

# SESAR 2020 PJ.14-W2-79a TRL6 Final TS IRS GAST D Extended Scope

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01.01.01	16.08.2022	Revised	Indra	Update according to S3JU comments
01.02.00	31.10.2022	Revised	Indra	W1 PJ.14-03-01 ATC and maintenance interface requirements (assessed to TRL6) added in W2 TS/IRS for completeness
01.03.00	07.11.2022	Revised	Indra	Updated sections related to ATC and maintenance interface to reflect ED_114B Change 1 decision not to standardize SNMPv2c technology. OE Terminal Airspace added. Minor editorial updates are also done.

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# I-CNSS

## INTEGRATED COMMUNICATION NAVIGATION AND SURVEILLANCE SYSTEM

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### Abstract

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This document is the Final Technical Specification/ Interface Requirements Specification (TS/IRS) for the PJ.14-W2-79a GAST D Extended Scope activities carried out within WP9 Dual Frequency Multi Constellation DFMC GBAS of the SESAR 2020 project PJ.14 I-CNSS. PJ.14-W2-79a seeks to further mature the wave 1 PJ.14-03-01 GAST D extended scope activities from TRL4 to TRL6 in wave 2. The activities address performance assessment of GAST D in challenging environments. These environments are severe ionospheric and scintillation conditions, ground segment RFI threats, and large and complex airport environments. The relevant performance requirements are specified in ICAO Annex 10 Vol. I and ICAO Doc. 8071 Vol. II and listed herein. In wave 2, there are no changes to the baseline architecture described in wave 1 D8.2.010.1 TS/IRS.

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# 1 Executive summary

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The TS/IRS covers the requirement specification for the task T3 GAST D Extended Scope of PJ.14-W2-79 DFMC GBAS solution. This task builds upon wave 1 GAST D extended scope activities and focuses on performance assessment of GAST D in challenging environments. These environments include severe ionospheric and scintillation conditions, ground segment RFI threats, and large and complex airport environments.

Two technical enablers are further matured: GAST D extension to equatorial and Nordic regions (CTE-N07e) and GBAS robustness towards interference (CTE-N07f). The wave 1 PJ.14-03-01 technical enabler CTE-N07g addressing ground station provision of GBAS approach service performance parameters to ATCO and maintenance personnel is re-assessed at TRL6. The target maturity level for the GAST D Extended Scope solution is TRL6 in wave 2.

VDB ground measurement equipment and a runway coverage simulation tool were developed and technically validated in SESAR 2020 Wave 1. The equipment was used to validate among other ICAO minimum VDB field strength requirement for autoland in 36ft to 100ft above the runway. Building upon this work, PJ.14-W2-79a seeks to validate the ICAO Doc 8071 Vol. II  $\pm 3$  dB measurement uncertainty requirement. To this aim, a horizontally polarized VDB measurement antenna that fits on a measurement van and provides omnidirectional characteristic for an installation in 12 feet above ground is developed and used as part of the validation platform to technically verify the  $\pm 3$  dB measurement uncertainty requirement.

The relevant performance requirements for the performance assessment in the environments addressed by CTE-N07e and CTE-N07f are defined in ICAO Annex 10 Vol. I and Doc 8071 Vol. II and listed herein. A further refinement of the ICAO SARPs into ground station system level requirements is deemed unnecessary.

## 2 Introduction

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### 2.1 Purpose of the document

The TS/IRS covers the requirement specification for the subtask T3 GAST D Extended Scope of PJ.14-W2-79 DFMC GBAS solution.

### 2.2 Scope

PJ.14-W2-79a GAST D Extended Scope builds upon SESAR wave 1 solution PJ.14-03-01 GBAS task T3 GAST D Extended Scope, aiming to mature the GAST D extended scope functionality from TRL4 to TRL6.

The addressed functionality aims to further improve the performance of the GAST D solution within the following areas:

Operation under adverse conditions

- T3.1.1 GAST D Ionosphere monitoring and analysis
- T3.3 GAST D Ground Station Threats (RFI)

GBAS operation and maintenance at large and complex airports and support demonstration of regulatory compliance

- T3.2 VDB Measurement Equipment

For the above subtasks, the technical specifications are covered by the ICAO SARPs [13] and ICAO 8071 Vol. II [14]. Table 1 and Table 2 indicate the ICAO requirements that apply for the different PJ.14-W2-79a subtasks.

A further refinement of the requirements that are listed in Tables 1 and 2 is not carried out in this TS/IRS as the GAST D Ground Station is considered a black box in the context of assessing the compliance to the ICAO requirements.

PJ.14-W2-79a also includes a continuation of SESAR 2020 wave 1 PJ.14-01-01 activity to develop a European Ionosphere Threat model in support of GBAS implementation. This work is not part of TS/IRS scope.

A methodology and tools for the identification and source location of multipath threats on GBAS reference stations at an airport was developed and validated in PJ.14-03-01 in wave 1. This tool and performance assessment of multipath conditions is continued outside SESAR programme wave 2 and not discussed further in this TS/IRS.

The TS/IRS re-captures the requirement specification for an ATC and maintenance interface that was developed within the subtask T3 of PJ.14-03-01 GBAS solution. The associated technical enabler, CTE-N07g, is considered to have reached maturity TRL6 and for completeness included in this final TRL6 TS/IRS. The data that is identified by PJ.14-03-01 as candidate status information to be made available to external stakeholders over the GBAS Ground Station's ATC and Maintenance interface was



presented at end of SESAR 2020 wave 1 to EUROCAE WG28 for consideration in a future revision of ED\_114B. The final set of data parameters specified by EUROCAE WG28 is published in ED-114B Change 1.

Subtasks of T3 GAST D Extended Scope and applicable ICAO Annex 10 Volume I requirements		
Subtask	Reference to ICAO requirement	Description of requirement
T3.1.1 Ionospheric monitoring and analysis	ICAO Annex 10 Vol 1 appendix B section 3.6.7.3.4 Ionospheric gradient mitigation (adverse conditions)	The requirement specifies that ionospheric gradients that would otherwise cause an out of spec range measurement shall have a detection probability equal or greater than $1-1 \times 10^{-9}$ .
	ICAO Annex 10 Vol 1 appendix B section 3.6.7.1.3.2 Additional continuity of service requirements for FAST D (nominal conditions)	Performance requirement under nominal conditions (probability of false exclusion of satellite under nominal conditions).
	ICAO Annex 10 Vol 1 appendix B section 3.6.7.2.3.5.2 Ionospheric uncertainty estimate parameter for FAST D ground subsystems	The ground subsystem shall broadcast an ionospheric delay gradient parameter in the VDB message such that the protection level integrity risk requirements (appendix B 3.6.7.1.2.2) are satisfied.
T3.2 VDB Measurement Equipment	ICAO Annex 10 Vol 1, section 3.7.3.5.4.4.1.2 ICAO Annex 10 Vol 1, section 3.7.3.5.3.2	The VDB Measurement Equipment is updated with a new VDB Antenna. The VDB Antenna must fulfil the following requirements: 1.The given power flux density limits are (ICAO 3.7.3.5.4.4.1.2): - Upper bound: $-27 \text{ dBW/m}^2$ - Lower bound $-99 \text{ dBW/m}^2$ 2.The antenna must be mounted on the van in 12ft about local ground (ICAO 3.7.3.5.4.4.1.2). 3.The VDB Antenna must work within the GBAS frequency band of 112.050 to 117.900 MHz (ICAO 3.7.3.5.4.1).

	<p>ICAO Annex 10 Vol 1 Service volume: §3.7.3.5.3                  ICAO Annex 10 Vol 1 Appendix B Field strength: §3.7.3.5.4.4.1                  Relevant subsection in §3.6.4 Data content:                  4.2 Type 1 message – pseudo-range corrections                  4.3 Type 2 message – GBAS-related data                  4.4 Type 3 message – NULL message                  4.5 Type 4 message – Final Approach Segment (FAS)                  4.11 Type 11 message – pseudorange corrections 30s smoothed pseudo-ranges</p>	
T3.3 GBAS Ground Subsystem threats	ICAO Annex 10 Vol I Appendix B section 3.7.3.4	SBAS and GBAS receivers shall not output misleading information in the presence of interference including interference levels above those specified in ICAO Annex 10 Vol I App B section 3.7.

Table 1 PJ.14-W2-79a GAST D Extended Scope subtasks and applicable ICAO Annex 10 Vol. I requirements.

Subtasks of T3 GAST D Extended Scope and applicable ICAO Doc 8071 Vol. II requirements		
Subtask	Reference to ICAO requirement	Description of requirement
T3.2 VDB Measurement Equipment	ICAO Doc 8071 Vol. II See “Table II-4-2B. Summary of minimum ground test requirements — GBAS VHF data broadcast” (Runway Surface Coverage)	<p>The VDB Measurement Equipment is updated with a new VDB Antenna. The VDB Antenna must fulfil the following requirements:</p> <ol style="list-style-type: none"> <li>1. The VDB Antenna must have an omni-directional characteristic, in order to minimize the error contribution through the computed antenna correction.</li> <li>2. The installed VDB antenna on the VAN must be calibrated.</li> <li>3. The antenna gain correction lookup table (Frequency and direction dependent) must be available which is the main output of the calibration.</li> <li>4. The accuracy of the calibration must be known in</li> </ol>

		order to be able to fulfil the ICAO +/- 3 dB accuracy requirement
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**Table 2 PJ.14-W2-79a GAST D Extended Scope subtask and applicable ICAO Doc.8071 Vol II requirements**

## 2.3 Intended readership

The intended readership of this document is PJ.14-W2-79 solution partners and SESAR Joint Undertaking.

The document is also relevant for other stakeholders interested in the GAST D operation in challenging environments (e.g., low latitudes, large and complex airports, strong RFI interference) as well as for other SESAR 2020 projects such as VLD1-W2 DREAMS.

## 2.4 Background

The work in PJ.14-W2-79a GAST D Extended scope builds upon previous work from both SESAR1 15.3.6 and the GAST D Extended scope activities in SESAR 2020 wave 1 PJ.14-03-01 Task 3 GAST D Extended scope.

In SESAR 1 15.3.6 a prototype GAST D ground subsystem was installed at Frankfurt airport and verified to maturity level TRL6 for the implemented solutions and monitors. In SESAR 1, several additional threats were identified by the international GBAS community, including Radio Frequency Interference (RFI) and ionospheric disturbance in combination with tropospheric disturbance. To operate GAST D ground subsystems globally, these challenges need to be assessed and mitigated. PJ.14-03-01 task T3 GAST D Extended Scope in SESAR 2020 wave 1 addressed these additional threat scenarios. The maturity level of the T3 GAST D Extended Scope was assessed to TRL4 at the end of wave 1. The aim of PJ.14-W2-79a is to reach TRL6 at the end of wave 2.

Additionally, during SESAR 1 it was found that VDB coverage, especially for large and complex airport, could be challenging. Consequently, follow-up activities were identified for SESAR 2020, focusing on measurement equipment and simulations. In wave 1, the VDB measurement equipment from SESAR 1 was enhanced with more advanced functionality and a runway coverage simulation tool was developed to provide a feasible means to verify that the VDB field coverage conforms with ICAO Annex 10 Vol. I requirements. In wave 2, a horizontally polarized VDB measurement antenna to be located on the roof of a van is developed and will be used together with the VDB measurement equipment to technically verify ICAO Doc 8071 Vol. II  $\pm 3$  dB measurement uncertainty requirement.

The number of incidents of deliberate or inadvertent interference that render GPS inoperable for critical infrastructure operations is increasing. PJ.14-03-01 worked on determining achievable performance for detection and mitigation strategies to improve robustness of GAST D Ground Subsystem towards GNSS vulnerabilities to RFI. A low cost RFI event logger was developed in 2017, installed in six locations in Europe, and used to gather data of different types of interference for analysis in wave 1. An improved version of this RFI event logger, developed outside SESAR programme, is used to collect raw RFI event data for analysis taking place in PJ.14-W2-79a. The logged RFI data is used to monitor the RFI threat space evolution, obtain a more detailed threat profile, as well establish the probability of occurrence based on the selected sites.

GBAS reference station antennas are subject to disruption through multiple reception of reflected GNSS signals (multipath) typically caused by nearby buildings, vehicles, and technical maintenance work, among other. A methodology based on existing tools for the identification and source location of multipath threats on GBAS reference stations at an airport was developed and validated in PJ.14-03-01. Such a tool supports cost-efficient siting and maintenance of the GBAS reference stations. This tool and performance assessment of multipath conditions is continued outside SESAR programme wave 2 and not discussed further in this TS/IRS.

In order to better integrate with existing infrastructure on airport and to facilitate a smoother integration process, both for the service provider and the manufacturer, an ATC and maintenance interface was defined and validated in PJ.14-03-01 wave 1. In wave 1 GBAS service status data parameters to be made available to external users were identified and a suitable interface protocol was proposed. The set of parameters and use of SNMP as transfer protocol has been input to EUROCAE WG28 as candidate for standardization. On the Ground Station side, the definition of the status parameters and the protocol for conveying the data to the ATC systems is considered complete. Remaining work on this subject involves implementing and verifying the use of GBAS status data in an operational setting in the ATC systems and is out of scope for the technical solution PJ.14-W2-79.

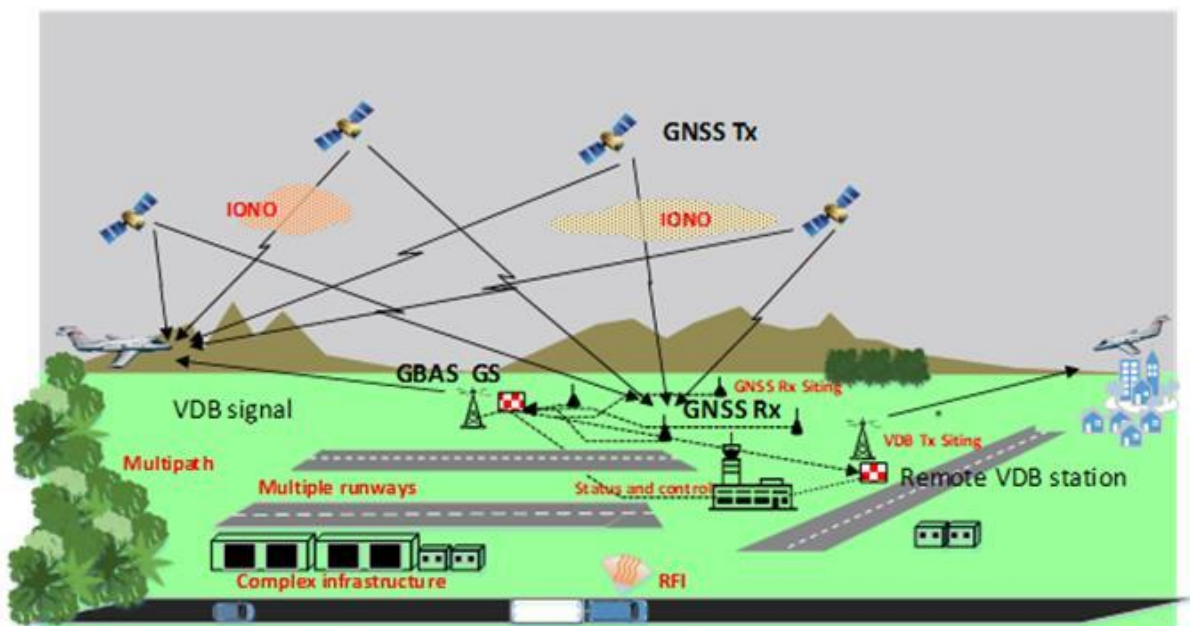


Figure 2-1 PJ.14-W2-79a GAST D Extended Scope focus areas in wave 2 (severe iono conditions, operation & maintenance in large and complex airport environments, RFI ground threats).

## 2.5 Structure of the document

This document follows the structure of TS/IRS template present in the SESAR2020 programme library for the enabling solution projects. Paragraphs and Appendices not applicable to the proposed technological solution are indicated as "Not Applicable".

The structure of the document is composed of the following sections:

**Section 1:** Executive Summary

**Section 2:** This section introduces the document.

**Section 3:** Provides general context of the solution for which technical specifications are included herein

**Section 4:** Contains functional architecture overview.

**Section 5:** The TS/IRS template states that alternative requirement options shall be presented in this section. Currently no alternatives are defined.

**Section 6:** Provides assumptions considered in the Technical Specification

**Section 7:** Lists the relevant references used within the document.

**Appendix A:** According to the TS/IRS template appendix A covers Service Description Document. The PJ.14-W2-79a subtask considered in this TS/IRS is not providing Services in the sense defined by EATMA Guidance Material. Not applicable.

## 2.6 Glossary of terms

Term	Definition	Source of the definition
GAST D	Single constellation single frequency (GPS L1) GBAS Approach Service Type for CAT II/III performance level	ICAO Annex 10 Vol 1 (paraphrased)

Table 3: Glossary

## 2.7 Acronyms and Terminology

Term	Definition
<b>ANSP</b>	Air Navigation Service Provider
<b>ATC</b>	Air Traffic Control
<b>CAT</b>	Category
<b>CC</b>	Capability Configuration
<b>CNS</b>	Communication Navigation and Surveillance
<b>EATMA</b>	European ATM Architecture
<b>GAST</b>	GBAS Approach Service Type
<b>GBAS</b>	Ground Based Augmentation System
<b>GS</b>	Ground Station or Ground Subsystem

<b>ICAO</b>	International Civil Aviation Organization
<b>I-CNSS</b>	Integrated Communication Navigation and Surveillance System
<b>INTEROP</b>	Interoperability Requirements
<b>IRS</b>	Interface Requirements Specification
<b>NAF</b>	NATO Architecture Framework
<b>NSV</b>	NAF System View
<b>OI</b>	Operational Improvement
<b>O&amp;M</b>	Operation and Maintenance
<b>OSED</b>	Operational Service and Environment Definition
<b>QoS</b>	Quality of Service
<b>RFI</b>	Radio Frequency Interference
<b>SARPs</b>	Standards and Recommended Practices
<b>SESAR</b>	Single European Sky ATM Research Programme
<b>SNMP</b>	Simple Network Management Protocol
<b>SJU</b>	SESAR Joint Undertaking (Agency of the European Commission)
<b>TRL</b>	Technology Readiness Level
<b>TS</b>	Technical Specification
<b>TVALP</b>	Technical Validation Plan
<b>TVALR</b>	Technical Validation Report
<b>V&amp;V</b>	Validation and Verification
<b>VDB</b>	VHF Data Broadcast
<b>VHF</b>	Very High Frequency
<b>W1</b>	Wave 1
<b>W2</b>	Wave 2
<b>WP</b>	Work Package

Table 4: Acronyms and terminology

## 3 SESAR Solution Impacts on Architecture

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### 3.1 Target Solution Architecture

#### 3.1.1 SESAR Solution Overview

The PJ.14-W2-79a GAST D Extended Scope solution addresses the two preparatory operational improvements (POIs):

- GBAS Applicability to challenging operational environments in LVC (POI-0025-NAV).
- GAST D Applicability to Equatorial and Nordic regions (POI-0026-NAV).

The two POIs were defined in solution PJ.14-03-01 GBAS in wave 1. The PJ.14-03-01 GAST D Extended Scope addressed the single constellation single frequency GBAS technological solution (GBAS SC/SF) in new environments, seeking to provide a global solution that met the operational and performance requirements in more challenging environments.

The GAST D extended scope solution considers GBAS operating in geographical regions with severe ionospheric conditions. The derivation of efficient mitigation strategies requires the study of the characteristics of the ionospheric (plasma bubbles, ionospheric gradients, and amplitude and phase scintillation) and tropospheric anomalies. A technical enabler for this scenario was introduced in wave 1, namely:

- CTE-N07e - "GBAS CAT II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions".

The GBAS system (both SC/SF and MC/MF solution) operating in large and complex airport environments faces both technical challenges such as multipath from obstacles on or around the airport and RFI (unintentional and intentional, in particular jamming and spoofing) threats from a variety of sources, as well as infrastructure and O&M cost/complexity issues that can slow down widespread deployment. Solving GBAS GS siting issues in complex airport (due to either natural and man-made obstacles) and seeking mitigation solutions to undesired interference are a few key factors that are essential for GBAS to meet the requirements of a globally deployable system. A second technical enabler for such complex environments thus introduced in wave 1, namely:

- CTE-N07f - "GBAS robustness towards interference".

A third preparatory operational improvement (POI) was addressed in wave 1 PJ.14-03-01 and revisited in PJ.14-W2-79a:

- Enhanced interoperability and efficiency of GBAS infrastructure (POI-0027-NAV).

This POI is addressed by the technical enabler:

- CTE-N07g - "GBAS Ground Station status data provision".



This technical enabler from wave 1 PJ.14-03-01 is revisited to confirm the completeness of the enabler in order to move maturity to TRL6. All development and validation activities were carried out in PJ.14-03-01. This included a security risk analysis activity.

For completeness and reader convenience, the requirements related to CTE-N07g are repeated in this Final TS/IRS report so as to document that the enabler has matured to TRL6.

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution	Enabler ID	Enabler Title	Enabler coverage
PJ.14-W2-79a	System: GBAS Ground Station (14-03-01) Functional Block: GBAS GS Function: Atmospheric Threat Monitoring	CTE-N07e	GBAS CAT II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions	Fully
PJ.14-W2-79a	System: GBAS Ground Station (14-03-01) Functional Block: GBAS GS Function: Radio Interference Monitoring	CTE-N07f	GBAS robustness towards interference	Fully
PJ.14-W2-79a	System: GBAS Ground Station  Functional Block:  GBAS GS Technical Supervision  Function: GBAS GS status provision	CTE-N07g	GBAS Ground Station status data provision	Fully

Table 5: SESAR Solution PJ.14-W2-79a GAST D Extended Scope and related Functional Blocks/Roles & Enablers

### 3.1.1.1 Deviations with respect to the SESAR Solution definition

No deviation identified.

### 3.1.1.2 Relevant Use Cases

Relevant use cases were originally defined in SESAR 1, 6.8.5, D11 GBAS CAT III OSED [20]:

- 5.1 GBAS Arrival Flight
- 5.2 GBAS Arrival Departure Flight Management
- 5.3 GBAS/ILS Optimised Mixed Arrival Management
- 5.4 GBAS/ILS Arrival/Departure Flight Management

### 3.1.1.3 Applicable standards and regulations

See Table 1 and Table 2

### 3.1.2 Capability Configurations required for the SESAR Solution

SESAR Solution ID and Title	Capability Configurations (CCs)	Sub-Operating Environments where the CCs operate	Capabilities	Nodes	Stakeholders
PJ.14-W2-79a GBAS	Navigation Infrastructure Ground Based [PJ.14-W2-79a]	Airport, Terminal Airspace	Navigation	Approach ATS	Civil Service Provider, Military Service Provider, CNS

Table 6: List of Capability Configuration required for the SESAR Solution

### 3.2 Changes imposed by the SESAR Solution on the baseline Architecture

Enabler ID	Enabler Title	Changes
CTE-N07e	GBAS CAT II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions	No changes to wave 1 baseline architecture needed.
CTE-N07f	GBAS robustness towards interference	No changes to wave 1 baseline architecture needed.
CTE-N07g	GBAS Ground Station status data provision	No changes to wave 1 baseline architecture needed.  A new STD enabler, STD-136, is introduced in EATMA to cover the EUROCAE amendment: ED-114B Change 1.

Table 7: List of changes due to the SESAR Solution

# 4 Technical Specifications

## 4.1 Functional architecture overview

PJ.14-W2-79a deals with development of robustness measures and mitigation techniques to handle challenging GBAS Ground Station operational environments. The environments are:

- Adverse atmosphere conditions (incl. severe ionospheric gradient and scintillation conditions in combination with tropospheric disturbance)
- RFI threat scenarios

From a GBAS Ground Station perspective, the adverse conditions are handled by implementing monitoring algorithms and mitigation measures. These algorithms are ground station internal functions that are not further detailed in EATMA.

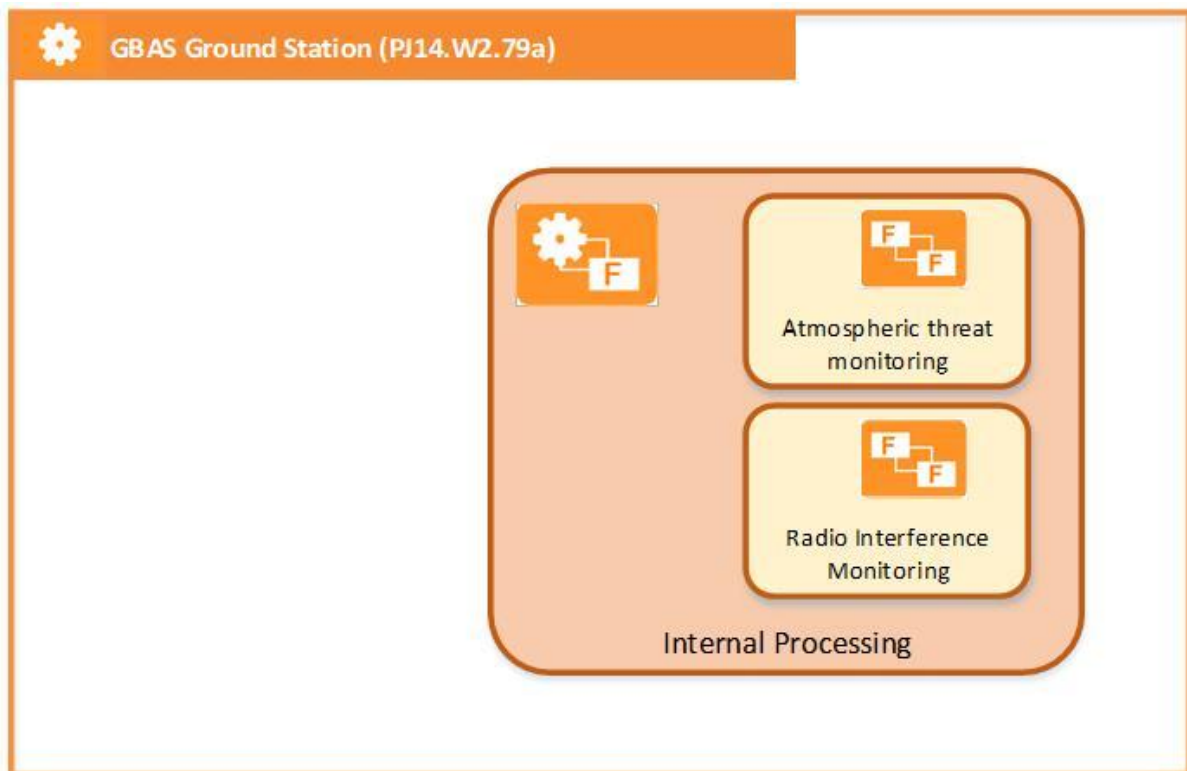


Figure 4-1 Technical system GBAS Ground Station hosting the Internal Processing functional block with functions that are addressed in PJ.14-W2-79a.

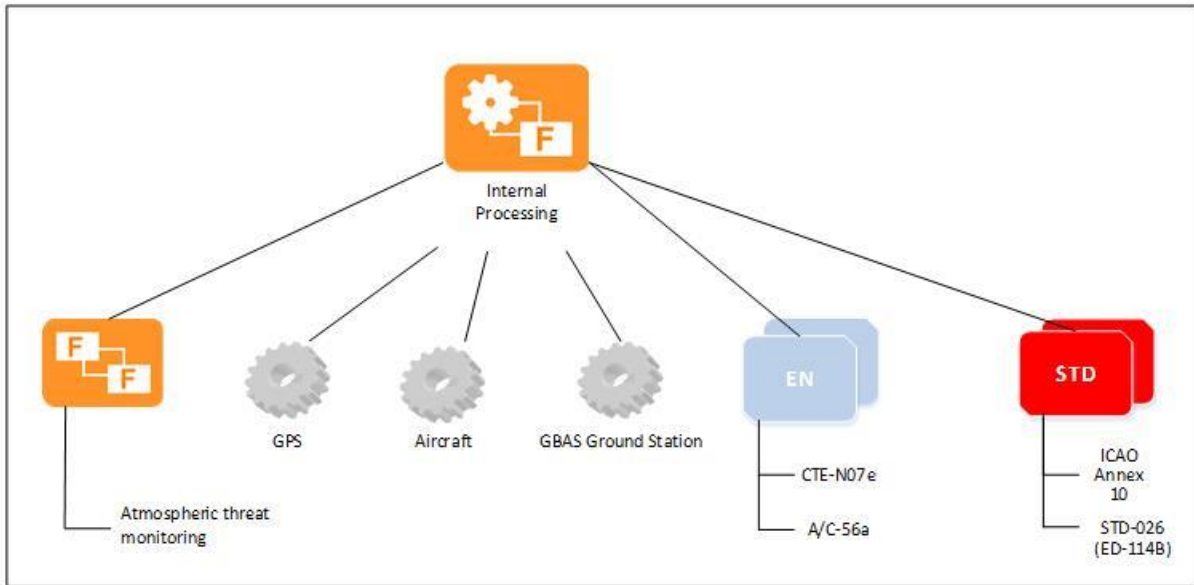


Figure 4-2 Context for subtask ST3.1.1. Ionospheric monitoring and analysis for non mid-latitude regions

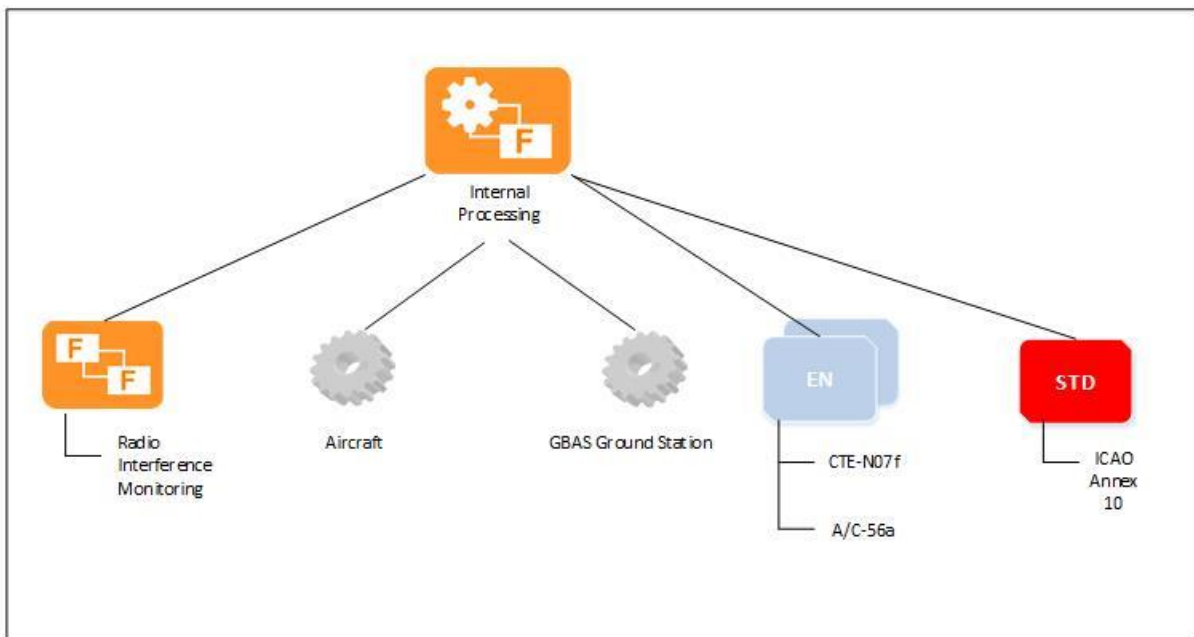


Figure 4-3 Context for subtask ST3-3 GBAS Ground Station RFI threats

### 4.1.1 Resource Connectivity view (one section per NSV-1)

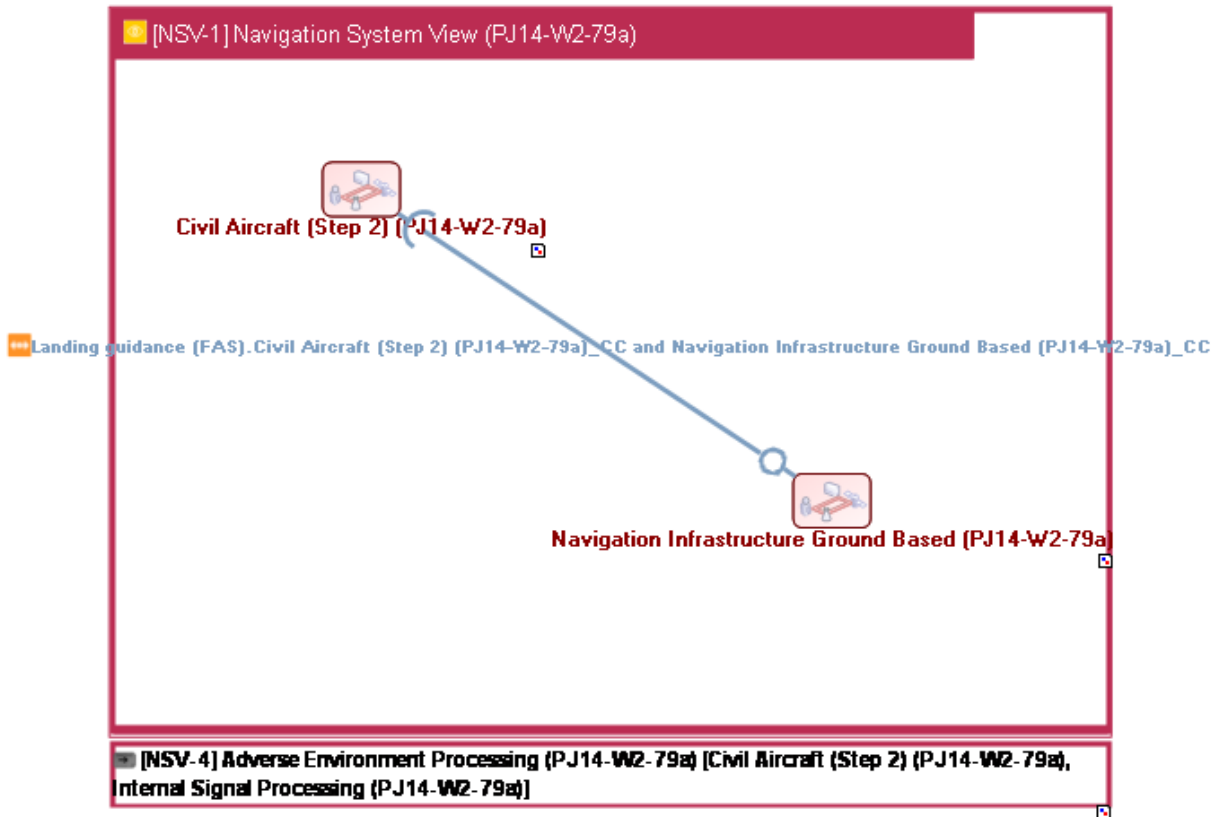


Figure 4-4 NSV-1 Navigation System view for PJ14-W2-79a GAST D Extended Scope

### 4.1.1.1 Resource Infrastructure view (of the NSV-2)

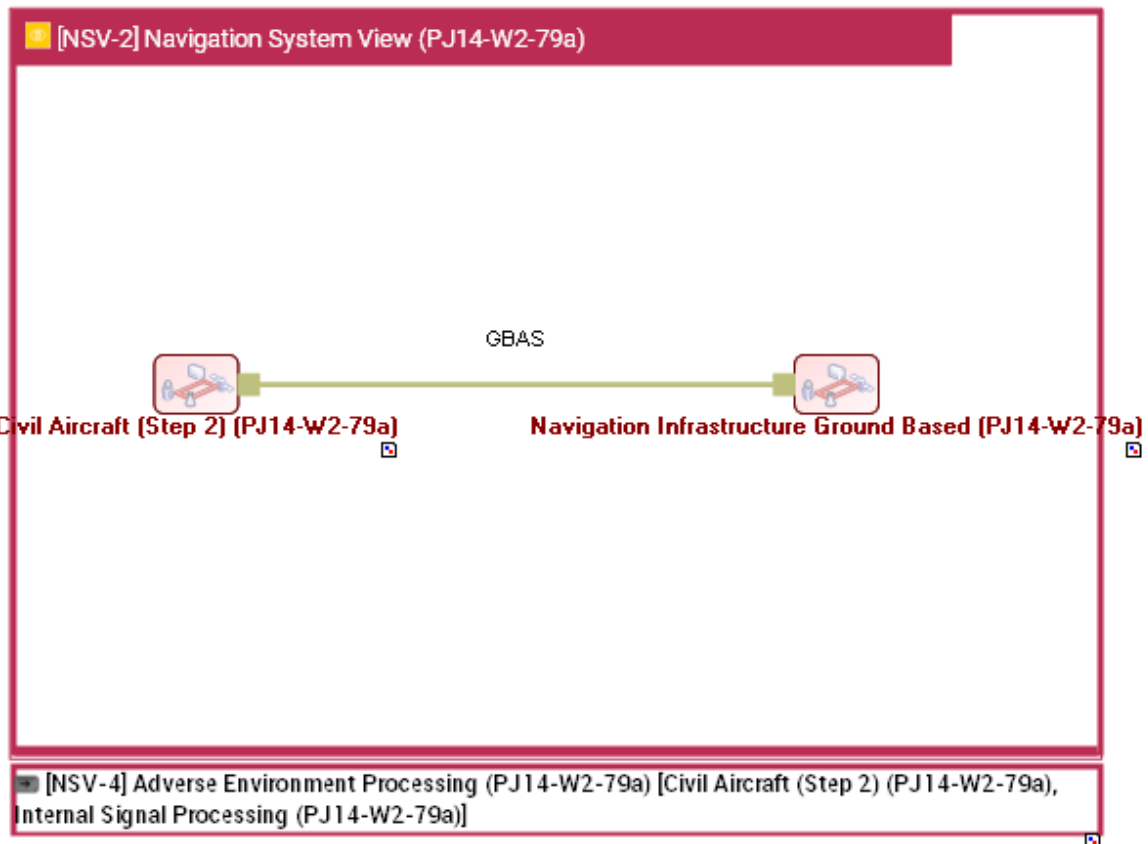


Figure 4-5 NSV-2 Infrastructure connectivity model for GBAS navigation system using GAST D

### 4.1.1.2 Resource Orchestration view

The NSV-4 view depicts the Internal Signal Processing functions of the technical system GAST D Ground Station that detect and mitigate for adverse environment conditions that degrade the GNSS signals received by the Ground Station. The two adverse conditions in this view are Adverse Atmosphere conditions (severe ionospheric gradient and scintillation conditions in combination with tropospheric disturbance) and Radio Frequency Interference. The monitors are used to improve the robustness and performance of the ground station under such adverse conditions.

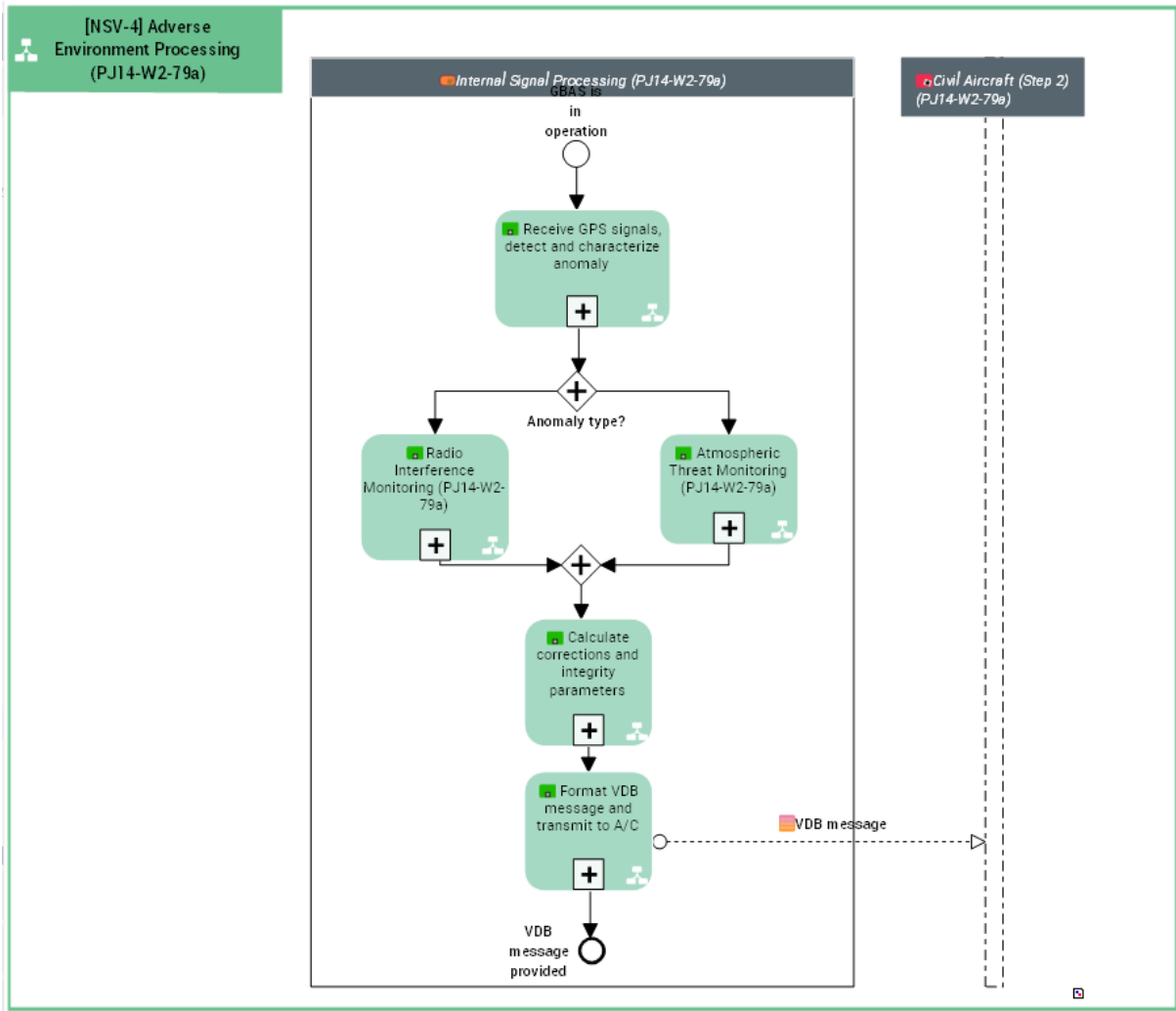


Figure 4-6 NSV-4 Resource orchestration view of PJ14-W2-79a GAST D Extended Scope.

Function	Description
Atmospheric Threat Monitoring (PJ14-W2-79a)	GS internal function linked to technical enabler CTE-N07e. GBAS operating in equatorial and Nordic regions can encounter severe ionospheric conditions. The GBAS Ground Station needs to detect and/or mitigate for adverse ionospheric conditions in combination with tropospheric disturbances in order to ensure compliance with the ICAO performance requirements.
Calculate corrections and integrity parameters	Descriptive function - not linked to an enabler. Represents the GAST D ground station internal function to calculate the GAST D corrections and integrity parameters that are transmitted to the aircraft in the VDB message.



Format VDB message and transmit to A/C	Descriptive function - not linked to an enabler. Represents the GAST D ground station internal function to format and transmit the VDB message to the aircraft.
Radio Interference Monitoring (PJ14-W2-79a)	GS internal function linked to technical enabler CTE-N07f. The GBAS Ground Station needs to detect and/or mitigate for adverse radio frequency interference in order to improve GAST D ground station robustness towards GNSS vulnerabilities to RFI.
Receive GPS signals, detect and characterize anomaly	Descriptive function - not linked to an enabler. The GAST D receives GPS signals from up to four GNSS antennas. The received GPS signals are degraded by various noise sources.

#### 4.1.2 Resource Composition

See section 4.1.1.2.

#### 4.1.3 Service view

Not applicable.

### 4.2 Functional and non-Functional Requirements

#### 4.2.1 Requirements related to wave 2 validation activities

The relevant performance requirements are specified in ICAO SARPs and ICAO Doc. 8071 Vol. II and reproduced in Tables 1 and 2. No further refinement of the requirements are necessary to carry out the technical validations in wave 2.

[REQ]

Identifier	REQ-14-W2-079.a-TS-IONO.0001
Title	GAST D GS compliance to ICAO Ionospheric gradient mitigation requirement
Requirement	The GAST D Ground Station shall comply with ICAO Annex 10 Vol 1 appendix B section 3.6.7.3.4 Ionospheric gradient mitigation (adverse conditions ).
Status	<validated>

Rationale	The requirement specifies that ionospheric gradients that would otherwise cause an out of spec range measurement shall be detected with a probability of 1-10E-9.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a
<ALLOCATED_TO>	<Enabler>	CTE-N07e_GBAS CAT II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions
<ALLOCATED_TO>	<System>	GBAS Ground Station
<ALLOCATED_TO>	<Functional block>	Internal Processing
<ALLOCATED_TO>	<Functional>	Atmospheric Threat Monitoring

[REQ]

Identifier	REQ-14-W2-079.a-TS-IONO.0002
Title	GAST D GS compliance to ICAO Additional continuity of service requirements
Requirement	The GAST D Ground Station shall comply with ICAO Annex 10 Vol 1 appendix B section 3.6.7.1.3.2 Additional continuity of service requirements for FAST D (nominal conditions)
Status	<validated>
Rationale	Performance requirement under nominal conditions (probability of false exclusion of satellite under nominal conditions).
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a
<ALLOCATED_TO>	<Enabler>	CTE-N07e_GBAS CAT II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions
<ALLOCATED_TO>	<System>	GBAS Ground Station
<ALLOCATED_TO>	<Functional block>	Internal Processing
<ALLOCATED_TO>	<Functional>	Atmospheric Threat Monitoring

[REQ]

Identifier	REQ-14-W2-079.a-TS-IONO.0003
Title	GAST D GS compliance to ICAO Ionospheric uncertainty estimate parameter requirement
Requirement	The GAST D Ground Station shall comply with ICAO Annex 10 Vol 1 appendix B section 3.6.7.2.3.5.2 Ionospheric uncertainty estimate parameter for FAST D ground subsystems.
Status	<validated>
Rationale	The ground subsystem shall broadcast an ionospheric delay gradient parameter in the VDB message such that the protection level integrity risk requirements (appendix B 3.6.7.1.2.2) are satisfied.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a
<ALLOCATED_TO>	<Enabler>	CTE-N07e_GBAS CAT II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions
<ALLOCATED_TO>	<System>	GBAS Ground Station

<ALLOCATED_TO>	<Functional block>	Internal Processing
<ALLOCATED_TO>	<Functional>	Atmospheric Threat Monitoring

[REQ]

Identifier	REQ-14-W2-079.a-TS-VDB.0001
Title	VDB Antenna compliance to ICAO Annex 10 Vol. 1 section 3.7.3.5.4.4.1.2.
Requirement	The VDB Antenna shall fulfil ICAO Annex 10 Vol. 1 section 3.7.3.5.4.4.1.2.
Status	<validated>
Rationale	<p>The VDB Measurement Equipment is updated with a new VDB Antenna, in order to measure the field strength (power flux density) on the runway, which is part of the regular GBAS ground measurement.</p> <p>The VDB Antenna must fulfil the following requirements:</p> <ol style="list-style-type: none"> <li>1.The given power flux density limits are (ICAO 3.7.3.5.4.4.1.2): <ul style="list-style-type: none"> <li>- Upper bound: -27 dBW/m<sup>2</sup></li> <li>- Lower bound -99 dBW/m<sup>2</sup></li> </ul> </li> <li>2.The antenna must be mounted on the van in 12ft about local ground (ICAO 3.7.3.5.4.4.1.2).</li> <li>3.The VDB Antenna must work within the GBAS frequency band of 112.050 to 117.900 MHz (ICAO 3.7.3.5.4.1).</li> </ol>
Category	<Maintainability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a

[REQ]

Identifier	REQ-14-W2-079.a-TS-VDB.0002
Title	VDB Antenna compliance to ICAO Annex 10 Vol. 1 section 3.7.3.5.3.2.
Requirement	The VDB Antenna shall fulfil ICAO Annex 10 Vol. 1 section 3.7.3.5.3.2.
Status	<validated>
Rationale	Same as for "REQ-PJ14-W2-079.a-TS-VDB0.0001". NOTE! The VDB ground measurement is performed for 12ft (3.7 m) about local ground.
Category	<Maintainability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a

[REQ]

Identifier	REQ-14-W2-079.a-TS-VDB.0003
Title	VDB Antenna compliance to ICAO Annex 10 Vol. 1 Service volume section 3.7.3.5.3.
Requirement	The VDB Antenna shall fulfil ICAO Annex 10 Vol. 1 Service volume section 3.7.3.5.3.
Status	<validated>
Rationale	Same as for "REQ-PJ14-W2-079.a-TS-VDB0.0001".
Category	<Maintainability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a

[REQ]

Identifier	REQ-14-W2-079.a-TS-VDB.0004
Title	VDB Antenna compliance to ICAO Annex 10 Vol. 1 Appendix B Field Strength section 3.7.3.5.4.4.1.
Requirement	The VDB Antenna shall comply with ICAO Annex 10 Vol. 1 Appendix B Field Strength section 3.7.3.5.4.4.1.
Status	<validated>
Rationale	Same as for REQ-PJ14-W2-079.a-TS-VDB0.0001”.
Category	<Design>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a

[REQ]

Identifier	REQ-14-W2-079.a-TS-VDB.0005
Title	Data content support when using VDB Measurement Equipment with van mounted antenna
Requirement	The VDB Measurement Equipment when operating with the van-mounted VDB antenna shall support ICAO Annex 10 Vol. 1 Data content section §3.6.4: 4.2 Type 1 message – pseudo-range corrections 4.3 Type 2 message – GBAS-related data 4.4 Type 3 message – NULL message 4.5 Type 4 message – Final Approach Segment (FAS) 4.11 Type 11 message – pseudorange corrections 30s smoothed pseudo-range
Status	<validated>
Rationale	An additional check for proper data reception with the new VDB antenna is to decode successfully the content of the received GBAS Messages (MT1, MT2, MT3, MT4, MT11), if the measured field strength is within the allowed limits.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a

[REQ]

Identifier	REQ-14-W2-079.a-TS-VDB.0006
Title	ICAO Doc 8071 Vol II minimum ground test requirements
Requirement	The VDB Measurement Equipment when operating with the van-mounted VDB antenna shall support performing validation of ICAO Doc 8071 Vol. II See “Table II-4-2B. Summary of minimum ground test requirements —GBAS VHF data broadcast” (Runway Surface Coverage).
Status	<validated>
Rationale	<p>The VDB Measurement Equipment is updated with a new VDB Antenna. The VDB Antenna must fulfil the following requirements:</p> <ol style="list-style-type: none"> <li>1. The VDB Antenna must have an omni-directional characteristic in order to minimize the error contribution through the computed antenna correction.</li> <li>2. The installed VDB antenna on the VAN must be calibrated.</li> <li>3. The antenna gain correction lookup table (frequency and direction dependent) must be available which is the main output of the calibration.</li> <li>4. The accuracy of the calibration must be known order to be able to fulfil the ICAO +/- 3 dB accuracy requirement</li> </ol>
Category	<Maintainability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a

[REQ]

Identifier	REQ-14-W2-079.a-TS-RFI.0001
Title	The GAST D GS compliance to ICAO Annex 10 Vol 1 Appendix B section 3.7.3.4.
Requirement	The GAST D Ground Station shall comply with ICAO Annex 10 Vol 1 Appendix B section 3.7.3.4.
Status	<validated>
Rationale	SBAS and GBAS receivers shall not output misleading information in the presence of interference including interference levels above those specified in ICAO Annex 10 Vol I App B section 3.7.
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-79a
<ALLOCATED_TO>	<Enabler>	CTE-N07f_GBAS robustness towards interference
<ALLOCATED_TO>	<System>	GBAS Ground Station
<ALLOCATED_TO>	<Functional block>	Internal Processing
<ALLOCATED_TO>	<Functional>	Radio Interference Monitoring

#### 4.2.2 Requirements related to wave 1 PJ.14-03-01 ATC and Maintenance interface validation activities

Three technical requirements specific to the GAST D Ground Station ATC and Maintenance interface are defined in the tables below. All development and validation activities related to these requirements were carried out in SESAR 2020 wave 1 PJ.14-03-01. The requirements are repeated in this TRL6 TS/IRS for completeness and reader convenience.

[REQ]

Identifier	REQ-PJ.14-03-01-TS-IRS-0001
Title	The GBAS Ground Station service status data provision



Requirement	The GBAS Ground Station shall provide operations and maintenance service status data according to specifications defined in the GBAS GS status MIB (see wave 1 PJ.14-03-01 TS/IRS [21]).
Status	<validated>
Rationale	<p>The GBAS GS status data covers several uses, both operational status information to approach controllers in the APP unit and the controllers in the tower or remote tower as well as status information related to maintenance and technical supervision tasks.</p> <p>In the TS/IRS we use the terminology ATC interface and Maintenance interface to logically differentiate between the subset of data to be used by the different external ATM systems, but the data will be provided over one common physical interface.</p> <p>The technology proposed in wave 1 was SNMP v2c. During the subsequent standardization process it was acknowledged that this technology is now aged, and a more future proof technology should be the basis for standardization. The details of the protocol for the ATC/maintenance interface were not included in the standard. Candidate GBAS Ground Station Status Parameters are defined in Appendix B of [21]. These candidate Ground Station Status Parameters have been provided as input to the ED114B standardization work in EUROCAE WG28.</p>
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.14-03-01
<SATISFIES>	<Technical Enabler>	CTE-N07g GBAS GS status data provision
<ALLOCATED_TO>	<Function>	GBAS GS status provision (PJ.14-03-01)

[REQ]

Identifier	REQ-PJ.14-03-01-TS-IRS-0002
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Title	Realisation of GBAS Ground Station interface for service status data provision
Requirement	The GBAS Ground Station interface for providing operations and maintenance service status data shall be realised using SNMPv2c.
Status	<validated>
Rationale	Wave 2 note: Although SNMPv2c was the proposed protocol during Wave 1, it was agreed during the final stages of the issuing of Change 1 to <b>Error! Reference source not found.</b> that this technology is now aged, and a more future proof technology should be the basis for standardization. The details of the protocol for the ATC/maintenance interface were not included in the standard at this point.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.14-03-01
<SATISFIES>	<Technical Enabler>	CTE-N07g GBAS GS status data provision
<ALLOCATED_TO>	<Function>	GBAS GS status provision (PJ.14-03-01)

[REQ]

Identifier	REQ-PJ.14-03-01-TS-IRS-0003
Title	GBAS Ground Subsystem status data interface is read-only
Requirement	While the GBAS GS is in operational mode, access over the SNMP interface to parameters that might impact GBAS services <u>integrity</u> shall be limited to read-only for safety and security reasons.
Status	<validated>
Rationale	For safety and security reasons, the GBAS Ground Station shall only support 'read-only' access to the service status data that might impact integrity of the operational service.  Note that for Change 1 to <b>Error! Reference source not found.</b> the ATC/maintenance technical interface was not concluded. The requirement for this interface to be read-only still applies.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.14-03-01
<SATISFIES>	<Technical Enabler>	CTE-N07g GBAS GS status data provision
<ALLOCATED_TO>	<Function>	GBAS GS status provision (PJ.14-03-01)

## 5 Recommendation for Implementation

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The TVALR validation exercises carried out to validate the subtask T3.1.1 requirements show that the detection performance of the ionosphere gradient monitor and the code carrier divergence monitor are impacted by severe scintillation conditions. This in turn may lead to the need to perform a tradeoff between continuity, integrity, and availability. Note that it may be necessary to tighten siting restrictions with respect to the mid-latitudes to ensure integrity when integrity monitor performance is reduced. Further work to incorporate robustness to scintillation in the integrity monitors is recommended. The reader is referred to D9.1.400 TVALR [23] for further discussions on the validation results.

## 6 Assumptions

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The activities related to Ionosphere monitoring and analysis and RFI ground threat were dependent on collecting sufficient relevant data, thus supporting meaningful analysis and characterization of the environment under investigation.

While in the case of RFI threat it is assumed that the monitoring sites used for data capture and analysis collectively provide representative observations and statistics in terms of RFI occurrence rate, dominant type, power levels, etc. in the case of ionospheric monitoring, the data collection at Tenerife Norte has been carried out for a multi-year period allowing to capture multiple representative data sets during periods with disturbed ionosphere.

Relevant ionosphere and scintillation data were collected at Tenerife Norte Airport; however, insufficient adverse troposphere data was collected there. An attempt to collect troposphere data at Frankfurt Airport during the summer 2021 was made, but contrary to previous summers at Frankfurt, the sought-after troposphere conditions did not occur during the logging period.

# 7 References and Applicable Documents

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## 7.1 Applicable Documents

### Content Integration

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- [1] PJ.19-W2 D2.15 EATMA Guidance Material, 2020
- [2] EATMA Community pages
- [3] SESAR ATM Lexicon

### Content Development

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- [4] SESAR 2020 Concept of Operations Ed. 01.00.00 - 2019

### System and Service Development

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### Performance Management

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- [5] SESAR Performance Framework Ed. 01.00.01 – 2019
- [6] PJ19-14 D2.6 SESAR 2020 Validation Strategy Ed.00.01.00, October 2019
- [7] PJ.19-04 D4.0.1 Validation Targets – SESAR 2020 Wave 2 & Wave 3 Ed. 00.01.00 May 2021

### Validation

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- [8] D3.7 System Engineering - Development Methodology for V/VP, V/VI, and Demonstration Platform Ed.00.01.00, June 2019
- [9] Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational Federating Projects
- [10] European Operational Concept Validation Methodology (E-OCVM) – 3.0 February 2020

### System Engineering

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- [11] SESAR 2020 Requirements and Validation Guidelines Wave 2 Ed.00.02.02 May 2021

### Safety

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- [12] SESAR 2020 Safety Reference Material, Ed. 00.04.01, December 2018
- [13] Guidance to Apply the SESAR 2020 Safety Reference Material, Ed.3.01, December 2018
- [14] WP16-06.01b D04 Resilience Engineering Guidance Final Deliverable Ed.1.0, April 2017

## Human Performance

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- [15] SESAR Human Performance Assessment Process V1 to V3 - incl. VLD, Ed. 00.03.01 January 2020

## Environment Assessment

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- [16] SESAR Environment Assessment Process D4.0.080, Ed. 04.00.00, September 2019

## Security

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- [17] Security Risk Assessment methodology for SEAR 2020, Ed. 02.00.00, September 2017

## 7.2 Reference Documents

- [18] ICAO Annex 10, Vol. I, SARPS, Amendment 91, applicable from November 2018
- [19] ICAO Doc. 8071 Volume II, Testing of Satellite-based Radio Navigation Systems
- [20] SESAR 1 06.08.05 D11, GBAS CAT II/III Functional Description Update Report V2, ed. 00.01.01, May 2013
- [21] SESAR 2020 PJ.14-03-01 D8.2.010.1 Final TS/IRS V2 GAST D, ed. 01.03.00, November 2019
- [22] EUROCAE ED-114B MOPS for GBAS ground systems to support precision approach and landing (CAT III)
- [23] SESAR 2020 PJ.14-W2-79a D9.1.400 TVALR TRL6 GAST D Extended Scope, ed. 00.01.04, October 2022

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