



ADS-B Ground Surveillance Specifications for first iteration

Document information

Project title	Surveillance Ground System Enhancements for ADS-B
Project N°	15.04.05.a.
Project Manager	EUROCONTROL
Deliverable	ADS-B Surveillance Specifications for first iteration
Deliverable ID	Del D18
Edition	00.01.00

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Abstract

The present document describes the first iteration of specifications for the ADS-B Surveillance System. The selection of the requirements upon which these specifications are based are derived from the preceding deliverable D17. The specifications address the functional ADS-B Ground Surveillance Domain without addressing any physical implementation. It includes the following key information:

- Scope and context of the ADS-B Surveillance System.
- The allocation of enhancements for project Iteration 1 (from D17).
- High Level specifications for the ADS-B Ground Surveillance Domain with an indication of the possible system components to which this specification is applicable.

The document serves as input to the subsequent project tasks which will further elaborate the high level specifications into detailed specifications for the ADS-B Ground Surveillance Domain components. It will be revisited as appropriate in the course of the project work on iteration 1.

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Document History

Edition	Date	Status	Author	Justification
00.00.01	29/11/2010	Draft	Leo van der Hoorn	New Document
00.00.02	21/12/2010	Draft	Leo van der Hoorn	Updates after first review by all contributors and review WebEx Meetings.
00.00.03	26/01/2010	Draft	Leo van der Hoorn	Further updates as result of project partner review comments
00.00.04	20/02/2011	Draft	Leo van der Hoorn	Adapt to SJU TS Template Adjustments to review of parallel tasks T01-T04
00.00.05	28/02/2011	Draft	Leo van der Hoorn	Added traceability to NATO

				document for security related requirements
				Corrections as result of D05 Review sessions.
00.01.00	03/03/2011	Final	Leo van der Hoorn	Minor editorial remarks

IPR (foreground)

This deliverable consists of SJU foreground.

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Executive summary

The present document describes the first iteration of specifications for the ADS-B Surveillance System. The selection of the requirements upon which these specifications are based are derived from the preceding deliverable D17 (Ref [1]). The specifications address the functional ADS-B Ground Surveillance Domain without addressing any physical implementation. It includes the following key information:

- Scope and context of the ADS-B Surveillance System.
- The allocation of enhancements for project Iteration 1 (from [1])
- High Level specifications for the ADS-B Ground Surveillance Domain with an indication of the possible system components to which this specification is applicable.

The Project covers enhancements to the baseline by a number of drivers (applications and technological enhancements) which can be clustered as follows:

- 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

In accordance with the set of enhancements defined in [1], high level requirements are described in order to support:

- the ADS-B RAD Application.
- First ADS-B/WAM Integration steps.
- A number of alternative security enhancements.
- The DO260-B transponder standard.

The document serves as input to the subsequent project tasks which will further elaborate the high level specifications into detailed specifications for the ADS-B Ground Surveillance Domain components. It will be revisited as appropriate in the course of the project work on iteration 1.

1 Introduction

1.1 Purpose of the document

This document describes the high level requirements for the first iteration of specifications for the ADS-B Ground Surveillance System

It is to be used as the input document for the project tasks producing the component specifications for ADS-B Ground Station, Surveillance Data Processing and Distribution systems as well as for the enhancements to the baseline interfaces.

The requirements shall be at a high level and shall be allocated to one or more of the above mentioned components.

1.2 Intended readership

The audience of this document includes

- Projects 15.04.05.a and b,
- any other SJU projects that may require ADS-B Surveillance Systems for their validation activities

1.3 Inputs from other projects

The following on-going and past activities have contributed to establishing the high level requirements for the ADS-B Ground Surveillance System:

- EUROCONTROL CASCADE Program
- Requirements Focus Group (RFG) and associated EUROCAE/RTCA standardisation activities for ADS-B Surveillance Applications (Ref [7], Ref [8])
- ADS-B Avionics equipment standardisation by EUROCAE/RTCA(Ref [4],[5], [6])

1.4 Structure of the document

Chapter 1: Purpose and scope; Requirements structure; Component purpose and high level overview

Chapter 2: General component description;

Chapter 3: ADS-B Ground Surveillance Functional and Non-Functional Requirements

Chapter 4: Referenced documents

1.5 Requirements Definitions – General Guidance

Requirements have been developed according to the SESAR Requirements and V&V Guidelines [2].

They are broken down according to the source of the requirements, derived from the allocation which was done in Ref [1].

The layout follows the description in [3]

In accordance with the guidelines in [3], requirement identifiers follow the scheme:

REQ-15.04.05.a-D18-00xx.yyyy, where

xx	Meaning
10	ADS-B RAD Functional req.
20	ADS-B RAD Performance req.

30	WAM integration req.
40	Security req.
50	Civil/Military req.
60	1090ES Technology req.
00	Other

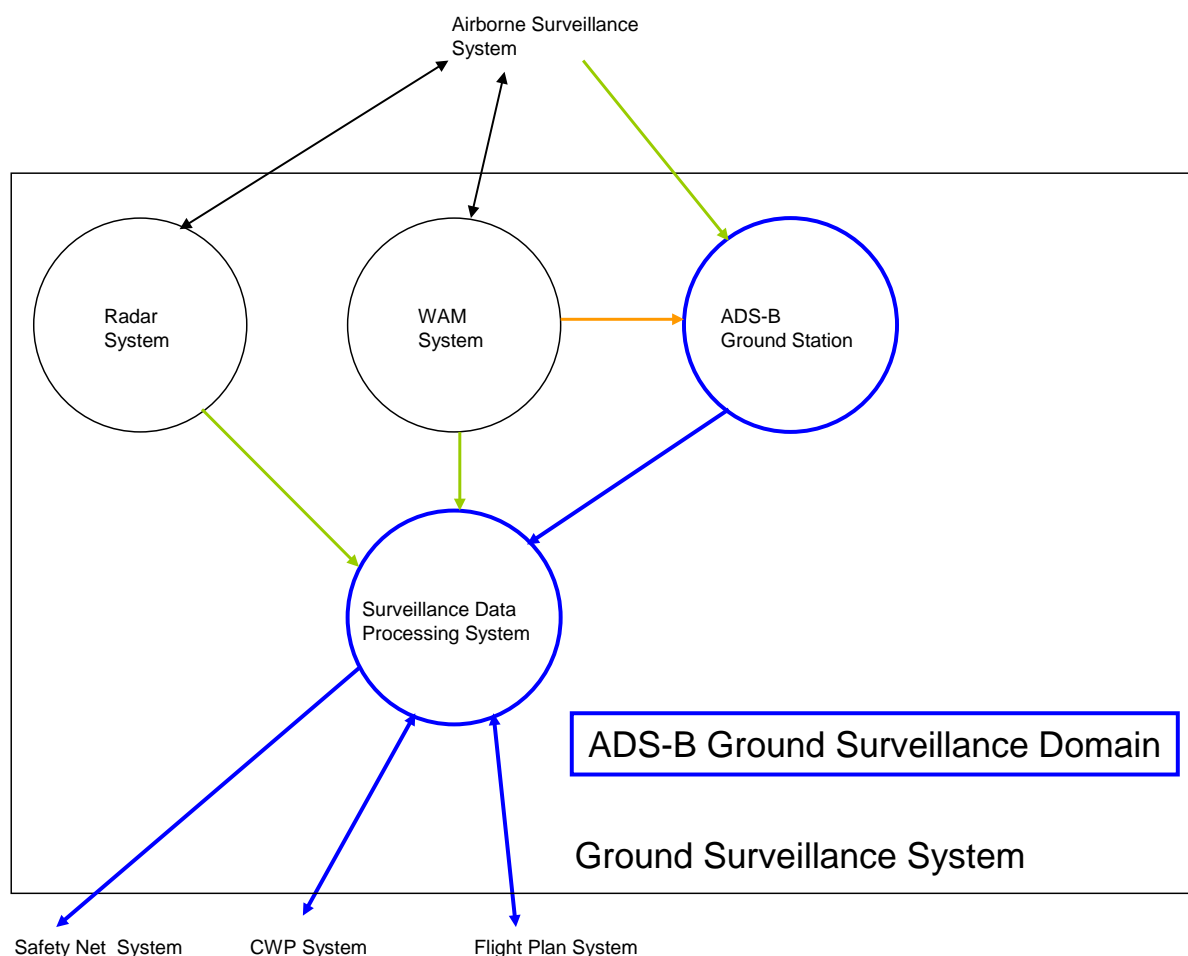
Table 1 Requirement Identifier Allocation





1.6 Component Purpose and Overview

The ADS-B Ground Surveillance Domain is a subset of the overall Ground Surveillance System, and adds the reception, processing and integration of ADS-B data into the surveillance data provided to the ATM System.

It consists of sets of networked ground stations plus data distribution and filtering functions, as well as tracking/fusion capabilities with other surveillance sources.

The figure below depicts a functional context diagram of the future Ground Surveillance System, where the impacted system elements are marked in Blue.

**Figure 1 ADS-B Ground Surveillance Domain Context**

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

In the context of this project, the following functional components are addressed:

- ADS-B Ground Station

The term 'ADS-B Ground Station' in this document refers to a 1090ES Ground Station. The primary function of the ADS-B Ground Station is to receive 1090 MHz RF input on the Air Interface, extract data from the 1090 MHz ES messages, assemble the data into ASTERIX Category 21 ADS-B Reports and send these reports over the Ground Interface.

This specification is not intended to dictate the physical architecture of the equipment. In alignment with the chosen baseline specifications for ADS-B Ground Stations(Ref [9]), the definition of an ADS-B Ground Station is intended to include a distributed architecture where 1090 ES reception functionality is located remotely and the report assembly for one or more sites is hosted centrally in a common server. This distributed architecture allows for the integration of WAM systems and ADS-B Ground Stations. It allows also for physical implementations where SDPD functionality is implemented in the common server of the ADS-B Ground Stations.

- Surveillance Data Processing and Distribution (SDPD)

The baseline for the SDPD is the ARTAS multi-sensor tracking system. This system associates surveillance reports originating from different surveillance technologies (radar, WAM, ADS-B, and ADS-C) and fuses the associated reports into a unique system track. The system tracks are assembled into ASTERIX CAT 62 System Track Messages and these messages are sent over the Ground Interface.

Despite the fact that an existing physical implementation of an SDPD has been chosen as the baseline, the allocation (or non-allocation) of specific requirements to the SDPD should be interpreted as a functional allocation. This specification should not prevent different physical ADS-B Ground Domain implementations. For example, ADS-B Ground Station functionality hosted in a server common to remote 1090ES reception functionality could be implemented in a physical SDPD system.

- Interfaces

The Interfaces subject to modification by the project refer to:

- ASTERIX CAT21, Ed. 1.4, July 2009 (ref [10])
- ASTERIX CAT 23,Ed 1.2, March 2009 (ref [11])
- ASTERIX CAT 62, Ed 1.10, December 2009 (ref [12])
- ASTERIX CAT 63, Ed 1.3, July 2007 (ref [13])

1.7 Acronyms and Terminology

Term	Definition
ACC	Accuracy
ADD	Aircraft Derived Data
ADS-B	Automatic Dependent Surveillance - Broadcast

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Term	Definition
ADS-B ADD	Aircraft Derived Data for ATC tools (“ADS-B out” application)
ADS-B NRA	Enhanced ATS in Non Radar Areas (“ADS-B out” application)
ADS-B RAD	Enhanced ATS in Radar Areas (“ADS-B out” application)
ARTAS	ATM suRveillance Tracker And Server
ASPA-FIM	Flight-deck Interval Management (“ADS-B in” Airborne Spacing Application)
ASSUMP	Assumption
ASTERIX	All-purpose Structured EUROCONTROL Surveillance Information Exchange
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSA-AIRB	Enhanced Traffic Situational Awareness during Flight Operations (“ADS-B in” ATSAW application)
ATSA-ITP	In-Trail Procedure in procedural airspace (“ADS-B in” ATSAW application)
ATSA-SURF	Enhanced Traffic Situational Awareness on the Airport Surface (“ADS-B in” ATSAW application)
ATSA-VSA	Enhanced Visual Separation on Approach (“ADS-B in” ATSAW application)
ATSAW	Air Traffic Situation Awareness
ATX	ASTERIX
CAT	Data Category
DO	RTCA Document
ED	EUROCAE Document
ES	Extended Squitter
EUROCAE	European Organisation for Civil Aviation Equipment
FIM	Flight-deck Interval Management
GS	Ground Station
INTEROP	Interoperability
IP1	Implementation Package 1

Term	Definition
ITP	In-Trail Procedure
Mode S	MODE Select
MOPS	Minimum Operational Performance Standards
NACp	Navigation Accuracy for Position
NM	Nautical Mile
NRA	Non Radar Airspace
OPA	Operational Performance Assessment
OPA-ASSUMP	Assumption made during the OPA
OR	Operational Requirement
OSD	Operational Services and Environment Description
PIR	Project Initiation Report
PR	Performance Requirement
REQ	Requirement
RF	Radio Frequency
RFG	Requirement Focus Group
RTCA	Radio Technical Commission for Aeronautics
SDPD	Surveillance Data Processing and Distribution
SESAR	Single European Sky ATM Research (Programme)
SG 4	Sub Group 4
SJU	SESAR Joint Undertaking
SPI IR	Surveillance Performance and Interoperability Implementing Rule
SPR	Safety and Performance Requirements
SPR-INTEROP	Safety, Performance and Interoperability Requirements
SSR	Secondary Surveillance Radar
SWP	Sub Work Package
TMA	Terminal Manoeuvring Area
TOA	Time Of Arrival

Term	Definition
Tx	Transmission
VSA	Visual Separation on Approach
WAM	Wide Area Multi-Lateration
WG 51	Working Group 51
WP	Work Package

2 General Component Description

2.1 Context

A high level context of the ADS-B Ground Surveillance Domain is shown in Figure 1.

The following Figure gives a more detailed overview of the component boundaries and interfaces.

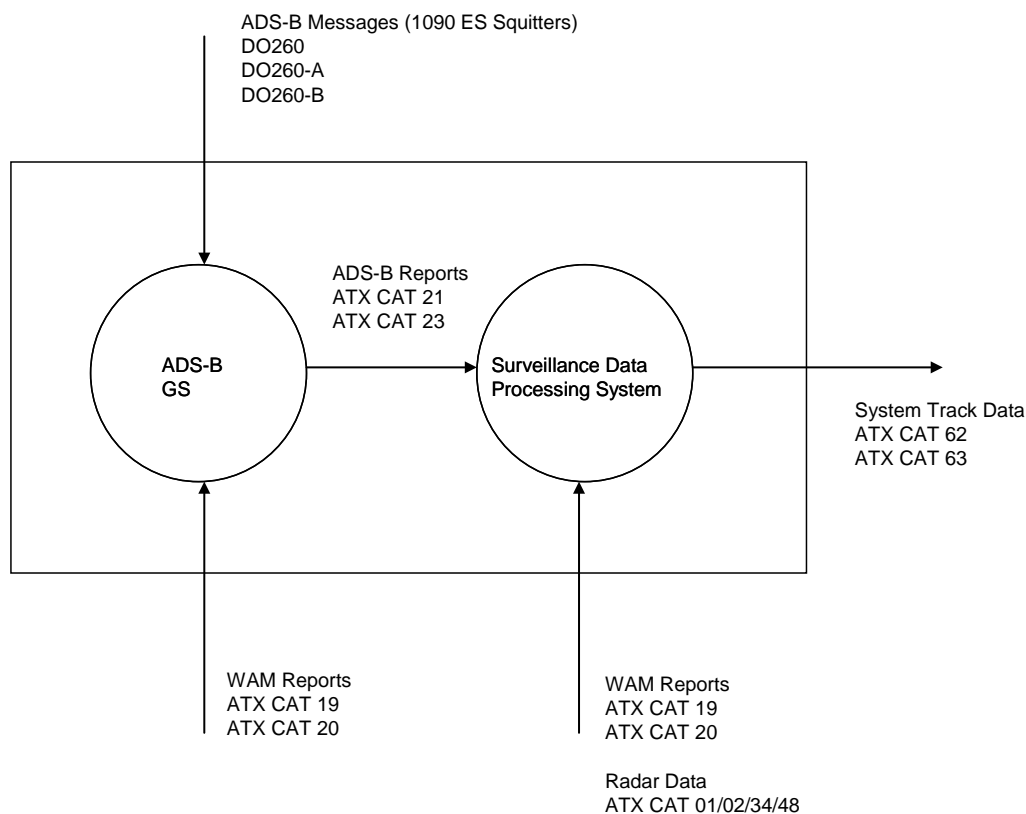


Figure 2 Component Context

2.2 Component Modes and States

Detailed Modes and States of the sub-components are described in the baseline documents ref [9], and [14].

This document will be used as the reference document for further detailed specifications for ADS-B Ground Stations (D05), SDPD (D06) and ASTERIX Interfaces (D07) related to Iteration 1.

Any change towards the Modes and States as a result of this document will be further detailed into those above mentioned deliverables.

2.3 Major Component Capabilities

The major components and capabilities are as described in Section 1.6 of this document

2.4 User Characteristics

The ADS-B Ground Surveillance System shall be capable to be integrated into a multi-sensor surveillance environment as an additional means of surveillance. This usage targets the core European airspace.

The ADS-B Ground Surveillance System shall also be able to be deployed in lower density non-core European airspace. This type of airspace could be Non-Radar Airspace (NRA) in which the ADS-B Ground Surveillance System will be the sole means of surveillance.

The scalability and various potential physical architectures of this system will allow for a surveillance solution adaptable to the local traffic and local ATM system environment.

2.5 Operational Scenarios

The ADS-B Ground Surveillance System is foreseen to be used in a high-density traffic environment (en-route and/or TMA), including multiple surveillance techniques. High quality aircraft position data and other aircraft derived data will contribute to accurate Flight Plan updates and conformity monitoring.

Nevertheless due to its scalability (see User Characteristics above), such a system could also be deployed in non-core European airspace.

2.6 Functional

Due to the bottom-up approach adopted for this first iteration of specifications, a functional decomposition or analysis linking to modeling performed by X.1.7 and/or B.4.3 projects is not applicable to this document.

2.7 Service View

N/A

3 ADS-B Ground Surveillance Functional and non-Functional Requirements

3.1 General

The Project covers enhancements to the baseline by a number of drivers (applications and technological enhancements) which can be clustered as follows:

- 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

The Baseline Definition document (Project deliverable D17) has established the following enhancements to be taken into account for the first iteration:

ADS-B applications	Integration with WAM	Security and civil-military interop	1090 ES Technology
ADS-B RAD ATSA-ITP ATSA-VSA ATSA-AIRB	Simple ADS-B target report validation	Multi sensor data fusion consistency checks Use of increased timestamp accuracy for TOA functionalities Power measurements. And range correlation Angle of arrival measurements Track consistency verification (velocity versus position change).	ED102A/DO260B

Table 2 Enhancements for Iteration 1

The baseline (as described in ref [1]) for the enhancements will be the current ground Surveillance System Specifications, which reflect the requirements for ADS-B in Non Radar Airspace (ADS-B NRA) and (in the case of SDPD) also ADS-B in Radar Airspace (ADS-B RAD), since most of the data fusion related requirements are already included.

The Project will thus build on the results of relevant IP1 work (such as EUROCONTROL CASCADE Programme regarding ADS-B & WAM and the Surveillance Products & Services regarding ARTAS and ASTERIX) as well as industry standardisation (such as EUROCAE WG51 SG4).

ADS-B Surveillance requirements related to applications defined in SESAR Projects are not applicable to the first iteration. These requirements are expected to be mature for inclusion from the second iteration. It is for this reason that the requirements specified in this document follow a bottom-up approach and requirements are not derived from the SESAR Operational Thread.

The high level specifications in this document relate to the En-Route and Approach ATC Domain.

3.2 ADS-B Applications

3.2.1 ADS-B RAD Application Requirements

The following applications, of which published standards by EUROCAE/RTCA are currently available, have been taken into account:

- ADS-B RAD - Enhanced ATS in Radar Areas (ED-161/DO-318)
- ATSA VSA - Enhanced Visual Separation on Approach (ED-160/DO-314)
- ATSA ITP - In-trail procedure in Procedural Airspace (ED-159/DO-312)
- ATSA-AIRB - Enhanced Traffic Situation Awareness during flight operations (ED-164/DO-319)

The three ATSA applications were assessed in order to determine if the enabling “ADS-B out” requirements of those applications would have an impact on the ground surveillance segment.

The result of this assessment showed that these applications have no impact on the ground surveillance segment.

This leaves only the ADS-B RAD application as application to be assessed for the first iteration of specifications.

The following picture is taken from the ED-161 document and shows the functional architecture for the ADS-B RAD application.

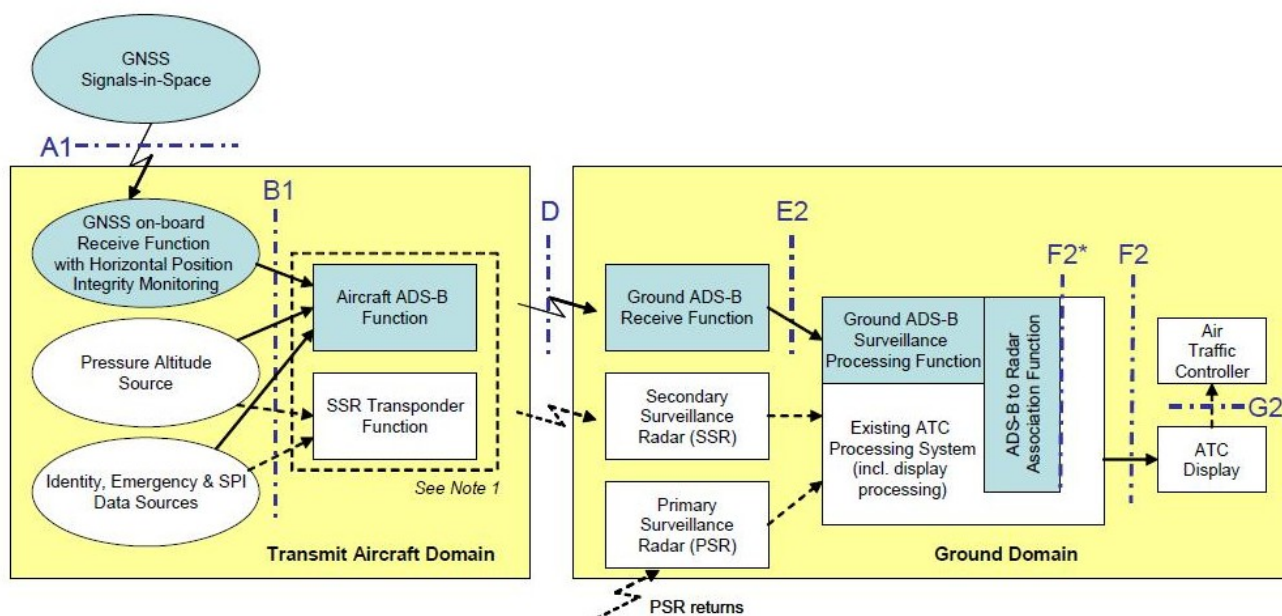


Figure 3 ADS-B RAD Functional Architecture

The ‘Ground Domain’ in ED-161/DO-318 consists of:

- Ground ADS-B Receive Function
- Secondary Surveillance Radar
- Primary Surveillance Radar
- Ground ADS-B Surveillance processing Function
- ADS-B to Radar Association Function
- The existing ATC Processing System
- ATC Display
- Air Traffic Controller

ED-161/DO-318 requirements are limited to:

- Ground ADS-B Receive Function
- Ground ADS-B Surveillance Processing Function
- ADS-B to Radar Association Function

This document maps those requirements on the ADS-B Ground Surveillance Domain as defined in, Figure 3 ADS-B RAD Functional Architecture according to the following Table:

ED-161/DO-318 Functional Component	P15.4.5a Functional Component
Ground ADS-B Receive Function	ADS-B Ground Station
Ground ADS-B Surveillance Processing Function	SDPD
ADS-B to Radar Association Function	SDPD

Table 3 Mapping of ED-161 Functions to Project 15.4.5a functions

The following tables list all identified high level ADS-B Ground Surveillance Domain requirements for the ADS-B RAD application. The requirements are allocated to one or more ADS-B Ground Surveillance Domain Components. If a requirement is allocated to a specific component, the detailed specifications and necessary quantifications will be developed in the subsequent project tasks dealing with component specifications.

[REQ]

Identifier	REQ-15.04.05.a-D18-0010.0001
Requirement	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.
Title	ADS-B Receive
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-26	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0010.0002
Requirement	<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; • Pressure altitude ; • Quality Indications of Horizontal Position ; • Aircraft Identity ; Emergency Indicators ; • Special Position Identification ; • Time of Applicability . <p>NOTE: <i>Emergency Indicators and SPI are provided only when selected by the flight crew.</i></p>

Title	ADS-B Data Provision
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-27	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0010.0003
Requirement	When direct recognition procedures are used by the 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,
Title	Aircraft Identity Retain
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Operational>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-28	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0010.0004
Requirement	The “Ground ADS-B Receive” function shall provide in each ADS-B surveillance report a time of applicability (Interface E2) of the position information
Title	Time Of Applicability provision
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-29	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0010.0005
Requirement	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,
Title	Separate Times Of Applicability provision

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Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-30	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0010.0006
Requirement	The “Ground ADS-B Surveillance Processing” function shall time-register the asynchronously received ADS-B position updates from ADS-B-equipped aircraft
Title	Position Updates Time registration
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-31	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0010.0007
Requirement	The “ADS-B to Radar Association” function shall enable the switching between ADS-B and radar surveillance sources (e.g., as a backup during a failure) without requiring the ATCO to perform a <ul style="list-style-type: none"> • Re-verification of altitude data, and • Re-identification of aircraft identity,
Title	Surveillance Source Switching
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Operational>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-32	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0001
Requirement	The likelihood of an ADS-B Ground Domain system integrity failure shall be 2E-05 or less per hour.
Title	System Integrity
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement

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Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-33	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0002
Requirement	The likelihood of a “Ground ADS-B Receive” function continuity failure shall be 1E-05 or less per hour.
Title	Receive Function Continuity
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Reliability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-34	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0003
Requirement	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. <i>Note: It is assumed that all latency on the “Ground ADS-B Receive” function is compensated.</i>
Title	Latency
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-35	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0004
Requirement	The time of applicability conveyed in the ADS-B surveillance report shall have an absolute accuracy relative to UTC of ± 0.1 seconds or less.
Title	Time Accuracy
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>

V&V Method	<Test>
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[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-36	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0005
Requirement	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. <i>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.</i>
Title	Position Error Introduction
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-37	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0006
Requirement	The ADS-B Ground Domain (including data link) shall not degrade altitude resolution to worse than 100 feet.
Title	Altitude Resolution Degradation
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-38	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0007
Requirement	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.
Title	Report Handling Capacity
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement

Category	<Capacity>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-39	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0008
Requirement	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%. <i>Notes:</i> 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.
Title	Loss of Position Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-40	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0009
Requirement	The probability that the ADS-B Ground Domain detects a loss of ADS-B-reported altitude, and provides an indication of such to the existing ATC Processing System shall be at least 99%. <i>Notes:</i> 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.
Title	Loss of Altitude Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-41	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0010
Requirement	The probability that the "ADS-B to Radar Association" function detects an

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	inconsistency between an ADS-B and radar-reported emergency code, and provides an indication of such to the existing ATC Processing System shall be at least 99%. <i>Note: This requirement, taken together with ASSUMP 37, will ensure that the appropriate safety objectives are met.</i>
Title	Emergency Code Inconsistency Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-42	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0011
Requirement	The probability that the “ADS-B to Radar Association” function detects an inconsistency between ADS-B and SSR aircraft identity data (i.e., Mode A or aircraft identification), and provides an indication of such to the existing ATC Processing System shall be at least 99%. <i>Note: This requirement, taken together with ASSUMP 38, will ensure that the appropriate safety objectives are met.</i>
Title	SSR Inconsistency Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-43	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0012
Requirement	The probability that the “ADS-B to Radar Association” function detects an inconsistency between ADS-B and SSR aircraft pressure altitude data, and provides an indication of such to the existing ATC Processing System shall be at least 99%. <i>Note: This requirement, taken together with ASSUMP 48 will ensure that the appropriate safety objectives are met.</i>
Title	Pressure Altitude Inconsistency Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-44	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>

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<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>
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[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0013
Requirement	<p>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%.</p> <p><i>Notes:</i></p> <p>1. Alternatively, the requirement might be fulfilled by the existing ATC Processing System, i.e., beyond interface F2*.</p> <p>2. This requirement, taken together with ASSUMP 39, will ensure that the appropriate safety objectives are met.</p>
Title	Duplicate Aircraft identities Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-45	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0014
Requirement	<p>The probability that the “ADS-B to Radar Association” function detects a large ADS-B position error, and provides an indication of such to the existing ATC Processing System shall be at least 99%, where a large error is at least 40% of the separation minima for the ADS-B-RAD environment.</p> <p><i>Notes:</i></p> <p>1. This requirement, taken together with ASSUMP 43, will ensure that the appropriate safety objectives are met.</p> <p>2. This requirement is conditional on the sustained corruption of the horizontal position information itself or its quality indicators. Very conservative assumptions have been made on the nature of the resulting horizontal position errors (and their probability distribution) as well as the detection capability of the “ADS-B to Radar Association” function (see Appendix C-1.1 for a detailed discussion). Local safety assessments should take this into due account.</p> <p>3. It is assumed that corresponding ADS-B horizontal position errors greater than 10 NM are always detected,</p>
Title	Large ADS-B Position Error Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-46	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0015
Requirement	<p>The probability that the “ADS-B to Radar Association” function detects a significant ADS-B horizontal position error, and provides an indication of such to the existing ATC Processing System, shall be at least 90%, where a significant error is at least equal to the NIC boundary but less than 40% of the separation minima for the ADS-B-RAD environment.</p> <p><i>Note 1: This requirement, taken together with ASSUMP 43, will ensure that the appropriate safety objectives are met.</i></p> <p><i>Note 2: This requirement is closely linked to SPR 46 (refer also to Note 2 thereof).</i></p>
Title	Significant ADS-B Position Error Detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161:SPR-47	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0016
Requirement	The probability that the “ADS-B to Radar Association” function detects an error of more than 500 ft between ADS-B and SSR pressure altitudes shall be at least 99%.
Title	ADS-B and SSR pressure altitude error detection
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-48	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0017
Requirement	<p>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%.</p> <p><i>Notes:</i></p> <ol style="list-style-type: none"> <i>Additional requirements are subject to local implementation. Other considerations may apply (see OSA: §C.5.1.5 - “Loss of track information”).</i> <i>Data continuity for a single aircraft is inherently encompassed by this requirement 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</i>

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	<i>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.</i>
Title	Track Update probability en-route
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-49	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0018
Requirement	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.
Title	Mode A Code Change Detection En-route
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-50	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0019
Requirement	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.
Title	Emergency/SPI Change Detection en-Route
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-51	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0020
Requirement	For En Route aircraft, if the position accuracy quality indicator (NACp) is not received within 24 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 926 meters (or less) as a substitute for the NACp requirement. <i>Note: Alternatively, the requirement might be fulfilled by the existing ATC Processing System, i.e., beyond interface F2*.</i>
Title	NACp Reception Time-Out En-Route
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-52	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0021
Requirement	The probability of providing a Surveillance Report containing newly received ADS-B Position data of sufficient quality associated with any aircraft in TMA airspace within 5 seconds shall be 97%. <i>Notes:</i> 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.
Title	Track Update probability TMA
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-53	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0022
Requirement	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.
Title	Mode A Code Change Detection TMA
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Performance>

V&V Method	<Test>
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[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-54	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0023
Requirement	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.
Title	Emergency/SPI Change Detection TMA
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-55	<Full>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0020.0024
Requirement	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 substitute for the NACp requirement. <i>Note: Alternatively, the requirement might be fulfilled by the existing ATC Processing System, i.e., beyond interface F2*.</i>
Title	NACp Reception Time-Out TMA
Status	<In Progress>
Importance	<Essential>
Rationale	ED-161 Ground Domain Requirement
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161/SPR-56	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

3.3 Integration of ADS-B with WAM

3.3.1 Simple position data comparison

The vast majority of currently deployed ADS-B 1090 ES systems are integral part of a WAM system. Such integration offers not only the advantage of infrastructure sharing between the two surveillance systems but also the potential for substantial improvement of the 1090ES detection capability (and hence performance robustness of ADS-B reception) by taking into account multilateration derived

data during the squitter decoding process. This is related mainly with target acquisition, handling of duplicate Mode S addresses, protection against spoofing, as well as integrity and continuity enhancements.

Integration with WAM as a protection against spoofing overlaps with the requirements described in Section 3.3 Security and Civil/Military Interoperability.

The first iteration of specifications contains a requirement for a simple validation of received ADS-B positions with an independent surveillance source (WAM). This first step will provide protection against spoofing and integrity enhancements. It will establish the foundation for further integration of the two surveillance sources.

The following tables list all identified high level ADS-B Ground Surveillance Domain requirements for the ADS-B report target validation functionality. The requirements are allocated to one or more ADS-B Ground Surveillance Domain Components. If a requirement is allocated to a specific component, the detailed specifications will be developed in the subsequent project tasks dealing with component specifications.

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0001
Requirement	The ADS-B Ground Surveillance Domain should be capable to receive output from a WAM system in ASTERIX CAT 020 version 1.7.
Title	WAM Reception
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Functional>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0002
Requirement	<p>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:</p> <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
Title	WAM Decoding
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

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Identifier	REQ-15.04.05.a-D18-0030.0003
Requirement	The ADS-B Ground Surveillance Domain should be capable to receive WAM system status messages in ASTERIX CAT 019 version 1.2.
Title	WAM Status Reception
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0004
Requirement	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: <ul style="list-style-type: none"> • Time of Applicability • System Status
Title	WAM Status Decoding
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0005
Requirement	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 CAT019 as a criterion for the enabling of the ADS-B validity check.
Title	WAM System Status Use
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0006
Requirement	If REQ-15.04.05.a-D18-0030.0002 is implemented, the ADS-B Ground Surveillance Domain should correlate ADS-B reports received through 1090ES

	with reports received from a WAM System in ASTERIX CAT020 version 1.7.
Title	ADS-B/WAM Report association
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0007
Requirement	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.
Title	ADS-B/WAM Position Data Comparison
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0008
Requirement	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
Title	ADS-B/WAM Consistency Reporting
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0009
Requirement	If REQ-15.04.05.a-D18-0030.0008 is implemented, the validation result (positive/negative) should be used by the SDPD to determine if the ADS-B report shall be used.
Title	ADS-B/WAM Consistency Use
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity

Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0030.0010
Requirement	If REQ-15.04.05.a-D18-0030.0009 is implemented, the validation result (positive/negative) should be reported to the end user of the surveillance data
Title	ADS-B/WAM Consistency Forwarding
Status	<In Progress>
Importance	<Desirable>
Rationale	ADS-B/WAM Shared infrastructure opportunity
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	SJU PIR Review P15.4.5.a 23/03/2010	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

3.4 Security

3.4.1 Angle of arrival measurements

Position information contained in ADS-B ASTERIX reports only relies on the ES transmitted by the target. This makes the ADS-B system a candidate to receive false positions that may be reported 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.

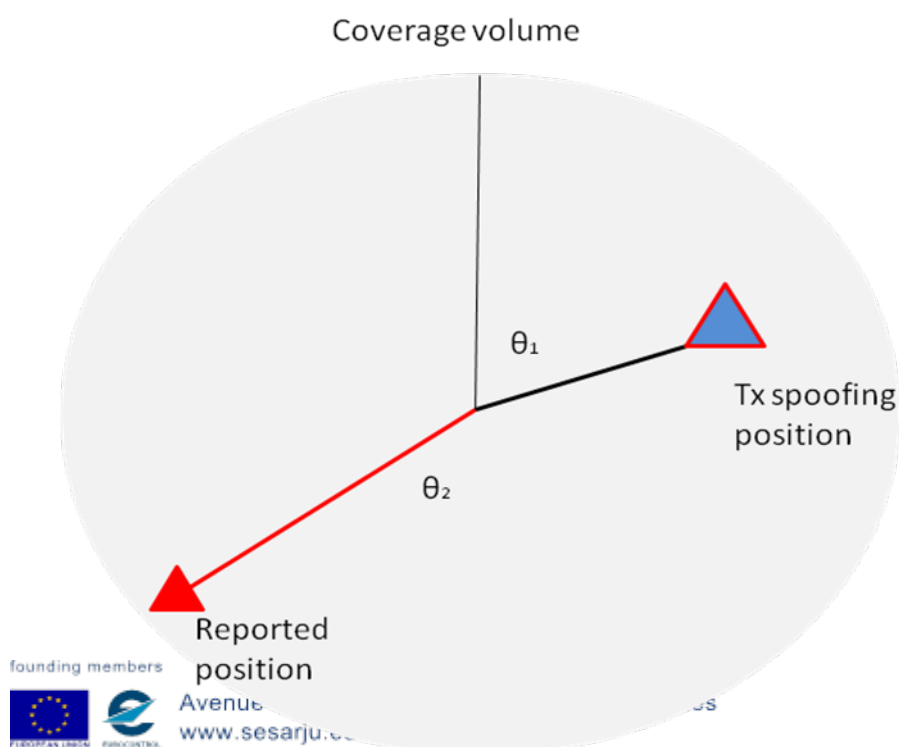


Figure 4 Angle of Arrival validation principle

The direction of arrival measured from the received ES will be compared with the direction of arrival of the received ES, based on the reported position. The direction of arrival measurement, in particular the accuracy of the direction of arrival, can be very dependant of the implementation, so a tolerance interval has to be established to ensure a correct segmentation of the coverage without making the design of the equipment too technology dependant.

Note that the angle of arrival measurement is required as an integrity tool, not as a location method. Due to this fact, the resolution of this angle of arrival determination does not pretend to be as accurate as in other surveillance systems.

The following tables list all identified high level ADS-B Ground Surveillance Domain requirements for the angle of arrival validation functionality. The requirements are allocated to one or more ADS-B Ground Surveillance Domain Components. If a requirement is allocated to a specific component, the detailed specifications will be developed in the subsequent project tasks dealing with component specifications.

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0001
Requirement	The ADS-B Ground Surveillance Domain should have the capability to determine the direction of arrival of the received ES.
Title	Angle of Arrival Detection
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0002
Requirement	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
Title	Angle of Arrival Measurement
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0003
Requirement	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.
Title	Angle of Arrival Storage
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0004
Requirement	If REQ-15.04.05.a-D18-0040.0002 is implemented, the ADS-B Ground Surveillance Domain shall calculate the direction of arrival of each of the received position ES using the reported position and the known GS position.
Title	Reported Angle of Arrival calculation
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0005
Requirement	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.
Title	Angle of Arrival Verification
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

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Identifier	REQ-15.04.05.a-D18-0040.0006
Requirement	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".
Title	Angle of Arrival Inconsistency Detection
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0007
Requirement	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.
Title	Direction of Arrival Failure Reporting
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0008
Requirement	If REQ-15.04.05.a-D18-0040.0007 is implemented, the angle of arrival validation result (positive/negative) should be used by the SDPD to determine if the ADS-B report shall be used.
Title	ADS-B Report Usage
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0009
Requirement	If REQ-15.04.05.a-D18-0040.0008 is implemented, the angle of arrival validation result (positive/negative) should be reported to the end user of the surveillance data
Title	Direction of Arrival Failure Forwarding
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

3.4.2 Track consistency verification

3.4.2.1 Position versus Velocity Check

Actual and historic position and velocity information of the same target could be used to cross-check the credibility of both data items.

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0050
Requirement	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.
Title	ADS-B Position Change versus Velocity validation
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

3.4.3 Power measurements and range correlation

Position information contained in ADS-B ASTERIX reports only relies on the ES transmitted by the target. This makes the ADS-B system a candidate to receive false positions that may be reported by spoofing targets.

Depending on the type of transponder of the target and other parameters such as the antenna gain, height, distance, the ADS-B system will expect to receive ES messages from a target that will be inside a range of power values.

Next figure has been taken from ED129 appendix F and could be taken as power reference for 0dB gain antenna systems:

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

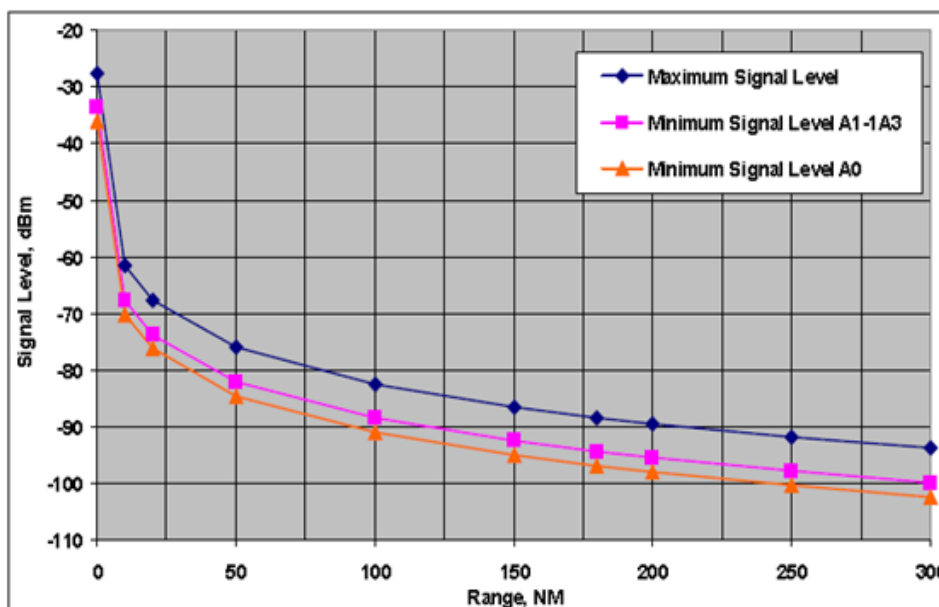


Figure 5 Power Reference for 0Db gain antenna systems

The power measured from the received ES will be used to verify that the power-range of the received ES is contained inside the interval for each of the positions reported by the aircraft.

The following tables list all identified high level ADS-B Ground Surveillance Domain requirements for the power/range validation functionality. The requirements are allocated to one or more Components. If a requirement is allocated to a specific component, the detailed specifications will be developed in the subsequent project tasks dealing with component specifications.

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0040
Requirement	The ADS-B Ground Surveillance Domain should have the capability to measure the power of the received ES
Title	ES Reception Power Detection

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Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0041
Requirement	The ADS-B Ground Surveillance Domain should be capable to detect the equipment class of the transmitting aircraft.
Title	Equipment Class Detection
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0042
Requirement	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.
Title	ES Reception Power Measurement
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0043
Requirement	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
Title	Expected Reception Power Calculation
Status	<In Progress>
Importance	<Desirable>

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Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0044
Requirement	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)
Title	Reception Power Increment Calculation
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0045
Requirement	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.
Title	Reception Power Validation
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0046
Requirement	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".
Title	Reception Power Inconsistency Detection

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Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0047
Requirement	If REQ-15.04.05.a-D18-0040.0046 is implemented, the ADS-B Ground Surveillance Domain shall report "Power/Range inconsistency" in ADS-B reports created out of marked messages.
Title	ES Reception Power / Range Inconsistency Reporting
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0048
Requirement	If REQ-15.04.05.a-D18-0040.0047 is implemented, the power/range validation result (positive/negative) should be used by the SDPD to determine if the ADS-B report shall be used.
Title	ADS-B Report Usage
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0049
Requirement	If REQ-15.04.05.a-D18-0040.0048 is implemented, the power/range validation result (positive/negative) should be reported to the end user of the surveillance data
Title	ES Reception Power / Range Inconsistency Forwarding

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Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

3.4.4 Multi-sensor data fusion consistency checks

The following tables list all identified high level ADS-B Ground Surveillance Domain requirements for multi-sensor data fusion consistency checks. The requirements are allocated to one or more ADS-B Ground Surveillance Components. If a requirement is allocated to a specific component, the detailed specifications will be developed in the subsequent project tasks dealing with component specifications.

The requirements in this section are directly copied from the ED-161 document and as such are expressed as “soft” requirements which can be further elaborated in the applicable sub systems.

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0010
Requirement	In short, the "ADS-B to Radar Association" is an essential operational requirement to support the display in the mixed ADS-B and radar environment. This top-down operational requirement has been further substantiated by the safety assessment. As the function had already been identified for operational needs, it was also considered for its safety benefits in the OSA. Clearly, because the function inherently compares the positions and identities of different surveillance sources for the same aircraft, it also offers some useful safety benefits in a multi-sensor environment, in particular to detect inconsistencies between ADS-B and radar information. Hence, the "ADS-B to Radar Association" function is included in the barriers of the OSA event trees and provides useful gains towards achieving the safety targets.
Title	Multi Sensor Environment Safety Benefits
Status	<In Progress>
Importance	<Essential>
Rationale	Additional Recommendations by ED-161
Category	<Safety>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161 – Page 42	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0011
Requirement	If an automation system does not currently have a bias compensation function, one should be implemented and must also be considered in determining requirements for ADS-B, as it is an additional error component (residual bias).
Title	Multi Sensor Environment Bias Compensation
Status	<In Progress>
Importance	<Essential>

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Rationale	Additional Recommendations by ED-161
Category	<Functional>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161 – OPA ASSUMP 8	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0012
Requirement	It is assumed that the ATC processing system has a multisensory registration function to detect and compensate for systematic biases between radar and ADS-B.
Title	Multi Sensor Environment Bias Compensation
Status	<In Progress>
Importance	<Essential>
Rationale	Additional Recommendations by ED-161
Category	<Functional>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161 – SSE ASSUMP 18	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0013
Requirement	It is recommended the ATC processing system performs a multi-sensor registration function to detect and compensate for systematic biases between radar and ADS-B such that the residual biases are limited to a maximum of 0.05 degrees (azimuth) and 40 meters (range) (see SSE analysis results discussed in §D.5 and §D.6).
Title	Multi Sensor Environment Bias Compensation Performance
Status	<In Progress>
Importance	<Essential>
Rationale	Additional Recommendations by ED-161
Category	<Performance>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161 – SSE ASSUMP 18	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0014
Requirement	In addition to providing enhanced tracker accuracy, sensor fusion can provide a supplementary means of integrity monitoring for En Route airspace that enhances the position integrity available from radar and/or ADS-B measurement data. This is achieved by monitoring radar and ADS-B position measurements versus the best available aircraft position estimate, to discriminate against large

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	position errors.
Title	Multi Sensor Environment Integrity Monitoring
Status	<In Progress>
Importance	<Essential>
Rationale	Additional Recommendations by ED-161
Category	<Functional>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161 – SSE ASSUMP 18	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0015
Requirement	In a multi-sensor environment, in addition to the above functionality, another mitigation means for spoofing could be implemented i.e. the validity check of the ADS-B message to detect incompatible positions w.r.t. the Independent Surveillance sensors, such as SSR Mode-S and/or WAM or the system track.
Title	Multi Sensor Environment Security Enhancement
Status	<In Progress>
Importance	<Desirable>
Rationale	Additional Recommendations by ED-161
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED-161 – SSE ASSUMP 18	<Full>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

3.4.5 Time of Arrival versus Distance Validation

The proposed enhancements are applicable in an operational scenario which foresees multiple ADS-B Ground Stations/1090ES reception functionality in a cluster configuration with the overall ADS-B System output provided by a Central Processing Unit as shown in the figure below.

The principle of this security enhancement lies in a correlation between the correlation of Time of Arrival of Extended Squitters and the reported distance from multiple receivers.

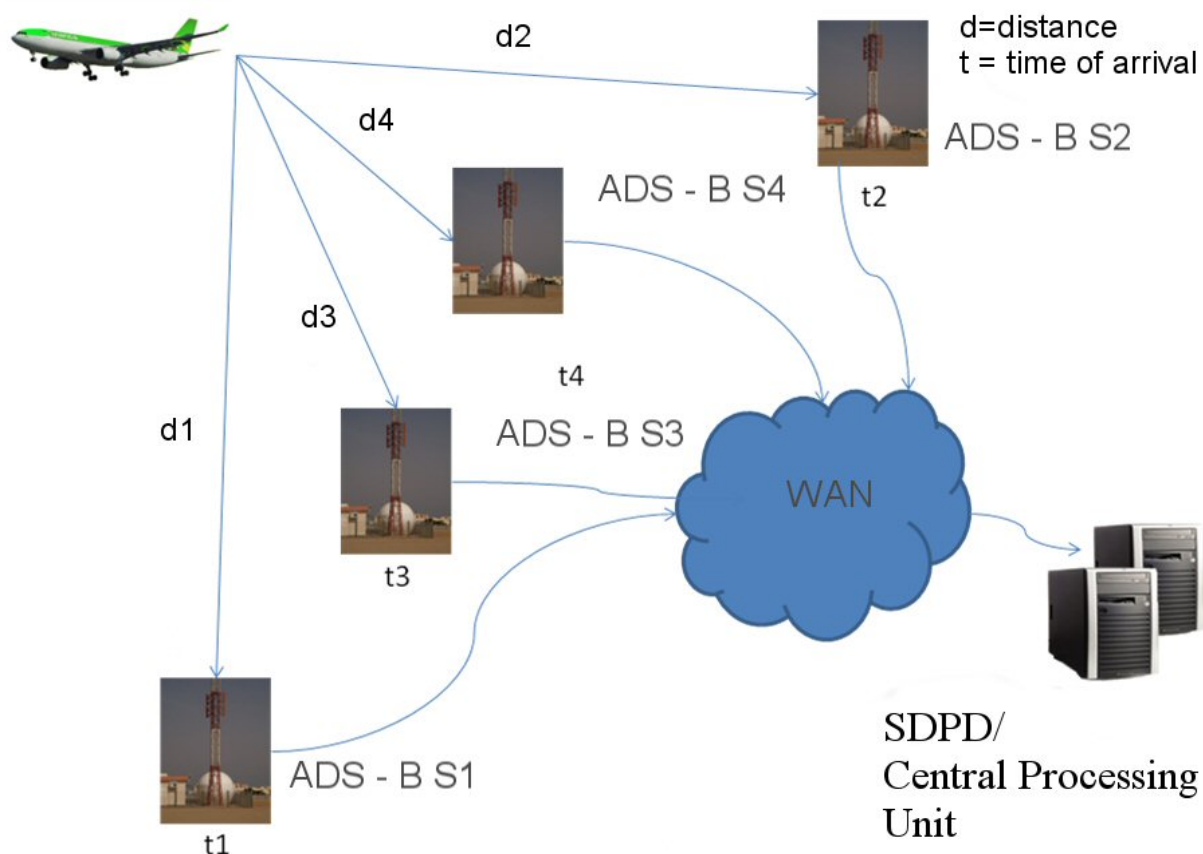


Figure 6 Principle of Time of Arrival versus Distance validation

The following tables list all identified high level ADS-B Ground Surveillance Domain requirements for enhancements exploiting the time difference of arrival techniques.. The requirements are allocated to one or more ADS-B Ground Surveillance Domain Components. If a requirement is allocated to a specific component, the detailed specifications will be developed in the subsequent project tasks dealing with component specifications.

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0030
Requirement	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.
Title	Target Distance calculation
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0031
Requirement	The ADS-B Ground Surveillance Domain should have a function elaborating

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	the consistency of TOA versus calculated distance from an ADS-B receiver for multiple ADS-B receivers having received the same position squitter.
Title	Calculated Distance versus TOA validation
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0032
Requirement	If "n" consecutive position updates for which the TOA/distance consistency check yields inconsistent, then the ADS-B Ground Surveillance Domain shall mark the message as "inconsistent TOA/distance".
Title	TOA versus Distance Inconsistency Detection
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0033
Requirement	The ADS-B Ground Surveillance Domain shall report "inconsistent TOA/distance" in ADS-B reports created out of marked messages.
Title	ES TOA / Distance Inconsistency Reporting
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0034
Requirement	The TOA/distance consistency check result (positive/negative) should be used by the SDPD to determine if the ADS-B report shall be used.
Title	ADS-B Report Usage
Status	<In Progress>
Importance	<Desirable>

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Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0040.0035
Requirement	If REQ-15.04.05.a-D18-0040.0034 is implemented, the TOA/distance consistency check result (positive/negative) should be reported to the end user of the surveillance data
Title	ES TOA / Distance Inconsistency Forwarding
Status	<In Progress>
Importance	<Desirable>
Rationale	Proposed Security Enhancement
Category	<Security>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	NATO C3 Agency Technical Note 1407	<Partial>
<APPLIES_TO>	<Subsystem>	SDPD	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

3.5 Civil Military Interoperability

The ADS-B Surveillance System should be interoperable with the military aircraft ADS-B In/Out solution defined in 9.24. The project will follow the outcome of Project 9.24, but for Iteration 1, no tangible requirements for the ADS-B Ground Surveillance Domain have been identified.

3.6 1090ES Technology

3.6.1 ED102A/DO260B Compatibility

The following table lists all identified high level ADS-B Ground Surveillance Domain requirements for enhancements related to ED102A/DO260B compatibility. The requirements are allocated to one or more ADS-B Ground Surveillance Domain Components. If a requirement is allocated to a specific component, the detailed specifications will be developed in the subsequent project tasks dealing with component specifications.

[REQ]

Identifier	REQ-15.04.05.a-D18-0060.0060
Requirement	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.
Title	DO-260B Message Reception
Status	<In Progress>
Importance	<Essential>
Rationale	DO-260B Compatibility
Category	<Interoperability>

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V&V Method	<Test>
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[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED102A/DO260B	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0060.0061
Requirement	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.
Title	DO-260B Message Decoding
Status	<In Progress>
Importance	<Essential>
Rationale	DO-260B Compatibility
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED102A/DO260B	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0060.0062
Requirement	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.
Title	DO-260/DO-260A Backward Compatibility
Status	<In Progress>
Importance	<Essential>
Rationale	DO-260B Compatibility
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED102A/DO260B	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Full>

[REQ]

Identifier	REQ-15.04.05.a-D18-0060.0063
Requirement	The ADS-B System ground surveillance domain shall be able to transform the introduced DO-260B changes into Standard ASTERIX Category 21 data items.
Title	DO-260B encoding into ATX CAT 021
Status	<In Progress>
Importance	<Essential>
Rationale	DO-260B Compatibility
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

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Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED102A/DO260B	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

[REQ]

Identifier	REQ-15.04.05.a-D18-0060.0064
Requirement	The ADS-B Ground Surveillance shall be able to output the DO-260B changes via Standard ASTERIX Category 21 data reports.
Title	ATX Category 21 Output
Status	<In Progress>
Importance	<Essential>
Rationale	DO260B Compatibility
Category	<Interoperability>
V&V Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	ED102A/DO260B	<Partial>
<APPLIES_TO>	<Subsystem>	ADS-B GS	<Partial>
<APPLIES_TO>	<Subsystem>	Interfaces	<Partial>

3.6.1.1 Summary of Differences between RTCA DO-260A and RTCA DO-260B

3.6.1.1.1 Eliminated Fields in 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

3.6.1.1.2 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

3.6.1.1.3 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

3.6.1.1.4 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

3.7 Component Internal Data Requirements

This specification does not prescribe any particular internal component architecture.

3.8 Design and Construction Constraints

No design or construction constraints have been identified.

3.9 Component Interface Requirements

The ADS-B Ground Surveillance System uses the EUROCONTROL ASTERIX Surveillance Standard for all message exchange with other ground ATM system components as well as for internal communication between ADS-B Ground Station and Surveillance Data Processing components.

For the reception of airborne data the ADS-B Ground Surveillance System uses the ED-102A/DO-260B standard, but shall also be compatible with ED-102/DO-260 and DO-260A standards.

4 References

- [1] SJU 15.04.05a Specification Baseline Document, D17, Ed. 00.01.00, Oct 2010
- [2] SESAR Requirements and V&V Guidelines Latest version
- [3] SESAR Toolbox User Manual Latest version
- [4] EUROCAE/RTCA MOPS for 1090 MHz ADS-B, ED-102/DO-260, Sept. 2000
- [5] RTCA MOPS for 1090ES ADS-B and TIS-B, DO-260A, Dec. 2006 (includes Changes 1 and 2)
- [6] EUROCAE/RTCA MOPS for 1090ES ADS-B and TIS-B, ED-102A/DO-260B, Dec. 2009
- [7] EUROCAE/RTCA SPIR Document for ADS-B NRA Application, ED-126/DO-303, Dec. 2006
- [8] EUROCAE/RTCA SPIR Document for ADS-B RAD Application, ED-161/DO-318, Sept. 2009
- [9] EUROCAE ED129: Technical Specification for a 1090 MHz Extended Squitter ADS-B Ground Station, June 2010
- [10] EUROCONTROL ASTERIX Standards CAT 21, Ed 1.8, Jan 2011,
- [11] EUROCONTROL ASTERIX Standards CAT 23, Ed 1.2, March 2009
- [12] EUROCONTROL ASTERIX Standards CAT 62, ED 1.10, December 2009
- [13] EUROCONTROL ASTERIX Standards CAT 63, Ed 1.3, July 2007
- [14] EUROCONTROL ARTAS V8, System/Segment Specifications, Doc. 46 127 300 - 305

4.1 Use of copyright/patent material /classified material

No copyright/patent material is included in this specification

Appendix A Traceability

The project intends to import all requirements defined in this document as well as the lower level derived requirements as specified in Deliverables D5,D6 and D7, into a requirements management tool (like DOORS).

Such a tool will then generate an overall traceability matrix which could be included in this document at a later stage.

- END OF DOCUMENT -