030.0004 | If REQ-15.04.05.a-D18-0030.0003 is implemented, ADS-B Ground Surveillance Domain should process and decode received WAM data in ASTERIX CAT019 version 1.2. The following minimum set of data item should be decoded: • Time of Applicability • System Status | 0030.0080 | The 1090 GS WAM Integration function shall extract at least the following items from the received ATX019 reports: ▪ I019/140 ▪ I019/550 ▪ | Y |
| 0030.0005 | If REQ-15.04.05.a-D18-0030.0004 is implemented, the ADS-B Ground Surveillance Domain shall use the WAM System Status received by ASTERIX | 0030.0090 | The ADS - B/WAM Validity check (see REQ-15.04.05.a-D05-0030.0140 and 0030.0150) shall be performed only in case the information reported in I019/550 respects the following condition: NOGO = 00. | Y |

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|---|-----------------------------|--|---|
| | CAT019 as a criterion for the enabling of the ADS-B validity check. | 0030.0100 | The ADS-B/WAM Validity check (see REQ-15.04.05.a-D05-0030.0140 and 0030.0150) shall not be performed when the I019/550 subfield in incoming ATX019 reports indicates the following condition: NOGO = 10 or =11 or =01. | Y |
| | | 0030.0102 | If the ADS-B/WAM Validity check is not performed because of the conditions stated in REQ-15.04.05.a-0030.0100, the 1090 GS shall issue ATX021 reports with the WAI bits set to the value 10 (=not validated by the WAM integration function), ref. [17]. | Y ²³ |
| | | 0030.0104 | If the ADS-B/WAM Validity check is not performed because of the conditions stated in REQ-15.04.05.a-0030.0100, the 1090 GS shall issue an appropriate ATX023 message. | Y |
| 0030.0006 | If REQ-15.04.05.a-D18-0030.0002 is implemented, the ADS-B Ground Surveillance Domain should correlate ADS-B reports received through 1090 ES with reports received from a WAM System in ASTERIX CAT020 version 1.7. | 0030.0110 | For each target position update (Pre-validated Position) assembled from 1090 ES data, the 1090 GS shall identify a relevant WAM target report (Reference Report) in order to perform the ADS – B/WAM Validity check (REQ-15.04.05.a-D05-0030.0140 and 0030.0150). | Y |
| | | 0030.0120 | The Pre Validated Position and Reference Report shall refer to the same time of applicability within a preset tolerance. | Y |

²³ Overlap with D09-0030.0320.

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|--|-----------------------------|--|---|
| | | 0030.0130 | The Reference Report shall be determined using only those ATX020 Reports referring to the same aircraft 24 bit Address as the Pre-validated Position. NOTE: The case of duplicate addresses is to be considered at a later stage. | Y |
| 0030.0007 | If REQ-15.04.05.a-D18-0030.0006 is implemented, the ADS-B Ground Surveillance Domain shall verify the validity of ADS-B reports by comparing ADS-B position data with position data of correlated WAM reports. | 0030.0140 | If the distance between the Pre Validated Position and the position indicated in the associated WAM Reference Report is less than a preset threshold, the Pre Validated Position shall be reported in ATX021 with the WAI bits set to 00 (= consistent with WAM), ref. [17]. | Y ²³ |
| | | 0030.0150 | If the distance between the Pre Validated Position and the position indicated in the associated WAM Reference Report is greater than the preset threshold The Pre Validated Position shall be reported in ATX021 with the WAI bits set to 01 (=inconsistent with WAM), ref. [17]. | Y ²³ |
| | | 0030.0155 | The threshold used for comparison of the Pre-validated and Reference positions shall be a configurable parameter. | Y |
| 0030.0008 | If REQ-15.04.05.a-D18-0030.0007 is implemented, the validation result (positive/negative) shall be reported in the CAT021 ADS-B report | | Covered by the requirements REQ-15.04.05.a-D05-0030.0140 and 0030.0150. | Y |

C.3.2 Time of Arrival versus Distance Validation

The description of this security enhancement in D18 Sec. 3.4.5, ref. [19], implies the following:

1. The term 'external sensor' is referring to either external ADS-B receivers or other 1090 GS. Therefore, in this scenario the following definitions are made:

-**Target Data:** Data Stream coming from an external sensor containing information related to the Target in the form of raw (implementation dependent) ADS-B messages or ATX021 target reports in the case where the external sensor is a 1090 GS.

-**System Operational Status Data:** Data Stream coming from an external sensor containing information related to the Operational Status of the external sensor. This information may be in ATX023 status reports in the case where the external sensor is a 1090 GS; otherwise implementation dependent messages can be used.

2. TOA/Distance validation can be performed only in configurations with two or more ADS-B Receivers or 1090 GS as external sensors with overlapping coverage and a separate TOA/Distance validation function that receives and processes the data coming from these sensors in order to perform the TOA/Distance Validity Check. This Validity Check can be performed only if at least two sensors can see simultaneously the same target hence providing in output the same position report.

The Test's Aim is to verify the following operational condition in order to declare the ADS-B report Valid:

- *The same target 1090 ES is received by multiple external sensors hence the TOA/Distance Validation Function receives multiple position reports for the same target, which will differ in their time of arrival depending on the distance of the target from the corresponding sensor. Thus the sensor nearest to the target will provide a position report sooner than the other sensors. The second nearest sensor will provide the same report a bit later and so on. In this way the following validity conditions apply for each incoming 1090 ES position message:*

- *Time of Reception of position message in the nearest sensor is less than the Time of reception of the same position message in the second nearest sensor.*

- *Target Distance from nearest sensor is less than Target Distance from second nearest sensor.*

3. The TOA/Distance Validation function represents a Functional Element able to perform the functions stated in the following Requirements. This assumption allows to each industry to implement the TOA/Distance validation in accordance with their chosen physical architecture.

4. The data coming from the external sensors shall be used in the TOA/Distance Validity Check only in case the external sensor Operational Status (contained in ATX023 status report if the sensor is a 1090 GS) is reported as healthy.

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|---|---|
| 0040.0030 | The ADS-B Ground Surveillance Domain should be capable to determine the distance of a target from an ADS-B receiver by using the received horizontal position data, the received altitude data and the static receiver position. | 0040.0010 | The TOA/Distance validation function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0040.0020 | The 1090 GS TOA/Distance validation function shall be able to manage simultaneously n (with n >= 2) different Target Data streams coming from different 1090 ES receive functions (=external sensors) NOTE: External sensors may be 1090 GS or 1090 ES receivers. Then data streams would be in ATX021 or in raw 1090 ES format, respectively. | Y |
| | | 0040.0025 | If the 1090 GS TOA/Distance Validation function uses data from external 1090 GS, then it shall be able to receive and decode ATX021 target reports from these systems. | Y |
| | | 0040.0050 | The association of external sensors to the 1090 GS TOA/Distance validation function should be configurable. | Y |
| | | 0040.0060 | The 1090 GS TOA/Distance validation function shall be able to manage simultaneously n (with n >= 2) different System Operational Status Data streams, one per associated external sensor. NOTE: External sensors may be 1090 GS or 1090 ES receivers. Then operational status data streams would be in ATX023 or in custom format, respectively. | Y |
| | | 0040.0065 | If the 1090 GS TOA/Distance Validation function uses 1090 GS as external sensors, then it should be able to receive and decode ATX023 status messages from these systems. | Y |
| | | 0040.0070 | The reception of each of the n external sensor Operational Status Data streams should be managed via a configurable Time out parameter. Refer to REQ-15.04.05a-D05-0040.0060. | Y |

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|---|----------------------------|--|---|
| | | 0040.0080 | If REQ-15.04.05.a-D05-0040.0070 is implemented and Time out expires [i.e. no System Operational Status Data information has been received during the timeout period], a relevant ATX023 notification shall be issued. | Y |
| | | 0040.0090 | In case one of the n external sensor Operational Status time outs expires, the 1090 GS TOA/Distance validation function shall exclude the corresponding target data stream from the TOA/Distance Validity check. | Y |
| | | 0040.0100 | The TOA/Distance validation function shall be able to calculate the distance of each target from the associated sensor per target report received from that sensor. | Y |
| 0040.0031 | The ADS-B Ground Surveillance Domain should have a function elaborating the consistency of TOA versus calculated distance from an ADS-B receiver for multiple ADS-B receivers having received the same position | 0040.0110 | The TOA/Distance validation function shall exclude from the TOA/Distance Validity check the target data streams coming from external sensors whose Operational status is not declared healthy. | Y |

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|---|
| | squitter. | 0040.0120 | The TOA/Distance validation function shall verify, for each 1090 ES position message received by n (n>=2) different receive functions, that the following conditions are true: “Time of Reception of position message in the nearest ADS – B sensor <= Time of reception of position message – in the second nearest ADS – B sensor. AND “Target Distance from nearest ADS – B sensor <= Target Distance second nearest ADS – B sensor | Y |
| | | 0040.0124 | If a 1090 ES position message has been received by n < 2 external sensors, the 1090 GS TOA/Distance validation function shall mark it as “TOA/Distance Not Validated”. | Y |
| | | 0040.0128 | If a 1090 ES position message fails the TOA/Distance validity check per REQ-15.04.05.a-0040.0120, then the 1090 GS TOA/Distance validation function shall mark it as “TOA/Distance Inconsistent”. | Y |
| | | 0040.0130 | If a 1090 ES position message passes the TOA/Distance validity check per REQ-15.04.05.a-0040.0120, then the 1090 GS TOA/Distance validation function shall mark it as “TOA/Distance Consistent”. | Y |

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|-----------------|----------------------------|--|---|
| | | 0040.0140 | For each 1090 ES position message marked as "TOA/Distance Not Validated", the 1090 GS shall issue the corresponding ATX021 report with the TOA bits set to the value 10, ref. [17]. | Y |
| | | 0040.0150 | For each 1090 ES position message marked as "TOA/Distance Consistent", the 1090 GS shall issue the corresponding ATX021 report with the TOA bits set to the value 00, ref. [17]. | Y |
| | | 0040.0160 | For each 1090 ES position message marked as "TOA/Distance Inconsistent", the 1090 GS shall issue the corresponding ATX021 report with the TOA bits set to the value 01, ref. [17]. | Y |

C.3.3 Power versus Distance Validation

The signal strength (power level) of the 1090 ES messages received by the 1090 GS can be estimated through the path attenuation formula described in ED-129, Appendix F, which permits the calculation of path loss as a function of the target distance from the receiver.

This formula can be used to generate the table shown in Figure 5 below.

RECEIVED SIGNAL STRENGTH

| Target Range (NM) | Maximum Signal Level (dBm) | Minimum Signal Level (dBm) | |
|-------------------|----------------------------|----------------------------|--------|
| | | A1-A3 | A0 |
| 0.2 | -27.6 | -33.6 | -36.1 |
| 10 | -61.6 | -67.6 | -70.1 |
| 20 | -67.7 | -73.7 | -76.2 |
| 50 | -76.0 | -82.0 | -84.5 |
| 100 | -82.4 | -88.4 | -90.9 |
| 150 | -86.4 | -92.4 | -94.9 |
| 180 | -88.3 | -94.3 | -96.8 |
| 200 | -89.4 | -95.4 | -97.9 |
| 250 | -91.8 | -97.8 | -100.3 |
| 300 | -93.8 | -99.8 | -102.3 |

DESIRED SIGNAL LEVELS VERSUS TARGET DISTANCE FROM 1090 ES RECEIVER

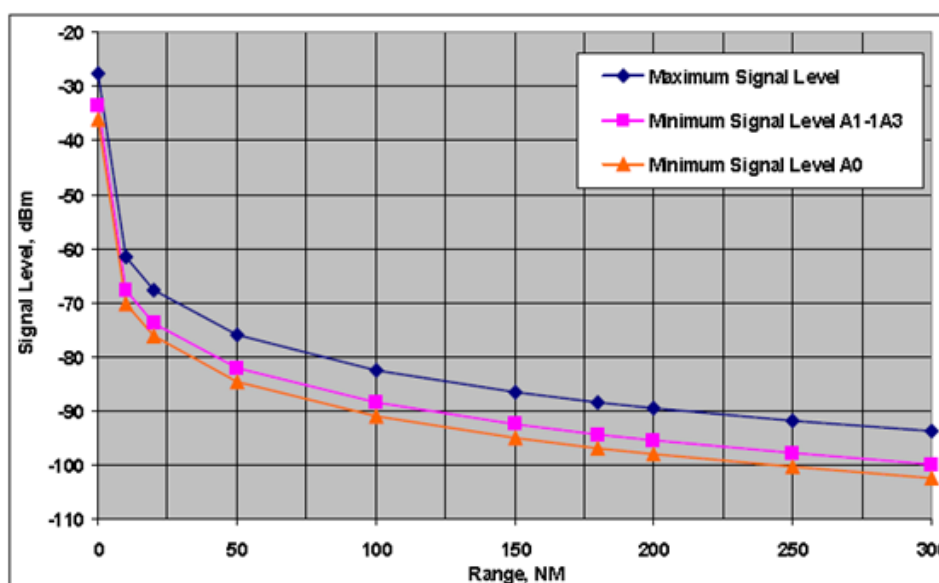


Figure 5 Power Reference for 0dB gain antenna systems

Three different curves are plotted in this figure:

- the minimum signal level for A0 class transponders;
- the minimum signal level for A1-A3 class transponders; and finally
- the maximum signal level for all transponder classes.

It should be noted that the 1090 GS does not know the transponder class of the targets, because it is not indicated in the 1090 ES messages received.

The 1090 GS will receive 1090 ES messages whose average power level will vary depending on target distance according to the curves shown on Figure 5. The Power variation rate versus distance function should be the same for all transponder types.

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|---|-----------------------------|---|---|
| 0040.0040 | The ADS-B Ground Surveillance Domain should have the capability to measure the power of the received 1090 messages. | 0050.0005 | The 1090 GS Power versus Distance validation function should be activated/ deactivated via a configurable parameter. | Y |
| | | 0050.0010 | The 1090 GS Power versus Distance validation function shall measure an appropriate metric of the signal level of incoming 1090 ES position messages received for targets in "target data maintenance" mode (see ED-129 chapter 3). | Y |
| | | 0050.0030 | The signal level metric measurement parameters of the 1090 GS Power versus Distance validation function shall be configurable. | Y |
| 004.0041 | The ADS-B Ground Surveillance Domain should be capable to detect the equipment class of the transmitting aircraft. | | N/A ²⁴ | Not feasible ²⁴ |
| 0040.0042 | Once a valid position message is received for a target in "target data maintenance" mode (see ED-129 chapter 3), the ADS-B Ground Surveillance Domain should estimate the transmission power of it. | 0050.0040 | The 1090 GS Power versus Distance validation function shall calculate (per ED-129 App. F) the theoretical value of the chosen signal level metric for incoming 1090 ES position messages received for targets in "target data maintenance" mode. | Y |

²⁴ Not supported by current 1090 ES standards.



| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|--|-----------------------------|---|---|
| 0040.0043 | If REQ-15.04.05.a-D18-0040.0042 is implemented, the ADS-B Ground Surveillance Domain shall calculate the distance of the target from the ADS-B receiver using the reported position and altitude | | | |
| 0040.0044 | If REQ-15.04.05.a-D18-0040.0042 is implemented, the ADS-B Ground Surveillance Domain shall determine the approximate distance of each of the received ES using the measured power and equipment class. (see ED129 appendix F) | | | |
| 0040.0045 | If REQ-15.04.05.a-D18-0040.0042 is implemented, the ADS-B Ground Surveillance Domain shall compare the distance obtained from the received position data with the distance calculated using measured power increments. | 0050.0080 | For each generated target position report, the Power versus Distance validation function shall compare the measured signal level metric with the calculated theoretical value. | Y |
| 0040.0046 | If REQ-15.04.05.a-D18-0040.0045 is implemented and if "n" consecutive position updates for which the difference between the approximate distance and the reported distance is greater than "x" Nm have been received in "t" seconds, then the ADS-B Ground Surveillance Domain shall mark the message as "Power/Distance inconsistency". | 0050.0100 | If the difference between theoretical and measured signal level metric values exceeds a preset threshold, then the 1090 GS shall issue the resulting ATX021 report with the PRV bits set to 01 (= power/distance inconsistent), ref. [17]. | Y |
| | | 0050.0104 | If the difference between theoretical and measured signal level metric values does not exceed the preset threshold, then the 1090 GS shall issue the resulting ATX021 report with the PRV bits set to 00 (= power/distance consistent), ref. [17]. | Y |

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|---|-----------------------------|---|---|
| | | 0050.0106 | The signal level metric calculation parameters and the preset threshold used for comparing theoretical and monitored signal levels shall be configurable parameters. | Y |
| | | 0050.0108 | While the power versus distance validation function is deactivated, the 1090 GS shall issue ATX021 report with the PRV bits set to 10 (=power versus distance not validated), ref. [17]. | Y |
| 0040.0047 | If REQ-15.04.05.a-D18-0040.0046 is implemented, the ADS-B Ground Surveillance Domain shall report "Power/Distance inconsistency" in ADS-B reports created out of marked messages. | | Covered by REQ-15.04.05.a-0050.0100 | Y |

C.3.4 Angle of Arrival Validation

The position information contained in ATX021 reports relies only on the data extracted from the 1090 ES transmitted by the target. a/c. Consequently the ADS-B system runs the risk of reporting false positions supplied by spoofing targets.

If the ADS-B System is able to determine the direction or sector of arrival of the received ES messages, then this direction can be correlated with the angle of arrival obtained from the position reported by the aircraft in order to validate the position report.

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|--|-----------------------------|---|---|
| 0040.0001 | The ADS-B Ground Surveillance Domain should have the capability to determine the direction of arrival of the received ES | 0060.0015 | The 1090 GS Angle of Arrival validation function should be activated/ deactivated via a configurable parameter ²⁵ . | Y |
| | | 0060.0018 | While the Angle of Arrival validation function is not activated, the 1090 GS shall issue all ATX021 reports with the AoA bits set to 10 (=not validated by the AoA function), ref. [17]. | Y |
| 0040.0002 | If REQ-15.04.05.a-D18-0040.0001 is implemented, each time a valid position message is received for a target in "target data maintenance" mode (see ED-129 chapter 3), the ADS-B Ground Surveillance Domain should measure the direction of arrival of it | 0060.0010 | The 1090 GS Angle of Arrival validation function shall register the real direction of arrival of each 1090 ES position message received for targets in "target data maintenance" mode. | Y |
| 0040.0003 | If REQ-15.04.05.a-D18-0040.0002 is implemented, the ADS-B Ground Surveillance Domain shall register a real direction of arrival of each of the received ES. | 0060.0020 | The resolution of the direction of arrival for the Angle of Arrival validation function shall be configurable | Y |
| | | 0060.0030 | The resolution of the direction of arrival for the Angle of Arrival validation function shall define a sector of arrival. | Y |
| 0040.0004 | If REQ-15.04.05.a-D18-0040.0002 is implemented, the ADS-B Ground Surveil- | 0060.0040 | The 1090 GS Angle of Arrival validation function shall calculate the theoretical direction of arrival of each of the received 1090 ES posi- | Y |

²⁵ This requirement imposes the use of appropriate antennas. [ASSUMPTION_4] is therefore not applicable.

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|--|-----------------------------|--|---|
| | lance Domain shall calculate the direction of arrival of each of the received position ES using the reported position and the known GS position. | | tion messages for targets in "target data maintenance" mode using the reported position and the known 1090 GS receiver location. | |
| 0040.0005 | If REQ-15.04.05.a-D18-0040.0004 is implemented, the ADS-B Ground Surveillance Domain shall compare the real direction of arrival with the calculated direction of arrival using the reported position. | 0060.0050 | When the theoretical direction of arrival of a 1090 ES position message is contained within the real sector of arrival, the Angle of Arrival Validation function shall mark the message as "valid". | Y |
| | | 0060.0060 | When a calculated direction of arrival is not contained inside the real sector of arrival, the Angle of Arrival Validation function shall mark the message as "not matching". | Y |
| 0040.0006 | If REQ-15.04.05.a-D18-0040.0005 is implemented and if "n" consecutive position updates defined as "not matching" have been received, then the ADS-B Ground Surveillance Domain shall mark the message as "direction of arrival Failure". | 0060.0070 | When a received 1090 ES position message is marked by the Angle of Arrival validation function as "not matching", and the <i>n</i> - 1 previous consecutive position messages for the same target were also marked as "not matching", the 1090 GS shall set the AoA bits in the resulting ATX021 report to the value 01 (=direction of arrival inconsistency), ref. [17]. | Y |
| | | 0060.0072 | The parameter " <i>n</i> " (minimum number of consecutive "not matching" position messages for the Angle of Arrival Validation function) shall be configurable. | Y |
| | | 0060.0074 | When a 1090 ES position message is received and marked by the Angle of Arrival validation function as "not matching", and the <i>m</i> previously received consecutive position messages were also marked "not matching" but <i>m</i> is less than <i>n</i> -1, then the 1090 GS shall issue the corresponding ATX021 report with the AoA bits set to 00 (=consistent direction of arrival), ref. [17]. | Y |
| | | 0060.0076 | When a 1090 ES position message is received and marked by the Angle of Arrival validation function as "valid", the 1090 GS shall issue the corresponding ATX021 report with the AoA bits set to 00 (=consistent direction of arrival), ref. [17]. | Y |

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|--|-----------------------------|--|---|
| 0040.0007 | If REQ-15.04.05.a-D18-0040.0006 is implemented, the ADS-B Ground Surveillance Domain shall report "direction of arrival failures" in ADS-B reports created out of marked messages. | | Covered by REQ-15.04.05.a-D05-0060.0070 | Y |

C.3.5 Track Consistency Verification

Ref. [19] proposes in Sec. 3.4.2 a position and velocity cross-check as a means of means of verifying the consistency of the track reported by ADS-B targets.

| REQ-15.04.05.a-D18-Req. ID | D18 Requirement | REQ-15.04.05.a-D05-Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|----------------------------|--|----------------------------|---|---|
| 0040.0050 | The ADS-B Ground Surveillance Domain should validate ADS-B report consistency by evaluating the ADS-B received target velocity against the ADS-B received target position change. | 0070.0010 | The 1090 GS Track Consistency verification function should be activated/ deactivated via a configurable parameter. | Y ²⁶ |
| | | 0070.0015 | While the Track Consistency verification function is deactivated, the 1090 GS shall issue all ATX021 reports with the PVC bits set to 10 (=not validated for position/velocity changes), ref. [17]. | N ³⁰ |
| | | 0070.0020 | For each incoming 1090 ES position message from any target in “data maintenance mode”, the 1090 GS Track Consistency verification function shall verify track consistency by comparing the velocity values reported by that target against the velocity calculated using the reported target lat/long positions. | Y |
| | | 0070.0022 | The 1090 GS Track Consistency verification function shall mark position messages as “Velocity Inconsistent”, if the calculated velocity deviates from the reported one by a preset threshold (or more). | Y ²⁷ |

²⁶ Overlap with D09-0100.0010, 0100.0040, 0100.0070, 0100.0100, 0100.0130, 0100.0160, 0100.0190, 0100.0220 and 0100.0250.

²⁷ Overlap with D09-0100.0020, 0100.0050, 0100.0080, 0100.0110, 0100.0140, 0100.0170, 0100.0200, 0100.0230 and 0100.0260.

| REQ-15.04.05.a-D18- Req. ID | D18 Requirement | REQ-15.04.05.a-D05- Req. ID | GS Requirement for 1 st Iteration | 3 rd Iteration Applicability |
|-----------------------------|-----------------|-----------------------------|---|---|
| | | 0070.0024 | The 1090 GS Track Consistency verification function shall mark position messages as “Velocity Consistent”, if the calculated velocity deviates from the reported one by less than the preset threshold. | Y ²⁸ |
| | | 0070.0026 | The preset threshold used by the 1090 GS Track Consistency verification function shall be configurable. | Y ²⁹ |
| | | 0070.0030 | For each 1090 ES position message marked by the Track Consistency verification function as “Velocity Inconsistent”, the 1090 GS system shall issue the corresponding ATX021 report with the PVC bits set to 01, ref. [17]. | N ³⁰ |
| | | 0070.0040 | For each 1090 ES position message marked by the Track Consistency verification function as “Velocity Consistent”, the 1090 GS system shall issue the corresponding ATX021 report with the PVC bits set to 00, ref. [17]. | N ³⁰ |

²⁸ Overlap with D09-0100.0030, 0100.0060, 0100.0090, 0100.0120, 0100.0150, 0100.0180, 0100.0210, 0100.0240 and 0100.0270.

²⁹ Overlap with D09-0100.0370, 0100.0380, 0100.0390, 0100.0400, 0100.0410, 0100.0420, 0100.0430, 0100.0440 and 0100.0450.

³⁰ Replaced by D09-0100.0730.

Appendix D Summary of Differences between DO-260A and DO-260B

D.1 Eliminated Fields from DO-260A

1. Receiving ATC Services (set to reserved)
2. CDTI Traffic Display Capability
3. IFR Capability Flag
4. Position Offset Applied
5. Surveillance Integrity Level

Newly defined Source Integrity Level is considered equivalent for backward compatibility with Version 1 receivers.

6. Barometric Altitude Quality

D.2 Added Fields in DO-260B

1. Lateral and Longitudinal GPS Antenna Offset

Encoding includes a value denoting GPS Antenna Offset has been applied by GPS position source

2. Integrity Fields replacing Version 1 Surveillance Integrity Level:

- a. Source Integrity Level
- b. System Design Assurance (SDA) Level
- c. Source Integrity Level Supplement

3. 1090ES IN

4. UAT IN

5. Geometric Vertical Accuracy

6. Added second NIC Supplement to encode 0,3 nautical mile containment radius

7. Moved Single Antenna Flag from Airborne Position Message to Aircraft Operational Status Message

8. Replaced Single Antenna Flag in Airborne Position Message bit with new NIC Supplement bit

9. Additional NICs are encoded for Surface Position Messages using added NIC Supplement bit in the Aircraft Operational Status Message transmitted when on-the-Ground

D.3 Modified Fields in DO-260B

1. Modified Following Fields:

- a. Aircraft/Vehicle Length and Width Code modified to add "No Data" encoded value
- b. TCAS Operational
- c. NIC encoding of a containment radius of less than 0,3 nautical miles added

2. Removed vertical component of NIC, NAC_P and NAC_V

3. Target State Data has been modified:

- a. Eliminated “Target Heading/Track Angle” and “Target Heading/Track Indicator” are replaced with “Selected Heading Status”, “Selected Heading Sign” and “Selected Heading”
 - b. Eliminated “Target Altitude Type”, “Target Altitude Capability” and “Target Altitude” are replaced with “Selected Altitude Type” and “MCP/FCU Selected Altitude or FMS Selected Altitude”
 - c. Added “Barometric Pressure Setting (Minus 800 millibars)”
 - d. Mode Bits modified adding MCP / FCU Mode Bits Data (“Status of MCP/FCU Mode Bits”, “Autopilot Engaged”, “VNAV Mode Engaged”, “Altitude Hold Mode”, “Approach Mode”, and “LNAV Mode Engaged”)
4. Emergency/Priority Message modified: added the Mode A Code
 5. Quantization of lower values of Surface Movement field in Surface Position Message changed to add value denoting “stopped” with the speed of 0 knots.
 6. Target State and Status Message is modified:
 - a. New “Subtype” Code for the Target State and Status Message due to the modified format (for backward compatibility)
 - b. Target State and Status Message is modified: eliminated Emergency/Priority, incorporated new fields and added TCAS Operational and Reserved for ADS-R Flag bits

D.4 Other Changes in DO-260B

Note: Those changes shall have no influence on ADS-B Ground System.

1. Mode A Code required to be broadcast when on-the-Ground as well as Airborne
2. Test Message that previously conveyed Mode A Code is no longer transmitted
3. Modified Emergency/Priority Message (added the Mode A Code) is transmitted continuously instead of only during an emergency condition:
 - a. Mode A Code (1000)₈ terminates transmission of Emergency/Priority Message so message is transmitted only when an emergency condition exists
 - b. Transmit rate is 0,2 Hz except it increases to 1,25 Hz for 24 seconds when the Mode A code is changed
4. NACV is now transmitted when on the surface as well as when airborne
5. TCAS Resolution Advisory (RA) Message transmitted when a TCAS RA is active providing data on the RA.

Transmitted at a 1.25 Hz rate during and immediately following an active RA

Appendix E ED-129 compliance

This Appendix lists the 1090 GS requirements stated in ED-129 [11] and indicates in the column “Applicability” whether they are applicable to this specification, with regard to REQ-15.04.05.a-D05-0000.0010.

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|--------------|--|---------------------|---|
| ED129_REQ_1 | In accordance with ED-126, system capacity refers to the maximum number of aircraft for which all the service surveillance performance parameters must be provided. ED-126 Requirement PR 41 (Annex B, Section B.4.5.2) states that the ground segment of the system shall have the capacity to handle the reports from the maximum load of aircraft in the environment as described in ED-126 Annex A, Section A.2.4 (i.e. a maximum instantaneous count of traffic of 15 aircraft en-route and 7 in TMA). | n | Superseded by Sec. 3.3.2 |
| ED129_REQ_2 | The 1090 GS shall have the capacity to simultaneously process 1090 MHz ADS-B messages from at least 300 individual airborne targets, transmitting such messages at the standard rates defined in DO-260/A | n | Superseded by Sec. 3.3.2 |
| ED129_REQ_3 | The 1090 GS shall have the capacity to output corresponding ATX021 reports at a maximum data driven rate of four ATX021 reports per target per second, unless constrained by Ground Station configuration, while meeting the latency requirements specified in ED-129 Section 3.4. | y | |
| ED129_REQ_4 | An overload mechanism shall be provided to detect when the number of targets exceeds a configurable capacity threshold. | y | |
| ED129_REQ_5 | When the threshold is exceeded the 1090 GS shall set the ODP bit in item I023/100 of ATX023 Ground Station Status reports. | y | |
| ED129_REQ_6 | The 1090 GS shall include the capability to detect communications overloads. | y | |
| ED129_REQ_7 | When such an overload is detected, the 1090 GS shall set the OXT bit in item I023/100 of ATX023 Ground Station Status reports. | y | |
| ED129_REQ_8 | Optionally the 1090 GS may act to mitigate an overload condition, for example by reducing sensitivity or range of coverage. However, such mitigation actions are outside the scope of this specification. | y | |
| ED129_REQ_9 | The maximum latency from the time of receipt of a 1090 ES message sent by the transponder on board an aircraft to the output of the corresponding ATX021 report shall be 0.5 seconds for all targets within the service volume up to the maximum stated in ED-126 and under the worst case FRUIT environment specified in APPENDIX H. This requirement, which is derived from ED-126, shall apply to all data-driven ATX021 reports. It does not apply to reports generated in periodic mode. | y | Needs to be considered together with D05-0010.0120 for RAD airspaces. |
| ED129_REQ_10 | Based on the system integrity level defined in ED-126, the 1090 GS Software Assurance Level shall be equivalent to at least ED-109 level AL4. | n | This specification is for prototype development |
| ED129_REQ_11 | The decoder undetected message error rate shall be better than 1 in 10 ⁵ messages. An undetected message error is assumed for the purposes of this requirement to be one which results in an error in | y | Needs to be considered together with |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|--------------|---|---------------------|---|
| | either a position or a position quality field in an ATX021 position report. The analysis leading to these requirements is included in ED-129 APPENDIX C. | | - D05-0010.0100 for RAD airspaces, and - D09-0080.0090 for APT airspaces |
| ED129_REQ_12 | ED-126 SPR 17 requires that the Time of Applicability for Position output by the 1090 GS in ATX021 reports shall have an absolute accuracy relative to UTC of ± 0.2 seconds or less. This ED-126 requirement is met by the provisions of Section 3.10.4.8, since when T=1 the GS can determine the precise 0.2 second UTC epoch that the incoming position message is associated with. | n | Superseded by req. D05-0010.0130 |
| ED129_REQ_13 | The absolute accuracy of the Time of Message Reception items for position and velocity relative to UTC shall be ± 25 milliseconds or less. The 1090 GS shall be able to maintain this level of accuracy in the coasting state for at least 30 minutes. | y | |
| ED129_REQ_14 | The 1090 GS shall be able to maintain this level of accuracy in the coasting state for at least 30 minutes. | y | |
| ED129_REQ_15 | Position, velocity, altitude and other data shall be reported as received from the aircraft without loss of accuracy, when allowed by the ATX021 format. Where an ASTERIX report field has a different resolution from the corresponding data field in a 1090 ES ADS-B message, the value included in the ASTERIX report shall be of no greater resolution than the value received from the aircraft. | y | |
| ED129_REQ_16 | The 1090 GS shall achieve an Availability of 99.99%. | y | |
| ED129_REQ_17 | The 1090 GS will be polled for its monitoring data using Simple Network Management Protocol (SNMP), at a frequency that will depend on system performance criteria. | y | |
| ED129_REQ_18 | Polling will form part of an ADS-B Ground Station health check mechanism, which is performed by a connected central Control & Monitoring system, which is outside the scope of this Technical Specification. | y | |
| ED129_REQ_19 | If the downstream monitoring system does not receive a response to a poll request, it will re-send the request. | y | |
| ED129_REQ_20 | The 1090 GS system shall provide an external control and monitoring interface utilizing the Simple Network Management Protocol (SNMP). | y | |
| ED129_REQ_21 | The supplier of the ADS-B system shall provide the Management Information Base (MIB), used to locate data within the ADS-B system. | y | |
| ED129_REQ_22 | The transition between Operational and Maintenance mode, and between Maintenance and Operational mode, shall occur only as the result of a manual command from an operator. | y | |
| ED129_REQ_23 | The 1090 GS shall not allow configuration changes while in Operational mode. | y | |
| ED129_REQ_24 | After power-on initialization, the 1090 GS shall enter the mode it was previously in before power-off. | y | |
| ED129_REQ_25 | The mode of the 1090 GS shall be made available to the SNMP interface. | y | |
| ED129_REQ_26 | The operational state of the 1090 GS shall be made available to the SNMP interface. | y | |
| ED129_REQ_27 | If the Ground Station incorporates redundant LRUs to meet the Availability requirement defined in ED-129 Sec. 3.8, then the status of each LRU shall be made available to the SNMP interface. | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|--------------|--|---------------------|-------|
| ED129_REQ_28 | When the 1090 GS is in the Failed state the NOGO bit in item I023/100 of ATX023 Ground Station Status reports shall be set to 1, and the STAT field in item I023/110 of Service Status reports shall be set to "Failed". | y | |
| ED129_REQ_29 | When the 1090 GS is in the Initialisation state, including the period up until the UTC Time Source becomes UTC Coupled for the first time, the NOGO bit in item I023/100 of ATX023 Ground Station Status reports shall be set to 1, and the STAT field in item I023/110 Service Status reports shall be set to "Initialisation" in any ATX023 messages sent. | y | |
| ED129_REQ_30 | When the 1090 GS is in the Online state, the NOGO bit in item I023/100 of ATX023 Ground Station Status reports shall be set to 0 if the Ground Station is in the Operational mode, or 1 if it is in Maintenance mode. The STAT field in item I023/110 Service Status reports shall be set to "Normal". | y | |
| ED129_REQ_31 | By default the 1090 GS shall not output ATX021 reports in Maintenance mode or in the Initialisation or Failed state. If however the Ground Station is capable of being configured to output such reports for diagnostic purposes, the NOGO bit in Item 021/040 shall be set to 1 and the CL field shall also be set to 1 while in Maintenance mode or in the Initialization or Failed state. | y | |
| ED129_REQ_32 | Where buffers are used in the 1090 GS implementation, the 1090 GS should monitor buffer overflows. | y | |
| ED129_REQ_33 | The status of the buffer overflow test should be made available to the SNMP interface. | y | |
| ED129_REQ_34 | Failure of the buffer overflow test should cause the 1090 GS to enter the Failed state. | y | |
| ED129_REQ_35 | The 1090 GS should monitor processor overloads. | y | |
| ED129_REQ_36 | The status of the processor overload test should be made available to the SNMP interface. | y | |
| ED129_REQ_37 | Failure of the processor overload test should cause the 1090 GS to enter the Failed state. | y | |
| ED129_REQ_38 | Failure of the processor overload test should cause the 1090 GS to set the ODP bit of item 023/100 in ATX023 Ground Station Status reports. | y | |
| ED129_REQ_39 | The 1090 GS shall monitor target overloads. | y | |
| ED129_REQ_40 | The status of the target overload test shall be made available to the SNMP interface. | y | |
| ED129_REQ_41 | Failure of the target overload test shall cause the 1090 GS to generate a warning condition both on SNMP and by setting the ODP bit of item 023/100 in ATX023 Ground Station Status reports. | y | |
| ED129_REQ_42 | The 1090 GS shall monitor communication link overloads. | y | |
| ED129_REQ_43 | The status of the communication link overload test shall be made available to the SNMP interface. | y | |
| ED129_REQ_44 | Exceeding the configured bandwidth shall result in a warning condition being made available to the SNMP interface. | y | |
| ED129_REQ_45 | Failure of the communication link overload test shall cause the 1090 GS to set the OXT bit of item 023/100 in ATX023 Ground Station Status reports. | y | |
| ED129_REQ_46 | The 1090 GS shall indicate any communications losses detectable at the Ground Station, including as a minimum loss of Ethernet physical connectivity. | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|--------------|---|---------------------|-------|
| ED129_REQ_47 | The status of the communication link test shall be made available to the SNMP interface if a separate physical port is available. | y | |
| ED129_REQ_48 | The time state of the 1090 GS shall be made available to the SNMP interface. | y | |
| ED129_REQ_49 | The 1090 GS shall enter the Failed state if the time state becomes Not Coupled. | y | |
| ED129_REQ_50 | The TSV bit of item I023/100 in ATX023 Ground Station Status reports shall be set to 1 when the time state is "Not Coupled". | y | |
| ED129_REQ_51 | The TSV bit of item I023/100 in ATX023 Ground Station Status reports shall be zero when the time state is "Coasting" or "UTC Coupled". | y | |
| ED129_REQ_52 | The 1090 GS should monitor the equipment temperature. | y | |
| ED129_REQ_53 | The status of the equipment temperature test should be made available to the SNMP interface. | y | |
| ED129_REQ_54 | If the equipment temperature exceeds the maximum value expected over the specified operating temperature range, a warning condition should be reported to the SNMP interface. | y | |
| ED129_REQ_55 | The 1090 GS shall include a function to detect the loss of RF input from an external test transmission. | y | |
| ED129_REQ_56 | The 1090 GS shall process the test transmissions used in the end-to-end test, in order to verify correct reception. | y | |
| ED129_REQ_57 | The 1090 GS shall detect a loss of test transmissions of greater than x seconds, where x may be configurable but shall have a default value of 10 seconds. | y | |
| ED129_REQ_58 | The 1090 GS shall report loss of test transmissions to the SNMP interface. | y | |
| ED129_REQ_59 | The 1090 GS shall detect a loss of receiver sensitivity that prevents the Ground Station from meeting its surveillance requirements. A site monitor or equivalent method as required in ED-129 Section 6.3 may be used to facilitate this test. If the sensitivity falls below a threshold then a failure shall be indicated. This sensitivity threshold shall be set by a configurable parameter. | y | |
| ED129_REQ_60 | The 1090 GS shall report loss of receiver sensitivity to the SNMP interface. In addition it shall report as a warning on the SNMP interface if the receiver sensitivity falls below a configurable warning threshold. | y | |
| ED129_REQ_61 | The 1090 GS shall verify the decoder functionality to ensure that Extended Squitter test messages are decoded correctly. A site monitor or equivalent method as required in ED-129 Section 6.3 may be used to facilitate this test. | y | |
| ED129_REQ_62 | The status of the decoder functionality test shall be made available to the SNMP interface. | y | |
| ED129_REQ_63 | The 1090 GS shall automatically enter the Failed state if any part of the end-to-end test fails. | y | |
| ED129_REQ_64 | It is recommended that the 1090 GS should return automatically to the On-line state if and when all parts of the end-to-end test succeed again. | y | |
| ED129_REQ_65 | It shall be possible to command the 1090 GS between all available operating modes from the SNMP interface. | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|--------------|--|---------------------|-------------------------|
| ED129_REQ_66 | It shall be possible to modify all configurable 1090 GS parameters via the control and monitoring interface. | y | |
| ED129_REQ_67 | It shall be possible to install the 1090 GS software via the control interface. | y | |
| ED129_REQ_68 | It shall be possible to save and restore configurable parameters of the 1090 GS to and from external electronic media. | y | |
| ED129_REQ_69 | All configurable parameters listed as mandatory in ED-129 Appendix A shall be implemented. | y | |
| ED129_REQ_70 | The settings of all configuration parameters shall be preserved during power interruption or restart of the Ground Station. | y | |
| ED129_REQ_71 | The 1090 GS shall allow a change of mode to be commanded by authorized users only. | y | |
| ED129_REQ_72 | The 1090 GS shall permit a change of configuration to be commanded by authorized users only. | y | |
| ED129_REQ_73 | The 1090 GS shall have the capability to log user access activity. | y | |
| ED129_REQ_74 | The 1090 GS shall have the capability to log all warnings and changes of state or mode. | y | |
| ED129_REQ_75 | The 1090 GS shall have the capability to log control instructions. | y | |
| ED129_REQ_76 | The 1090 GS shall timestamp Log File Messages with a minimum resolution of 1 second. | y | |
| ED129_REQ_77 | The 1090 GS shall include the functionality to save log files to an external storage device. | y | |
| ED129_REQ_78 | The 1090 GS shall have the capability to retain log files in the event of loss of power. | y | |
| ED129_REQ_79 | The 1090 GS shall process the following 1090 MHz Extended Squitter messages: 1. Messages with DF = 17 from an airborne target 2. Messages with DF = 18 and CF = 0 or 1 from an airborne target 3. Messages with DF = 19 and AF = 0 | y | |
| ED129_REQ_80 | As an option, the 1090 GS may process non-ADS-B Mode S messages, TIS-B messages, surface target messages or other message types. Characteristics of the output from such message processing are not specified in this document. A configuration item or items shall be provided to disable the output from any optional message processing. | n | |
| ED129_REQ_81 | The interpretation of Extended Squitter messages depends on the version state (i.e. DO-260 vs. DO-260A) of the target. The version state is reported in message type 31 (Aircraft Operational Status). The only valid values for the version number field as of the date of this ED-129 spec are 0 (indicating a DO-260 compliant target) and 1 (indicating DO-260A), however the majority of version 0 participants do not transmit this message. In accordance with DO-260A, Section 2.2.3.2.7.2.5, ADS-B Receiving Subsystems initially shall assume a version number of ZERO (binary 000) for each target, until received data indicates otherwise. It must therefore be assumed that participants are transmitting messages in accordance with version 0 until a type 31 message is received indicating otherwise. | y | With update for DO-260B |
| ED129_REQ_82 | The ground station shall incorporate means to prevent the permanent assignment of an incorrect version number to version 0 participants. | y | |
| ED129_REQ_83 | Message formats in future versions of the 1090 ES MOPS are expected to be backward compatible with the messages defined in DO-260A (see DO-260A, Section 2.2.7.1). The ASTERIX I021/210 | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|--------------|--|---------------------|-------|
| | MOPS Version VNS subfield provides a mechanism to flag reports from targets using unsupported MOPS versions should this expectation become invalid. | | |
| ED129_REQ_84 | The 1090 GS shall process Extended Squitter messages using the formats described in DO-260A, Appendix N when the target version state is Assumed Version 0 or Confirmed Version 0. | y | |
| ED129_REQ_85 | The Ground Station shall process Extended Squitter messages using the formats described in DO-260A, Section 2.2.3.2 when the target version state is Confirmed Version 1. | y | |
| ED129_REQ_86 | For unrecognized versions, messages shall be processed in accordance with DO-260A, Section 2.2.3.2 and the I021/210 VNS subfield shall be set as specified in ED-129 Section 3.10.4.31. | y | |
| ED129_REQ_87 | At a minimum, the 1090 GS shall be able to produce separate ATX021 reports for at least two targets with the same Mode S address. The targets can be assumed to have at least 6 nautical miles of horizontal separation but could be at any altitude, including the same altitude. The first position message from one target may arrive at any point in the lifecycle (i.e. acquisition, maintenance) of the other target. | y | |
| ED129_REQ_88 | Targets with duplicate addresses shall meet the requirements for target acquisition, maintenance and termination described in ED-129 Sections 3.10.2.3.3, 3.10.2.5 and 3.10.2.6 respectively. | y | |
| ED129_REQ_89 | ATX021 reports for targets with duplicate addresses shall be transmitted as dictated by selected reporting mode (i.e. data-driven or periodic) as described in ED-129 Sections 3.10.2.2 and 3.10.2.3. Guidance on the processing of duplicate addresses is provided in ED-129 APPENDIX D. | y | |
| ED129_REQ_90 | At a minimum, the 1090 GS shall be able to process received Extended Squitter messages and generate for transmission to client systems the report types listed in ED-129 Table 4 with the indicated ASTERIX format and transmission mode, containing the data items specified in ED-129 Section 3.10.3. | y | |
| ED129_REQ_91 | The transmitted reports shall contain valid and unambiguous information obtained from the received Extended Squitter messages and compiled in accordance with the report assembly requirements stated in ED-129 Section 3.10.4. | y | |
| ED129_REQ_92 | The reports of ED-129 Table 4 shall be transmitted to (optionally multiple) external client systems over a wide area and/or local network. | y | |
| ED129_REQ_93 | At a minimum, the 1090 GS shall support transmission of the above ATX021, 23, and 247 reports over UDP/IP/Ethernet with a configurable IP address. | y | |
| ED129_REQ_94 | The 1090 GS shall be able to support transmission using IP Multicast. | y | |
| ED129_REQ_95 | For UDP a configuration parameter shall be provided to specify the maximum output rate permissible, in order that a communications overload can be flagged. | y | |
| ED129_REQ_96 | The 1090 GS shall support the transmission modes listed in ED-129 Table 4 as defined in the following ED-129 Subsections 3.10.2.2 and 3.10.2.3. | y | |
| ED129_REQ_97 | In this mode (Data Driven Transmission Mode), the 1090 GS shall generate and transmit an ATX021 report containing state vector information after every successful decoding (per ED-102 / DO-260 and DO-260A, and including track (re)-initialization whenever required) of a Position or Ve- | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|--|---------------------|--|
| | locity squitter. These reports shall contain the items specified in ED-129 Section 3.10.3.1.2. | | |
| ED129_REQ_98 | The 1090 GS shall be able to transmit a Ground Station Status report in ATX023 format whenever a change is detected in the Ground Station status. | y | |
| ED129_REQ_99 | The 1090 GS shall be able to transmit a Service Status report in ATX023 format whenever a change is detected in the status of a service. | y | |
| ED129_REQ_100 | If configured in periodic reporting mode, the 1090 GS shall periodically transmit an ATX021 state vector report with a period of x seconds, where x shall be configurable at a minimum within the range 0.5 to 15 seconds with 0.5 second increments. | y | The periodic mode is optional in Iteration 2 |
| ED129_REQ_101 | Periodic State Vector reports shall contain the fields specified in ED-129 Section 3.10.3.1.1. | y | |
| ED129_REQ_102 | Periodic State Vector reports shall be transmitted only when the following condition applies: Position information has been updated at least once (through the reception of one or more new position squitter messages with FTC ≠ 0) since the transmission of the previous periodic state vector report. | y | |
| ED129_REQ_103 | The 1090 GS shall transmit a Position State Vector report within 5 seconds of a change in either the Emergency/Priority Status or Surveillance Status value (ED-129 Section 3.10.4.30) for any target that has been fully acquired under the provisions of ED-129 Section 3.10.2.4. Such reports shall always include the latest position and other available data. | y | |
| ED129_REQ_104 | ATX023 Ground Station Status and Service Status reports shall also be transmitted in periodic mode, each with an independently configurable period. See ED-129 Section 3.10.3.2. | n | Only the data driven mode is considered in this specification. |
| ED129_REQ_105 | ASTERIX Category 247 version reports shall also be transmitted in periodic mode with an independently configurable period. See ED-129 Section 3.10.3.3. | n | |
| ED129_REQ_106 | By default, the 1090 GS shall not output ATX021 reports for targets that are in the acquisition phase, and are therefore not yet validated. An optional configuration parameter {ReportNonValidated} may be provided to enable transmission of ATX021 reports for targets that are not validated, for example in monitoring applications. By default reports shall not be sent for targets that have not been validated. | y | |
| ED129_REQ_107 | The 1090 GS shall determine whether the initial position it determines for a target lies within a credible area (or volume) relative to the Ground Station location. | y | |
| ED129_REQ_108 | The position calculated during the range check shall be reported only if reporting of non-validated targets has been enabled by the optional ReportNonValidated configuration parameter, and the range check is successful. In this case the CL subfield in the Target Report Descriptor item (I021/040) in ATX021 reports shall be 1 ("Report Suspect") and RC shall be 1 ("Range Check Passed, CPR Validation Pending"). | y | |
| ED129_REQ_109 | The CPR encoded position information used in the range check could be decoded into a credible position that is incorrect. Depending on the decoding method used, this incorrect position could corrupt subsequent decodes. The Ground Station shall validate that the first position reported is reasonable given the ES messages received. One method of validation is shown in ED-129 Figure 10, but other methods with comparable assurance may be used. | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|---|---------------------|-------------------------------|
| ED129_REQ_110 | If the target has passed CPR Validation, the CL subfield of item I021/040 in the first ATX021 report following CPR validation shall be 0 ("Report Valid"). The RC subfield shall be 0. | y | |
| ED129_REQ_111 | For targets that have passed the range check and CPR validation, the 1090 GS shall process new Extended Squitter position messages using Locally Unambiguous CPR Decoding. Position squitter messages with FTC = 0 are not considered a position update and they shall be ignored. | y | |
| ED129_REQ_112 | If a new airborne position message results in a position change that exceeds 6 nautical miles in less than 30 seconds, an ATX021 report shall not be generated unless the optional ReportNonValidated configuration parameter is set to "enabled". In this case, CL should be set to 1 and LDPJ shall be set to 1 in item I021/040 Target Report Descriptor. | y | |
| ED129_REQ_113 | Position updates which fail the Local Decoding Reasonableness Test shall not be used as a reference position for a subsequent local decode. They shall however be included in duplicate address processing (see Section 3.10.1.3) where they may be used to establish a new target. | y | |
| ED129_REQ_114 | The position jump distance limit in the Local Decoding Reasonableness Test for airborne targets shall be 6 nautical miles by default but may be configurable to other values. | y | |
| ED129_REQ_115 | Targets shall be reinitialised after no more than 120 seconds without a position update. Messages received after the 120-second timeout shall be treated as messages from a new target (i.e. the requirements for target acquisition in ED-129 Section 3.10.2.4 apply). | y | |
| ED129_REQ_116 | Positions excluded under the provisions of ED-129 Section 3.10.2.5 shall not be counted for the purposes of the 120-second timeout. | y | |
| ED129_REQ_117 | State Vector reports may be produced in Periodic and Data Driven Transmission mode in accordance with the configuration of the surveillance data service on the 1090 GS. | y | |
| ED129_REQ_118 | State Vector reports shall be produced in ATX021 Edition 1.4 format. Optionally Edition 0.23 format may also be supported (configurable). | n | Superseded by Sec. 3.9 |
| ED129_REQ_119 | State Vector reports shall contain the fields specified in ED-129 Sections 3.10.3.1.1 (for periodic reports) or 3.10.3.1.2 (for data driven reports). | y | |
| ED129_REQ_120 | State Vector report field contents shall be in accordance with the provisions in ED-129 Section 3.10.4. | y | |
| ED129_REQ_121 | Each state vector report shall contain at least the minimum data set shown in ED-129 Table 5. | n | Superseded by Sec. 3.1.2 |
| ED129_REQ_122 | Periodic ATX021 reports for targets with duplicate addresses shall contain the items specified in ED-129 Table 5 except for item I021/170 Target Identification. | n | Periodic mode is out of scope |
| ED129_REQ_123 | The 1090 GS may additionally include in Periodic reports the following optional ATX021 items shown in Table 6 (provided that they are configurable). In the case of targets with duplicate addresses, items or sub-fields shall be included in the report only if the Ground Station is able to associate the data they contain unambiguously with the target whose position is transmitted in the ATX021 message. | n | |
| ED129_REQ_124 | A 1090 GS may support multiple services with different characteristics (for example different volumes of coverage or different reporting periods). | n | Single service assumed |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|--|---------------------|-----------------------------------|
| ED129_REQ_125 | In data driven mode, State Vector reports shall be of two types, namely position and velocity. | n | Velocity reports are optional |
| ED129_REQ_126 | Data driven position reports shall be issued on the reception of a new position squitter (after track initialization) and shall contain at a minimum the fields listed in ED-129 Table 5. | y | |
| ED129_REQ_127 | Data driven position reports for targets with duplicate addresses shall contain the data items specified in ED-129 Table 5 except for I021/170 Target Identification. | y | |
| ED129_REQ_128 | Data driven position reports may also contain any of the optional items listed in ED-129 Table 6 for which new information has been received since the previous state vector (position or velocity) report. In the case of targets with duplicate addresses, items or sub-fields shall be included in the report only if the 1090 GS is able to associate the data they contain unambiguously with the target whose position is transmitted in the ATX021 message. | y | |
| ED129_REQ_129 | Data driven velocity reports shall be issued on the reception of a new velocity squitter provided at least one position report has been transmitted for the target since its last track (re)initialisation. | n | optional |
| ED129_REQ_130 | These reports shall contain at a minimum the items listed in ED-129 Table 7. | y | If velocity reports are supported |
| ED129_REQ_131 | Data driven velocity reports may also contain any of the optional items listed in ED-129 Table 6 for which new information has been received since the previous state vector (position or velocity) report. | y | |
| ED129_REQ_132 | Data-driven velocity reports shall not be issued for targets with duplicate addresses. | y | |
| ED129_REQ_133 | I021/090 Quality Indicators: Navigation accuracy category for velocity set in the primary subfield of I021/090, bits 6 to 8. Only the primary subfield shall be included, and bits 2 to 5 shall be set to zero. | y | |
| ED129_REQ_134 | In accordance with ED-129 Table 4, the 1090 GS shall report the status of the system and its components through the use of ATX023 reports. | y | |
| ED129_REQ_135 | ATX023 specifies three types of status reports: Ground Station Status, Service Status and Service Statistics. The 1090 GS shall be able to generate at least Ground Station Status and Service Status reports. | y | |
| ED129_REQ_136 | ATX023 reports shall include at a minimum the items listed in ED-129 Table 8 for Ground Station Status Reports and in ED-129 Table 9 for Service Status Reports. | y | |
| ED129_REQ_137 | The status reports shall in each case be transmitted periodically with a period of x seconds, where x shall be configurable from 1 to 127 seconds in one-second increments. | y | |
| ED129_REQ_138 | The period of the Ground Station Status reports shall be transmitted in the GSSP field of I023/100. The period of the Service Status reports shall be transmitted in the SSRP field of I023/101. | y | |
| ED129_REQ_139 | The RP field of I023/101 in Service Status reports shall contain the report period for ATX021 reports on that service. The SC field of I023/101 shall be set to 1 for an operational NRA service. | y | RAD Service to be added |
| ED129_REQ_140 | Additionally the 1090 GS shall transmit status reports in event driven mode, whenever a change occurs in the Ground Station status or configuration data items. | y | |
| ED129_REQ_141 | These reports shall indicate the ATX021 and 023 versions currently used by the 1090 GS. | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|--|---------------------|--|
| ED129_REQ_142 | ATX247 Edition 1.2 or later shall be used for ASTERIX Version reports, and they shall be transmitted periodically with a period of x minutes, where x shall be configurable from 0 (meaning no transmission) to at least 60 minutes in ten minute increments. | y | |
| ED129_REQ_143 | 1090 GS with multiple service capability may support different ATX021 and 023 versions per service. In that case a separate version report shall be issued for each service. | n | Single service assumed in this specification |
| ED129_REQ_144 | An ATX247 report shall be the first report transmitted after the 1090 GS service is initialized. This is in order that the ATX021 and 023 reports can be correctly interpreted. | y | |
| ED129_REQ_145 | The ASTERIX Version reports shall include at a minimum the items listed in ED-129 Table 10. | y | |
| ED129_REQ_146 | Data items extracted from ADS-B messages shall be included in ASTERIX target reports for a time period that does not exceed a value dependent on the data item and which may be configured differently per Ground Station Service. | y | |
| ED129_REQ_147 | If the validity time of a data item from ADS-B messages has been exceeded, the data item shall not be included in a report. | y | |
| ED129_REQ_148 | Fields for position, altitude, velocity, heading, NIC/NUC _P and NAC _V /NUC _R shall be included only when they contain new information received from the target since the last State Vector Report. | y | |
| ED129_REQ_149 | Reports triggered by Emergency or SPI status changes shall include the latest values received for the aforementioned fields as long as the information is still valid, even if the data has been sent in a prior report. | y | |
| ED129_REQ_150 | These validity periods shall be set taking into account the requirements of the ADS-B applications supported and the targeted operational environment. ED-129 Table 11 lists recommended validity periods based, where available, on ED-126 and DO-260/A requirements. Adaptations may be necessary for specific local conditions. | y | With DO-260B update |
| ED129_REQ_151 | The reported NIC supplement, NAC _P , SIL or HRD shall be taken from the message closest in time to the message containing the reported position (or velocity in the case of HRD). If they are equally spaced from the position message, the lower value shall be reported. | y | |
| ED129_REQ_152 | I021/008 Aircraft Operational Status: Aircraft Operational Status (I021/008) subfields shall be populated from Aircraft Operational Status messages (FTC = 31) in accordance with ED-129 Table 12. | y | |
| ED129_REQ_153 | I021/008 Aircraft Operational Status: Subfield bit values in I021/008 shall be the same as the respective subfield bit values in the Aircraft Operational Status Extended Squitter message. I021/008 subfields shall be ZERO if the corresponding subfield is not available in the Extended Squitter message. If all subfields are zero, then the I021/008 item shall be omitted from the ASTERIX report, as a zero value will be implied. | y | |
| ED129_REQ_154 | I021/010 Data Source Identification: The SIC and SAC reported in data item I021/010 shall be equal to the values of the SIC and SAC configuration items. The SIC and SAC values shall be formatted as binary unsigned integers. | y | |
| ED129_REQ_155 | I021/015 Service Identifier: The Service Identifier (I021/015) reported in data item I021/015 shall be equal to the value of the | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|---|---------------------|-------|
| | Service Identifier configuration item for the service that produced the report. The Service Identifier values shall be formatted as a binary unsigned integer. | | |
| ED129_REQ_156 | I021/016 Service Management: The Report Period item shall be set to zero for data driven reporting. In periodic mode the report period shall be encoded in accordance with the ASTERIX specification. | y | |
| ED129_REQ_157 | Emitter Category (I021/020) shall be assigned as shown in ED-129 Table 13. | y | |
| ED129_REQ_158 | The Emitter Category data item shall not be included in the report if the data in the ADS-B Emitter Category subfield of the ADS-B Aircraft Identification and Type Message has not been received or has expired. | y | |
| ED129_REQ_159 | I021/040 Target Report Descriptor: ATP (Address Type, bits 8, 7, 6 in the primary subfield) shall be 1 (duplicate address) if the Ground Station determines that this target may have the same 24-bit address as another target. If the Extended Squitter messages received from the target have DF = 18 with CF set to 1, ATP shall be 3. Otherwise the ATP field shall be 0 (24 bit ICAO address), indicating either DF = 17, or DF = 18 and CF = 0, or DF = 19 and AF = 0. | y | |
| ED129_REQ_160 | ARC (Altitude Reporting Capability, bits 5, 4 in the primary subfield). If an airborne position message with Q (ME bit 16, message bit 48) equals 1 has been received from the target and has not expired, the ARC field shall be 0. The ARC field shall be 1 if the Q bit in the airborne position message equals 0. If no airborne position message has been received, or if it has expired, then the ARC field shall be 2. | y | |
| ED129_REQ_161 | RC (Range Check, bit 3 in the primary subfield) shall be set if the range check has been passed but the CPR validation check is not yet complete. | y | |
| ED129_REQ_162 | RAB (bit 2 in the primary subfield) shall be 1 if the target address corresponds to a configured Site Monitor for the Ground Station {SiteMonitorAddress}, otherwise it shall be 0. | y | |
| ED129_REQ_163 | FX (Bit 1 of the primary subfield) shall be one and the first extend included if any of GBS, SIM, TST, SAA or CL (as defined below) are nonzero. | y | |
| ED129_REQ_164 | DCR (Differential Correction, bit 8 in the first extend) shall be 0. | y | |
| ED129_REQ_165 | GBS (Ground Bit Set, bit 7 in the first extend) shall be 0 for targets broadcasting airborne position messages. | y | |
| ED129_REQ_166 | SIM (Simulated Target, bit 6 in the first extend) shall be 0 when the Ground Station is reporting actual targets detected from Extended Squitter messages received over the RF interface in real time. If the Ground Station supports an optional reprocessing capability, SIM shall be 1 when the Ground Station is reprocessing recorded or simulated target data. | y | |
| ED129_REQ_167 | TST (Test Target, bit 5 in the first extend) shall be 1 if the target corresponds to a configured internal test target address for the Ground Station, otherwise it shall be 0. | y | |
| ED129_REQ_168 | SAA (Selected Altitude, bit 4 in the first extend) shall be 1 if the target transponder version has been confirmed as version 1 (DO-260A, and the last Target State and Status message (FTC = 29, Subtype 0) received for this target has not expired and has the Target Altitude Capability field set to | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|---|---------------------|-------|
| | either 1 or 2. In all other cases the SAA bit shall be 0. | | |
| ED129_REQ_169 | CL (Confidence Level, bits 3 and 2 in the first extend) shall indicate the confidence level (CL) of the report. CL shall be 0 ("Report Valid") unless otherwise specified in this document. If CL = 1 ("Report Suspect") and the reason for the report being suspect is defined in the second extend of I021/040, FX (bit 1 of the first extension) shall be 1 and the appropriate error bit or bits in the second extension shall be equal to 1. | y | |
| ED129_REQ_170 | I021/070 Mode 3/A Code: The Mode 3/A Code field shall be constructed from FTC = 23 subtype 7 messages in accordance with ED-129 Table 14. | y | |
| ED129_REQ_171 | I021/071 Time of Applicability for Position: Time of Applicability for Position values shall be rounded to the nearest 1/128th second to satisfy ATX021 constraints. | y | |
| ED129_REQ_172 | I021/071 shall be included in the report if the T bit (ME bit 21, message bit 53) of the last position message equals 1, the FTC of the last position message is 5, 6, 9, 10, 20 or 21, and the Ground Station is in either the UTC Coupled or the Coasting time state. | y | |
| ED129_REQ_173 | I021/071 shall be determined as follows: if (TOMR - t _{Fprevious}) < 200 ms then Time of Applicability = t _{Fprevious} else Time of Applicability = t _{Fnext} endif | y | |
| ED129_REQ_174 | Time of Message Reception for Position (I021/073) shall be included in the report when position is reported and any of the following apply: • The T bit (ME bit 21, message bit 53) of the last position message equals 0. • The T bit (ME bit 21, message bit 53) of the last position message equals 1 and the FTC of the last position message is 7, 8, 11-18 or 22. | y | |
| ED129_REQ_175 | Time of Message Reception for Position (I021/073) shall indicate the UTC time at which the leading edge of the P1 pulse of the last position squitter was received. The time of message reception shall be rounded to the nearest 1/128th second (LSB of I021/073) for this item. | y | |
| ED129_REQ_176 | Time of Message Reception for Position – High Precision (I021/074) shall indicate the fractional UTC second at which the leading edge of the P1 pulse of the last position squitter was received. The fractional time of message reception shall be rounded to the nearest multiple of 2 exp-30 s. I021/074 shall not be included in the report unless I021/073 is also included. FSI in I021/074 shall refer to the whole second in I021/073. | y | |
| ED129_REQ_177 | Time of Message Reception for Velocity (I021/075) shall indicate the UTC time at which the leading edge of the P1 pulse of the last velocity squitter was received. The time of message reception shall be rounded to the nearest 1/128th second (LSB of I021/075) for this item. | y | |
| ED129_REQ_178 | Time of Message Reception for Velocity – High Precision (I021/076) shall indicate the fractional | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|--|---------------------|-------|
| | UTC second at which the leading edge of the P1 pulse of the last velocity squitter was received. The fractional time of message reception shall be rounded to the nearest multiple of 2^{-30} s. FSI in I021/076 shall refer to the whole second in I021/075. | | |
| ED129_REQ_179 | Time of Report Transmission (I021/077) shall contain the time of transmission of the current ASTERIX report with an accuracy of ± 30 ms with respect to UTC. | y | |
| ED129_REQ_180 | Target Address (I021/080) bits 24 through 1 shall be equal to message bits 9 through 32 of the first position message received from a target. | y | |
| ED129_REQ_181 | Quality Indicators Item (I021/090) shall be encoded as specified in ED-129 Table 15. | y | |
| ED129_REQ_182 | Subfield bit values in I021/090 shall be the same as the respective subfield bit values in the Extended Squitter message. I021/090 subfields shall be ZERO if the corresponding subfield in the Extended Squitter is not available or has expired. | y | |
| ED129_REQ_183 | NUCp shall be determined from the position message FTC and Table 2-11 in DO-260 Change 1. | y | |
| ED129_REQ_184 | NIC shall be determined from the FTC of the latest position squitter message, the NIC supplement in the FTC = 31 Aircraft Operational Status squitter message closest in time to the position message, and Table 2-16 of DO-260A. | y | |
| ED129_REQ_185 | NIC _{BARO} , SIL and NAC _P shall be derived from the information received in the Target State and Status (FTC = 29) or Aircraft Operational Status (FTC = 31) Extended Squitter message closest in time to the position squitter message being reported. | y | |
| ED129_REQ_186 | For periodic state vector reports containing no velocity data (no item I021/150, I021/151 or I021/160), the NAC _V subfield shall be set to zero. | y | |
| ED129_REQ_187 | Targets with duplicate addresses shall be reported with the NUC _R and NUC _P parameters only, as for assumed version 0 targets. | y | |
| ED129_REQ_188 | Encoded Latitude and Longitude received in Airborne Position Messages FTC = 9-18 or 20-22 shall be decoded into latitude and longitude in accordance with ED-129 Sections 3.10.2.4 and 3.10.2.5 using the Compact Position Reporting algorithms in Appendix A of DO-260A. The result shall be encoded according to the ASTERIX specification for I021/130. | y | |
| ED129_REQ_189 | Encoded Latitude and Longitude received in Airborne Position Messages FTC = 9-18 or 20-22 shall be decoded into latitude and longitude in accordance with ED-129 Sections 3.10.2.4 and 3.10.2.5 using the Compact Position Reporting algorithms in Appendix A of DO-260A. The result shall be encoded according to the ASTERIX specification for I021/131. | y | |
| ED129_REQ_190 | Message Amplitude (I021/132) shall contain the amplitude of either: a) The ES message that triggered the current report when in data driven mode or b) The most recent ES message from the target when in periodic mode | y | |
| ED129_REQ_191 | The amplitude shall be the reference level determined by the preamble detector, encoded in dBm. | y | |
| ED129_REQ_192 | If the FTC of the last airborne position message is 20-22 and the "Altitude" data is valid, Geometric Altitude shall be equal to the "Altitude" in the last airborne position message | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|---|---------------------|-------|
| | converted to the encoding specified for I021/140 in the ASTERIX specification. | | |
| ED129_REQ_193 | If the FTC of the last airborne position message is 9-18 and the data in the "Altitude," "Difference From Baro Altitude Sign," and "Difference from Baro Altitude" fields are all valid, the Geometric Altitude shall be "Altitude" plus "Difference from Baro Altitude" if "Difference from Baro Altitude Sign" is zero and, "Altitude" minus "Difference from Baro Altitude" if "Difference from Baro Altitude Sign" is one. | y | |
| ED129_REQ_194 | I021/140 shall not be included in the report if either the "Difference from Baro Altitude" or "Altitude" field is all ZEROs. | y | |
| ED129_REQ_195 | If the "Difference from Baro Altitude" field is all ONES, I021/140 shall be encoded using the "greater than" value specified in the ATX021 specification. | y | |
| ED129_REQ_196 | I021/145 Flight Level: Altitude received in FTC = 0 messages shall not be reported. | y | |
| ED129_REQ_197 | If an unexpired airborne position message (FTC = 9-18) has been received from the target since the last State Vector Report was sent, then the Flight Level field shall be included in the report with the value derived from the Altitude field of the airborne position message as follows: - If the Q bit in the altitude field is 1 then the Flight Level field shall be the decimal value of the remaining bits, less 40, expressed as a 16-bit two's complement binary number. - If the Q bit is 0 then the Flight Level field shall be set according to the altitude extracted from the remaining bits using the 100-ft encoding specified in the Appendix to Chapter 3 of ICAO Annex 10, Volume IV. This altitude value (in feet) is divided by 100, multiplied by 4 and expressed as a 16-bit two's complement binary number. | y | |
| ED129_REQ_198 | The Flight Level field shall not be included in the report if one or more of the following apply: a) All bits in the Altitude field of the airborne position message are equal to zero; b) The Altitude field has the Q bit set to zero and does not contain a valid Gillham encoded altitude; c) The last airborne position message has FTC = 0, 20, 21 or 22; d) The airborne position message has expired; e) No surface or airborne position messages have been received since the last State Vector Report was sent; f) A surface position message has been received more recently than the last airborne position report. | y | |
| ED129_REQ_199 | I021/146 Intermediate State Selected Altitude: SAS shall be 0 ("no source information provided") if the field "Vertical Data Available/Source Indicator" in the Target State and Status squitter is equal to "No valid vertical target state data is available" (value 0). | y | |
| ED129_REQ_200 | I021/146 Intermediate State Selected Altitude: SAS shall be 1 ("source information provided") if the field "Vertical Data Available/Source Indicator" in the Target State and Status squitter is not equal to "No valid vertical target state data is available" (value 0). | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|---|---------------------|-------|
| ED129_REQ_201 | The "Source" subfield in I021/146 shall be in accordance with ED-129 Table 16. | y | |
| ED129_REQ_202 | The value in the "Altitude" subfield of I021/146 shall be: Altitude = $(100 * N - 1000) / 25$ where N is the value received in the Target State and Status Message field "Target Altitude". | y | |
| ED129_REQ_203 | I021/146 shall not be included in the report if $N > 1010$ (decimal) or if FTC = 29 has not been received or has expired. | y | |
| ED129_REQ_204 | Air Speed (I021/150) shall be included in reports only when the subtype of the last unexpired airborne velocity message (FTC = 19) is 3 or 4, the "Airspeed Type" is 0 and the value in the "Airspeed" subfield does not equal 0 or 1023 decimal. | y | |
| ED129_REQ_205 | The I021/150 "IM" subfield shall be 0 ("IAS"). | y | |
| ED129_REQ_206 | The I021/150 "Air Speed" subfield shall be the result of the following equations rounded to the nearest integer and expressed as an unsigned integer in binary format: Subtype 3 (normal): Air Speed = $2^{14} * (\text{value in Velocity Message field AIRSPEED} - 1) / 3600$ Subtype 4 (supersonic): Air Speed = $4 * 2^{14} * (\text{value in Velocity Message field AIRSPEED} - 1) / 3600$ | y | |
| ED129_REQ_207 | True Air Speed (I021/151) shall be included in the report only if all of the following conditions are true: a) An airborne velocity message (FTC = 19, subtype 3 or 4) has been received; b) The True Air Speed data from the last airborne velocity message has not expired; c) The Airspeed Type (ME bit 25) is 1; d) The Airspeed field (ME bits 26 through 35) does not equal 0. | y | |
| ED129_REQ_208 | If the last airborne velocity message is of subtype 3 (subsonic) and the value in the airspeed field is not 1023, then the True Airspeed field shall be: $(\text{Value in the airspeed field of the airborne position message}) - 1$ | y | |
| ED129_REQ_209 | If the last airborne velocity message is of subtype 4 (supersonic) and the value in the airspeed field is not 1023, then the True Airspeed field shall be: $4 * (\text{Value in the airspeed field of the airborne position message} - 1)$ | y | |
| ED129_REQ_210 | If the value of the Airspeed field is 1023, the Range Exceeded bit shall be 1 and the True Airspeed shall be 1022 knots for subtype 3 velocity messages and 4085 knots for subtype 4 velocity messages. | y | |
| ED129_REQ_211 | For Version 0 targets, Magnetic Heading (I021/152) shall be included only when the subtype of the last unexpired airborne velocity message (FTC = 19) is 3 or 4 and the "Magnetic Status Heading Bit" equals 1. | y | |
| ED129_REQ_212 | For Version 1 targets, I021/152 shall be included only when the subtype of the last unexpired airborne velocity message (FTC = 19) is 3 or 4, the "Heading Status Bit" equals 1 and the "Horizontal Reference Direction" from the last unexpired aircraft operational status message is 1. | y | |
| ED129_REQ_213 | The I021/152 "Magnetic Heading" subfield shall equal the "Magnetic Heading" (for Version 0 targets) or "Heading" (for Version 1 targets) in the last unexpired airborne velocity message. | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|---|---------------------|-------|
| ED129_REQ_214 | Barometric Vertical Rate (I021/155) shall be included only if all of the following are true: a) An airborne velocity message has been received and the information for vertical rate has not expired; b) The Source Bit for Vertical Rate in the airborne velocity message equals 1; c) The Vertical Rate in the airborne velocity message does not equal 0. | y | |
| ED129_REQ_215 | If the value in the Vertical Rate field of the airborne velocity message is between 1 and 510 inclusive, and the Vertical Rate Sign Bit (ME bit 37) is equal to 1, then the value of the Barometric Vertical Rate field shall be: -floor $\left(\frac{(\text{value in the Vertical Rate field} - 1) * 64}{6.25} + 0.5\right)$ | y | |
| ED129_REQ_216 | If the value in the Vertical Rate field of the airborne velocity message is between 1 and 510 inclusive, and the vertical rate sign bit (ME bit 37) is equal to 0, then the value of the Barometric Vertical Rate field shall be: floor $\left(\frac{(\text{value in the Vertical Rate field} - 1) * 64}{6.25} + 0.5\right)$ | y | |
| ED129_REQ_217 | If the value in the Vertical Rate field equals 511, the RE field shall be 1 and the Barometric Vertical Rate shall be determined using the equations above. | y | |
| ED129_REQ_218 | I021/157 shall be included only if all of the following are true: a) An airborne velocity message has been received and the information for vertical rate has not expired; b) The Vertical Rate Source bit in the airborne velocity message equals 0; c) The Vertical Rate in the airborne velocity message does not equal 0. | y | |
| ED129_REQ_219 | If the value in the Vertical Rate field of the airborne velocity message is between 1 and 510 inclusive, and the Vertical Rate Sign Bit (ME bit 37) is equal to 1, then the value of the Geometric Vertical Rate field shall be: -floor $\left(\frac{(\text{value in the Vertical Rate field} - 1) * 64}{6.25} + 0.5\right)$ | y | |
| ED129_REQ_220 | If the value in the Vertical Rate field of the airborne velocity message is between 1 and 510 inclusive, and the vertical rate sign bit (ME bit 37) is equal to 0, then the value of the Geometric Vertical Rate field shall be: floor $\left(\frac{(\text{value in the Vertical Rate field} - 1) * 64}{6.25} + 0.5\right)$ | y | |
| ED129_REQ_221 | If the value in the Vertical Rate field equals 511, the RE field shall be 1 and the Geometric Vertical Rate shall be determined using the equations above. | y | |
| ED129_REQ_222 | The Ground Vector field shall be included in the ATX021 report only when all of the following are true: a) An Airborne Velocity Message (FTC = 19) with a subtype of 1 or 2 has been received since the last ATX021 report for the target; b) The data in that Airborne Velocity Message has not expired; c) Neither the N/S Velocity nor the E/W Velocity subfields contain all zeros. | y | |
| ED129_REQ_223 | Ground Speed shall be the magnitude of the vector sum of the N/S Velocity and the E/W velocity reported in the Airborne Velocity Message expressed as a 15 bit unsigned integer with a least sig- | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|---|---------------------|----------------|
| | nificant bit of 2^{-14} nautical miles per second. | | |
| ED129_REQ_224 | The Track Angle shall be the direction of the vector sum of the N/S Velocity and the E/W Velocity measured in degrees from True North in a clockwise direction, expressed as a 16 bit unsigned integer with a least significant bit equal to $360^{\circ}/2^{16}$. | y | |
| ED129_REQ_225 | Ground Speed and Track Angle shall be rounded to the nearest multiple of LSB in the ATX021 report. | y | |
| ED129_REQ_226 | If the value in either the N/S Velocity or the E/W Velocity is 1023, the RE bit shall be 1 and the Ground Speed and Track Angle fields shall be determined as described in ED-129 figure 12. | y | |
| ED129_REQ_227 | Target Identification Data Item (I021/170) bits 48 through 1 shall contain a bit-for-bit copy of bits 9-56 of the last Aircraft Identification and Type Message received from the target. | y | |
| ED129_REQ_228 | The Target Identification Data Item (I021/170) shall not be included in ATX021 reports when the Aircraft Identification and Type message data has never been received or has expired. | y | |
| ED129_REQ_229 | I021/200 Target Status: The value of the Priority Status subfield shall be determined from the latest Extended Squitter Aircraft Status Message (FTC = 28) or Target State and Status Message (FTC = 29, available from Version 1 targets only). The value of I021/200 Priority Status shall be equal to the value of the Emergency/Priority Status from the latest FTC = 28 or 29 message. Priority status for reports from targets with duplicate addresses shall be 0. | y | |
| ED129_REQ_230 | The value of the Surveillance Status subfield shall be equal to the value of the Surveillance Status field in the latest Airborne Position Message. | y | |
| ED129_REQ_231 | Expired data in either Priority Status or Surveillance Status shall be encoded with a value of ZERO. | y | |
| ED129_REQ_232 | I021/210 MOPS Version: The Version Not Supported (VNS) field (bit 7) shall be 0 if the target version state is Assumed Version 0, Confirmed Version 0 or Confirmed Version 1. Bit 7 shall be 1 if the target version state is Unrecognized Version. | y | DO-260B update |
| ED129_REQ_233 | The Version Number (VN) field (bits 6-4) shall be 0 if the target version state is Assumed Version 0 or Confirmed Version 0. VN shall be 1 if the target version state is Confirmed Version 1. VN shall be the value reported in the latest aircraft operational status message (FTC = 31, ME bits 41-43) if the target version state is Unrecognized Version. VN shall be 0 in reports for targets with duplicate addresses. | y | |
| ED129_REQ_234 | The Link Technology Type shall be 2 (1090 ES). | y | |
| ED129_REQ_235 | Subfield bit values in I021/271 shall be the same as the respective subfield bit values in the Extended Squitter message. I021/271 subfields shall be ZERO if the corresponding subfield in the Extended Squitter is not available or has expired. | y | |
| ED129_REQ_236 | The receiver sensitivity requirements a) and b) below apply to a standalone 1090 ES Ground Station made up of a single ADS-B receiver in order to support a range of up to 160NM as assumed in ED-126. As stated above they assume the Reference (0dB gain) Antenna. Where a different configuration is used (such as a different antenna gain or where there are multiple distributed receivers | y | |

| Req-id | Requirement from ED-129 | Applicability (y/n) | Notes |
|---------------|--|---------------------|---|
| | making up the ground station, as in a WAM system) and/or a different coverage volume is required, the manufacturer may specify and test against alternative receiver sensitivity figures provided this is fully justified by analysis. That analysis shall show that the receiver sensitivity is sufficient to meet the range requirement. | | |
| ED129_REQ_237 | Valid 1090 ES ADS-B Messages with a carrier frequency between 1089 and 1091 MHz applied directly to the connector at the 1090 GS Receiver at a level of -88 dBm shall produce a Successful Message Reception (SMR) rate of 90% or better. | y | |
| ED129_REQ_238 | Additionally, valid 1090 ES ADS-B Messages with a carrier frequency between 1089 and 1091 MHz applied directly to the connector at the 1090 GS Receiver at a level of -91 dBm shall produce a rate of Successful Message Reception of 15% or better at ambient temperature conditions. | y | |
| ED129_REQ_239 | In the absence of interference or overloads, the standalone 1090 GS made up of a single ADS-B receiver shall achieve a Successful Message Reception (SMR) rate of 99% or better when the desired signal level applied directly to the connector at the 1090 ES Ground Station receiver is between -85 dBm and -20 dBm. | y | |
| ED129_REQ_240 | The 1090 GS equipment will be used in a similar manner to, and in conjunction with, civil telecommunications equipment. The ETSI EN 300 019 [REF30] has been chosen as an appropriate specification for environmental performance. | n | This specification is for Prototype development |
| ED129_REQ_241 | Equipment (including standard packaging) shall be capable of storage at weather-protected, partly temperature-controlled locations as defined by ETSI EN 300 019 Class 1.1. | n | |
| ED129_REQ_242 | All equipment (including standard packaging) shall be capable of being transported by careful transportation as defined by ETSI EN 300 019 Class 2.2. | n | |
| ED129_REQ_243 | Equipment installed at indoor locations shall be capable of use at partly temperature controlled locations as defined by ETSI EN 300 019 Class 3.2. | n | |
| ED129_REQ_244 | Equipment installed at indoor locations where the environment is fully controlled in terms of temperature and humidity shall be capable of use in temperature-controlled locations as defined by ETSI EN 300 019 Class 3.1. | n | |
| ED129_REQ_245 | Equipment installed at outdoor locations shall be capable of use in a non-weather protected environment as defined by ETSI EN 300 019 Class 4.1. (See Note) | n | |
| ED129_REQ_246 | The system shall comply with all current EU regulatory standards including: <ul style="list-style-type: none"> • 2006/95/EC Low Voltage Directive; • 2004/108/EC Electromagnetic compatibility (EMC); • 2002/96/EC Waste electrical and electronic equipment (WEEE); • 2002/95/EC The restriction of the use of certain hazardous substances in electrical and electronic equipment (ROHS). | n | |
| ED129_REQ_247 | The system shall be CE marked to demonstrate compliance with EU directives for product safety. | n | |

Appendix F 1090 MHz Interference environment in ECAC RAD Airspaces

This Appendix describes the 1090 MHz FRUIT (False Replies Uncorrelated in Time) characteristics of the worst case interference environment in ECAC RAD airspaces foreseen for the coming years until 2025. It is based on estimates provided in a CASCADE report [18] on the ECAC RAD FRUIT environments as well as two relevant reports from Project 15.01.06, namely ref. [21] and [22].

These characteristics should serve to quantify the decoding performance and integrity requirements of the 1090 GS.

F.1 Background

Automatic Dependent Surveillance-Broadcast (ADS-B) operates in the 1090MHz band and is subject to interference from surveillance systems (both ground and airborne) operating in the same band (i.e. conventional SSR, Multilateration, IFF, Mode-S, TCAS/ACAS and ADS-B). This interference is typically expressed in terms of numbers of 1090 MHz messages (FRUIT) received per second as a function of their type (i.e. Mode A/C, Mode S short squitter, Mode S long squitter etc) and their signal strength (see ref. [11], App. I).

The 2008 EUROCONTROL CASCADE report [18] provides estimates of the “highest” levels of interference that a 1090 GS will need to operate in both NRA and RAD areas in ECAC up to the year 2025. That report was based on simulations for eight NRA and ten RAD areas around Europe. The RAD test points chosen are shown in Figure 6 and coincide with location of the busiest airports in the ECAC area. The airspaces around these airports were assumed to be the most demanding RAD environments.

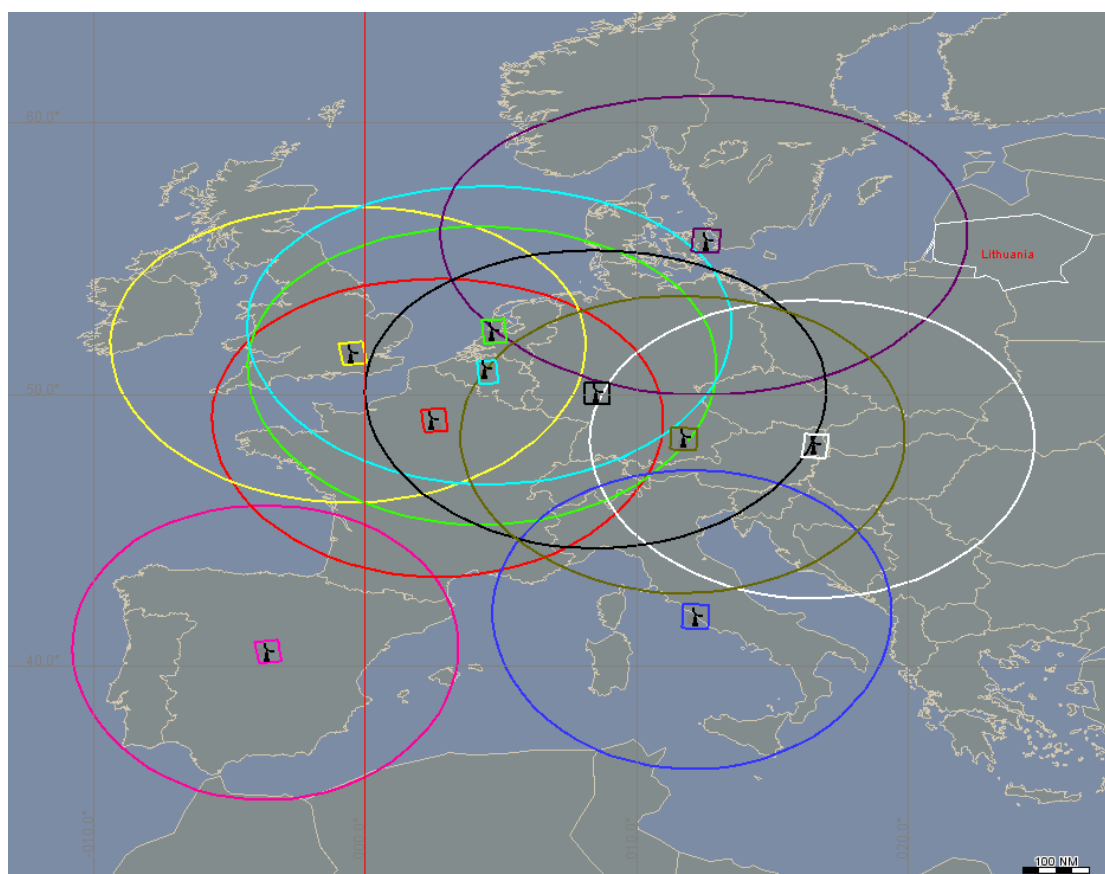


Figure 6 CASCADE Study RAD test point locations and areas of analysis, ref. [18]

More recently the SJU WP15.01.06 project has been exploring the SSR spectrum usage based on air and ground scenarios for the years 2011, 2015, 2020, 2025 and 2030 focusing on the German airspace. A scenarios deliverable was published end of 2010, ref. [22], but it did not include FRUIT estimates. A comparison of the scenarios used by 15.01.06 [22] and the CASCADE report [18] is given in the following section.

F.2 Air and Ground Scenarios

F.2.1 Aircraft Scenarios

The baseline air scenarios for 2008 in the CASCADE report [18] were created from CFMU flight data of the busiest hour in the busiest day of the year 2008. Additional transponder equipped VFR and military traffic, not present in the CFMU data, were included in these scenarios based on analyses of radar data. Mode S, TCAS and Extended Squitter aircraft equipage levels were based on results from airborne monitoring activities in 2008, where available. The 2025 air scenarios were created by extrapolating the baseline 2008 scenarios using traffic growth predictions contained in the 2008 STATFOR Long Term forecast report. Assumptions on the future aircraft equipage were based on known at the time plans for Mode S, ADS-B and TCAS equipage mandates.

The WP15.01.06 aircraft scenarios [22] were derived from:

- The busiest IFR air traffic scenario in Frankfurt TMA and the busiest VFR air traffic scenario in Munich TMA in the year 2009³¹.
- Data from airport systems (Frankfurt, Munich etc) concerning aircraft taxiing on the airport surface in 2010³²
- The total number of military aircraft in Germany in 2008.

The WP15.01.06 air traffic scenarios [22] for 2011, 2015, 2020, 2025, and 2030 were constructed from the above data using the (2010) Medium and (2008) Long Term STATFOR forecast reports.

F.2.1.1 Baseline Aircraft Scenario

The volume of interest in the CASCADE report [18] is a circular area of 330NM radius surrounding the Frankfurt test point.

Table 3 CASCADE Study[18] Baseline Aircraft Scenario (2008)

| Aircraft Type | Total Number of Aircraft | Number of Aircraft per NM ² |
|---------------|--------------------------|--|
| Civil IFR | 1042 | 3.046 10 ⁻³ |
| Civil VFR | 208 | 0.608 10 ⁻³ |
| Military | 104 | 0.304 10 ⁻³ |
| Total | 1348 | 3.9577 10⁻³ |

The volume of interest in the WP15.01.06 reports is (per ref. [21]):

5°-15° East, 46°-55°North => 208.440NM²

Table 4 WP15.01.06 Study [22] Baseline Aircraft Scenario (2009)

| Aircraft Type | Total Number of Aircraft | Number of Aircraft per NM ² |
|-------------------------|--------------------------|--|
| Civil IFR ³³ | 522 + 60 = 582 | 2.79 10 ⁻³ |
| Civil VFR | 763 | 3.66 10 ⁻³ |

³¹ These scenarios were not extracted for the same day as peaks of IFR traffic occur during the working week while VFR traffic peaks occur during the week-end. Furthermore it was assumed that all aircraft without Call Sign under FL 100 can be considered as IFR. It is not specified whether military aircraft recorded on those days were filtered out.

³² It is not specified whether the retained values were maxima or averages during 2010.

³³ Aircraft taxiing on the airport surface are added to Civil IFR.

| | | |
|-----------------|-------------|-------------------------------|
| Military | 133 | 0.638 10⁻³ |
| Total | 1478 | 7.0908 10⁻³ |

There are clearly significant differences between the civil aircraft numbers reported in the two scenarios, which are attributable to the different assumptions used. It should be noted however that the recording used by WP15.01.06 to extract IFR aircraft seems to align with the results of the CASCADE Study (extrapolated to 2009). This (25.09.2009) recording indicates 892 aircraft contained in the snapshot. Taking into account the SESAR volume (208.440NM²), the aircraft density is 4.28 10⁻³ aircraft per NM². In the 2008 CASCADE baseline scenario, the aircraft density is 3.9577 10⁻³ aircraft per NM², and if the growth predicted for 2009 (3.7%, cf below) is taken into account the resulting aircraft density is 4.09 10⁻³ aircraft per NM², which is quite close to the 25.09.2009 snapshot.

F.2.1.2 Aircraft Scenario for 2025

In the CASCADE report [18] scenario traffic extrapolation was performed by applying the growth rates indicated in the 2008 STATFOR Long Term Forecast to the 2008 baseline scenario.

The specific growth rate was chosen using the following methodology:

- For aircraft in the L and M altitude band (0 to 10000ft), the STATFOR growth rate for an individual State was used.
- For aircraft in the H and U altitude band (above 10000ft), the STATFOR growth rate for air traffic flows between European Statistical Regional Areas (ESRA) was used based on the departure and arrival airport contained in the CFMU data for a particular flight.

This growth rate has been applied to all types of aircraft: IFR, VFR and Military. The altitude of the aircraft has been used to determine which STATFOR growth rate to apply.

Table 5 CASCADE Study [18] Aircraft Scenario for 2025

| Aircraft Type | Total Number of Aircraft | Number of Aircraft per NM² |
|----------------------|---------------------------------|--|
| Civil IFR | 1689 | 4.937 10⁻³ |
| Civil VFR | 337 | 0.985 10⁻³ |
| Military | 169 | 0.494 10⁻³ |
| Total | 2194 | 6.413 10⁻³ |

In the WP15.01.06 [22] scenario, STATFOR growth was applied to IFR only. For VFR, a growth of 0.1% was applied. The number of Military aircraft was reduced.

Table 6 WP15.01.06 Aircraft Scenario for 2025 [22]

| Aircraft Type | Total Number of Aircraft | Number of Aircraft per NM² |
|-------------------------------|---------------------------------|--|
| Civil IFR³³ | 785 + 84 = 869 | 4.169 10⁻³ |
| Civil VFR | 775 | 3.718 10⁻³ |
| Military | 131 | 0.628 10⁻³ |
| Total | 1775 | 8.516 10⁻³ |

The differences between the two scenarios are attributable to the baseline differences noted previously and also to the different growth rates applied (see Table 7 below).

Table 7 Air Traffic Growth Rates 2009-2025

| | WP15.01.06 | | | CASCADE | |
|-------------|-------------------|------------|------------|---------------------------------------|--|
| | IFR | VFR | MIL | IFR, VFR, MIL < 10000ft | IFR, VFR, MIL > 10000 ft |
| 2009 | NA | NA | NA | 3.7 | 2.1 |

| | WP15.01.06 | | | CASCADE | |
|-----------|------------|-----|-----|----------------------------|-----------------------------|
| | IFR | VFR | MIL | IFR, VFR, MIL < 10000ft | IFR, VFR, MIL > 10000 ft |
| 2010 | 1.1 | 0.1 | NA | 3.7 | 2.1 |
| 2011 | 3.3 | 0.1 | NA | 3.7 | 2.1 |
| 2012-2014 | 3.1 | 0.1 | NA | 3.7 | 2.1 |
| 2015 | 3.1 | 0.1 | NA | 2.3 | 0.9 |
| 2016-2020 | 2.7 | 0.1 | NA | 2.7 | 1.0 |
| 2021-2025 | 2.2 | 0.1 | NA | 2.2 | 0.7 |

F.2.1.3 Aircraft Types and Equipage

Table 8 Aircraft type and equipage [21]

| Equipage | 2011 | 2008 | 2025 | 2025 |
|---------------------------------|------------|---------|------------|---------|
| | WP15.01.06 | CASCADE | WP15.01.06 | CASCADE |
| Mode S transponder | | | | |
| IFR | 97 % | 95 % | 100 % | 100 % |
| VFR | 95 % | 50 % | 100 % | 100 % |
| Mil | 100 % | 90 % | 100 % | 100 % |
| Enhanced VDL | | | | |
| IFR | 0 % | | 30% | |
| VFR | 0 % | | 0% | |
| Mil | | | | |
| Extended Squitter | | | | |
| IFR | 75% | 75 % | 100% | 100 % |
| VFR | 0% | 0 % | 80% | 0 % |
| Mil | 4 % | 70 % | 100 % | 100 % |
| TCAS | | | | |
| IFR | 100 % | 83 % | 100 % | 100 % |
| VFR | 0 % | 0 % | 0 % | 0 % |
| Mil | 14 % | 0 % | 13 % | 0 % |
| ACAS Hybrid Surveillance | | | | |
| IFR | 0 % | | 90 % | |
| VFR | 0 % | | 0 % | |
| Mil | 4 % | | 9 % | |

It should be noted that the case of ACAS Hybrid Surveillance was considered only in the WP15.01.06 report [22]. ACAS Hybrid Surveillance should reduce the number of ACAS communications.

F.2.2 Ground Interrogator Environments

F.2.2.1 Baseline Scenario: Ground Sensor Environment

Table 9 Civil Ground Sensors – Baseline, ref. [21]

| | Mode A/C | | Mode S | |
|--------------------------|------------|---------|------------|---------|
| | WP15.01.06 | CASCADE | WP15.01.06 | CASCADE |
| | 2011 | 2008 | 2011 | 2008 |
| Austria | 6 | 7 | 1 | 1 |
| Belgium | 3 | 5 | 5 | 2 |
| Bosnia and Herze- | 0 | 6 | 2 | 0 |

| | Mode A/C | | Mode S | |
|------------------------------------|--------------------|-----------------|--------------------|-----------------|
| | WP15.01.06 2011 | CASCADE 2008 | WP15.01.06 2011 | CASCADE 2008 |
| govina | | | | |
| Croatia | 0 | 2 | 2 | 1 |
| Czech Republic | 1 | 2 | 2 | 2 |
| Denmark | 2 | 6 | 1 | 1 |
| France | 7 | 17 | 18 | 13 |
| Germany | 15 | 15 | 13 | 12 |
| Hungary | 0 | 0 | 3 | 3 |
| Italy | 5 | 9 | 23 | 19 |
| Luxemburg | 0 | 0 | 2 | 2 |
| Netherlands | 6 | 5 | 1 | 6 |
| Poland | 10 | 10 | 0 | 3 |
| Serbia and Montene- gro | 0 | 2 | 3 | 3 |
| Slovakia | 0 | 1 | 2 | 1 |
| Slovenia | 0 | 3 | 1 | 1 |
| Switzerland | 0 | 1 | 6 | 6 |
| United Kingdom | 22 | 20 | 26 | 16 |
| total | 77 | 111 | 111 | 92 |

NOTES:

These values can be compared with the Mode S Interrogator Code Allocation status (provided by the EUROCONTROL MICA Cell) for the countries above:

- 131 Mode S radars³⁵ have been allocated an interrogator code before July 201.
- 93 Mode S radars³⁵ have been allocated an interrogator code before End of December 2008. The number of 92 operational Mode S radars in the CASCADE scenario can be considered a bit too high³⁴.

Based on the information provided by the MICA Cell, there are still 63 Mode A/C radars for the countries above in July 2011.

Consequently, the total number of civil radar installed in the countries listed above is:

- $131 + 63 = 194$ radars installed per the information provided by MICA Cell.
- $77 + 111 = 188$ radars installed per the WP15.16 baseline.
- $111 + 92 = 203$ radars installed per the CASCADE baseline (195 if the 8 military radars are removed).

Table 10 Military Ground Sensors - Baseline

| | Mode A/C | | Mode S | |
|-------------------------------------|--------------------|-----------------|--------------------|-----------------|
| | WP15.01.06 2011 | CASCADE 2008 | WP15.01.06 2011 | CASCADE 2008 |
| Austria | 2 | 10 | 2 | 0 |
| Belgium | 5 | 8 | 0 | 0 |
| Bosnia and Herze- govina | 0 | 2 | 0 | 0 |
| Croatia | 0 | 7 | 0 | 0 |
| Czech Republic | 4 | 7 | 2 | 2 |
| Denmark | 4 | 2 | 0 | 0 |
| France | 51 | 51 | 1 | 0 |
| Germany | 50 | 57 | 7 | 7 |
| Hungary | 1 | 1 | 3 | 2 |
| Italy | 7 | 11 | 0 | 0 |
| Luxemburg | 0 | 0 | 0 | 0 |

³⁴ In fact 8 radars were counted as Civil whereas they are military (5 for Netherlands and 3 for Poland). 84 operational Mode S radars (92 – 8) would seem a more realistic value.

| | Mode A/C | | Mode S | |
|-----------------------|--------------------|-----------------|--------------------|-----------------|
| | WP15.01.06 2011 | CASCADE 2008 | WP15.01.06 2011 | CASCADE 2008 |
| Netherlands | 2 | 0 | 5 | 0 |
| Poland | 3 | 5 | 3 | 0 |
| Serbia and Montenegro | 0 | 0 | 0 | 0 |
| Slovakia | 2 | 0 | 0 | 0 |
| Slovenia | 2 | 1 | 0 | 0 |
| Switzerland | 2 | 0 | 0 | 0 |
| United Kingdom | 11 | 24 | 2 | 1 |
| total | 146 | 186 | 25 | 12 |

NOTES:

a. These values can be compared with the Mode S Interrogator Code Allocation status for military radars (provided by MICA Cell) in the countries listed above:

- 44 Mode S radars³⁵ have been allocated an interrogator code before July 2011.
- 22 Mode S radars³⁵ have been allocated an interrogator code before End of December 2008.

The MICA Cell does not have the list of military Mode A/C radars.

b. The WP15.01.06 Study military ground sensor scenario for 2011 includes also a representative day-to-day deployment of mobile military IFF interrogators on board ground vehicles and ships. In general, mobile interrogators are short range systems influencing only a limited area as far as 1030/1090 MHz RF load is concerned. Therefore, the mobile environment has been set up only for the core area of the scenarios, i.e. Germany.

The most important characteristics of the mobile environment are:

- The scenario 2011 includes a total of 55 mobile interrogators spread over the area of Germany. These systems reflect a typical daily worst case density and distribution, caused by the necessity of military training, instruction, functional checks, and exercise activities. All the mobile interrogators are assumed to be not Mode S capable.
- The scenario takes also into account the activity of ten Mode S capable IFF interrogators operated on ships of the German Navy. Five ships are operating in the North Sea and five in the Baltic Sea.

In the CASCADE report [18], no detail about mobile military interrogators has been provided.

F.2.2.2 2025 Scenario: Ground Sensors

The 2025 scenarios used the following assumptions for civil ground sensors:

| No | WP15.01.06 | CASCADE |
|----|---------------------------------------|--|
| 1. | No radar installed at new location | No radar installed at new location |
| 2. | All radars Mode S capable | 50% of the 2008 Mode A/C radars upgraded to Mode S |
| 3. | 10% of the 2011 radars decommissioned | 25% of the 2008 Mode A/C radars decommissioned |

The table below indicates the resulting number of civil ground sensors.

Table 11 Civil Ground Sensors - 2025

| Type | WP15.01.06 | CASCADE |
|--------------|------------|------------|
| Mode AC | 0 | 28 |
| Mode S | 179 | 148 |
| Total | 179 | 176 |

NOTES:

³⁵ That does not mean that all these radars are operational in Mode S.

In the WP15.01.06 scenario all interrogators are Mode S capable and are operated in clusters. Clusters are not taken into account in the CASCADE scenario. At the time being, the two DFS clusters are the only operating civil clusters in Europe. No other country (except Luxembourg) is considering implementing Mode S cluster.

The 2025 scenarios used the following assumptions for military ground sensors:

| No | WP15.01.06 | CASCADE |
|----|---|--|
| 1. | 52% of the interrogators deployed in the scenario are Mode S capable and are operated in clusters ³⁶ | None of the 2008 Mode A/C radars would be decommissioned |
| 2. | 4 Belgium air defence sites are decommissioned | 66.66% would be upgraded to Mode S. |
| 3. | Two mobiles and all ship-borne interrogators are Mode S capable | 33.33% would continue to operate as Mode A/C. |

The resulting numbers of military ground sensors for 2025 are listed below:

Table 12 Military Ground Sensors - 2025

| Type | WP15.01.06 | CASCADE |
|--------------|------------|------------|
| Mode AC | 68 | 63 |
| Mode S | 99 | 135 |
| Total | 167 | 198 |

F.2.2.3 Ground Sensors – Summary for 2025

The Table below indicates the total number of radars in the postulated 2025 environments (without taking into account mobile platforms)

Table 13 Total number of ground sensors - 2025 scenario

| Type | WP15.01.06 | CASCADE |
|--------------|------------|------------|
| Mode AC | 68 | 91 |
| Mode S | 278 | 283 |
| Total | 346 | 374 |

NOTES:

- There are also 55 mobile platforms (2 are Mode S) and 10 shipborne platforms (all Mode S) that may be taken into account.
- Active WAM and MLAT interrogations need to be accounted separately.
- Mode S clustering is accounted for in the WP15.01.06 scenario, but not in the CASCADE one.

F.2.3 Modelling Assumptions

Table 14 Modelling Assumptions comparison, per ref. [21]

| No | WP15.01.06 | CASCADE |
|----|--|--|
| 1. | Maximum TCAS transmission power 55 dBm | TCAS II transmission power 54dBm |
| 2. | Mode S transponder sensitivity -78 dBm | Mode S transponder sensitivity -78 dBm |
| 3. | Lockout range equal to operational range | Lockout range 5 NM less than operational |

³⁶ Concerning military Mode radars operating in cluster:

- Six Mode S capable air defence systems deployed in Germany are operated in one Mode S cluster.
- Four other clusters are planned to be deployed by GAF
- Five Mode S sites deployed in the Netherlands are clustered as well.

| No | WP15.01.06 | CASCADE |
|-----|---|---|
| | | range |
| 4. | Smooth earth model, no terrain effects | Smooth earth model, no terrain effects |
| 5. | Short Squitter transmission rate 1Hz | Short Squitter transmission rate 1Hz |
| 6. | Transponder transmit power Mode S transponder 57 dBm Mode A/C transponder 56 dBm | Transponder transmit power: 57 dBm |
| 7. | Extended Squitter transmission rate scenario 2011: 4.2Hz scenario 2015 upwards: 6.2Hz | Extended Squitter transmission rate scenario 2008: 1.9Hz scenario 2025: 6.2Hz |
| 8. | 2 selective interrogations per scan per aircraft plus re-interrogations if required ³⁷ . | 1.4 selective interrogations per scan per aircraft |
| 9. | Operational range ³⁸ ASR:100 NM RSR:150 NM | Operational range ASR:60 or 100 NM RSR:150, 200, 250NM |
| 10. | Scan rate ASR:4.8s RSR:11.8s | Scan rate ASR:4s or 6s RSR:6s or 8s |
| 11. | Mode A/C IRF ³⁹ ASR:240 Hz RSR:120 Hz 8 hits per dwell (Monopulse) | Mode A/C IRF ASR:275 or 400 Hz RSR:200 or 275 Hz 16 hits per dwell |
| 12. | Mode S all-call IRF ⁴⁰ ASR:130 Hz RSR:53 Hz 8 all-call periods per dwell | Mode S all-call IRF ASR:250 or 400 Hz RSR:100, 125, 170 Hz 16 all-call periods per dwell |
| 13. | duration of all-call period based on operational range ⁴¹ | 2:1 ratio for duration of roll-call and all-call period |
| 14. | pr=0,5 | pr=0,5 |
| 15. | Pure Mode S MIP (Mode S AllCall + Mode A (short P4) / Mode S RollCall / Mode S AllCall + Mode C (short P4) / Mode S Roll Call | Pure Mode S MIP (Mode S AllCall + Mode A (short P4) / Mode S RollCall / Mode S AllCall + Mode C (short P4) / Mode S Roll Call |
| 16. | transmission power: ASR: 55 dBm RSR: 59 dBm | transmission power: 60 dBm for all radars |

The WP15.01.06 Study [22] assumes the radar parameters applied by DFS, but it should be noted that radars operating in neighbouring countries may have different radar parameter values. As a consequence, these radars may well generate more FRUIT than radars in Germany, and that factor

³⁷ In the CASCADE report, it is assumed that an aircraft is interrogated once per scan to get the altitude. The value 1.4 is used to take into account required re-interrogations. In the WP15.01.06 scenario, each Mode S interrogator performs a surveillance altitude request and a Comm-B identity request-short for each Mode S transponder on the roll-call list during each antenna sweep. In practice interrogation patterns vary per operator based on local conditions.

³⁸ In reality ranges vary per operator. Typical values might be from 100NM to 180NM for approach radars and 150NM to 250NM for en route radars.

³⁹ IRF can vary a lot from one operator to another. The maximum frequency is 450Hz. Even if 8 hits per dwell is a common value, some radars are over interrogating. One might consider that 16 is the worst case scenario.

⁴⁰ For Mode S radars, an IRF above 200Hz should not be used. Concerning the number of All Call interrogations, 8 interrogations with a PR=0.5 is a common value, but some operators are using 6 All Call interrogations with a PR=0.5 whereas others are using 10 All Call interrogations with a PR=1. Typical values for ASR would be comprised between 130Hz and 180Hz. Typical values for ERR would be comprised between 70Hz and 130Hz.

⁴¹ The duration of the Roll-Call period depends on the operator. A commonly used ratio is 2:1 as provided in the CASCADE study [18]. The duration of the All-Call period is based on the operational range.

ought to be taken into account. In this respect the CASCADE report [18] seems to be closer to the worst case scenario.

F.3 FRUIT Rate Estimates

FRUIT rate estimates are currently available only from the CASCADE report [18].

The tables below show the total number of transmissions per second for each type of FRUIT (all signal levels) calculated at each RAD test point in Figure 6 for the 2008 and 2025 scenarios respectively.

Table 15 Total FRUIT transmissions per second for 2008 scenarios, ref. [18]

| Test point name | Radar Mode A/C | TCAS Mode A/C | Mode S All-Call | Mode S Roll-Call | TCAS Mode S | Short Squitter | Ex-tended Squitter | Total |
|---------------------------------|----------------|---------------|-----------------|------------------|-------------|----------------|--------------------|---------|
| Frankfurt Airport | 114,895 | 153 | 2,173 | 1,236 | 209 | 340 | 462 | 119,468 |
| Munich Airport | 93,291 | 139 | 1,839 | 974 | 167 | 291 | 399 | 97,101 |
| Paris Charles de Gaulle Airport | 70,752 | 121 | 1,885 | 1,176 | 231 | 355 | 485 | 75,003 |
| London Heathrow Airport | 60,493 | 117 | 1251 | 1,383 | 257 | 320 | 454 | 64,276 |
| Brussels Airport | 99,533 | 158 | 2,319 | 1,437 | 247 | 346 | 494 | 104,534 |
| Schiphol Airport | 98,596 | 184 | 1,875 | 1,433 | 256 | 336 | 471 | 103,151 |
| Rome Fiumicino Airport | 17,430 | 16 | 604 | 310 | 44 | 150 | 209 | 18,764 |
| Madrid Barajas Airport | 10,980 | 23 | 95 | 21 | 49 | 161 | 232 | 11,561 |
| Copenhagen Airport | 25,390 | 22 | 333 | 136 | 32 | 139 | 192 | 26,244 |
| Vienna Airport | 57,779 | 76 | 952 | 725 | 117 | 225 | 323 | 60,197 |

Table 16 Total FRUIT transmissions per second for RAD 2025 scenarios, ref. [18]

| Test point name | Radar Mode A/C | TCAS Mode A/C | Mode S All-Call | Mode S Roll-Call | TCAS Mode S | Short Squitter | Ex-tended Squitter | Total |
|---------------------------------|----------------|---------------|-----------------|------------------|-------------|----------------|--------------------|---------|
| Frankfurt Airport | 81,854 | 0 | 53,702 | 2,676 | 670 | 602 | 3,577 | 143,081 |
| Munich Airport | 62,850 | 0 | 40,061 | 2,146 | 505 | 507 | 3,032 | 109,100 |
| Paris Charles de Gaulle Airport | 47,734 | 0 | 31,129 | 2,280 | 641 | 591 | 3,497 | 85,872 |
| London Heathrow Airport | 34,870 | 0 | 29,404 | 1,667 | 580 | 521 | 3,094 | 70,136 |
| Brussels Airport | 66,153 | 0 | 46,570 | 2,496 | 705 | 589 | 3,534 | 120,046 |
| Schiphol Airport | 65,401 | 0 | 49,498 | 2,260 | 753 | 624 | 3,646 | 122,181 |
| Rome Fiumicino Airport | 13,305 | 0 | 9,826 | 354 | 114 | 262 | 1,538 | 25,398 |
| Madrid Barajas Airport | 4,772 | 0 | 1,900 | 351 | 125 | 277 | 1,606 | 9,030 |
| Copenhagen Airport | 15,934 | 0 | 11,460 | 391 | 113 | 263 | 1,544 | 29,705 |
| Vienna Airport | 38,391 | 0 | 23,342 | 1,735 | 428 | 451 | 2,672 | 67,019 |

The highest FRUIT rates are encountered at the Frankfurt Airport. The following figure shows the cumulative FRUIT rate at the Frankfurt Airport for 2025 as function of signal level.

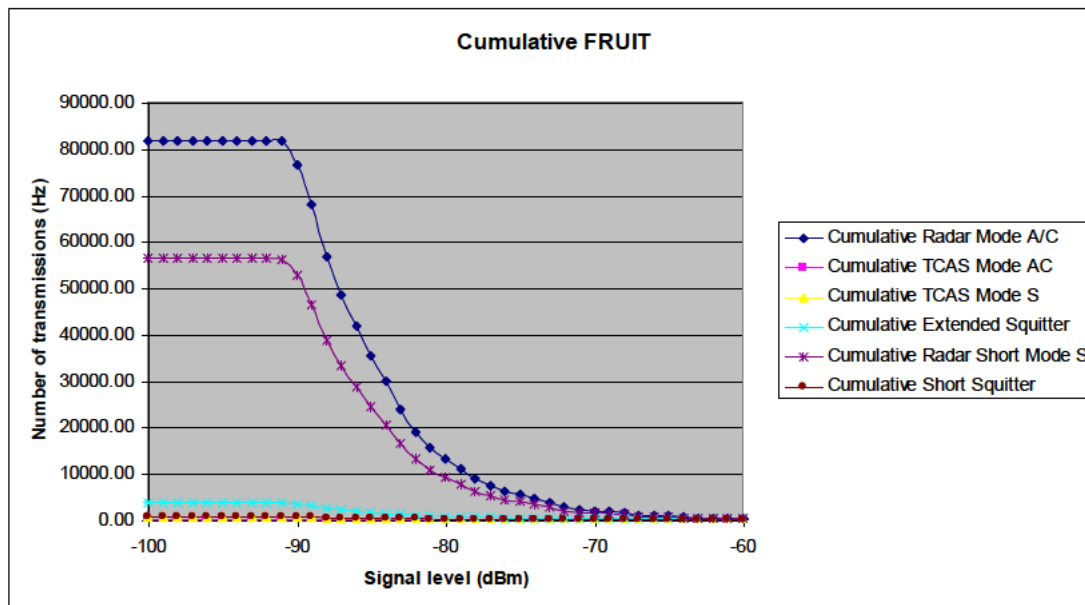


Figure 7 Cumulative FRUIT levels at Frankfurt Airport for 2025, ref. [18]

The following Table lists the numeric values from which Figure 7 was created.

Table 17 Cumulative FRUIT rates at Frankfurt Airport for 2025, ref. [18]

| Signal level (dBm) | Mode A/C (Hz) | All Call (Hz) | Roll Call (Hz) | Short Squitter (Hz) | Extended Squitter (Hz) | TCAS Mode AC (Hz) | TCAS Mode S (Hz) |
|--------------------|---------------|---------------|----------------|---------------------|------------------------|-------------------|------------------|
| -30 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -32 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -34 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -35 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -36 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -38 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -39 | 0.00 | 0.00 | 1.06 | 2.00 | 12.40 | 0.00 | 0.72 |
| -40 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -41 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -42 | 0.00 | 0.00 | 1.06 | 2.00 | 12.40 | 0.00 | 0.72 |
| -43 | 0.00 | 0.00 | 1.06 | 2.00 | 12.40 | 0.00 | 0.72 |
| -44 | 0.00 | 0.00 | 1.06 | 2.00 | 12.40 | 0.00 | 0.72 |
| -45 | 0.00 | 0.00 | 1.06 | 2.00 | 12.40 | 0.00 | 0.72 |
| -46 | 0.00 | 0.00 | 1.59 | 3.00 | 18.60 | 0.00 | 1.08 |

| Signal level (dBm) | Mode A/C (Hz) | All Call (Hz) | Roll Call (Hz) | Short Squitter (Hz) | Extended Squitter (Hz) | TCAS Mode AC (Hz) | TCAS Mode S (Hz) |
|--------------------|---------------|---------------|----------------|---------------------|------------------------|-------------------|------------------|
| -47 | 0.00 | 0.00 | 1.06 | 2.00 | 12.40 | 0.00 | 0.72 |
| -48 | 0.00 | 0.00 | 2.11 | 4.00 | 24.80 | 0.00 | 1.44 |
| -49 | 186.08 | 140.28 | 4.72 | 4.00 | 24.80 | 0.00 | 2.70 |
| -50 | 0.00 | 0.00 | 0.53 | 1.00 | 6.20 | 0.00 | 0.36 |
| -51 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -54 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -55 | 145.61 | 104.08 | 3.39 | 1.00 | 6.20 | 0.00 | 1.44 |
| -56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -63 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -64 | 204.48 | 146.27 | 3.77 | 1.00 | 6.20 | 0.00 | 2.34 |
| -65 | 427.55 | 291.40 | 9.41 | 3.00 | 12.40 | 0.00 | 4.32 |
| -66 | 26.18 | 2.76 | 1.10 | 1.00 | 6.20 | 0.00 | 0.54 |
| -67 | 26.18 | 2.76 | 1.10 | 1.00 | 6.20 | 0.00 | 0.54 |
| -68 | 607.58 | 410.49 | 17.28 | 4.00 | 24.80 | 0.00 | 5.40 |
| -69 | 202.37 | 156.37 | 4.67 | 1.00 | 6.20 | 0.00 | 1.44 |
| -70 | 105.14 | 70.84 | 4.72 | 1.00 | 6.20 | 0.00 | 0.54 |
| -71 | 331.33 | 223.87 | 7.68 | 2.00 | 12.40 | 0.00 | 2.70 |
| -72 | 472.89 | 331.79 | 14.59 | 3.00 | 18.60 | 0.00 | 5.76 |
| -73 | 989.16 | 657.23 | 25.68 | 6.00 | 37.20 | 0.00 | 8.64 |
| -74 | 997.73 | 665.06 | 32.15 | 8.00 | 43.40 | 0.00 | 11.34 |
| -75 | 869.03 | 560.32 | 24.20 | 7.00 | 43.40 | 0.00 | 7.74 |
| -76 | 437.97 | 273.26 | 13.82 | 4.00 | 18.60 | 0.00 | 6.12 |
| -77 | 1284.63 | 808.11 | 35.50 | 9.00 | 43.40 | 0.00 | 9.90 |
| -78 | 1657.62 | 1121.33 | 52.41 | 11.00 | 62.00 | 0.00 | 12.42 |
| -79 | 1985.40 | 1285.28 | 69.54 | 15.00 | 74.40 | 0.00 | 12.96 |
| -80 | 2127.21 | 1443.76 | 62.54 | 14.00 | 80.60 | 0.00 | 14.76 |
| -81 | 2412.24 | 1561.42 | 86.14 | 18.00 | 74.40 | 0.00 | 17.10 |
| -82 | 3458.30 | 2228.10 | 111.15 | 23.00 | 136.40 | 0.00 | 27.72 |
| -83 | 4983.26 | 3240.55 | 179.54 | 33.00 | 179.80 | 0.00 | 36.90 |
| -84 | 5830.35 | 3752.77 | 191.28 | 39.00 | 229.40 | 0.00 | 43.92 |
| -85 | 5645.12 | 3725.68 | 188.54 | 40.00 | 235.60 | 0.00 | 41.22 |
| -86 | 6428.85 | 4220.37 | 211.27 | 45.00 | 279.00 | 0.00 | 44.82 |
| -87 | 6554.64 | 4230.51 | 222.36 | 46.00 | 285.20 | 0.00 | 47.16 |
| -88 | 8201.33 | 5218.08 | 282.02 | 58.00 | 359.60 | 0.00 | 55.44 |
| -89 | 11366.28 | 7410.11 | 363.92 | 76.00 | 471.20 | 0.00 | 112.14 |
| -90 | 8731.37 | 5921.95 | 281.30 | 62.00 | 384.40 | 0.00 | 87.66 |
| -91 | 4990.96 | 3406.76 | 149.65 | 37.00 | 229.40 | 0.00 | 32.40 |
| -92 | 166.74 | 90.19 | 5.83 | 1.00 | 6.20 | 0.00 | 2.16 |

| Signal level (dBm) | Mode A/C (Hz) | All Call (Hz) | Roll Call (Hz) | Short Squitter (Hz) | Extended Squitter (Hz) | TCAS Mode AC (Hz) | TCAS Mode S (Hz) |
|--------------------|---------------|---------------|----------------|---------------------|------------------------|-------------------|------------------|
| -93 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| -94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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