DES HE SESAR solution 0504 exploratory research plan

Deliverable ID:	**D7.1**
Project acronym:	**SATERA**
Grant:	**101164313**
Call:	**HORIZON-SESAR-2023-DES-ER-02**
Topic:	**HORIZON-SESAR-2023-DES-ER2-WA2-1**
Consortium coordinator:	**UPV**
Edition date:	**30 November 2025**
Template edition:	**02.00.01**
Edition:	**01.00**
Status:	**Official**
Classification:	**PU**

Abstract

This Document describes the overview of the Validation Plan for SATERA (SESAR solution # 0504) "Integrity-oriented, space-based aircraft composite surveillance using dependent and independent data streams". It aims at defining the scope, validation exercises and simulator specifications to validate the solution # 0504 against the relevant performance metrics described in EASSP and EUROCAE standard documents to achieve TRL 2.

Authoring & approval

Author(s) of the document

Organisation name	Date
COLLINS	24-Nov-2025
UPV	24-Nov-2025
UC	24-Nov-2025
ENAIRE	24-Nov-2025
UNITOV	25-Nov-2025

Reviewed by

Organisation name	Date
COLLINS	30-Nov-2025
UPV	30-Nov-2025
UC	30-Nov-2025
ENAIRE	30-Nov-2025
UNITOV	30-Nov-2025
INPE	30-Nov-2025

Approved for submission to the SESAR 3 JU by

Organisation name	Date
COLLINS	30-Nov-2025
UPV	30-Nov-2025
UC	30-Nov-2025
ENAIRE	30-Nov-2025
UNITOV	30-Nov-2025
INPE	30-Nov-2025

Rejected by[1]

Organisation name	Date

[1] Representatives of the beneficiaries involved in the project.

Document history

Edition	Date	Status	Organisation author	Justification
00.01	24-Nov-2025	Draft	COLLINS	1st Draft
01.00	30-Nov-2025	Official	COLLINS	Submission to the S3JU

Copyright statement

Disclaimer

The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR 3 Joint Undertaking be responsible for any use that may be made of the information contained herein.

SATERA

SPACE-BASED COMPOSITE ADS-B AND MULTILATERATION SYSTEM VALIDATION THROUGH SCALABLE SIMULATIONS

SATERA

This document is part of a project that has received funding from the SESAR 3 Joint Undertaking under grant agreement No 101164313 under European Union's Horizon Europe research and innovation programme.

Table of contents

EUROPEAN PARTNERSHIP

Co-funded by
the European Union

List of figures

List of tables

1 Executive summary

This document provides the description of the Validation Plan of SATERA (SESAR solution # 0504). It aims at defining the scope, validation exercises and simulator specifications to validate the solution # 0504 against the relevant performance metrics described in EASSP and EUROCAE standard documents. The scope of the validation plan includes the functional validation of the new surveillance solution over continental areas and operational validation over NAT and EURSAM corridors.

The expected performance contributions described in the document are in-line with the performance benefits mentioned in the intermediate OSED.

The project will validate the composite space-based ADS-B + E-MLAT surveillance over continental, NAT and EURSAM corridors through two validation exercises. To achieve the target maturity level (TRL 2), the validation will be done in simulation through a simulator developed in MATLAB.

The validation approach comprises of the development of system simulator in MATLAB to integrate various technical components and simulate the complete system under two types of air traffic: (1) Continental, and (2) Oceanic (NAT and EURSAM corridors). The overall objective of the validation plan is to demonstrate that solution 0504 supports the provision of ATC services with 3 and 5 NM horizontal separation according to the requirements set out in EUROCONTROL ESASSP.

The outcomes of validation exercises will be reported in D7.2 Exploratory Research Report (ERR).

2 Introduction

2.1 Purpose of the document

This Document describes the overview of the exploratory research plan for SATERA (SESAR solution # 0504) “Integrity-oriented, space-based aircraft composite surveillance using dependent and independent data streams”. It provides the scope and context of the exploratory research plan, key performance contributions and impacts, detailed approach to validate the solution, validation objectives and detailed overview of the validation exercises.

The overall purpose of this document is to provide a comprehensive outline of the validation plan starting with the definition of relevant performance metrics described in EASSP and EUROCAE documents. The document also describes the overview of the simulator architecture for the integration of various technical components including the communication network simulator, processing of ADS-B data on-board LEO satellites, and the processing of positioning data at the central processing station. A detailed exploratory research plan is then described to validate solution # 0504 in MATLAB for maturity assessment at TRL 2. It also outlines the validation objectives and exercises planned for the validation of the solution at TRL 2. The validation plan consists of two validation exercises. The first one focuses on the functional validation of the solution through simulation over continental areas using multiple over-land routes. The second one focuses on the operational validation of the solution through simulation over oceanic areas (NAT and EURSAM corridors) considering the real-time trajectory data from FlightAware and ENAIRE corresponding to the busiest day of the year 2024.

2.2 Intended readership

This document is shaped for a broad audience of stakeholders who are directly or indirectly involved in the advancement, regulation, and operational deployment of the solution. The intended readership includes, but is not limited to:

- European Commission (EC) and SESAR JU: For their roles in initiating and sponsoring projects to advance ATM capabilities.
- Regulatory Bodies and Aviation Authorities: Including EASA, overseeing safety and regulation, crucial for integrating new airspace operations.
- Global Institutions: Such as ICAO and UNOOSA, highlighting the need for global operational harmonization.
- EUROCONTROL Member States and National or Multinational Space Agencies: Planning policies and strategies for space and advanced aviation operations integration.
- Air Navigation Service Providers (ANSPs): Managing daily air traffic and integrating diverse operations within the ATM system.
- Aerospace Industry Stakeholders: Manufacturers and operators needing insights into interoperability and operational frameworks.
- Commercial Space Operators: Engaged in launch and satellite operations, benefiting from ATM integration processes.
- Research Institutions and Academia: Contributing to the knowledge base on space-based CNS and its integration into the European ATM.

Co-funded by the European Union

- Policymakers and Government Agencies: Setting policies on airspace and space operations.
- Airspace Users: Including commercial, general aviation, and unmanned aircraft operators adapting to new operations.
- Other Industry Partners: Highlighting the need for advancements in communication, surveillance, and navigation to support future operations.

2.3 Background

The concept of composite space-based surveillance to be developed in SATERA is built on the provision of automatic dependent surveillance-broadcast (ADS-B) from space platforms which has recently emerged as a key enabler to extend the trajectory-based operations (TBO) concept to oceanic areas.

In the context of relevant previous works, the SESAR exploratory research (ER) project SALSA (Satellite-based ADS-B for lower separation minima application) **¡Error! No se encuentra el origen de la referencia.** evaluated the performance and value of ADS-B in the context of enhanced surveillance and reviewed separation standards in the non-radar airspace. SALSA developed a system-of-systems approach by combining space-based ADS-B with other sources of surveillance based on ground, air, and oceanic. In a similar way, the SESAR ER project SAPIENT (Satellite and terrestrial architectures improving performance, security, and safety in ATM) **¡Error! No se encuentra el origen de la referencia.** addressed a new innovative application in the field of CNS/ATM system focusing exploitation of the synergies of Communications and Navigation technologies and the 4D trajectory management concept.

Moreover, the Canadian company Aireon has developed the first space-based ADS-B system based on the USA-owned satellite communication company Iridium. Aireon has equipped some of the Next Generation Iridium satellites launched as of 2017 with ADS-B receivers and leverages the Iridium network to relay ADS-B messages received on the satellites to ANSPs via dedicated datalinks over the Iridium network. Aireon space-based ADS-B entered service in the NAT region in 2019, leading to a reduction of separation minima from 40-50NM to 14NM and enabling the designation of the airspace below FL330 as a free-flight region, thus unblocking TBO therein.

Last but not least, the European company Startical (partially owned by the SATERA partner ENAIRE) launched in early 2020s the development of an ad-hoc LEO satellite constellation aiming at providing space-based ADS-B surveillance and VHF voice communications in a seamless way, i.e., using the same aircraft equipage and ANSP equipment currently used to provide these services using ground-based infrastructure.

2.4 Structure of the document

The document follows the following structure:

- Section 1 (Executive Summary) provides a summary of the key information and elements contained in the exploratory research plan.
- Section 2 (Introduction) presents the purpose of the document, the intended audience, background on which SATERA Solution is built, the structure of the document and the main acronyms and terminology used throughout the document.

- Section 3 (Context of exploratory research plan) provides an overview of the validation plan, key R&I benefits, a summary of the stakeholder involvement and the key performance contributions of the solution.
- Section 4 (Exploratory research plan) describes a detailed description of the validation approach, simulator architecture and development, validation objectives and assumptions, and brief overview of the validation exercises.
- Section 5 (Validation exercises) outlines the two validation exercises in detail covering the scope, objectives, assumptions, solution/reference scenarios, performance contributions etc.
- Section 6 (References and Applicable Documents) identifies the documents (name, reference, source project) this ERP document must comply to or uses as additional inputs.

2.5 Glossary of terms

Term	Definition	Source of the definition
NAT Corridor	A specific section of airspace covering the North Atlantic route used by aircraft for transatlantic flights. It includes flight position, operational, and meteorological reporting requirements for aircraft in the corridor.	ICAO Annex 3, NAT SPG (North Atlantic Systems Planning Group)
EUR-SAM Corridor	A designated air route connecting Europe and South America, requiring position, operational, and meteorological reporting from aircraft.	ICAO Annex 3, EUR-SAM TMG (Transatlantic Management Group)
En-route Operations	The segment of flight when an aircraft is operating between departure and arrival, requiring compliance with ATC, meteorological, and position reporting.	ICAO Annex 3

Table 1: glossary of terms

2.6 List of acronyms

Term	Definition
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance – Contract
ANSP	Air Navigation Service Provider
AoA	Angle of Arrival
ATC	Air Traffic Controller
ATM	Air Traffic Management

ATS	Air Traffic Services
CNS	Communication, Navigation and Surveillance
CPDLC	Controller Pilot Data Link Communication
CPS	Central Processing Station
DES	Digital European Sky
DOP	Dilution of Precision
E-MLAT	Enhanced Multilateration
ENR	En Route
ERP	Exploratory research plan
EURSAM	Europe-South America
FDoA	Frequency Difference of Arrival
FIR	Flight Information Region
FoA	Frequency of Arrival
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HF	High Frequency
ICAO	International Civil Aviation Organization
ID	Identifier
LEO	Low Earth Orbit
NAT	North Atlantic
OSED	Operational service and environment description
RCP	Required Communication Performance
RNP	Required Navigation Performance
RSP	Required Surveillance Performance
SATCOM	Satellite Communication
SB	Space-based

EUROPEAN PARTNERSHIP
Co-funded by the European Union

SES	Single European Sky
SESAR	Single European Sky ATM research
SESAR 3 JU	SESAR 3 Joint Undertaking
TBM	Time-based Management
TBO	Trajectory Based Operations
ToA	Time of Arrival
TRL	Technology Readiness Level
WAM	Wide Area Multilateration

Table 2: list of acronyms

3 Context of the exploratory research plan

3.1 Exploratory research plan context

SATERA specific objective SO10 sets the scene for the project's Exploratory Research Plan (ERP) by outlining high-level validation objectives:

- Validate the TRL2 maturity (i.e., concept formulated and validated by analytical/simulation techniques) of the concept proposed as per SO1.
- Validate the scalability of the end-to-end simulator.

The concept developed to achieve SO1 consists of a reliable space-based surveillance system to provide composite ADS-B + E-MLAT surveillance from a constellation of small satellites in LEO orbits capable to detect and track aircraft worldwide and develop a set of functional and non-functional requirements so that the theoretical system performance meets the requirements set by EUROCAE draft ED-142A.

The second high level validation objective is linked to SATERA specific objective SO9:

- Assemble the constellation simulator, the network simulator, and the detection and tracking systems in a system evaluation tool, capable of simulating end-to-end the operation of up to a maximum of 225 aircraft at a time, as per SO5. The simulator will be capable of computing the performance metrics defined in EUROCONTROL ESASSP Ed 1.3 [3] by applying the methods described in that standard.

Both SO1 and SO9 also identify the references from which the success criteria for SATERA validation objectives should be sourced. Finally, SO10 also identifies the validation exercises the SATERA team will run to assess the TRL2 concept maturity and the validation scenarios to be used in each of them:

- one exercise over continental areas where ground-based surveillance systems are available (to cross-check data provided by space-based surveillance systems against those provided by ground-based ones) and
- one exercise over two oceanic areas to showcase the operations enabled by space-based composite ADS-B+E-MLAT systems in areas where there is no ground-based surveillance infrastructure.

The first exercise will be run on a validation scenario defined over Spanish continental territory, from where SATERA partner ENAIRE can provide high-quality surveillance data from state-of-the-art ground-based infrastructure. These data will be instrumental to enabling a thorough benchmarking of SATERA simulated against real-world, operational systems.

The second exercise will be configured over the North Atlantic (NAT) corridor and the EUR/SAM corridor, spanning form Southern Europe to South America. The NAT corridor has been selected because it is the oceanic area with highest density of operations, being the most challenging one from the performance requirements point of view. The EUR/SAM corridor has been chosen because it runs through the Equator, which is the most challenging area because of both coverage and signal propagation issues affecting system performance. Moreover, SATERA partner ENAIRE will provide surveillance data on from ground-based infrastructure in the Canarias Flight Information Region, thus enabling the assessment of the seamless integration of SATERA into conventional, ground-based surveillance networks. Simulations in the second exercise will assume the number of flights corresponding to the busiest day in both corridors in 2024 as a baseline, as well as mid/long-term scenarios according to available traffic forecasts from trustworthy sources to showcase system's scalability.

Standard surveillance performance monitoring techniques will be used to assess the quality of the data delivered by SATERA. More specifically, the UPV team will build on their experience with EUROCONTROL SASS-C (a state-of-the-art surveillance performance assessment tool used by ANSPs worldwide to assess their systems' performance against applicable standards such as EUROCONTROL ESSASP ED. 1.3 OR EUROCAE ED-129B). SASS-C first builds a high-quality reference trajectory applying multi-source data fusion and smoothing techniques. SATERA will apply similar techniques to build reference trajectories/ground-truths from available ADS-B data.

Since the simulation time of the communication network (especially the Inter Satellite Link subnetwork) is computationally intensive and time consuming, simulations in the second exercise will be ran on each of the Oceanic Flight Information Regions the corresponding corridor spans over. Nonetheless, the representativeness of the results will be confirmed by means of a combination of simulation and analytical assessments.

This high-level validation objectives and success criteria, as well as validation exercises, scenarios assumptions will be further elaborated in the applicable sections of this document.

3.2 Scope

The scope of the exploratory research plan is to provide a comprehensive overview of the validation plan for SESAR solution # 0504 comprising of the development of system simulator to integrate various technical components of SATERA and benchmarking the solution against some key performance metrics including update rate, separation minima, integrity indicator.

The ERP for solution # 0504 is developed based on the operational environment and characteristics defined in the intermediate OSED and intermediate FRD, already submitted to SJU for approval. To validate the solution at TRL 2, a simulator will be developed in MATLAB to integrate all the functional and technical components including the Satellite Constellation (a network of LEO satellites equipped with antennas able to detect ADSB messages), the receiving stations (onboard satellites), the ComNet (intersatellite communication, and downlink), and the Central Processing Station (CPS). These components interact through well-defined interfaces to enable the end-to-end acquisition, processing, and delivery of surveillance information. The interfacing between these technical components is crucial for effective execution of the overall system. The ERP will describe this interfacing and integration of technical components, to be developed in the simulator, in line with the identified interactions in the intermediate FRD. The operational validation of the solution will be carried out through validation exercise # 2, where the solution will be validated using NAT and EURSAM actual historical trajectory data provided by FlightAware and ENAIRE.

3.3 Key R&I needs

The main research question that was identified since the very beginning of SATERA project (already identified indeed in the Description of Action in the Grant Agreement) is:

EUROPEAN PARTNERSHIP
Co-funded by the European Union

- Can a space-based Wide Area Multilateration System support 5/3 NM surveillance applications in areas where the use of ground-based surveillance systems is not feasible?

A second question that emerged during the development of the SATERA solution is:

- What type of surveillance application would SATERA enable in case 3/5 NM applications prove not to be feasible?

The former are quite high-level questions and naturally lead to several more specific ones:

- **RQ1.** Are the surveillance data produced by SATERA representative of a real-world environment? In other words, since SATERA will produce surveillance data from synthetic traffic, how similar will be these data to those produced by actual surveillance systems?
- **RQ2.** Is SATERA a scalable solution? I.e., which is the projected system capacity? Is there any potential bottleneck that might limit the benefits in terms of capacity that are expected from SATERA when the system is deployed and fully operational?
- **RQ3.** Does SATERA meet world-wide agreed applicable requirements (e.g., EUROCONTROL ESASSP) for surveillance systems enabling 5/3 NM under normal conditions?
- **RQ4.** Considering that part of the SATERA solution components (i.e., the space segment) will be exposed to space weather conditions that might affect the propagation of electromagnetic waves SATERA relies on, could SATERA meet world-wide agreed applicable requirements (e.g., EUROCONTROL ESASSP) for surveillance systems enabling 5/3 NM under abnormal space weather conditions?
- **RQ5.** Interference with SATERA is beyond the reach of common intruders. However, in light of the current geopolitical context, intentional attacks by state actors on critical aeronautical infrastructures such as SATERA cannot be neglected. Therefore, the question of whether SATERA can meet globally agreed applicable requirements (e.g., EUROCONTROL ESASSP) for surveillance systems enabling 5/3 NM under abnormal conditions caused by intentional electromagnetic attacks—particularly spoofing, including saturation spoofing—becomes especially relevant.
- **RQ6.** There is a significant qualitative leap between the separations currently applied in oceanic airspace and the 5/3 NM separations targeted by SATERA. Moreover, the ESASSP requirements for 5/3 NM surveillance applications might be hard to meet, especially when the system is under the attack of state agents. Therefore, this research question arises in a natural way: which might be the level of service that could be provided by SATERA in case it cannot meet world-wide agreed applicable requirements (e.g., EUROCONTROL ESASSP) for surveillance systems enabling 5/3 NM under the previous operating environments? A solution might consist of providing an additional integrity estimator for ADS-B reported positions in areas by cross-checking them with positions calculated by means of MLAT techniques.

The research team has identified the following research needs based on the previous research questions:

- **RN_1.** The project shall validate the fidelity of the surveillance data generated by SATERA, demonstrating that outputs derived from synthetic traffic are representative of real-world surveillance data.
- **RN_2.** The project shall validate the scalability of the SATERA solution, including system capacity and potential bottlenecks under increased traffic loads.

- **RN_3.** The project shall validate whether SATERA meets globally agreed applicable requirements (e.g., EUROCONTROL ESASSP) for surveillance systems enabling 5/3 NM separation applications under nominal operating conditions in oceanic environments.
- **RN_4.** The project shall validate whether SATERA meets globally agreed applicable requirements (e.g., EUROCONTROL ESASSP) for surveillance systems enabling 5/3 NM separation applications under abnormal natural degradations of the electromagnetic environment (e.g., severe space weather).
- **RN_5.** The project shall validate whether SATERA meets globally agreed applicable requirements (e.g., EUROCONTROL ESASSP) for surveillance systems enabling 5/3 NM separation applications under intentional electromagnetic interference (e.g., jamming, spoofing, saturation spoofing).
- **RN_6.** The project shall identify and define alternative levels of service or surveillance applications that SATERA may support when ESASSP requirements for 5/3 NM separation applications cannot be fully met.

Specific validation objectives, outlined later in Section 4.3, are designed to address these research needs through the SATERA validation exercises.

3.4 Estimated performance contributions

As described in SATERA Intermediate OSED, SATERA introduces several new features in alignment with the SESAR 3 Joint Undertaking Project Handbook and the SESAR DES Performance Framework—such as a GNSS-independent surveillance layer, a composite ADS-B + E-MLAT system, and an integrity indicator—along with corresponding performance metrics. These elements are expected to influence multiple KPAs (Capacity, Cost Efficiency, Operational Efficiency, and Safety) and KPIs, including En-route throughput in challenging airspace per unit time (CAP2), Flights per ATCO-hour on duty (CEF2), Technology Cost per flight (CEF3), Actual average fuel burn per flight (FEFF1), and Total number of accidents with ATM contributions per year (SAF1).

However, while the SATERA Solution may enable many of these performance benefits, it will not directly deliver them, as realizing such improvements also depends on operational and procedural changes within oceanic airspace control that fall outside the scope of this project. Therefore, SATERA validation will focus on assessing the system performance against the requirements defined in the latest edition of the EUROCONTROL Specification for ATM Surveillance Systems Performance (ESASSP), which is the reference document for ATM surveillance systems requirements across Europe. The ESASSP defines required and recommended performance requirements with a Quality-of-Service approach. Two ATC services are addressed by the latest edition of the ESASSP: 5NM_C and 3NM_C, i.e., the provision of 3 NM or 5 NM of horizontal separation by Air Traffic Controllers (ATCO) based on surveillance data from cooperative surveillance systems.

SATERA will verify compliance with the requirements and recommendations defined in the ESASSP for the two ATC services across all validation scenarios considered in the project. This approach is based on two main reasons. First, no other separation standards currently offer globally agreed requirements described in publicly available documents with the same level of detail as the ESASSP does for 5/3 NM separations, including the associated methods for estimating performance metrics. Second, several ESASSP requirements—particularly those linked to RMS errors—are consistent with the system performance expected from the preliminary assessments carried out by the SATERA team in WP5. Nevertheless, as this is an exploratory research project, the team will not limit itself to assessing performance solely against ESASSP requirements. Leveraging ENAIRE's expertise in Airspace Management, the project will also identify alternative levels of service that support wider separations while still enabling the performance benefits described in the OSED, particularly in scenarios where ESASSP requirements may not be fully met (e.g., degraded modes under strong intentional interference).

Table 3 and Table 4 list the ESASSP requirements applicable to SATERA for both ATC services. Since SATERA ERP focuses on the assessment of the computation of the 2D position by means of MLAT techniques, requirements related to altitude, aircraft identity, emergency/SPI and rate of climb/descent have been excluded despite its relevance. Future research work targeting more mature solutions closer to operational environments shall address those metrics. Requirements listed in Table 3 and Table 4 will lay the foundations for the SATERA performance assessment.

Req. #	Quality of Service	Mandatory performance	Recommended performance
5N_C-R1	Measurement interval for performance assessments	Less than or equal to 8 seconds	Less than or equal to 6 seconds
5N_C-R2	Probability of update of horizontal position	Greater than or equal to 97% for 100% of the flights, and	Greater than or equal to 97% for 100% of the flights, and
		Greater than or equal to 97% global, counting only target reports based on a horizontal position measurement with a data age lower than or equal to 10 sec	Greater than or equal to 99 % global, counting only target reports based on a horizontal position measurement with a data age lower than or equal to 10 sec
5N_C-R3	Ratio of missed 3D position involved in long gaps (larger than 3 x MIs + 10%)	Less than or equal to 0.5%	
5N_C-R4	Horizontal position RMS error	Less than or equal to 500 m global and less than 550 m for 100% of the flights	Less than or equal to 350 m global and less than 385 m per flight
5N_C-R5	Ratio of target reports involved in series of at least 3 consecutive correlated horizontal position errors larger than 926 m – 0.5 NM		Less than or equal to 0.03%
5N_C-R17	Track velocity speed (optional data item) RMS error	Less than or equal to 6 m/s for straight line and less than or equal to 11 m/s for turn	Less than or equal to 4 m/s for straight line and less than or equal to 8 m/s for turn
5N_C-R18	Track velocity angle (optional data item) RMS error	Less than or equal to 10° for straight line and less than or equal to 25° for turn	
5N_C-R19	Density of uncorrelated false target reports		Less than 10 false target reports per area of 900 NM^2 and over a duration of 450 applicable measurement intervals

5N_C-R20	Number per hour of falsely confirmed track close to true tracks		Less than or equal to 2 non-coincident falsely confirmed tracks per hour that are closer than 13000 m – 7 NM from true tracks

Table 3. ESASSP performance requirements for the provision of an ATC service of 5 NM of horizontal separation applicable to SATERA

Req. #	Quality of Service	Mandatory performance	Recommended performance
3N_C-R1	Measurement interval for performance assessments	Less than or equal to 5 seconds	Less than or equal to 4 seconds
3N_C-R2	Probability of update of horizontal position	Greater than or equal to 97% for 100% of the flights, and	Greater than or equal to 97% for 100% of the flights, and
		Greater than or equal to 97% global, counting only target reports based on a horizontal position measurement with a data age lower than or equal to 7 sec	Greater than or equal to 99 % global, counting only target reports based on a horizontal position measurement with a data age lower than or equal to 7 sec
3N_C-R3	Ratio of missed 3D position involved in long gaps (larger than 3 x MIs + 10%)	Less than or equal to 0.5%	
3N_C-R4	Horizontal position RMS error	Less than or equal to 300 m global and less than 330 m for 100% of the flights	Less than or equal to 210 m global and less than 230 m per flight
3N_C-R5	Ratio of target reports involved in series of at least 3 consecutive correlated horizontal position errors larger than 555 m – 0.3 NM		Less than or equal to 0.03%
3N_C-R17	Track velocity speed (optional data item) RMS error	Less than or equal to 6 m/s for straight line and less than or equal to 11 m/s for turn	Less than or equal to 4 m/s for straight line and less than or equal to 8 m/s for turn
3N_C-R18	Track velocity angle (optional data item) RMS error	Less than or equal to 10° for straight line and less than or equal to 25° for turn	
3N_C-R19	Density of uncorrelated false target reports		Less than 2 false target reports per area of 100 NM^2 and over a duration of 720 applicable measurement intervals
3N_C-R20	Number per hour of falsely confirmed track close to true tracks		Less than or equal to 1 falsely confirmed track per hour that are closer than 16700 m – 9 NM from true tracks

Table 4. ESASSP performance requirements for the provision of an ATC service of 3 NM of horizontal separation applicable to SATERA

3.5 Initial and exit maturity levels

The SESAR solution 0504 'Integrity-oriented, space-based aircraft composite surveillance using dependent and independent data streams' has started from the initial maturity level of TRL0 and aims to achieve TRL2 by the end of project activities.

Project/ Proposed SESAR solution(s) ID	Proposed SESAR solution(s) title	Initial maturity level	Exit maturity level	Reused validation material from past R&I Initiatives
0504	Integrity-oriented, space-based aircraft composite surveillance using dependent and independent data streams	TRL0	TRL2	N/A

Table 5: maturity levels table

Co-funded by the European Union

4 Exploratory research plan

4.1 Exploratory research plan approach

The SATERA Exploratory Research Plan (ERP) is based on the Description of the Action (DoA) included in the project Grant Agreement (GA) and serves a twofold purpose:

1. To validate the accuracy and fidelity of the surveillance data generated by the SATERA solution.
2. To assess whether the surveillance data provided by SATERA would enable the provision of Air Traffic Control (ATC) services with 5 NM and 3 NM horizontal separation minima in Oceanic Control Areas (OCAs) lacking continuous ground-based surveillance coverage, in compliance with the requirements set out in the EUROCONTROL Specification for ATC Surveillance Systems Performance (ESASSP) Ed. 1.3 **¡Error! No se encuentra el origen de la referencia.**, commonly referred to as non-radar (NRAD) OCAs.

A key caveat is that the **SATERA ERP will not directly address** the impact on Key Performance Areas (**KPA**) **or** Key Performance Indicators (**KPI**) **at** the SESAR **programme level**. SATERA supports the initial stages of developing a technological solution that, when validated at TRL 8 or higher, could enable the performance improvements described in the associated Operational Services and Environment Definition (OSED) and ECO-EVAL deliverables.

Therefore, **this ERP focuses on assessing the feasibility of 5 NM and 3 NM surveillance applications supported by the SATERA solution**, particularly in areas without ground-based surveillance infrastructure, and considering the environmental conditions under which such a solution must operate. However, the traceability from the surveillance application to measurable performance benefits is not straightforward, as it depends on other technological enablers and operational changes that fall outside the scope of SATERA.

To this end, the SATERA Team will integrate the solution components developed in WP3, WP4, WP5, and WP6 into the System Evaluation Tool (SET). This integration will enable the validation of the feasibility of surveillance applications supported by the SATERA solution through the validation exercises described in the remainder of this section.

Validation exercise #1 will consist of crosschecking SATERA data against results provided by ground-based, state-of-the-art surveillance systems using an industrial validation platform which is a *de facto* standard validation tool used by Air Navigation Service Providers (ANSPs) and Civil Aviation Authorities (CAA) worldwide (EURONCONTROL SASS-C). To this end, the research team will use surveillance data (ADS-B) from flights above FL150. These data will cover mainly En-route (cruise) operations and some climb/descend manoeuvres.

Validation exercise #1 does not aim to validate the SATERA solution itself, but rather to verify the fidelity of the SATERA System Evaluation Tool (SET) by assessing how closely the quality of surveillance data it generates aligns with that of similar, state-of-the-art ground-based systems used for 5 NM and 3 NM surveillance applications. This exercise #1 unfolds into three sub-exercises:

Validation exercise #1.1 will pursue the validation of the reference trajectories RTs generated by the SET by benchmarking them with reference trajectories built using SASS-C for the same flights. The accuracy of the RTs is instrumental for the subsequent validation activities for two main reasons. First, these trajectories form the cornerstone of any surveillance performance assessment technique.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

Second, the SATERA SET will use these RTs as Ground Truth (i.e., the actual aircraft trajectory) to estimate the ToA, FoA, and AoA, from which the MLAT fixes will be computed. Given that the SATERA SET builds reference trajectories (RTs) from ADS-B-reported positions, only this type of surveillance data will be used in this exercise. ENAIRE will use ADS-B data from specific data sets to generate RTs using SASS-C. ENAIRE will then export both the reference trajectories and the ADS-B data used to construct them in CSV format. The UPV team will import the RTs and their corresponding ADS-B data into the SATERA SET and generate new RTs using the imported ADS-B data. Subsequently, UPV researchers will use the SATERA SET Performance Assessment Module to compute distance metrics between both sets of RTs and verify compliance with the defined acceptance thresholds

Validation exercise #1.2 will focus on estimating the fidelity of the surveillance data provided by SATERA through the comparison of these data with surveillance data collected from ground-based, state-of-the-art surveillance systems using validated ADS-B RTs. To this end, data sets containing surveillance data provided by ENAIRE and MLAT data computed using SATERA SET for the same flights will be assessed using the VERIF function of the well-established SASS-C suite and the relevant performance metrics (see Table 3 andTable 4 above in Section 3.4 for details) will be computed. The same metrics will be computed using SATARA SET with the same data and benchmarked against the metrics obtained using SASS-C. Exercise #1.2 will address performance requirements for both 5 NM and 3 NM surveillance applications.

Validation E

exercise #1.1 will be run in the Flight Information Regions (FIR) Madrid and Barcelona, both in Spanish airspace. Since SATERA will use reference trajectories for the validation of requirements for 5/3 NM surveillance applications in En-route operations in NRAD OCAs, only En-route trajectory segments will be used. Therefore, opportunity traffic above FL150 records will be used in this validation exercise. Two hours of selected flights recorded between 10:00 and 12:00 UTC on four different days will be used to obtain a representative sample of a size consistent with the recommendations in ESASSP Ed. 1.3. **Validation exercise #1.2 will use the same data sets as validation exercise #1.1**.

Validation exercise #2 will focus on the validation of the SATERA solution itself. It will consist of computing ESASSP performance metrics for 5/3 NM surveillance applications (see Table 3 and Table 4 above in Section 3.4 for details) using SATERA-generated datasets in two relevant operational scenarios: the North Atlantic (NAT) and Europe-South America (EUR/SAM) corridor. The NAT corridor has been selected due to its high traffic density, whereas the EUR/SAM corridor has been chosen because it crosses equatorial regions where poor DOP conditions and strong ionospheric activity are expected.

The SATERA SET will ingest ADS-B data from Collins’ FlightAware feed and will generate RTs to be used as ground truth for generating MLAT data for aircraft flying in NRAD OCAs in both the NAT and EUR/SAM corridors. These RTs will then be used to assess the performance of the SATERA solution against the selected ESASSP requirements.

Validation exercise #2 will comprise three sub-exercises:

Validation exercise #2.1 will **assess the scalability** of the SATERA solution, mainly driven by the communication network. In this Exercise, two validation threads will be executed: first, the performance assessment will be conducted in the entire NAT corridor using several simultaneous flights that can be affordably simulated. Then, the assessment will be replicated but now conducted in each of the OCAs in the NAT separately. Network performance metrics obtained in each scenario will be compared to develop a model to project the overall network behaviour from OCA-level assessments ad to identify the maximum system capacity in terms of simultaneous aircraft.

Validation exercise #2.2 will **address** SATERA **performance in the NAT corridor**, whereas **Validation exercises #2.3** will **target** SATERA **performance assessment in the EUR/SAM corridor.** Based on the outcomes of validation exercise #2.1, validation exercises #2.2 to #2.5 will consist of simulations conducted at OCA level. Simulations for validation exercise 2.2 will be conducted in the following OCAs: Bodø, Reykjavik, Shanwick, Gander, Santa Maria, and New York. Simulations for validation exercise 2.3 will be conducted in the following FIRs: Canarias, Sal Oceanic, Dakar Oceanic, Atlantic (Brazil), and Recife. Large-scale, non-real time simulations will be conducted in those areas using real-world traffic data from FlightAware provided by SATERA partner COLLINs. Ground Truth trajectories will be generated using the same techniques as the ones used to generate RTs (indeed, Ground Truth trajectories will be used later in the experiments as RTs to assess surveillance performance metrics). Based on the outcomes from WP3 and WP5, only ToAs will be estimated on board SATERA LEO constellation satellites within the range of the aircraft transponders considering the error models developed in WP3 and reported in the corresponding deliverables. Data packages with decoded ADS-B data, the digitised signal features and other required data including PPT messages and satellite ephemeris will be assembled at each simulated satellite and injected into the communication network simulator that will propagate them until the different ground stations on the Earth surface and then to the Central Processing Station (CPS). MLAT tracks will then be initiated and updated using TDOA, measurements and then fused with ADS-B based tracks through the Multi Target Tracking function featured by the SATERA SET CPS. Integrity checks will be implemented on the tracked data exploiting the SATERA integrity check based on the comparison of ABS-B and MLAT data. The CPS will output target reports in ASTERIX CAT020 and CAT023 that will be recorded for performance assessment. The SATERA surveillance performance monitoring tool integrated into the SATERA SET will then be used to obtain ESASSP performance metrics and produce results that will be digitally recorded, enabling both graphical representation on the SET Graphical User Interface (GUI) and the generation of reports in pdf format.

Numerical experiments will be conducted under a several environmental conditions (see section 4.4 for details):

- Nominal conditions, accounting for the degradation of signals due to electromagnetic wave propagation through the Earth atmosphere, including ionospheric effects under normal solar activity.
- Abnormal (non-normal) conditions due to space weather conditions.
- Abnormal (non-nominal) conditions due to intentional GNSS interference (jamming).
- Abnormal (non-nominal) conditions due to spoofing attacks to GNSS.
- Abnormal (non-nominal) conditions due to intentional interferences (jamming) to the ADS-B receiving system.
- Abnormal conditions due to spoofing attacks to the ADS-B receiving system.

4.2 Stakeholders' expectations and involvement

	Involvement	Why it matters to the stakeholder
ANSP	ANSPs are Involved as the project partner	The outcomes of the validation activities will benefit the air traffic controllers through provision of reliable

	and member of the advisory board. In context of the validation activities, the identification of appropriate routes and provision of data for overland routes is provided by the ANSPs.	and accurate positioning data of the aircrafts to support safe and efficient air traffic management. ANSPs will exploit the validation results to analyse the new business model to offer new and economic benefit to end users. For ANSPs, KPAs of interest where the solution impacts positively include the operational efficiency, capacity and safety.
Scheduled airlines	No direct involvement	For airliners, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.
Military	No direct involvement	Like commercial airlines, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.
CNSaaS provider	No direct involvement	For this futuristic CNSaaS provider, the successful validation of the solution, along with other changes in the oceanic ATM procedure, will enable revenue from ANSPs, strategic role in CNS services. This will eventually enable high-performance surveillance globally. The realization of the whole system will require necessary infrastructure deployment (satellites, ground stations), development of data processing algorithms, service provision.

Table 6: stakeholders' expectations and involvement

4.3 Validation objectives

This section defines the validation objectives for the Exploratory Research Plan. The overarching objective is to demonstrate that SATERA supports the provision of ATC services with 3 and 5 NM horizontal separation according to the requirements set out in EUROCONTROL ESASSP. The provision of such services will enable operational changes that will impact on KPAs listed in section 3.4, although traceability is not obvious and will be skipped.

Validation objectives have been coded as OBJ-SATERA-TRL2-ERP-00X, being X consecutive numbers.

For each validation objective, success criteria have been identified and coded as CRT-SATERA-TRL2-ERP- 00X.00X, where:

Co-funded by the European Union

- CRT stands for success criteria,
- REQ/OPT specifies whether the success criteria are required or optional (see Note 1 below).
- SATERA refers to the project name,
- TRL2 indicates the TRL addressed by the objective,
- The first three digits (00X) refer to the specific objective,
- The last three digits (00X) represent the sequential numbering of success criteria associated with that objective.

NOTE 1: Success criteria for OBJ-SATERA-TRL2-ERP-003 to OBJ-SATERA-TRL2-ERP-016 are defined based on the ESASSP requirements listed in Table 3 and Table 4. These requirements specify either mandatory or recommended performance levels. Accordingly, five required and six optional success criteria have been defined for these objectives. Each objective will be scored with a double scale, represented as "X/Y," where X indicates the number of required success criteria met, and Y indicates the number of optional success criteria met. Validation objectives OBJ-SATERA-TRL2-ERP-001 and OBJ-SATERA-TRL2-ERP-002 will be considered 'Passed' if all the required success criteria are met.

Identifier	Validation Objective	R&I Need
OBJ-SATERA-TRL2-ERP-001	To validate SATERA ground truth/reference trajectories for the assessment of ESASSP requirements for ATC 5 NM_C ATC service.	RN_1
OBJ-SATERA-TRL2-ERP-002	To validate SATERA ground truth/reference trajectories for the assessment of ESASSP requirements for ATC 3 NM_C ATC service.	RN_1
OBJ-SATERA-TRL2-ERP-003	To assess whether SATERA meets, under nominal conditions, the ESASSP requirements for surveillance systems supporting the provision of ATC services with 5 NM horizontal separation in continental airspace, where ground-based surveillance systems are deployed.	RN_1
OBJ-SATERA-TRL2-ERP-004	To assess whether SATERA meets, under nominal conditions, the ESASSP requirements for surveillance systems supporting the provision of ATC services with 5 NM horizontal separation in continental airspace, where ground-based surveillance systems are deployed.	RN_1
OBJ-SATERA-TRL2-ERP-005	To assess the scalability of the SATERA platform regarding the communication support for different components considering a large-scale scenario.	RN_2
OBJ-SATERA-TRL2-ERP-006	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 5 NM_C ATC in OCAs (nominal conditions).	RN_3
OBJ-SATERA-TRL2-ERP-007	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 3 NM_C ATC in OCAs (nominal conditions).	RN_3
OBJ-SATERA-TRL2-ERP-008	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 5 NM_C ATC	RN_4

	in OCAs (abnormal conditions due to space weather conditions).	
OBJ-SATERA-TRL2-ERP-009	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 3 NM_C ATC in OCAs (abnormal conditions due to space weather conditions).	RN_4
OBJ-SATERA-TRL2-ERP-010	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – jamming).	RN_5
OBJ-SATERA-TRL2-ERP-011	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – jamming).	RN_5
OBJ-SATERA-TRL2-ERP-012	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – spoofing).	RN_5
OBJ-SATERA-TRL2-ERP-013	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – spoofing).	RN_5
OBJ-SATERA-TRL2-ERP-014	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences –jamming).	RN_5
OBJ-SATERA-TRL2-ERP-015	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences – jamming).	RN_5
OBJ-SATERA-TRL2-ERP-016	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences – spoofing).	RN_5
OBJ-SATERA-TRL2-ERP-017	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences –jamming).	RN_5
OBJ-SATERA-TRL2-ERP-018	To demonstrate that SATERA enables the provision of an ADS-B integrity estimator based on the cross-check between reported (ADS-B) and calculated (MLAT) positions.	RN_6

Table 7: list of SATERA validation objectives

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-001
Objective	To validate SATERA ground truth/reference trajectories for the assessment of ESASSP requirements for ATC 5 NM_C ATC service.
Title	Validation of SATERA Reference Trajectories for ESASSP ATC 5 NM_C Assessment
Category	NA
Key environment conditions	En route operations. Flights conducted over continental Spanish territory. Nominal environment conditions.
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Terminal Area High-Complexity

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-001.001	The rms value of the difference between SASS-C and SSET RTs less than or equal to 50 m global and less than 55 m per flight (1/10th the required rms error in the ESASSP) when defined on the same reference frame

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-001.001	Difference between SASS-C and SSET RTs less than or equal to 35 m global and less than 38 m per flight (1/10th the recommended rms error in the ESASSP) when defined on the same reference frame

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-002
Objective	To validate SATERA ground truth/reference trajectories for the assessment of ESASSP requirements for ATC 3 NM_C ATC service.

Identifier	OBJ-SATERA-TRL2-ERP-002
Title	Validation of SATERA Reference Trajectories for ESASSP ATC 3 NM_C Assessment
Category	NA
Key environment conditions	En route operations. Flights conducted over continental Spanish territory. Nominal environment conditions.
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Terminal Area High-Complexity

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-002.001	Difference between SASS-C and SSET RTs less than or equal to 30 m global and less than 33 m per flight (1/10th the required rms error in the ESASSP) when defined on the same reference frame

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-002.001	Difference between SASS-C and SSET RTs less than or equal to 21 m global and less than 23 m per flight (1/10th the recommended rms error in the ESASSP) when defined on the same reference frame

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-003
Objective	To assess whether SATERA meets, under nominal conditions, the ESASSP requirements for surveillance systems supporting the provision of ATC services with 5 NM horizontal separation in continental airspace, where ground-based surveillance systems are deployed.

Identifier	OBJ-SATERA-TRL2-ERP-003
Title	To assess SATERA performance against ESASSP requirements for 5 NM_C ATC in continental airspace.
Category	NA
Key environment conditions	En route operations. Flights conducted over continental Spanish territory. Nominal environment conditions.
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Terminal Area High-Complexity

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-003.001	ESASSP required performance criterion 5N_C-R2 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-003.002	ESASSP required performance criterion 5N_C-R3 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-003.003	ESASSP required performance criterion 5N_C-R4 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-003.004	ESASSP required performance criterion 5N_C-R17 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-003.005	ESASSP required performance criterion 5N_C-R18 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-003.006	Performance metrics for any ESASSP applicable required criterion for 5 NM surveillance application computed using SASS-C VERIF and SATERA SET performance assessment function do not differ more than 10%.

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-003.001	ESASSP recommended performance criterion 5N_C-R2 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-003.002	ESASSP recommended performance criterion 5N_C-R4 is met under nominal conditions when assessed using SASS-C VERIF

CRT-OPT-SATERA-TRL2-ERP-003.003	ESASSP recommended performance criterion 5N_C-R5 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-003.004	ESASSP recommended performance criterion 5N_C-R17 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-003.005	ESASSP recommended performance criterion 5N_C-R19 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-003.006	ESASSP recommended performance criterion 5N_C-R20 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-003.007	Performance metrics for any ESASSP applicable recommended criterion for 5 NM surveillance application computed using SASS-C VERIF and SATERA SET performance assessment function do not differ more than 10%

[OBJ]

Identifier	**OBJ-SATERA-TRL2-ERP-004**
Objective	To assess whether SATERA meets, under nominal conditions, the ESASSP requirements for surveillance systems supporting the provision of ATC services with 3 NM horizontal separation in continental airspace, where ground-based surveillance systems are deployed.
Title	To assess SATERA performance against ESASSP requirements for 3 NM_C ATC in RAD airspace.
Category	NA
Key environment conditions	En route operations. Flights conducted over continental Spanish territory. Nominal environment conditions.
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Terminal Area High-Complexity

[OBJ Suc]

Identifier	**Success Criterion (required)**

CRT-REQ-SATERA-TRL2-ERP-004.001	ESASSP required performance criterion 3N_C-R2 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-004.002	ESASSP required performance criterion 3N_C-R3 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-004.003	ESASSP required performance criterion 3N_C-R4 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-004.004	ESASSP required performance criterion 3N_C-R17 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-004.005	ESASSP required performance criterion 3N_C-R18 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-004.006	Performance metrics for any ESASSP applicable required criterion for 3 NM surveillance application computed using SASS-C VERIF and SATERA SET performance assessment function do not differ mot than 10%.

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-004.001	ESASSP recommended performance criterion 3N_C-R2 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-004.002	ESASSP recommended performance criterion 3N_C-R4 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-004.003	ESASSP recommended performance criterion 3N_C-R5 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-004.004	ESASSP recommended performance criterion 3N_C-R17 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-004.005	ESASSP recommended performance criterion 3N_C-R19 is met under nominal conditions when assessed using SASS-C VERIF
CRT-OPT-SATERA-TRL2-ERP-004.006	ESASSP recommended performance criterion 3N_C-R20 is met under nominal conditions when assessed using SASS-C VERIF
CRT-REQ-SATERA-TRL2-ERP-003.007	Performance metrics for any ESASSP applicable recommended criterion for 3 NM surveillance application computed using SASS-C VERIF and SATERA SET performance assessment function do not differ more than 10%.

Identifier	OBJ-SATERA-TRL2-ERP-005
Objective	To assess the scalability of the SATERA platform regarding the communication support for different components considering a large-scale scenario.
Title	SATERA scalability assessment
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Nominal environment conditions
TRL Phase	2

[OBJ Trace]

EUROPEAN PARTNERSHIP
Co-funded by the European Union

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-005.001	SATERA solution shall be able to track 225 simultaneous aircraft in the NAT corridor, extrapolating from the validation experiment set.
CRT-REQ-SATERA-TRL2-ERP-005.002	The maximum communication latency measured in a global and/or distributed NAT and EUR/SAM assessments shall not exceed 500 ms.
CRT-REQ-SATERA-TRL2-ERP-005.003	The simulator must incorporate realistic details of Ground Stations locations and their elevation angles, calculating exactly when a satellite can physically downlink its stored data

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-005.001	The communication network simulator should aim to achieve a Packet Delivery Ratio (PDR) exceeding 99.5% to ensure high-fidelity communication.
CRT-OPT-SATERA-TRL2-ERP-005.002	The network simulator should implement a strict Time-To-Live (TTL) mechanism that automatically discards any ADS-B data if its total latency (time in transit) exceeds 500 ms before reaching the processing engine.

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-006
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 5 NM_C ATC in OCAs (nominal conditions).
Title	SATERA performance assessment for 5 NM_C ATC in OCAs under nominal conditions.
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Nominal environment conditions
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-006.001	ESASSP required performance criterion 5N_C-R2 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-006.002	ESASSP required performance criterion 5N_C-R3 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-006.003	ESASSP required performance criterion 5N_C-R4 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-006.004	ESASSP required performance criterion 5N_C-R17 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-006.005	ESASSP required performance criterion 5N_C-R18 is met under nominal conditions

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-006.001	ESASSP recommended performance criterion 5N_C-R2 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-006.002	ESASSP recommended performance criterion 5N_C-R4 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-006.003	ESASSP recommended performance criterion 5N_C-R5 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-006.004	ESASSP recommended performance criterion 5N_C-R17 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-006.005	ESASSP recommended performance criterion 5N_C-R19 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-006.006	ESASSP recommended performance criterion 5N_C-R20 is met under nominal conditions

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-007
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 3 NM_C ATC in OCAs (nominal conditions).

EUROPEAN PARTNERSHIP
Co-funded by the European Union

Identifier	OBJ-SATERA-TRL2-ERP-007
Title	SATERA performance assessment for 5NM_C ATC in OCAs under nominal conditions.
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Nominal environment conditions
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-007.001	ESASSP required performance criterion 3N_C-R2 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-007.002	ESASSP required performance criterion 3N_C-R3 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-007.003	ESASSP required performance criterion 3N_C-R4 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-007.004	ESASSP required performance criterion 3N_C-R17 is met under nominal conditions
CRT-REQ-SATERA-TRL2-ERP-007.005	ESASSP required performance criterion 3N_C-R18 is met under nominal conditions

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-007.001	ESASSP recommended performance criterion 3N_C-R2 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-007.002	ESASSP recommended performance criterion 3N_C-R4 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP 007.003	ESASSP recommended performance criterion 3N_C-R5 is met under nominal conditions

CRT-OPT-SATERA-TRL2-ERP-007.004	ESASSP recommended performance criterion 3N_C-R17 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-007.005	ESASSP recommended performance criterion 3N_C-R19 is met under nominal conditions
CRT-OPT-SATERA-TRL2-ERP-007.006	ESASSP recommended performance criterion 3N_C-R20 is met under nominal conditions

[OBJ]

Identifier	**OBJ-SATERA-TRL2-ERP-008**
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 5 NM_C ATC in OCAs (abnormal conditions due to space weather conditions).
Title	SATERA performance assessment for 5 NM_C ATC in OCAs under abnormal space weather conditions
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Abnormal environment conditions (space weather)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	**Success Criterion (required)**
CRT-REQ-SATERA-TRL2-ERP-008.001	ESASSP required performance criterion 5N_C-R2 is met under abnormal conditions due to space weather conditions
CRT-REQ-SATERA-TRL2-ERP-008.002	ESASSP required performance criterion 5N_C-R3 is met under abnormal conditions due to space weather conditions
CRT-REQ-SATERA-TRL2-ERP-008.003	ESASSP required performance criterion 5N_C-R4 is met under abnormal conditions due to space weather conditions

CRT-REQ-SATERA-TRL2-ERP-008.004	ESASSP required performance criterion 5N_C-R17 is met under abnormal conditions due to space weather conditions
CRT-REQ-SATERA-TRL2-ERP-008.005	ESASSP required performance criterion 5N_C-R18 is met under abnormal conditions due to space weather conditions

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-008.001	ESASSP recommended performance criterion 5N_C-R2 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-008.002	ESASSP recommended performance criterion 5N_C-R4 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP 008.003	ESASSP recommended performance criterion 5N_C-R5 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-008.004	ESASSP recommended performance criterion 5N_C-R17 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-008.005	ESASSP recommended performance criterion 5N_C-R19 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-008.006	ESASSP recommended performance criterion 5N_C-R20 is met under abnormal conditions due to space weather conditions

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-009
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 3 NM_C ATC in OCAs (abnormal conditions due to space weather conditions).
Title	SATERA performance assessment for 3 NM_C ATC in OCAs under abnormal space weather conditions
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Abnormal environment conditions (space weather)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-009.001	ESASSP required performance criterion 3N_C-R2 is met under abnormal conditions due to space weather conditions
CRT-REQ-SATERA-TRL2-ERP-009.002	ESASSP required performance criterion 3N_C-R3 is met under abnormal conditions due to space weather conditions
CRT-REQ-SATERA-TRL2-ERP-009.003	ESASSP required performance criterion 3N_C-R4 is met under abnormal conditions due to space weather conditions
CRT-REQ-SATERA-TRL2-ERP-009.004	ESASSP required performance criterion 3N_C-R17 is met under abnormal conditions due to space weather conditions
CRT-REQ-SATERA-TRL2-ERP-009.005	ESASSP required performance criterion 3N_C-R18 is met under abnormal conditions due to space weather conditions

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-009.002	ESASSP recommended performance criterion 3N_C-R2 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-009.003	ESASSP recommended performance criterion 3N_C-R4 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP 009.004	ESASSP recommended performance criterion 3N_C-R5 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-009.006	ESASSP recommended performance criterion 3N_C-R17 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-009.007	ESASSP recommended performance criterion 3N_C-R19 is met under abnormal conditions due to space weather conditions
CRT-OPT-SATERA-TRL2-ERP-009.008	ESASSP recommended performance criterion 3N_C-R20 is met under abnormal conditions due to space weather conditions

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-010
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – jamming).
Title	SATERA performance assessment for 3 NM_C ATC in OCAs under abnormal conditions due to GNSS jamming
Category	NA

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Identifier	OBJ-SATERA-TRL2-ERP-010
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Abnormal environment conditions (GNSS jamming)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-010.001	ESASSP required performance criterion 5N_C-R2 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-REQ-SATERA-TRL2-ERP-010.002	ESASSP required performance criterion 5N_C-R3 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-REQ-SATERA-TRL2-ERP-010.003	ESASSP required performance criterion 5N_C-R4 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-REQ-SATERA-TRL2-ERP-010.004	ESASSP required performance criterion 5N_C-R17 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-REQ-SATERA-TRL2-ERP-010.005	ESASSP required performance criterion 5N_C-R18 is met under abnormal conditions due to intentional GNSS interferences (jamming).

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-010.001	ESASSP recommended performance criterion 5N_C-R2 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP-010.002	ESASSP recommended performance criterion 5N_C-R4 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP 010.003	ESASSP recommended performance criterion 5N_C-R5 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP-010.004	ESASSP recommended performance criterion 5N_C-R17 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP-010.005	ESASSP recommended performance criterion 5N_C-R19 is met under abnormal conditions due to intentional GNSS interferences (jamming).

Co-funded by the European Union

CRT-OPT-SATERA-TRL2-ERP-010.006	ESASSP recommended performance criterion 5N_C-R20 is met under abnormal conditions due to intentional GNSS interferences (jamming).

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-011
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – jamming).
Title	SATERA performance assessment for 3 NM_C ATC in OCAs under abnormal conditions due to GNSS jamming
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Abnormal environment conditions (GNSS jamming)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-011.001	ESASSP required performance criterion 3N_C-R2 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-REQ-SATERA-TRL2-ERP-011.002	ESASSP required performance criterion 3N_C-R3 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-REQ-SATERA-TRL2-ERP-011.003	ESASSP required performance criterion 3N_C-R4 is met under abnormal conditions due to intentional GNSS interferences (jamming).

CRT-REQ-SATERA-TRL2-ERP-011.004	ESASSP required performance criterion 3N_C-R17 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-REQ-SATERA-TRL2-ERP-011.005	ESASSP required performance criterion 3N_C-R18 is met under abnormal conditions due to intentional GNSS interferences (jamming).

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-011.001	ESASSP recommended performance criterion 3N_C-R2 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP-011.002	ESASSP recommended performance criterion 3N_C-R4 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP 011.003	ESASSP recommended performance criterion 3N_C-R5 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP-011.004	ESASSP recommended performance criterion 3N_C-R17 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP-011.005	ESASSP recommended performance criterion 3N_C-R19 is met under abnormal conditions due to intentional GNSS interferences (jamming).
CRT-OPT-SATERA-TRL2-ERP-011.006	ESASSP recommended performance criterion 3N_C-R20 is met under abnormal conditions due to intentional GNSS interferences (jamming).

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-012
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – spoofing).
Title	SATERA performance assessment for 5 NM_C ATC in OCAs under abnormal conditions due to GNSS spoofing
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Abnormal environment conditions (GNSS spoofing)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-012.001	ESASSP required performance criterion 5N_C-R2 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-012.002	ESASSP required performance criterion 5N_C-R3 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-012.003	ESASSP required performance criterion 5N_C-R4 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-012.004	ESASSP required performance criterion 5N_C-R17 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-012.005	ESASSP required performance criterion 5N_C-R18 is met under abnormal conditions due to spoofing attacks to GNSS.

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-012.001	ESASSP recommended performance criterion 5N_C-R2 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-012.002	ESASSP recommended performance criterion 5N_C-R4 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP 012.003	ESASSP recommended performance criterion 5N_C-R5 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-012.004	ESASSP recommended performance criterion 5N_C-R17 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-012.005	ESASSP recommended performance criterion 5N_C-R19 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-012.006	ESASSP recommended performance criterion 5N_C-R20 is met under abnormal conditions due to spoofing attacks to GNSS.

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-013
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional GNSS interferences – spoofing).
Title	SATERA performance assessment for 3 NM_C ATC in OCAs under abnormal conditions due to GNSS spoofing
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Abnormal environment conditions (GNSS spoofing)

EUROPEAN PARTNERSHIP
Co-funded by the European Union

Identifier	OBJ-SATERA-TRL2-ERP-013
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-013.001	ESASSP required performance criterion 3N_C-R2 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-013.002	ESASSP required performance criterion 3N_C-R3 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-013.003	ESASSP required performance criterion 3N_C-R4 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-013.004	ESASSP required performance criterion 3N_C-R17 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-REQ-SATERA-TRL2-ERP-013.005	ESASSP required performance criterion 3N_C-R18 is met under abnormal conditions due to spoofing attacks to GNSS.

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-013.001	ESASSP recommended performance criterion 3N_C-R2 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-013.002	ESASSP recommended performance criterion 3N_C-R4 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP 013.003	ESASSP recommended performance criterion 3N_C-R5 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-013.004	ESASSP recommended performance criterion 3N_C-R17 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-013.005	ESASSP recommended performance criterion 3N_C-R19 is met under abnormal conditions due to spoofing attacks to GNSS.
CRT-OPT-SATERA-TRL2-ERP-013.006	ESASSP recommended performance criterion 3N_C-R20 is met under abnormal conditions due to spoofing attacks to GNSS.

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-014
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences –jamming).
Title	SATERA performance assessment for 5 NM_C ATC in OCAs under abnormal conditions due to ADS-B jamming
Category	NA
Key environment conditions	En route operations. Flight conducted over NRAD oceanic areas Abnormal environment conditions (ADS-B receiver jamming)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-014.001	ESASSP required performance criterion 5N_C-R2 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-014.002	ESASSP required performance criterion 5N_C-R3 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-014.003	ESASSP required performance criterion 5N_C-R4 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-014.004	ESASSP required performance criterion 5N_C-R17 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-014.005	ESASSP required performance criterion 5N_C-R18 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.

Identifier	Success Criterion (optional)

EUROPEAN PARTNERSHIP
Co-funded by the European Union

CRT-OPT-SATERA-TRL2-ERP-014.001	ESASSP recommended performance criterion 5N_C-R2 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-014.002	ESASSP recommended performance criterion 5N_C-R4 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP 014.003	ESASSP recommended performance criterion 5N_C-R5 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-014.004	ESASSP recommended performance criterion 5N_C-R17 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-014.005	ESASSP recommended performance criterion 5N_C-R19 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-014.006	ESASSP recommended performance criterion 5N_C-R20 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-015
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences –jamming).
Title	SATERA performance assessment for 3 NM_C ATC in OCAs under abnormal conditions due to ADS-B jamming
Category	NA
Key environment conditions	En route operations Flight conducted over NRAD oceanic areas Abnormal environment conditions (ADS-B receiver jamming)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-015.001	ESASSP required performance criterion 3N_C-R2 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-015.002	ESASSP required performance criterion 3N_C-R3 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-015.003	ESASSP required performance criterion 3N_C-R4 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-015.004	ESASSP required performance criterion 3N_C-R17 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-REQ-SATERA-TRL2-ERP-015.005	ESASSP required performance criterion 3N_C-R18 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.

Identifier	Success Criterion (optional)
CRT-OPT-SAT5RA-TRL2-ERP-014.001	ESASSP recommended performance criterion 3N_C-R2 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-015.002	ESASSP recommended performance criterion 3N_C-R4 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP 015.003	ESASSP recommended performance criterion 3N_C-R5 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-015.004	ESASSP recommended performance criterion 3N_C-R17 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-015.005	ESASSP recommended performance criterion 3N_C-R19 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.
CRT-OPT-SATERA-TRL2-ERP-015.006	ESASSP recommended performance criterion 3N_C-R20 is met under abnormal conditions due to intentional interferences (jamming) to the ADS-B receiving system.

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-016
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 andTable 4 for 5 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences – spoofing).

Identifier	OBJ-SATERA-TRL2-ERP-016
Title	SATERA performance assessment for 5 NM_C ATC in OCAs under abnormal conditions due to ADS-B spoofing
Category	NA
Key environment conditions	En route operations Flight conducted over NRAD oceanic areas Abnormal environment conditions (ADS-B receiver spoofing)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-016.001	ESASSP required performance criterion 5N_C-R2 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-REQ-SATERA-TRL2-ERP-016.002	ESASSP required performance criterion 5N_C-R3 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-REQ-SATERA-TRL2-ERP-016.003	ESASSP required performance criterion 5N_C-R4 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-REQ-SATERA-TRL2-ERP-016.004	ESASSP required performance criterion 5N_C-R17 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-REQ-SATERA-TRL2-ERP-016.005	ESASSP required performance criterion 5N_C-R18 is met under abnormal conditions due to spoofing attacks to the receiving system.

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-016.001	ESASSP recommended performance criterion 5N_C-R2 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP-016.002	ESASSP recommended performance criterion 5N_C-R4 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP 016.003	ESASSP recommended performance criterion 5N_C-R5 is met under abnormal conditions due to spoofing attacks to the receiving system.

CRT-OPT-SATERA-TRL2-ERP-016.004	ESASSP recommended performance criterion 5N_C-R17 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP-016.005	ESASSP recommended performance criterion 5N_C-R19 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP-016.006	ESASSP recommended performance criterion 5N_C-R20 is met under abnormal conditions due to spoofing attacks to the receiving system.

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-017
Objective	To assess SATERA performance against ESASSP requirements listed in Table 3 and Table 4 for 3 NM_C ATC in OCAs (abnormal conditions due to intentional ADS-B interferences – spoofing).
Title	SATERA performance assessment for 3 NM_C ATC in OCAs under abnormal conditions due to ADS-B spoofing
Category	NA
Key environment conditions	En route operations Flight conducted over NRAD oceanic areas Abnormal environment conditions (ADS-B receiver spoofing)
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-017.001	ESASSP required performance criterion 3N_C-R2 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-REQ-SATERA-TRL2-ERP-017.002	ESASSP required performance criterion 3N_C-R3 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-REQ-SATERA-TRL2-ERP-017.003	ESASSP required performance criterion 3N_C-R4 is met under abnormal conditions due to spoofing attacks to the receiving system.

CRT-REQ-SATERA-TRL2-ERP-017.004	ESASSP required performance criterion 3N_C-R17 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-REQ-SATERA-TRL2-ERP-017.005	ESASSP required performance criterion 3N_C-R18 is met under abnormal conditions due to spoofing attacks to the receiving system.

Identifier	Success Criterion (optional)
CRT-OPT-SATERA-TRL2-ERP-017.001	ESASSP recommended performance criterion 3N_C-R2 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP-017.002	ESASSP recommended performance criterion 3N_C-R4 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP 017.003	ESASSP recommended performance criterion 3N_C-R5 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP-017.004	ESASSP recommended performance criterion 3N_C-R17 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP-017.005	ESASSP recommended performance criterion 3N_C-R19 is met under abnormal conditions due to spoofing attacks to the receiving system.
CRT-OPT-SATERA-TRL2-ERP-017.006	ESASSP recommended performance criterion 3N_C-R20 is met under abnormal conditions due to spoofing attacks to the receiving system.

[OBJ]

Identifier	OBJ-SATERA-TRL2-ERP-018
Objective	To demonstrate that SATERA enables the provision of an ADS-B integrity estimator based on the cross-check between reported (ADS-B) and calculated (MLAT) positions.
Title	ADS-B integrity estimator
Category	NA
Key environment conditions	En route operations Flight conducted over NRAD oceanic areas Normal or abnormal conditions.
TRL Phase	2

[OBJ Trace]

Relationship	Linked Element Type	Identifier
<COVERS>	<SESAR Solution>	SESAR Solution 0504
<COVERS>	<Enabler>	N/A
<COVERS>	<Sub-Operating Environment>	Very High Complexity En-Route
<COVERS>	<Sub-Operating Environment>	Medium Complexity En-Route

[OBJ Suc]

Identifier	Success Criterion (required)
CRT-REQ-SATERA-TRL2-ERP-018.001	The system shall demonstrate the capability to compute an independent MLAT-derived aircraft position with sufficient accuracy to enable a meaningful cross-check against the ADS-B reported position during En-route operations over oceanic and remote areas.
CRT-REQ-SATERA-TRL2-ERP-018.002	The system shall provide an ADS-B integrity estimate by quantifying the positional deviation between the MLAT-calculated and ADS-B-reported positions under both normal and abnormal operational conditions.
CRT-REQ-SATERA-TRL2-ERP-018.003	The system shall demonstrate that the ADS-B integrity estimator reliably detects integrity degradations by identifying when the deviation threshold between MLAT and ADS-B positions exceeds predefined limits.

4.4 Validation assumptions

The following assumptions defined in the SATERA OSED apply to all validation exercises:

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
VAL-ASSUMPT-SATERA-TRL2-ERP-001	Orbit Altitude of at Least 500 km	Periodically replenishing satellites every 6 to 12 months may be a more cost-effective approach than implementing extensive control measures to counteract orbital decay.	Significant atmospheric drag, reducing satellite lifespan and increasing maintenance needs.	N/A
VAL-ASSUMPT-SATERA-TRL2-ERP-002	Ground Station antennas	Ground stations are equipped with Active Electronically Scanned Arrays (AESA) operating in the Ka band (26.5–40 GHz) for both uplink and downlink.		N/A
VAL-ASSUMPT-SATERA-	Downlink antennas	On the satellite side, antenna simpler antennas are		N/A

Co-funded by the European Union

TRL2-ERP-003		assumed, with a gain between 8 and 10 dBi		
VAL-ASSUMPT-SATERA-TRL2-ERP-004	ISL physical layer (mmWave or optical link)	The system will operate in the Ka band, with frequencies around 20–30 GHz or an optical link in the near infrarred. Each satellite will establish Inter-Satellite Links (ISLs) with four others in the same orbital plane, two ahead and two behind, and with two satellites in adjacent orbital planes (cross-links). For cross-links, there are two types of connections: ascending and descending. As satellites cross each other, the communication direction must switch accordingly. In a rhombic lattice constellation, when a satellite passes in front, the northbound satellite will be connected to one antenna and the southbound satellite to another.	This physical-layer layout guarantees intra-plane connectivity even in the event of a satellite failure. The cross-links between orbital planes provide the flexibility needed to reach satellites in view of the ground stations, maintaining low communication latencies.	N/A

Table 8: validation assumptions applicable to all validation exercises

The following validation assumptions apply to specific validation exercises. They have been listed here and will be referred to when they are applicable to avoid repetition.

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment

VAL-ASSUMPT-SATERA-TRL2-ERP-005	SATERA nominal conditions	Receivers on board SATERA satellites are exposed to **standard space weather conditions** in LEO orbits: Geomagnetic activity: • Planetary Kp index ≤ 3 for the entire interval under analysis; and • Dst index > −50 nT (i.e., no geomagnetic storm conditions). Solar activity: • $70 \leq F10.7 \leq 150$ sfu, with no major solar flares or SEP events reported by NOAA SWPC. Particle environment: • No proton or electron events above NOAA warning thresholds at energies ≥ 10 MeV. Ionospheric conditions: • Global or regional ionospheric conditions within their 20th–80th historical percentiles (TEC and scintillation indices), i.e. no strong scintillation or ionospheric storm signatures[2]).		N/A

[2] Ionospheric absorption less than 0.2 dB even under auroral or polar cap conditions, and typically <0.04 dB at mid-latitudes.

		• The effect of Faraday rotation is accounted for in the link budget as a systematic 3 dB loss, assuming that circular polarised antennas are used. **Receivers** on board SATERA satellites **are not exposed to intentional interferences** (either jamming or spoofing).		
VAL-ASSUMPT-SATERA-TRL2-ERP-006	Abnormal weather conditions	TBD (See NOTE 2)	Conditions defined in light of D3.4 outcomes (see NOTE 3)	TBD (See NOTE 2)
VAL-ASSUMPT-SATERA-TRL2-ERP-007	GNSS attack (1) – jamming	Nominal satellite position and synchronisation errors are increased by a factor of 2 for 5 minutes for all satellites in view from a fixed point.	This condition simulates the effect of a GNSS jammer on a stratospheric platform (see NOTE 3).	N/A
VAL-ASSUMPT-SATERA-TRL2-ERP-008	GNSS attack (2) – jamming	Deny GNSS signals for 5 minutes for the satellites in view from a fixed point	This condition simulates the effect of a GNSS jammer on a stratospheric platform (see NOTE 3).	N/A
VAL-ASSUMPT-SATERA-TRL2-ERP-009	GNSS attack (3) – spoofing	Add a 100-meter bias to the satellites position for 5 minutes for the satellite in view from a fixed point	This condition simulates the effect of a GNSS spoofer on a stratospheric platform (see NOTE 3).	N/A
VAL-ASSUMPT-SATERA-	ADS-B attack (1) – jamming	Apply twice the nominal ADS-B position error for 5	This condition simulates the effect of a jammer on a	N/A

TRL2-ERP-010		minutes to the satellites in view from a fixed point	stratospheric platform (see NOTE 3).	
VAL-ASSUMPT-SATERA-TRL2-ERP-011	ADS-B attack (1) – jamming	Deny reception of ADS-B messages for 5 minutes for the satellites in view from a fixed point	This condition simulates the effect of a jammer on a stratospheric platform (see NOTE 3).	N/A
VAL-ASSUMPT-SATERA-TRL2-ERP-012	ADS-B attack (3) – spoofing	Inject a false aircraft for 5 minutes	This condition simulates the effect of a spoofer on a stratospheric platform (see NOTE 3).	N/A

Table 9 environmental conditions applicable to SATERA validation exercises

NOTE 2. Rationale for VAL-ASSUMPT- SATERA-TRL2-ERP-006. Within WP3, the SATERA Team is conducting a dependability assessment of the spaceborne hardware and software to determine the abnormal space-weather conditions that the SATERA equipment shall be capable of withstanding. The UC team will deliver the corresponding results by the end of February 2026, and the schedule of the validation exercises has been aligned with this deadline.

NOTE 3. Rationale for VAL-ASSUMPT- SATERA-TRL2-ERP-007 to VAL-ASSUMPT- SATERA-TRL2-ERP-012. Regarding the spoofing or jamming of ADS-B and GNSS signals, it is important to recall that a receiver on board a satellite is intrinsically much more robust than one located on the ground. In fact, the ability to jam or spoof a receiver depends on several parameters:

- The ratio between the nominal transmitter power and the jammer/spoofer power
- The square of the ratio between the distances of the jammer/spoofer and the nominal transmitter
- The ratio between the antenna gains of the jammer/spoofer and the nominal transmitter
- The difference in spreading gain (in the case of GNSS signals, which are spread-spectrum), meaning the ratio of their instantaneous bandwidths

More specifically, assuming that the targeted receiver receives both the nominal signal and the interfering signal (temporarily neglecting the spreading modulation):

$$P_{Rx,N} = const * G_{rx,N} G_{tx,N} P_{TX,N} / R_N\hat{}2$$

$$P_{Rx,J} = const * G_{rx,J} G_{tx,J} P_{TX,J} / R_N\hat{}2$$

To have an effect on the receiver, the power received from the jammer must exceed the detection threshold. When this occurs, the effective coverage of the receiver is reduced. In general, it can be stated that the nominal signal can still be correctly received only if the jammer signal at the receiver results in an S/J ratio lower than this threshold.

Conversely, if the S/J ratio exceeds the threshold, the jammer will dominate:

$$\frac{S}{J}=\frac{P_{Rx,N}}{P_{Rx,J}}=\frac{const\,\frac{G_{rx,N}G_{tx,N}P_{TX,N}}{R_N^2}}{const\,\frac{G_{rx,J}G_{tx,J}P_{TX,J}}{R_J^2}}=\frac{G_{rx,N}G_{tx,N}}{G_{rx,J}G_{tx,J}}\frac{P_{TX,N}R_J^2}{P_{TX,J}R_N^2}>Th$$

From the equation, it is possible to observe that for a satellite-based receiver and a ground-based jammer/spoofer, the ratio described is generally very favourable to the nominal signal due to the following reasons:

- **For an ADS-B receiver**, the large distance between the ground-based jammer and the satellite greatly reduces the jammer's received power.
- **For a GNSS receiver**, the difference in antenna gain is significant: the GNSS antenna on the satellite points toward the zenith and has very low gain toward the nadir or, in general, at negative elevation angles. As a result, a ground-based jammer is strongly attenuated.

Moreover, in the specific case of the **SATERA system**, it is important to recall that it is designed so that each aircraft in the coverage area has at least four satellites in view. This means that the system can still receive ADS-B data even if **three out of four satellites** are under attack.

However, one possible attack scenario that must be considered is the use of a **stratospheric platform** carrying a jammer or spoofer. In this case, at least for a short period, the jammer/spoofer might be closer to the satellite than the aircraft, which can be particularly dangerous for ADS-B jamming, potentially resulting in a **complete denial of service** for the satellite that has the stratospheric platform in view.

For GNSS signals, however, the ability to interfere remains limited because the satellite's antenna still has very low gain at negative elevation angles.

In any case, the following table will present the possible attacks, their effects on the system, their feasibility, and the system's resilience elements.

Attack Type	Expected Effect	Feasibility	SATERA Resilience mechanisms
ADS-B Jamming from ground	Reduction of the Satellite in view coverage (or antenna sector coverage) due to the reduced sensitivity of the satellite ADS-B receivers	Easy	• Satellite is intrinsically more robust of Ground based receiver (due to higher distance) • Satellite redundancy (at least for) for ADS-B signal reception • Sector antennae reduce the effect of the jammer • DBF can be used for null steering

ADS-B Jamming from stratospheric	Deny of service o the satellite (or antenna sector)	Difficult	• Satellite redundancy (at least for) for ADS-B signal reception • Sector antennae reduce the effect of the jammer • DBF can be used for null steering • the platform is capable to work for limited time and space due to its limited weight and limited battery power
ADS-spoofing from ground (smart signals to reduce the receiver capability to decode the ADS-B message)	Deny of service on the satellite (or antenna sector)	Medium	• Satellite is intrinsically more robust of Ground based receiver (due to higher distance) • Satellite redundancy (at least for) for ADS-B signal reception • Sector antennae reduce the effect of the spoofer • DBF can be used for null steering
ADS-spoofing from stratospheric platform (smart signals to reduce the receiver capability to decode the ADS-B message)	Deny of service o the satellite (or antenna sector)	Difficult	• Satellite redundancy (at least for) for ADS-B signal reception • Sector antennae reduce the effect of the spoofer • DBF can be used for null steering
ADS-fake aircraft injection (from ground or stratospheric platform)	Wrong/False injected in the system	Difficult	• Integrity algorithm • Sector antennae reduce the effect of the spoofer • DBF can be used for null steering

GNSS jamming from ground	Reduction of the GNSS performance (satellite position and synchronization) till the deny of service	Very difficult (due to the distance, the gain of the antenna)	• Sequential filters are used to reduce the measurement error or to forecast the satellite position even in the case of deny of service exploiting orbit propagation (for minutes)
GNSS jamming from stratospheric platform	Reduction of the GNSS performance (satellite position and synchronization) till the deny of service	Very difficult (due to the distance, the gain of the antenna)	• Sequential filters are used to reduce the measurement error or to forecast the satellite position even in the case of deny of service exploiting orbit propagation (for minutes)
GNSS spoofing from ground	Wrong/fake satellite position	Very difficult (due to the distance, the gain of the antenna)	• On board satellite receiver can be equipped with RAIM algorithm to detect the attack and discard the fake measurement
GNSS spoofing from stratospheric platform	Wrong/fake satellite position	Very difficult (due to the distance, the gain of the antenna)	• On board satellite receiver can be equipped with RAIM algorithm to detect the attack and discard the fake measurement

Table 10. Summary of abnormal conditions due to intentional interferences

4.5 Validation exercises list

[EXE]

Identifier	TVAL.01.1-SATERA-0504-TRL2
Title	Assessment of the accuracy of reference trajectories generated by SATERA SET.
Description	ADS-B data provided by ENAIRE will be used to generate a set of RTs using SASS-C VERIF. These trajectories and the ADS-B they are based on will be exported in CSV format and injected into SATERA SET, which will build RTs using the same ADS-B data sets that were

EUROPEAN PARTNERSHIP

Co-funded by the European Union

	previously used in SASS-C. The SATERA SET Performance Assessment Module will then compute distance metrics between trajectories to verify compliance with the defined acceptance thresholds.
KPA/TA addressed	N/A
Addressed expected performance contribution(s)	N/A
Maturity level	TRL2
Use cases	UC1: aircraft flying over continental areas with ground-based surveillance
Validation technique	Non-real-time simulation
Validation platform	SATERA System Evaluation Tool/EUROCONTROL SASS-C VERIF
Validation location	Valencia (SP), Madrid (SP)
Start date	07/01/2025
End date	16/01/2025
Validation coordinator	UPV
Status	Planned
Dependencies	N/A

[EXE Trace]

Linked Element Type	N/A
<SESAR Solution>	0504
<Project>	SATERA
<Sub-Operating Environment>	Very High Complexity En-Route Terminal Airspace-High complexity
<Validation Objective>	OBJ-SATERA-TRL2-ERP-001 OBJ-SATERA-TRL2-ERP-002

Table 11: validation exercise #1.1 layout

[EXE]

Identifier	TVAL.01.2-SATERA-0504-TRL2

Title	Benchmark of SATERA against state-of-the-art ground-based surveillance systems for 5/3 NM surveillance application
Description	ADS-B data provided by ENAIRE in CSV will be injected in SATERA SET. These data will correspond to selected flights in Spanish airspace were ground-based surveillance coverage is available. Based on the data provided by ENAIRE, SATERA SET will be used to generate a set of RTs that will be used as ground truth to produce MLAT positions along the same flight trajectories, which will be assessed against ESASSP requirements for 5/3 NM surveillance applications using SATER SET performance assessment function. These MLAT data will be also exported in ASTERIX CAT020 and will be injected in SASS-C. ENAIRE will assess these SATERA-generated data against ESASSP requirements for 5/3 NM surveillance applications according to their engineering practices.
KPA/TA addressed	N/A
Addressed expected performance contribution(s)	Provision of 5/3 NM surveillance application
Maturity level	TRL2
Use cases	UC1: aircraft flying over continental areas
Validation technique	Large scale non-real-time simulation
Validation platform	SATERA System Evaluation Tool/EUROCONTROL SASS-C VERIF
Validation location	Valencia (SP), Madrid (SP)
Start date	19/01/2025
End date	30/01/2025
Validation coordinator	UPV
Status	Planned
Dependencies	Validation exercise #1.1

[EXE Trace]

Linked Element Type	N/A
<SESAR Solution>	0504

Co-funded by the European Union

<Project>	SATERA
<Sub-Operating Environment>	Very High Complexity En-Route Terminal Airspace-High complexity
<Validation Objective>	OBJ-SATERA-TRL2-ERP-003 OBJ-SATERA-TRL2-ERP-004

Table 12: validation exercise #1.2 layout

[EXE]

Identifier	TVAL.02.1-SATERA-0504-TRL2
Title	Assessment of SATERA solution scalability
Description	COLLINS will provide with ADS-B data of flights in the NAT corridor in the busiest day of 2024. UPV will use SATERA SET to build ground-truth trajectories based on that ADS-B data. Then, using SATERA SET the UPV team will generate TOA measurement estimates on board the satellites from simulated ADS-B messages broadcasted by the aircraft in the data set. The UC will embed both the measurements, the corresponding ADS-B data, along with other control data, in packets that will be injected into the network simulator module of the SATERA SET and will be propagated across the ISL subnetwork. These packets will be delivered to the CPS in the order they reach the ground station. The UC will assess the received packets to obtain network performance metrics (e.g., network latency or rate of loss packets). The assessment will be carried out over the entire NAT region and individually within each of its constituent Oceanic Control Areas.
KPA/TA addressed	N/A
Addressed expected performance contribution(s)	Provision of communication to SATERA supporting the tracking of 225 simultaneous aircraft.
Maturity level	TRL2
Use cases	UC2: aircraft flying over NRAD oceanic areas
Validation technique	Large-scale non-real-time simulation
Validation platform	SATERA System Evaluation Tool
Validation location	Coimbra (PT), Cork (IR), Valencia (SP)
Start date	07/01/2025

End date	30/01/2025
Validation coordinator	UC
Status	Planned
Dependencies	N/A

[EXE Trace]

Linked Element Type	N/A
<SESAR Solution>	0504
<Project>	SATERA
<Sub-Operating Environment>	Very High Complexity En-Route
<Validation Objective>	OBJ-SATERA-TRL2-ERP-005

Table 13: validation exercise #2.1 layout

[EXE]

Identifier	TVAL.02.2-SATERA-0504-TRL2
Title	SATERA solution assessment for 5/3 NM surveillance application in the NAT corridor
Description	FlightAware ADS-B data from flights in the NAT corridor corresponding to the busiest day in 2024 will be provided by COLLINS. These data will be used to generate ground truths for all the aircraft trajectories in the dataset using SATERA SET. Subsequently, the SATERA SET will be employed to generate MLAT and ADS-B tracks for flights operating within each of the Oceanic Control Areas comprising the NAT corridor (Bodø, Reykjavik, Shanwick, Gander, Santa Maria, and New York), considering both nominal and abnormal conditions. The SATERA SET performance assessment function will be used afterwards to assess MLAT data against ESASSP requirements for the 5/3 NM surveillance application.
20KPA/TA addressed	N/A
Addressed expected performance contribution(s)	Provision of 5/3 NM surveillance application
Maturity level	TRL2

Use cases	UC2: aircraft flying over NRAD oceanic areas
Validation technique	Large-scale non-real-time simulation
Validation platform	SATERA System Evaluation Tool
Validation location	Valencia (SP). Cork (IR), Coimbra (PT)
Start date	02/02/2025
End date	27/02/2025
Validation coordinator	UPV
Status	Planned
Dependencies	Validation exercise #1.1 Validation exercise #1.2 Validation exercise #2.1

[EXE Trace]

Linked Element Type	N/A
<SESAR Solution>	0504
<Project>	SATERA
<Sub-Operating Environment>	Very High Complexity En-Route
<Validation Objective>	OBJ-SATERA-TRL2-ERP-006 OBJ-SATERA-TRL2-ERP-007 OBJ-SATERA-TRL2-ERP-008 OBJ-SATERA-TRL2-ERP-009 OBJ-SATERA-TRL2-ERP-010 OBJ-SATERA-TRL2-ERP-011 OBJ-SATERA-TRL2-ERP-012 OBJ-SATERA-TRL2-ERP-013 OBJ-SATERA-TRL2-ERP-014 OBJ-SATERA-TRL2-ERP-015 OBJ-SATERA-TRL2-ERP-016 OBJ-SATERA-TRL2-ERP-017 OBJ-SATERA-TRL2-ERP-018

Table 14: validation exercise #2.2 layout

[EXE]

[EXE]

Identifier	TVAL.02.3-SATERA-0504-TRL2
Title	SATERA solution assessment for 5/3 NM surveillance application in the EUR/SAM corridor
Description	FlightAware ADS-B data from flights in the EUR/SAM corridor corresponding to the busiest day in 2024 will be provided by COLLINS. These data will be used to generate ground truths for all the aircraft trajectories in the dataset using SATERA SE. Subsequently, the SATERA SET will be employed to generate MLAT and ADS-B tracks for flights operating within each of the Oceanic Control Areas comprising the EUR/SAM corridor (i.e., Canarias, Sal Oceanic, Dakar Oceanic, Atlantic (Brazil), and Recife), considering both nominal and abnormal conditions. The SATERA SET performance assessment function will be used afterwards to assess MLAT data against ESASSP requirements for the 5/3 NM surveillance application.
20KPA/TA addressed	N/A
Addressed expected performance contribution(s)	Provision of 5/3 NM surveillance application
Maturity level	TRL2
Use cases	UC2: aircraft flying over NRAD oceanic areas
Validation technique	Large-scale non-real-time simulation
Validation platform	SATERA System Evaluation Tool
Validation location	Valencia (SP), Cork (IR), Coimbra (PT)
Start date	02/03/2025
End date	01/04/2025
Validation coordinator	UPV
Status	Planned
Dependencies	Validation exercise #1.1 Validation exercise #1.2 Validation exercise #2.1

[EXE Trace]

Linked Element Type	N/A
<SESAR Solution>	0504
<Project>	SATERA
<Sub-Operating Environment>	Very High Complexity En-Route
<Validation Objective>	OBJ-SATERA-TRL2-ERP-006 OBJ-SATERA-TRL2-ERP-007 OBJ-SATERA-TRL2-ERP-008 OBJ-SATERA-TRL2-ERP-009 OBJ-SATERA-TRL2-ERP-010 OBJ-SATERA-TRL2-ERP-011 OBJ-SATERA-TRL2-ERP-012 OBJ-SATERA-TRL2-ERP-013 OBJ-SATERA-TRL2-ERP-014 OBJ-SATERA-TRL2-ERP-015 OBJ-SATERA-TRL2-ERP-016 OBJ-SATERA-TRL2-ERP-017 OBJ-SATERA-TRL2-ERP-018

Table 15: validation exercise #2.3 layout

4.6 Validation exercises planning

- Preparation of datasets: 01-12-2025 to 19-12-2025 (COLLINS, ENAIRE, UPV, UC)
- Validation exercise #1:
  - Validation exercise #1.1: 07 Jan to 16 Jan (UPV, ENAIRE)
  - Validation exercise #1.2: 19 Jan to 30 Jan (UPV, ENAIRE)
- Validation exercise #2.1:
  - Full NAT assessment (UC): 07 Feb to 13
  - Distributed NAT assessment (UC): 13 Feb to 27
- Validation exercise #2.2:
  - Assessment under normal conditions (UPV): 02 Feb to 06 Feb
  - Assessment under abnormal (jamming) conditions (UPV, UC, COLLINS): 09 Feb to 13 Feb
  - Assessment under abnormal (spoofing) conditions (UPV, UC, COLLINS): 16 Feb to 20 Feb.
  - Assessment under abnormal space weather conditions (UPV, UC, COLLINS): 23 Feb to 27 Feb.
- Validation exercise #2.3:
  - Assessment under normal conditions (UPV): 02 March to 06 March
  - Assessment under abnormal (jamming) conditions (UPV, UC, COLLINS): 09 March to 13 March
  - Assessment under abnormal (spoofing) conditions (UPV, UC, COLLINS): 16,17, 23-25 March
  - Assessment under abnormal space weather conditions (UPV, UC, COLLINS): 26,27,30,31 March, 1 April

4.7 Deviations with respect to the SESAR 3 JU project handbook

SATERA is expected to influence multiple KPAs (Capacity, Cost Efficiency, Operational Efficiency, and Safety) and KPIs, including En-route throughput in challenging airspace per unit time (CAP2), Flights per ATCO-hour on duty (CEF2), Technology Cost per flight (CEF3), Actual average fuel burn per flight (FEFF1), and Total number of accidents with ATM contributions per year (SAF1).

Nevertheless, while SATERA Solution may enable many of these performance benefits, it will not directly deliver them, as realizing such improvements also depends on operational and procedural changes within oceanic airspace control not addressed by this project. Therefore, SATERA validation will focus on assessing the system performance against the requirements defined in the latest edition of the EUROCONTROL Specification for ATM Surveillance Systems Performance (ESASSP), specifically, those listed in Table 3 and Table 4 in Section 3.4.

The traceability from the surveillance application to measurable performance benefits is not straightforward, as it depends on other technological enablers and operational changes that fall outside the scope of SATERA. Therefore, SATERA ERP does not target any of the program level KPA identified in the OSED. The assessment of how and to which extent the surveillance applications enabled by SATERA impact those KPAs shall be conducted as part of future research targeting higher maturity levels that account for the operational use of technological enablers.

5 Validation exercises

5.1 Validation exercise #1.1 plan.

5.1.1 Validation exercise description and scope

Operational Scope

Validation exercise #1.1 focuses on assessing the **fidelity of the Reference Trajectories (RTs)** generated by the SATERA SET in comparison with RTs produced by the SASS-C system for the same flights. The operational scope involves the following **actors and processes**:

- **ENAIRE** – Provides RT generated using proprietary ADS-B surveillance data and the data from which RTs have been generated.
- **UPV** – Generates RT using SATERA SET with the ADS-B data provided by ENAIRE and compares both.
- **SASS-C** – Serves as the established reference tool for generating benchmark RTs from ADS-B data.
- **SATERA SET** – The system under validation, responsible for reconstructing RTs and later using them as Ground Truth for performance assessments.

The process under evaluation is the **Reference Trajectory Generation**, which forms the basis of subsequent SATERA surveillance validation activities.

Key Validation Objectives and Scenarios

The primary objective of Exercise #1.1 is to **determine the level of fidelity between RTs generated by SATERA SET and those produced by SASS-C** from identical ADS-B data sets. High trajectory fidelity is essential, as these RTs will subsequently be used as Ground Truth to compute ToA, and MLAT position solutions.

Note 4: Validation exercise **#1.1** is not intended to validate the **SATERA Solution** itself, but rather to assess the **fidelity of the SATERA SET platform** that will be used in Validation exercises **#2.X**, where the solution will be validated.

Validation Scenarios:

- Simulations will be run in the **Madrid FIR** and **Barcelona FIR**.
- Eight hours of opportunity traffic of flights over FL150 in Spanish airspace controlled by ENAIRE will be recorded in four different days (two hours each). A total of 100 flights will be randomly selected to get a representative sample of traffic, large enough to have statistically sound results.
- Only **En-route trajectory segments** will be analysed, as they correspond to the operational context of 5 NM and 3 NM surveillance applications in NRAD OCA environments.
- Nominal conditions are assumed in all cases (see Section 4.4 for details)
- Two validation scenarios will be addressed:
    - Reference scenario: RT are generated using SASS-C.
    - Solution scenario: RT are generated using SATERA SET.

Validation Technique

The exercise applies to a **quantitative benchmarking technique**, consisting of:

1. Generating RTs in SASS-C from ENAIRE-provided ADS-B data.
2. Exporting the resulting CSV format.
3. Injecting ENAIRE's ADS-B datasets used in SASS-C into SATERA SET to build its own RTs.
4. Injecting SASS-C generated RTs into SATERA SET.
5. Using the SATERA SET Performance Assessment Module to compute **distance-based metrics** between SASS-C and SET trajectories.
6. Verifying whether the observed trajectory discrepancies fall within the predefined **acceptance of thresholds**.

This approach ensures an objective, tool-supported comparison consistent with established surveillance validation practices.

Validation Platform

- **SASS-C** is used to generate reference RTs and provide validated ADS-B-derived trajectory data.
- **SATERA SET** is the platform under evaluation, including its RT Builder and Performance Assessment Module.
- **CSV-based data exchange** ensures consistent input alignment across both systems.

Applicable TRL

This activity corresponds to **Technology Readiness Level (TRL) 2**, focusing on the analytical validation of key system concepts and methods—specifically, the feasibility and expected fidelity of RT generation based solely on ADS-B surveillance data.

5.1.2 Stakeholder's expectations and benefit mechanisms addressed by the exercise

Stakeholder	Involvement	Why it matters to the stakeholder
ANSP	ANSPs are Involved as the project partner and member of the advisory board. In context of the validation activities, the identification of appropriate routes and provision of data for overland routes is provided by the ANSPs.	The outcomes of the validation exercise will benefit the air traffic controllers through provision of reliable and accurate positioning data of the aircrafts to support safe and efficient air traffic management. ANSPs will exploit the validation results to analyse the new business model to offer new and economic benefit to end users. For ANSPs, KPAs of interest where the solution impacts positively include the operational efficiency, capacity and safety.
Scheduled airlines	No direct involvement	For airliners, the solution and the outcomes of the validation activities are relevant as it positively

		impacts the airlines in terms of operational efficiency and safety.
Military	No direct involvement	Like commercial airlines, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.

Table 16: stakeholders' expectations for validation exercise #1.1

5.1.3 Validation objectives.

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #01	Exercise validation objective	Exercise success criteria
OBJ-SATERA-TRL2-ERP-001	CRT-REQ-SATERA-TRL2-ERP-001.001 CRT-OPT-SATERA-TRL2-ERP-001.001	Fully covered	OBJ-SATERA-TRL2-ERP-001	CRT-REQ-SATERA-TRL2-ERP-001.001 CRT-OPT-SATERA-TRL2-ERP-001.001
OBJ-SATERA-TRL2-ERP-002	CRT-REQ-SATERA-TRL2-ERP-001.001 CRT-OPT-SATERA-TRL2-ERP-001.001	Fully covered	OBJ-SATERA-TRL2-ERP-002	CRT-REQ-SATERA-TRL2-ERP-001.001 CRT-OPT-SATERA-TRL2-ERP-001.001

Table 17: validation objectives addressed in validation exercise #1.1

5.1.4 Validation scenarios

5.1.4.1 Reference scenario

Figure 1 illustrates the reference scenario, which defined in Spanish ENR airspace both FIR Madrid (including the southern part managed by the Sevilla ACC) and FIR Barcelona. Therefore, the scenario covers the En-route high complexity sub-operating environment.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

Figure 1. Spanish airspace where validation exercise #1.1 will take place [4]

In the reference scenario, ENAIRE will compute RTs for randomly selected flights between FL150 and FL410 using EUROCONTROL SASS-C and exported in CSV format. The data set will contain mostly En-route flight plus some final ascent/initial descent segments corresponding to major Spanish TMA between FL155 and FL245.

Nominal conditions are assumed (See Section 4.4 for details).

5.1.4.2 Solution scenario(s)

Solution scenario will consist of the same flights selected in the Spanish airspace shown in Figure 1, but in this case, RTs will be generated using SATERA SET.

Nominal conditions are assumed (See Section 4.4 for details).

5.1.5 Exercise validation assumptions

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
VAL-ASSUMPT-SATERA-TRL2-ERP-005	SATERA nominal conditions	See Section 4.4	See Section 4.4	See Section 4.4

Table 18: validation exercise #1.1 assumptions

5.1.6 Limitations and impact on the level of significance

Neither the general assumptions in Section 4.4 nor the assumptions specific to validation vxercise #1.1 listed in Table 18: validation exercise #1.1 assumptions

limit the significance of the results. Concerning assumptions Table 18: validation exercise #1.1 assumptions

:

- SATERA solution pursues the provision of coverage in oceanic areas where ground-based surveillance services are not available. The vast majority of operations (if not all) in such areas are En-route. Some gentle turns or ascent/descent manoeuvres can also be executed during overseas fights. The dataset that will be used in validation exercise #1.1 contains data from En-route and TMA airspaces, thus containing both types of trajectories.
- SATERA SET will generate RT for validating the SATERA solution under normal conditions. Surveillance data generated by SATERA under both normal and several abnormal conditions will then be compared to those RT to assess the solution performance against ESASSP requirements.
- RT will be generated using ADS-B data. Considering 60 min trajectories in average with and ADS-B receiving stations with an output period of 2 s, there will be around 1,800 samples per trajectory. Considering 100 flights, the dataset will contain around 180,000 samples. This sample size is more than enough to compute statistically significant values for the metrics validation exercise 1.1 success criteria rely on.
- The flights that will be used in the validation will be collected across all Spanish continental airspace to avoid geographical biases. Data from aircraft flying in different days will be used to prevent time biases.

5.1.7 Validation exercise platform / tool and validation technique

5.1.7.1 Validation exercise platform / tool characteristics

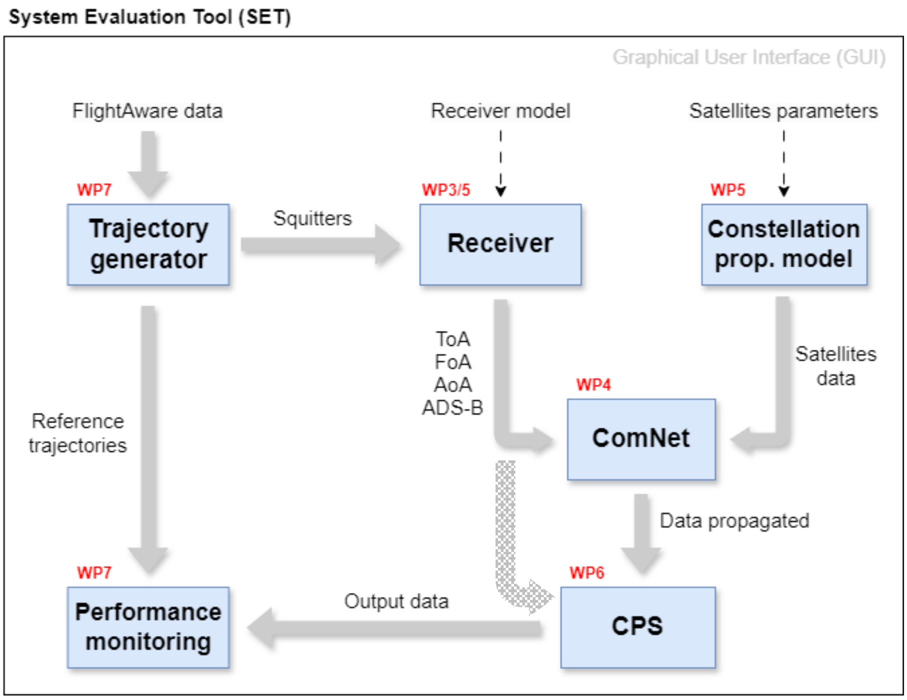

Figure 2. System Evaluation Tool architecture

The System Evaluation Tool (SET) is structured into six main functional blocks, illustrated in Figure 2. Each block performs clearly defined functions, exchanges specific input/output data with other blocks, and is orchestrated through the simulation settings configured in the Graphical User Interface (GUI), which is an overarching function not explicitly shown in Figure 2. The following paragraphs provide the functional description of SATERA SET.

1. Trajectory Generator (WP7)

Function

- To acquire ADS-B data, preprocess it, and generate high-fidelity reference trajectories used as ground truth.

Inputs:

- ADS-B data (CSV format)
- Scenario parameters (flight selection, time window)

Main Functions

- Loading and pre-processing of surveillance data
- Trajectory reconstruction via tracking filter
- Backward smoothing to obtain refined state estimates
- Generation of **reference trajectories (RTs)**
- Synthesis of **ADS-B squitters** derived from reference trajectories

Outputs

- Reference trajectories
- Synthetic squitters

Interfaces

- Receives from:
    - GUI (scenario configuration)
- Sends to:
    - Receiver Model (squitters)
    - Performance Monitoring (reference trajectories)

2. Receiver Model (WP3/5)

Function

- To recreate the air-to-space communication link and simulate the satellite-borne reception of ADS-B squitters.

Inputs

- Squitters from Trajectory Generator
- Satellite state vectors from Constellation Propagation Model
- Receiver parameters (RF characteristics, noise models) from GUI

Main Functions

- Air-to-space link recreation (SNR assessment, visibility)
- Application of measurement models and errors
- Generation of:
    - **ToA** (Time of Arrival measurement estimates)

    - **FoA** (Frequency of Arrival measurement estimates)
    - **AoA** (Angle of Arrival measurement estimates)
- Assembly of satellite packets including:
    - Observables (ToA/AoA/FoA)
    - ADS-B message payload
    - Satellite position/velocity

Outputs

- Satellite measurement packets containing:
    - ToA
    - AoA
    - FoA
    - ADS-B payload
    - Satellite state vector

Interfaces

- Receives from:
    - Trajectory Generator (squitters)
    - Constellation Propagation Model (satellite states)
    - GUI (receiver settings)
- Sends to:
    - ComNet

3. Constellation Propagation Model (WP5)

Function

- To propagate the orbital state of each satellite in the constellation.

Inputs

- Initial orbital parameters and constellation definition (from GUI)

Main Functions

- Orbit propagation
- Computation of position, velocity, and time-tags for each satellite

Outputs

- Satellite state vectors (position, velocity, time tags)

Interfaces

- Receives from:
    - *GUI* (satellite/constellation configuration)
- Sends to:
    - *Receiver Model* (satellite state vectors)

4. Communication Network (*ComNet*) (WP4)

Function

- To simulate the transmission of satellite packets across the space segment and the downlink channel to ground.

Inputs

- Measurement packets from Receiver

Main Functions

- Encapsulation and routing of packets
- Propagation through inter-satellite links (ISLs)
- Propagation through the downlink (DL)
- Modelling of delays, losses, congestion, and network behaviour
- Offline execution due to high computational cost

Outputs

- Network-propagated packets (stored for CPS retrieval)

Interfaces

- Receives from:
    - *Receiver Model* (measurement packets)
- Sends to:
    - *CPS* (via stored *ComNet* output database)

5. Central Processing Station (CPS) (WP6)

Function

- To perform multi-target tracking, aircraft association, and ADS-B integrity checks.

Inputs

- Network-delivered packets from ComNet
- CPS configuration (tracking parameters, association thresholds)

Main Functions

- Message grouping and aircraft association
- Track initiation, update, and termination
- Multi-Target Tracking (MTT)
- ADS-B integrity verification
- Formatting into surveillance standards (ASTERIX CAT020/CAT021)

- CPS can be configured to generate output date in either:
    - Event driven mode (outputs are generated as soon as there are enough input data).
    - Periodic delayed (output data are delivered at regular times driven by the Output Period – OP – configured through the GUI; the best – less noisy – position estimate within the OP is delivered.
    - Periodic predicted (the last aircraft state vector within the OP is projected into the next output time using the MTT tracking filter).

The periodic delayed mode will be selected in all SATERA validation exercises, with an OP of 2 s for 3 NM assessments and 3 s for 5 NM assessments.

Outputs

- Reconstructed aircraft tracks
- Integrity-annotated ADS-B messages
- Formatted surveillance data (ASTERIX CAT020, CAT021)

Interfaces

- Receives from either:
  - I1: *ComNet* (network-delivered packets)
  - I2: *CPS* (network-delivered packets bypassing CommNet block for specific tests).
  - For validation exercises #1.1 and #1.2 will be configured to skip the *ConNet* functional block, i.e. data from the *Receiver Model* will be directly injected into the *CPS* block
- Sends to:
  - *Performance Monitoring* (processed surveillance data)

6. Performance Monitoring Module (WP7)

Function

- Compute performance ESASSP performance metrics applying the methods described in ESASSP Ed. 1.3.

Inputs

- Reference trajectories (ground truth)
- CPS-reconstructed tracks
- Performance metrics and validation configuration

Main Functions

- Metric computation (accuracy, availability, integrity, etc.)
- Comparative assessment vs. reference trajectories
- Cross-validation with SASS-C trajectories
- Visualisation and reporting

Outputs

- Performance metrics
- Validation results
- Visualisation and analysis data

Interfaces

- Receives from:
  - *Trajectory Generator* (reference trajectories)
  - *CPS* (surveillance outputs)
  - *GUI* (metric selection/configuration)

EUROPEAN PARTNERSHIP
Co-funded by the European Union

- Sends to:
    - *GUI* for reporting/visualisationN

Note 5: Because of the high simulation time required by SATERA *ComNet*, the interface between the SATERA Receiver Model and the ComNet is implemeted off-line, using InfluxDB[3], an open-source Time Series Database (TSDB) optimized for storing, retrieving, and analyzing time-stamped data. InfluxDb stands out as a high-performance TSDB designed specifically to handle high write and query loads, making it superior to traditional relational databases for metric and event data. Its core advantages lie in its ability to ingest millions of data points per second with high efficiency and its specialized compression algorithms that drastically reduce storage costs for historical data. Furthermore, InfluxDB offers powerful built-in tools for data retention management, allowing users to automatically down-sample or expire older data, and provides a robust query ecosystem (using Flux or InfluxQL) that simplifies complex time-based analytics, such as moving averages and windowed aggregations.

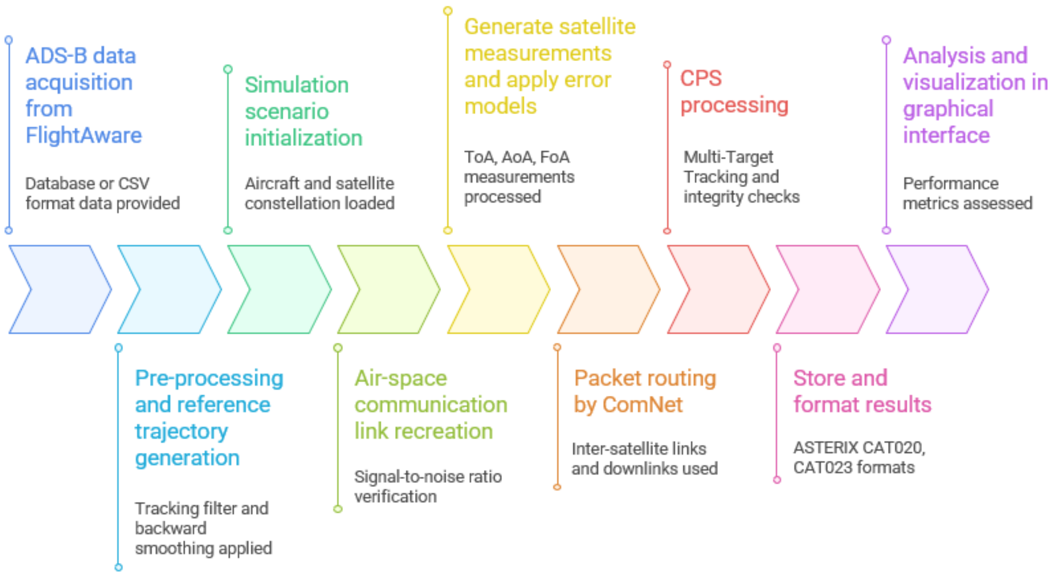

Figure 3. High-level workflow of the SATERA validation platform

Figure 3 provides a summarized view of the main workflow of the tool. This diagram captures the key functional stages, from ADS-B data acquisition to the generation of surveillance outputs and their performance evaluation:

1. ADS-B data acquisition

Raw surveillance data from external sources in CSV format are ingested into the SET. This includes timestamped ADS-B messages containing position, velocity, identification for all aircraft selected for the simulation scenario.

[3] https://www.influxdata.com/

EUROPEAN PARTNERSHIP
Co-funded by the European Union

2. Simulation initialisation (loading aircraft and satellites)

The simulation environment is prepared by loading:

- the set of aircraft to be simulated (based on the ADS-B data space-time filtering),
- the configuration of the satellite constellation (type of constellation, numbe and inclination of orbital planes, number of satellites per plane, initial states), and
- receiver settings (receiver sensitivity, error models).

3. Reference trajectory generation (tracking + smoothing)

ADS-B position/velocity reports are processed through:

- a tracking filter (e.g., Kalman-based), and
- a backward smoothing stage to reconstruct a continuous, high-quality trajectory for each aircraft.

These **reference trajectories** serve as the ground truth used for later performance assessment.

4. Air-to-space link reconstruction (SNR, visibility)

For each aircraft–satellite pair, the line-of-sight geometry and link budget are computed. This includes:

- visibility checks (elevation constraints, obstructions)
- signal-to-noise ratio assessment
- Doppler, path loss, and receiver sensitivity modelling

The outcome determines whether a squitter is “received” at a given satellite and forms the basis for measurement generation.

5. Measurement generation (ToA, AoA, FoA + error models)

For each valid reception event, the SET synthesises:

- **ToA** (time of arrival)
- **AoA** (angle of arrival)
- **FoA** (frequency of arrival)

These observables are computed from geometry and kinematics, and then corrupted using the receiver error models configured in the GUI. The satellite state vector and the ADS-B payload are packaged together with these observables.

6. Packet routing through ComNet (ISLs and downlink)

The satellite-generated packets are forwarded through the simulated communication network:

- inter-satellite links (ISLs)
- downlink paths to the ground segment

ComNet models routing behaviour, delays, jitter, buffering, and possible packet loss or reordering. Packets are ultimately delivered to the ground entry point and stored for processing.

7. CPS processing (MTT + integrity checks)

The Central Processing Station (CPS) performs:

- message grouping and aircraft association

- **Multi-Target Tracking (MTT)** to reconstruct aircraft trajectories
- ADS-B data integrity checks (format consistency, timestamp sanity, content validity)

The CPS produces multi-target state estimates and consolidated surveillance tracks.

8. Data formatting (ASTERIX CAT020/021)

The outputs of the CPS are encoded into operational surveillance formats:

- **ASTERIX CAT020** (radar target reports)
- **ASTERIX CAT021** (ADS-B and satellite-based surveillance data)

This ensures compatibility with standard ATM processing chains and enables comparison with other systems.

9. Performance analysis (metrics assessed and visualised)

The reconstructed tracks are compared against the reference trajectories. Performance monitoring computes metrics defined in ESASSP Ed. 1.3 using the methods set out in the same document, along with the SATERA integrity estimator applying the algorithms described in deliverable D6.2.

Visualisation tools integrated into the SATERA GUI allow inspection of the results and comparison with SASS-C and other benchmark datasets.

In validation exercise 1.1 only the Trajectory Generator and Performance monitoring blocks will be used.

5.1.7.2 Validation exercise technique

Validation exercise #1.1 will consist of non-real-time, large-scale simulations. This technique is commonly used in surveillance systems performance assessment, as there are no real time requirements and data recorded during several hours are usually needed to guarantee the statistical soundness of the results.

5.1.8 Data collection and analysis

5.1.8.1 Data and data collection methods

Validation exercise #1.1 will use both external and generated data. External data will consist of ADS-B data provided by ENAIRE containing the following data items from ASTERIX CAT021 target repors:

- I021/070 Mode 3/A Code in Octal Representation
- I021/071 Time of Applicability for Position
- I021/080 Target Address
- I021/090 Quality Indicators
- I021/130 Position in WGS-84 Co-ordinates
- I021/140 Geometric Height
- I021/145 Flight Level
- I021/160 Airborne Ground Vector
- I021/165 Track Angle Rate
- I021/170 Target Identification

Data generated by the project will consist of RTs produced by ENAIRE using proprietary data from their network of ADS-B receiving stations. Both external and project generated data will be provided in CSV

Co-funded by the European Union

format. A specific folder will be created in the SATERA SharePoint to share these data among the SATERA researchers involved in the validation exercise.

5.1.8.2 Analysis methods

UPV team will produce RTs by processing ENAIRE ADS-B data using SATERA SET applying forward-backward IMM filtering techniques (usually known as smoothing) to reduce transient errors due to changes between dynamic models and sample them at a regular rate.

UPV team will inject ENAIRE RTs in the SATERA SET and will estimate the rms error between these trajectories and the trajectories previously generated using SATERA SET. The results will be compared with the applicable success criteria to assess the achievement of the corresponding validation objectives.

5.1.9 Exercise planning and management

5.1.9.1 Activities

Validation exercise #1.1 will consist of the following activities:

- Activity1: Preparation of FlightAware datasets (the FlightAware datasets needed for all validation exercises will be created and validated before the exercises kick-off).
- Activity 2: Generation of RTs using SASS-C and proprietary ADS-B data.
- Activity 3: Generation of RTs using SATERA SET and ENAIRE ADS-B data.
- Activity 4: Processing RTs and generation of results.

5.1.9.2 Roles and responsibilities in the exercise

The following roles and responsibilities have been identified in validation exercise #1.1.

- UPV and ENAIRE will define the flights the dataset shall contain.
- ENAIRE will generate RTs using proprietary ADS-B data from their own ADS-B receiving stations network and will export them in CSV format.
- ENAIRE will make the RTs they have generated available to the UPV through the project SharePoint.
- UPV will generate TRs based on the ADS-B data provided by ENAIRE using SATERA SET.
- UPV will use SATERA SET to generate metrics comparing SASS-C RTs provided by ENAIRE and internally generated RTs from the ADS-B data provided by ENAIRE.
- UPV, ENAIRE will review the metrics and assess whether the applicable validation objectives have been achieved.

5.1.9.3 Time planning

Activity	2025	2026	
	W49	W2	W3
Activity 1	MS1.1-1		
Activity 2			

EUROPEAN PARTNERSHIP
Co-funded by the European Union

Activity 3		MS1.1-2		
Activity 4			MS1.1-3	

Table 19: detailed exercise #1.1-time planning

Validation exercise milestones:

- MS1.1-1: Validated FlightAware ADS-B data for validation exercise #1.1 available in the project SharePoint.
- MS1.1-2: RTs needed for validation exercise #1.1 have been generated; SASS-C RT trajectories available in the project SharePoint.
- MS1.1-3 Results from validation rxercise #1.1 have been generated.

5.1.9.4 Identified risks and mitigation actions

No risks affecting validation exercise #1.1 have been reported in STELLAR.

5.2 Validation exercise #1.2 plan.

5.2.1 Validation exercise description and scope

Operational Scope

Validation exercise #1.2 focuses on assessing the **fidelity of the surveillance performance metrics** generated by the SATERA SET compared to performance metrics produced by the SASS-C system for the same flights. The operational scope involves the following **actors and processes**:

- **COLLINS** – Provides FlightAware ADS-B surveillance data for a set of flights.
- **UPV** – Generates RTs for a set of flights based on the FlightAware ADS-B data provided by COLLINS.
- **UPV** –Provides ENAIRE with MLAT surveillance data in ASTERIX CAT020 using SATERA SET.
- **UPV** – Computes ESASSP performance metrics for the MLAT surveillance data generated using SATERA SET and the RTs previously generated from FlightAware ADS-B.
- **ENAIRE** – Computes ESASSP performance metrics for the MLAT surveillance data generated using SATERA SET.
- **SASS-C** – Serves as the established reference tool for computing ESASSP performance metrics.
- **SATERA SET** – The system under validation, responsible for generating MLAT data for performance assessments and for the computation of ESASSP performance metrics.

The process under evaluation is the **computation of ESASSP performance metrics**, which forms the basis of subsequent SATERA surveillance validation activities.

Key Validation Objectives and Scenarios

The primary objective of Exercise #1.2 is to **determine the level of fidelity between ESASSP performance metrics generated by SATERA SET and those produced by SASS-C** from comparable ADS-B data sets. The fidelity of performance metrics computed using SATERA SET are cornerstone since most of the success criteria for SATERA solution consist of comparing those metrics with thresholds defined in the ESASSP Ed. 1.3.

Co-funded by the European Union

Notie 5: validation vxercise **#1.2** is not intended to validate the **SATERA Solution** itself, but rather to assess the **fidelity of the SATERA SET platform** that will be used in validation exercises **#2.X**, where the solution will be validated.

Validation Scenarios: Same as for validation rxercise #1.1

Validation Technique

The exercise applies to a **quantitative benchmarking technique**, consisting of:

1. Generating MLAT surveillance data from FlightAware ADS-B data using SATERA SET. This process involves the generation of ground truth trajectories from ADS-B data using the techniques validated in validation exercise #1.1.
2. Exporting MLAT surveillance data generated by SATERA SET in ASTERIX CAT020 for further processing with SASS-C.
3. Injecting SATERA MLAT data into SASS-C VERIF and generating ESASSP performance metrics.
4. Generating ESASSP performance metrics for SATERA MLAT data using SATERA SET.
5. Comparing the performance metrics obtained using SASS-C VERIF with the ESASSP requirements. This process aims to assess the quality of the surveillance data themselves.
6. Comparing the performance metrics obtained using SASS-C VERIF with the performance metrics obtained using SATERA SET. This process aims to assess the fidelity of the performance metrics delivered by SATERA SET.

This approach ensures an objective, tool-supported comparison consistent with established surveillance validation practices.

Validation Platform

- **SATERA SET** is the platform under evaluation, including both the MLAT data generation and the performance metrics computation functions.
- **SASS-C** is used to generate reference performance metrics.
- **ASTERIX-based data exchange** ensures consistent input alignment across both systems.

Applicable TRL

This activity corresponds to **Technology Readiness Level (TRL) 2**, focusing on the analytical validation of key system concepts and methods—specifically, the feasibility and expected fidelity of RT generation based solely on ADS-B surveillance data.

5.2.2 Stakeholder’s expectations and benefit mechanisms addressed by the exercise

Stakeholder	Involvement	Why it matters to the stakeholder
ANSP	ANSPs are Involved as the project partner and member of the advisory board. In context of the validation activities, the identification of appropriate routes is	The outcomes of the validation exercise will benefit the air traffic controllers through provision of reliable and accurate positioning data of the aircrafts to support safe and efficient air traffic management. ANSPs will exploit the validation results to analyse the new business model to offer new and economic benefit to end users.

	provided by the ANSPs.	For ANSPs, KPAs of interest where the solution impacts positively include the operational efficiency, capacity and safety.
Scheduled airlines	No direct involvement	For airliners, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.
Military	No direct involvement	Like commercial airlines, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.

Table 20: stakeholders' expectations in validation exercise #1.2

5.2.3 Validation objectives.

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #01	Exercise validation objective	Exercise success criteria
OBJ-SATERA-TRL2-ERP-003	CRT-REQ-SATERA-TRL2-ERP-003.001 CRT-REQ-SATERA-TRL2-ERP-003.002 CRT-REQ-SATERA-TRL2-ERP-003.003 CRT-REQ-SATERA-TRL2-ERP-003.004 CRT-REQ-SATERA-TRL2-ERP-003.005 CRT-REQ-SATERA-TRL2-ERP-003.006 CRT-OPT-SATERA-TRL2-ERP-003.001 CRT-OPT-SATERA-TRL2-ERP-003.002 CRT-OPT-SATERA-TRL2-ERP-003.003 CRT-OPT-SATERA-TRL2-ERP-003.004	Fully covered	OBJ-SATERA-TRL2-ERP-003	CRT-REQ-SATERA-TRL2-ERP-003.001 CRT-REQ-SATERA-TRL2-ERP-003.002 CRT-REQ-SATERA-TRL2-ERP-003.003 CRT-REQ-SATERA-TRL2-ERP-003.004 CRT-REQ-SATERA-TRL2-ERP-003.005 CRT-REQ-SATERA-TRL2-ERP-003.006 CRT-OPT-SATERA-TRL2-ERP-003.001 CRT-OPT-SATERA-TRL2-ERP-003.002 CRT-OPT-SATERA-TRL2-ERP-003.003 CRT-OPT-SATERA-TRL2-ERP-003.004

	CRT-OPT-SATERA-TRL2-ERP-003.005 CRT-OPT-SATERA-TRL2-ERP-003.006 CRT-OPT-SATERA-TRL2-ERP-003.007 CRT-OPT-SATERA-			CRT-OPT-SATERA-TRL2-ERP-003.005 CRT-OPT-SATERA-TRL2-ERP-003.006 CRT-OPT-SATERA-TRL2-ERP-003.007 CRT-OPT-SATERA-
OBJ-SATERA-TRL2-ERP-004	CRT-REQ-SATERA-TRL2-ERP-004.001 CRT-REQ-SATERA-TRL2-ERP-004.002 CRT-REQ-SATERA-TRL2-ERP-004.003 CRT-REQ-SATERA-TRL2-ERP-004.004 CRT-REQ-SATERA-TRL2-ERP-004.005 CRT-REQ-SATERA-TRL2-ERP-004.006 CRT-OPT-SATERA-TRL2-ERP-004.001 CRT-OPT-SATERA-TRL2-ERP-004.002 CRT-OPT-SATERA-TRL2-ERP-004.003 CRT-OPT-SATERA-TRL2-ERP-004.004 CRT-OPT-SATERA-TRL2-ERP-004.005 CRT-OPT-SATERA-TRL2-ERP-004.006 CRT-OPT-SATERA-TRL2-ERP-004.007	Fully covered	OBJ-SATERA-TRL2-ERP-004	CRT-REQ-SATERA-TRL2-ERP-004.001 CRT-REQ-SATERA-TRL2-ERP-004.002 CRT-REQ-SATERA-TRL2-ERP-004.003 CRT-REQ-SATERA-TRL2-ERP-004.004 CRT-REQ-SATERA-TRL2-ERP-004.005 CRT-REQ-SATERA-TRL2-ERP-004.006 CRT-OPT-SATERA-TRL2-ERP-004.001 CRT-OPT-SATERA-TRL2-ERP-004.002 CRT-OPT-SATERA-TRL2-ERP-004.003 CRT-OPT-SATERA-TRL2-ERP-004.004 CRT-OPT-SATERA-TRL2-ERP-004.005 CRT-OPT-SATERA-TRL2-ERP-004.006 CRT-OPT-SATERA-TRL2-ERP-004.007

Table 21: validation objectives addressed in validation exercise #1.2

5.2.4 Validation scenarios

5.2.4.1 Reference scenario

Reference scenario for validation exercise #1.2 is the same as for validation exercise #1. 1. In the reference scenario, ESASSP performance metrics for MLAT surveillance data will be computed by ENARIE using EUROCONTROL SASS-C VERF.

Nominal conditions are assumed (See Section 4.4 for details).

EUROPEAN PARTNERSHIP
Co-funded by the European Union

5.2.4.2 Solution scenario(s)

In the solution scenario performance metrics will be computed using SATERA SET for the same flights as in the reference scenario.

Nominal conditions are assumed (See Section 4.4 for details).

5.2.5 Exercise validation assumptions

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
VAL-ASSUMPT-SATERA-TRL2-ERP-005	SATERA nominal conditions	See Section 4.4	See Section 4.4	See Section 4.4

Table 22: validation exercise #1.2 assumptions

5.2.6 Limitations and impact on the level of significance

Neither the general assumptions in Section 4.4 nor the assumptions specific to validation exercise #1.1 listed in Table 18: validation exercise #1.1 assumptions

limit the significance of the results. Concerning assumptions Table 18: validation exercise #1.1 assumptions

:

- SATERA solution pursues the provision of coverage in oceanic areas where ground-based surveillance services are not available. The vast majority of operations (if not all) in such areas are En-route. Some gentle turns or ascent/descent manoeuvres can also be executed during overseas fights. The dataset that will be used in validation exercise #1.1 contains data from En-route and TMA airspaces, thus containing both types of trajectories.
- SATERA SET will generate RT for validating the SATERA solution under normal conditions. Surveillance data generated by SATERA under both normal and several abnormal conditions will then be compared to those RT to assess the solution performance against ESASSP requirements.
- RT will be generated using ADS-B data. Considering 60 min trajectories in average with and ADS-B receiving stations with an output period of 2 s, there will be around 1,800 samples per trajectory. Considering 100 flights, the dataset will contain around 180,000 samples. This sample size is more than enough to compute statistically significant values for the metrics validation exercise 1.1 success criteria rely on.
- The flights that will be used in the validation will be collected across all Spanish continental airspace to avoid geographical biases. Data from aircraft flying in different days will be used to prevent time biases.

5.2.7 Validation exercise platform / tool and validation technique

5.2.7.1 Validation exercise platform / tool characteristics

See Section 5.1.7.1.

Only the Trajectory Generator and the Performance Monitoring blocks will be used in validation exercise 1.2.

5.2.7.2 Validation exercise technique

Validation exercise #1.2 will consist of non-real-time, large-scale simulations. This technique is commonly used in surveillance systems performance assessment, as there are no real time requirements and data recorded during several hours are usually needed to guarantee the statistical soundness of the results.

5.2.8 Data collection and analysis

5.2.8.1 Data and data collection methods

Validation exercise #1.2 will use both external data and data generated by the project. External data will consist of ADS-B data provided by COLLINS from FlightAware with the following data items:

- Pitr: Unix timestamp (in seconds) representing when the position record was processed.
- Type: Type of message. Normally, this field will say Position, meaning it has ADS-B position data.
- Ident: Flight identifier, usually the callsign.
- Air ground: Indicates whether the aircraft is airborne (A) or on the ground (G).
- Alt: Altitude (in feet) of the aircraft.
- AltChange: Rate or direction of altitude change. Often blank when altitude is stable.
- Atcident: Timestamp representing when the ADS-B data was generated by the aircraft. Normally, this field will be empty, meaning the aircraft is not broadcasting this timestamp. Most aircraft do not do so.
- Clock: Unix timestamp (in seconds) indicating when FlightAware recorded this message.
- Dest: Destination airport ICAO code.
- Facility hash: Identifier for the ADS-B receiving station. It is unique.
- Facility name: Name of the source that collected the data. Example: FlightAware ADS-B.
- Id: Message / track ID generated by FlightAware. It is unique.
- Gs: Ground speed (in knots).
- Heading: Aircraft heading (in degrees (0–359)).
- Lat: Latitude of the aircraft at that moment (in degrees).
- Lon: Longitude of the aircraft at that moment (in degrees).
- Orig: Origin airport ICAO code.
- Reg: Aircraft registration.
- UpdateType: Type of update. Usually A, for ADS-B update.

External data will be provided in CSV format. Data generated by the project will consist of MLAT target reports in ASTERIX CAT020 produced by the UPV team using SATERA SET. A specific folder will be created in the SATERA SharePoint to share these data among the SATERA researchers involved in the validation exercise.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

5.2.8.2 Analysis methods

UPV will compute performance metrics for the internally generated MLAT position data according to the procedures described in ESAASSP Ed. 1.3 Vol. 1 using RTs generated from the ADS-B data provided by COLLINS.

ENAIRE will compute performance metrics for the MLAT data generated by SATERA SET using SASS-C applying their own procedures and data to build RTs.

5.2.9 Exercise planning and management

5.2.9.1 Activities

Validation exercise #1.2 will consist of the following activities:

- Activity1: Preparation of FlightAware datasets (the FlightAware datasets needed for all validation exercises will be created and validated before the exercises kick-off).
- Activity 2: Generation of MLAT surveillance data using SATERA SET.
- Activity 3: Generation of performance metrics using SASS-C VERIF.
- Activity 4: Generation of performance metrics using SATERA SET.

5.2.9.2 Roles and responsibilities in the exercise

The following roles and responsibilities have been identified in Validation exercise #1.2.

- UPV, ENAIRE and COLLINS will define the flights the dataset shall contain.
- UPV generate MLAT surveillance data for the flights in the data set and will export them in ASTERIX CAT020.
- ENAIRE will compute applicable ESASSP performance metrics for the target reports provided by UPV using SASS-C VERIF.
- UPV will compute applicable ESASSP performance metrics for the MLAT surveillance data using SATERA SET.
- UPV, ENAIRE and COLLINS will review the metrics and assess whether the applicable validation objectives have been achieved.

5.2.9.3 Time planning

Activity	2025	2026	
	W50	W4	W5
Activity 1	MS1.2-1		
Activity 2		MS1.2-2	
Activity 3			MS1.2-3

Table 23: detailed exercise #1.2 time planning

Validation exercise milestones:

- MS1.2-1: Validated FlightAware ADS-B data for validation exercise #1.2 available in the project SharePoint.
- MS1.2-2: MLAT data for exercise #1.2 have been generated; target reports in ASTERIX CAT020 available in the project SharePoint.
- MS1.2-3 Results from validation exercise #1.2 have been generated.

5.2.9.4 Identified risks and mitigation actions

No risks affecting validation exercise #1.2 have been reported in STELLAR.

5.3 Validation exercise #2.1 plan

5.3.1 Validation exercise description and scope

Operational Scope

The objective of this exercise is to demonstrate that the real system can meet the established threshold for the number of tracked aircrafts by extrapolating data obtained from a distributed (i.e., per-FIR) assessment area. The operational scope involves the following **actors and processes**:

- **COLLINS** – Provides FlightAware ADS-B surveillance data.
- **UPV** – Generates RT using SATERA SET with the ADS-B data provided by COLLINS.
- **UPV** – Generates MLAT data from the ADS-B data provided by COLLINS using the SATERA SET Trajectory Generator and injects them into the *ComNet*.
- **UC** – Runs the communications simulations for the scenario slices using SATERA SET *ComNet* and collects data on communications performance.
- **SATERA SET** – *Trajectory generator* and Receiver model will be used to generate the data that will be injected into the SATERA SET *ComNet*.
- **SATERA SET *ComNet*** – The **SATERA subsystem under validation**, responsible for simulating communications on the space segment.

Key Validation Objectives and Scenarios

The primary objective of Exercise #2.1 is to **assess the scalability of the** SATERA communications subsystem.

Note 6: validation exercise **#2.1** is not intended to validate the **SATERA Solution** itself, but rather to assess the **capabilities of the communications simulator subsystem.**

Validation Technique

Because simulating the communication network (in particular, the Inter-Satellite Link subnetwork) is highly demanding in terms of computation and time, the second exercise will run separate simulations for each Oceanic Flight Information Region crossed by the corridor. The representativeness of the results will nevertheless be verified through a combination of simulation outputs and analytical evaluations.

Validation Platform

The primary objective of Exercise #2.1 is to **assess the scalability of the** SATERA communications subsystem. Thus, the exercise will be focused on the MATLAB functional component already developed and presented in Deliverable D4.2.

Applicable TRL

This activity corresponds to **Technology Readiness Level (TRL) 2**, focusing on the analytical validation of key system concepts and methods—specifically, the feasibility and expected scalability of the communications simulator based solely on ADS-B surveillance data.

5.3.2 Stakeholder's expectations and benefit mechanisms addressed by the exercise

Stakeholder	Involvement	Why it matters to the stakeholder
ANSP	ANSPs are Involved as the project partner and member of the advisory board.	The outcomes of the validation exercise will benefit the air traffic controllers through provision of reliable and accurate positioning data of the aircrafts to support safe and efficient air traffic management. ANSPs will exploit the validation results to analyse the new business model to offer new and economic benefit to end users. For ANSPs, KPAs of interest where the solution impacts positively include the operational efficiency, capacity and safety.
Scheduled airlines	No direct involvement	For airliners, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.
Military	No direct involvement	Like commercial airlines, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.

Table 2524: stakeholders' expectations validation exercise #2.1

5.3.3 Validation objectives.

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #01	Exercise validation objective	Exercise success criteria
OBJ-SATERA-TRL2-ERP-005	CRT-REQ-SATERA-TRL2-ERP-005.001	Fully covered	OBJ-SATERA-TRL2-ERP-005	CRT-REQ-SATERA-TRL2-ERP-005.001

	CRT-REQ-SATERA-TRL2-ERP-005.002 CRT-REQ-SATERA-TRL2-ERP-005.003 CRT-OPT-SATERA-TRL2-ERP-005.001 CRT-OPT-SATERA-TRL2-ERP-005.002			CRT-REQ-SATERA-TRL2-ERP-005.002 CRT-REQ-SATERA-TRL2-ERP-005.003 CRT-OPT-SATERA-TRL2-ERP-005.001 CRT-OPT-SATERA-TRL2-ERP-005.002

Table 2625: validation objectives addressed in validation exercise #2.1

5.3.4 Validation scenarios

5.3.4.1 Reference scenario

The oceanic North Atlantic airspace is divided in six Oceanic Control Areas, as shown in Figure 4

- Bodø
- Reykjavik
- Shanwick
- Gander
- Santa Maria, and
- New York

EUROPEAN PARTNERSHIP
Co-funded by the European Union

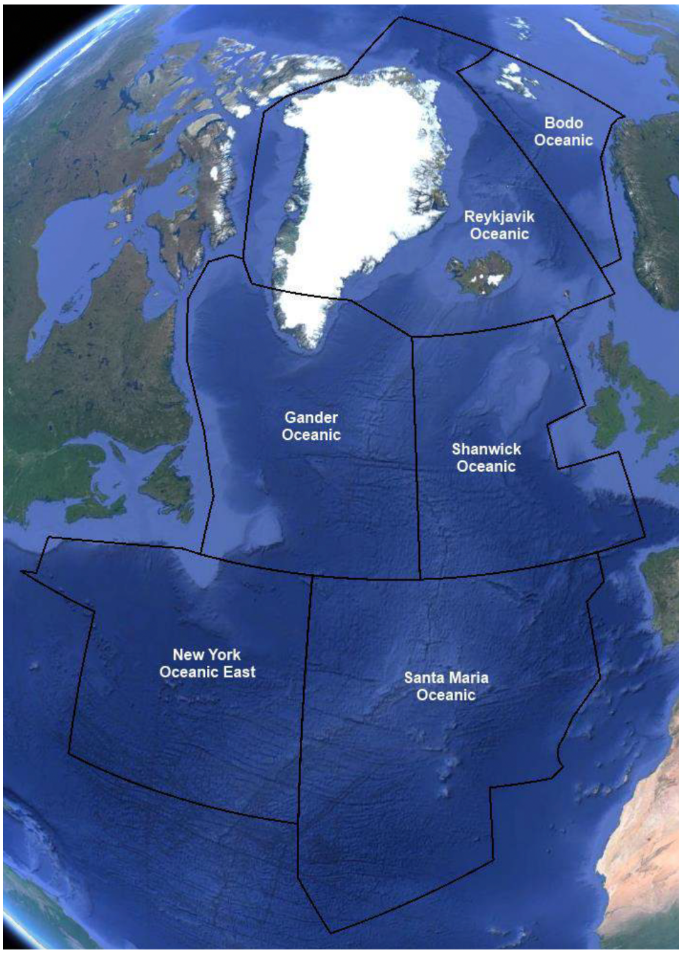

Figure 4. Oceanic Control Areas in the NAT region ¡Error! No se encuentra el origen de la referencia.

5.3.4.2 Solution scenario

Due to time constraints, simulating long intervals with a high number of aircraft is unfeasible, although the simulation performs as expected. Therefore, the validation campaign will focus on the following scenarios:

- **Full NAT region 10-minute simulation with 225 airplanes:** This scenario validates the simulation framework and its components, testing its ability to meet the imposed requirements of simulating 225 airplanes across all the NAT region in Figure 4. Given the computational expense of this scenario, it will only span 10 simulated minutes, as noted in the evaluation section of D4.2.
- **Full NAT region 10-minute simulation with 100 airplanes:** This scenario aims to demonstrate the relation between the number of simulated aircraft and the execution time in the whole NAT region by reducing the aircraft count from 225 to 100 while maintaining the same overall conditions as the previous scenario.
- **Distributed 10-minute simulation with 225 airplanes:** Similar to the first scenario, this one aims to simulate the same number of airplanes but does so by dividing the NAT corridor into the Oceanic Control Areas shown in Figure 4. This approach reduces the overall complexity of

the scenario and consequently the execution time, although it comes at the cost of lower simulation fidelity, since the areas are not completely independent.

- **Distributed 10-minute simulation with 100 airplanes:** This scenario complements the previous one by further reducing the number of simulated aircraft from 225 to 100. It continues to explore the relationship between aircraft count and simulation time.

These scenarios are designed to effectively evaluate the simulation framework while adhering to constraints of computational feasibility and maintaining relevance to real conditions.

5.3.5 Exercise validation assumptions

To ensure the validity of the short-duration simulations, the following assumptions have been made regarding environmental constraints and system behaviour:

- To reliably compare the distributed approaches to the full simulations, the input data will be resampled to guarantee significant traffic density in all separate airspace areas. It is assumed that the satellite network is functioning under nominal conditions with 100% availability. This means the framework does not consider satellite failures or any other disturbances affecting orbital propagation.

Simulations will be conducted under nominal conditions (see Section 4.4 for details).

5.3.6 Limitations and impact on the level of significance

Due to the previously mentioned computational constraints, the following limitations have emerged as a trade-off:

- Short simulation duration. While this validates the system's capacity to handle traffic loads, it restricts our ability to observe any potential long-term noisy temporal effects and is unrealistic for a global model.
- Artificial Boundaries in Distributed Scenarios. The way the airspace is partitioned introduces artificial boundaries, potentially leading to the loss or oversimplification of interactions that would typically occur across these boundaries.

Despite these limitations, the significance of scalability validation remains high. The core objective (demonstrating the communication network's ability to process high-volume data from 225 aircraft simultaneously) is effectively tested within the proposed scenario. Additional scenarios are suggested to reduce computational complexity, but this may come at the cost of fidelity, which could be noticeable under extremely demanding workloads.

5.3.7 Validation exercise platform / tool and validation

5.3.7.1 Validation exercise platform / tool characteristics

See Section 5.1.7.1.

Only the Trajectory Generator, the Receiver Model and CommNet functional blocks of SATERA SET will be used in validation exercise 2.1.

Co-funded by the European Union

5.3.7.2 Validation exercise technique

Validation exercise #2.1 will resort to large-scale, offline simulations. This approach is widely employed to evaluate surveillance system performance, since there are no real-time constraints and several hours of recorded data are typically required to ensure statistically reliable results.

5.3.8 Data collection and analysis

This section summarizes the data-acquisition strategy needed to replicate realistic operational environments, focusing on aircraft trajectories and satellite constellation ephemerides, as well as the analytical approach to benchmark the simulator's scalability and fidelity within the discrete-event simulation framework.

5.3.8.1 Data and data collection methods

Validation exercise #2.1 will use both external data and data generated by the project. External data will consist of ADS-B data provided by COLLINS from FlightAware with the following data items:

- Pitr: Unix timestamp (in seconds) representing when the position record was processed.
- Type: Type of message. Normally, this field will say Position, meaning it has ADS-B position data.
- Ident: Flight identifier, usually the callsign.
- Air ground: Indicates whether the aircraft is airborne (A) or on the ground (G).
- Alt: Altitude (in feet) of the aircraft.
- AltChange: Rate or direction of altitude change. Often blank when altitude is stable.
- Atcident: Timestamp representing when the ADS-B data was generated by the aircraft. Normally, this field will be empty, meaning the aircraft is not broadcasting this timestamp. Most aircraft do not do so.
- Clock: Unix timestamp (in seconds) indicating when FlightAware recorded this message.
- Dest: Destination airport ICAO code.
- Facility hash: Identifier for the ADS-B receiving station. It is unique.
- Facility name: Name of the source that collected the data. Example: FlightAware ADS-B.
- Id: Message / track ID generated by FlightAware. It is unique.
- Gs: Ground speed (in knots).
- Heading: Aircraft heading (in degrees (0–359)).
- Lat: Latitude of the aircraft at that moment (in degrees).
- Lon: Longitude of the aircraft at that moment (in degrees).
- Orig: Origin airport ICAO code.
- Reg: Aircraft registration.
- UpdateType: Type of update. Usually A, for ADS-B update.

External data will be provided in CSV format.

Data generated by the project will consist of TOA, AOA and FOA data, plus ADS-B data blocks and auxiliary control data generated using the SATERA SET. These data will be stored in an InfluxDB database by the SATERA *Receiver Module* for further processing by the *ComNet* module. Based on these input data, the SATERA ComNet will propagate these data through the ISL+down link networks and will record the delivered data in the InfluxDB.

5.3.8.2 Analysis methods

The analysis focuses on evaluating how the simulation framework handles the provided input data under the previously defined operational scenarios exploiting data recorded in the InfluxDB . This assessment will be divided into:

- **Scalability and efficiency analysis:** Evaluate the framework's performance capabilities by comparing the system's response to the different scale scenarios defined in the validation scenarios. Analysing the correlation between the number of aircraft and the resulting total simulation time will determine how the latter scales with the former, verifying the framework's capacity to process high-density inputs within a feasible timeframe.
- **Fidelity analysis:** Validate the distributed simulation by cross-referencing the outputs of these scenarios against their fully simulated counterpart, to ensure that reducing complexity via partitioning doesn't result in statistically significant deviations in the simulation outcome.

This approach validates the simulation framework's operational readiness by balancing computational scalability with model accuracy. By correlating simulation runtime with traffic density and cross-validating results against a full-scale baseline.

5.3.9 Exercise planning and management

5.3.9.1 Activities

Validation exercise #2.1 will consist of the following activities:

- Activity 1: Preparation of FlightAware datasets (the FlightAware datasets needed for all validation exercises will be created and validated before the exercises kick-off).
- Activity 2: Full simulation runs.
- Activity 3: Partitioned/distributed simulation runs.

5.3.9.2 Roles and responsibilities in the exercise

The following roles and responsibilities have been identified in validation exercise #2.1.

- UPV, ENAIRE and COLLINS will define the flights the dataset shall contain.
- UPV and UC will coordinate exercise execution and result analysis.

5.3.9.3 Time planning

Activity	2025	2026	
	W50	W2/W3	W4/W5
Activity 1	MS2.1-1		
Activity 2		MS2.1-2	
Activity 3			MS2.1-3

Table 26: detailed exercise #2.1 time planning

Validation exercise milestones:

Co-funded by the European Union

- MS2.1-1: Validated FlightAware ADS-B data for validation exercise #2.1 available in the project SharePoint.
- MS2.1-2: Full simulation run results have been generated
- MS2.1-3: Distributed/partitioned simulation run results have been generated

5.3.9.4 Identified risks and mitigation actions

No risks affecting validation exercise #2.1 have been reported in STELLAR.

5.4 Validation exercise #2.2 plan

5.4.1 Validation exercise description and scope

Operational Scope

Validation exercise #2.2 primarily focuses on **validating the SATERA solution in the** Nor Atlantic (**NAT**) corridor. To this purpose, the research team will primarily assess the **compliance of SATERA with the ESASSP requirements in the North Atlantic corridor**. Validation will also **address integrity issues**, especially when the system operates **under abnormal conditions**.

The operational scope involves the following **actors and processes**:

- **COLLINS** – Provides FlightAware ADS-B surveillance data for a set of flights.
- **UPV/UC** – Generates MLAT surveillance data based on the FlightAware ADS-B data provided by COLLINS.
- **UPV** – Computes ESASSP performance metrics for the MLAT surveillance data generated using SATERA SET and using RTs generated from FlightAware ADS-B.
- **SATERA SET** – The system under validation, responsible for generating MLAT data for performance assessments and for the computation of ESASSP performance metrics.

Key Validation Objectives and Scenarios

The primary objective of Exercise #2.2 is to validate the **SATERA Solution** in the NAT corridor.

Validation Scenarios:

- Simulations will cover the **NAT corridor.**
- Separate simulation will be conducted in the following Oceanic Control Areas (OACs):
  - Bodø
  - Reykjavik
  - Shanwick
  - Gander
  - Santa Maria, and
  - New York
- Simulations will cover the busiest day in the NAT corridor in 2024.
- Both **normal and abnormal conditions are assumed** in all cases (see Section 4.4 for details)
- Two validation scenarios will be addressed:
  - Performance metrics will be computed for 5 NM surveillance applications.
  - Performance metrics will be computed for 3 NM surveillance applications.

Validation Technique

EUROPEAN PARTNERSHIP
Co-funded by the European Union

The exercise applies to a **quantitative benchmarking technique**, consisting of:

1. Generating MLAT surveillance data from FlightAware ADS-B data using SATERA SET. This process involves the generation of ground truth trajectories from ADS-B data using the techniques validated in validation exercise #1.1.
2. Generating ESASSP performance metrics for SATERA MLAT data, the methods defined in ESASSP Ed. 1.3 Vol. 1 implemented in SATERA SET, previously validated in validation exercise #1.2.

This approach ensures an objective, tool-supported comparison consistent with established surveillance validation practices.

Validation Platform

- **SATERA SET** is a validation platform, including both the MLAT data generation and the performance metrics computation functions.

Applicable TRL

This activity corresponds to **Technology Readiness Level (TRL) 2**, focusing on the analytical validation of key system concepts and methods—specifically, the feasibility and expected fidelity of RT generation based solely on ADS-B surveillance data.

5.4.2 Stakeholder's expectations and benefit mechanisms addressed by the exercise

Stakeholder	Involvement	Why it matters to the stakeholder
ANSP	ANSPs are Involved as the project partner and member of the advisory board.	The outcomes of the validation exercise will benefit the air traffic controllers through provision of reliable and accurate positioning data of the aircrafts to support safe and efficient air traffic management. ANSPs will exploit the validation results to analyse the new business model to offer new and economic benefit to end users. For ANSPs, KPAs of interest where the solution impacts positively include the operational efficiency, capacity and safety.
Scheduled airlines	No direct involvement	For airliners, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.

Military	No direct involvement	Like commercial airlines, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.
CNSaaS provider	No direct involvement	For this futuristic CNSaaS provider, the successful validation of the solution, along with other changes in the oceanic ATM procedure, will enable revenue from ANSPs, strategic role in CNS services. This will eventually enable high-performance surveillance globally. The realization of the whole system will require necessary infrastructure deployment (satellites, ground stations), development of data processing algorithms, service provision.

Table 27: stakeholders' expectations validation exercise #2.2

5.4.3 Validation objectives.

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #2.2	Exercise validation objective	Exercise success criteria
OBJ-SATERA-TRL2-ERP-006	CRT-REQ-SATERA-TRL2-ERP-006.001 CRT-REQ-SATERA-TRL2-ERP-006.002 CRT-REQ-SATERA-TRL2-ERP-006.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-006.004 CRT-REQ-SATERA-TRL2-ERP-006.005 CRT-OPT-SATERA-TRL2-ERP-006.001	Fully covered	OBJ-SATERA-TRL2-ERP-006	CRT-REQ-SATERA-TRL2-ERP-006.001 CRT-REQ-SATERA-TRL2-ERP-006.002 CRT-REQ-SATERA-TRL2-ERP-006.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-006.004 CRT-REQ-SATERA-TRL2-ERP-006.005 CRT-OPT-SATERA-TRL2-ERP-006.001

	CRT-OPT-SATERA-TRL2-ERP-006.002 CRT-OPT-SATERA-TRL2-ERP-006.003 CRT-OPT-SATERA-TRL2-ERP-006.004 CRT-OPT-SATERA-TRL2-ERP-006.005 CRT-OPT-SATERA-TRL2-ERP-006.006			CRT-OPT-SATERA-TRL2-ERP-006.002 CRT-OPT-SATERA-TRL2-ERP-006.003 CRT-OPT-SATERA-TRL2-ERP-006.004 CRT-OPT-SATERA-TRL2-ERP-006.005 CRT-OPT-SATERA-TRL2-ERP-006.006
OBJ-SATERA-TRL2-ERP-007	CRT-REQ-SATERA-TRL2-ERP-007.001 CRT-REQ-SATERA-TRL2-ERP-007.002 CRT-REQ-SATERA-TRL2-ERP-007.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-007.004 CRT-REQ-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.001 CRT-OPT-SATERA-TRL2-ERP-007.002 CRT-OPT-SATERA-TRL2-ERP-007.003 CRT-OPT-SATERA-TRL2-ERP-007.004 CRT-OPT-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.006	Fully covered	OBJ-SATERA-TRL2-ERP-007	CRT-REQ-SATERA-TRL2-ERP-007.001 CRT-REQ-SATERA-TRL2-ERP-007.002 CRT-REQ-SATERA-TRL2-ERP-007.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-007.004 CRT-REQ-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.001 CRT-OPT-SATERA-TRL2-ERP-007.002 CRT-OPT-SATERA-TRL2-ERP-007.003 CRT-OPT-SATERA-TRL2-ERP-007.004 CRT-OPT-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.006
OBJ-SATERA-TRL2-ERP-008	CRT-REQ-SATERA-TRL2-ERP-008.001 CRT-REQ-SATERA-TRL2-ERP-008.002 CRT-REQ-SATERA-TRL2-ERP-008.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-008.004 CRT-REQ-SATERA-TRL2-ERP-008.005	Fully covered	OBJ-SATERA-TRL2-ERP-008	CRT-REQ-SATERA-TRL2-ERP-008.001 CRT-REQ-SATERA-TRL2-ERP-008.002 CRT-REQ-SATERA-TRL2-ERP-008.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-008.004 CRT-REQ-SATERA-TRL2-ERP-008.005

	CRT-OPT-SATERA-TRL2-ERP-008.001 CRT-OPT-SATERA-TRL2-ERP-008.002 CRT-OPT-SATERA-TRL2-ERP-008.003 CRT-OPT-SATERA-TRL2-ERP-008.004 CRT-OPT-SATERA-TRL2-ERP-008.005 CRT-OPT-SATERA-TRL2-ERP-008.006			CRT-OPT-SATERA-TRL2-ERP-008.001 CRT-OPT-SATERA-TRL2-ERP-008.002 CRT-OPT-SATERA-TRL2-ERP-008.003 CRT-OPT-SATERA-TRL2-ERP-008.004 CRT-OPT-SATERA-TRL2-ERP-008.005 CRT-OPT-SATERA-TRL2-ERP-008.006
OBJ-SATERA-TRL2-ERP-009	CRT-REQ-SATERA-TRL2-ERP-009.001 CRT-REQ-SATERA-TRL2-ERP-009.002 CRT-REQ-SATERA-TRL2-ERP-009.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-009.004 CRT-REQ-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.001 CRT-OPT-SATERA-TRL2-ERP-009.002 CRT-OPT-SATERA-TRL2-ERP-009.003 CRT-OPT-SATERA-TRL2-ERP-009.004 CRT-OPT-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.006	Fully covered	OBJ-SATERA-TRL2-ERP-009	RT-REQ-SATERA-TRL2-ERP-008.001 CRT-REQ-SATERA-TRL2-ERP-009.002 CRT-REQ-SATERA-TRL2-ERP-009.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-009.004 CRT-REQ-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.001 CRT-OPT-SATERA-TRL2-ERP-009.002 CRT-OPT-SATERA-TRL2-ERP-009.003 CRT-OPT-SATERA-TRL2-ERP-009.004 CRT-OPT-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.006
OBJ-SATERA-TRL2-ERP-0010	CRT-REQ-SATERA-TRL2-ERP-010.001 CRT-REQ-SATERA-TRL2-ERP-010.002 CRT-REQ-SATERA-TRL2-ERP-010.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-010.004	Fully covered	OBJ-SATERA-TRL2-ERP-0010	CRT-REQ-SATERA-TRL2-ERP-010.001 CRT-REQ-SATERA-TRL2-ERP-010.002 CRT-REQ-SATERA-TRL2-ERP-010.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-010.004

	CRT-REQ-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.001 CRT-OPT-SATERA-TRL2-ERP-010.002 CRT-OPT-SATERA-TRL2-ERP-010.003 CRT-OPT-SATERA-TRL2-ERP-010.004 CRT-OPT-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.006			CRT-REQ-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.001 CRT-OPT-SATERA-TRL2-ERP-010.002 CRT-OPT-SATERA-TRL2-ERP-010.003 CRT-OPT-SATERA-TRL2-ERP-010.004 CRT-OPT-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.006
OBJ-SATERA-TRL2-ERP-011	CRT-REQ-SATERA-TRL2-ERP-011.001 CRT-REQ-SATERA-TRL2-ERP-011.002 CRT-REQ-SATERA-TRL2-ERP-011.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-011.004 CRT-REQ-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.001 CRT-OPT-SATERA-TRL2-ERP-011.002 CRT-OPT-SATERA-TRL2-ERP-011.003 CRT-OPT-SATERA-TRL2-ERP-011.004 CRT-OPT-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.006	Fully covered	OBJ-SATERA-TRL2-ERP-011	CRT-REQ-SATERA-TRL2-ERP-011.001 CRT-REQ-SATERA-TRL2-ERP-011.002 CRT-REQ-SATERA-TRL2-ERP-011.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-011.004 CRT-REQ-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.001 CRT-OPT-SATERA-TRL2-ERP-011.002 CRT-OPT-SATERA-TRL2-ERP-011.003 CRT-OPT-SATERA-TRL2-ERP-011.004 CRT-OPT-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.006
OBJ-SATERA-TRL2-ERP-012	CRT-REQ-SATERA-TRL2-ERP-012.001 CRT-REQ-SATERA-TRL2-ERP-012.002 CRT-REQ-SATERA-TRL2-ERP-012.003 ESASSP	Fully covered	OBJ-SATERA-TRL2-ERP-012	CRT-REQ-SATERA-TRL2-ERP-012.001 CRT-REQ-SATERA-TRL2-ERP-012.002 CRT-REQ-SATERA-TRL2-ERP-012.003 ESASSP

	CRT-REQ-SATERA-TRL2-ERP-012.004 CRT-REQ-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.001 CRT-OPT-SATERA-TRL2-ERP-012.002 CRT-OPT-SATERA-TRL2-ERP-012.003 CRT-OPT-SATERA-TRL2-ERP-012.004 CRT-OPT-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.006			CRT-REQ-SATERA-TRL2-ERP-012.004 CRT-REQ-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.001 CRT-OPT-SATERA-TRL2-ERP-012.002 CRT-OPT-SATERA-TRL2-ERP-012.003 CRT-OPT-SATERA-TRL2-ERP-012.004 CRT-OPT-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.006
OBJ-SATERA-TRL2-ERP-013	CRT-REQ-SATERA-TRL2-ERP-013.001 CRT-REQ-SATERA-TRL2-ERP-013.002 CRT-REQ-SATERA-TRL2-ERP-013.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-013.004 CRT-REQ-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.001 CRT-OPT-SATERA-TRL2-ERP-013.002 CRT-OPT-SATERA-TRL2-ERP-013.003 CRT-OPT-SATERA-TRL2-ERP-013.004 CRT-OPT-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.006	Fully covered	OBJ-SATERA-TRL2-ERP-013	CRT-REQ-SATERA-TRL2-ERP-013.001 CRT-REQ-SATERA-TRL2-ERP-013.002 CRT-REQ-SATERA-TRL2-ERP-013.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-013.004 CRT-REQ-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.001 CRT-OPT-SATERA-TRL2-ERP-013.002 CRT-OPT-SATERA-TRL2-ERP-013.003 CRT-OPT-SATERA-TRL2-ERP-013.004 CRT-OPT-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.006
OBJ-SATERA-TRL2-ERP-014	CRT-REQ-SATERA-TRL2-ERP-014.001 CRT-REQ-SATERA-TRL2-ERP-014.002	Fully covered	OBJ-SATERA-TRL2-ERP-014	CRT-REQ-SATERA-TRL2-ERP-014.001 CRT-REQ-SATERA-TRL2-ERP-014.002

	CRT-REQ-SATERA-TRL2-ERP-014.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-014.004 CRT-REQ-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.001 CRT-OPT-SATERA-TRL2-ERP-014.002 CRT-OPT-SATERA-TRL2-ERP-014.003 CRT-OPT-SATERA-TRL2-ERP-014.004 CRT-OPT-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.006			CRT-REQ-SATERA-TRL2-ERP-014.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-014.004 CRT-REQ-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.001 CRT-OPT-SATERA-TRL2-ERP-014.002 CRT-OPT-SATERA-TRL2-ERP-014.003 CRT-OPT-SATERA-TRL2-ERP-014.004 CRT-OPT-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.006
OBJ-SATERA-TRL2-ERP-015	CRT-REQ-SATERA-TRL2-ERP-015.001 CRT-REQ-SATERA-TRL2-ERP-015.002 CRT-REQ-SATERA-TRL2-ERP-015.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-015.004 CRT-REQ-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.001 CRT-OPT-SATERA-TRL2-ERP-015.002 CRT-OPT-SATERA-TRL2-ERP-015.003 CRT-OPT-SATERA-TRL2-ERP-015.004 CRT-OPT-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.006	Fully covered	OBJ-SATERA-TRL2-ERP-015	CRT-REQ-SATERA-TRL2-ERP-015.001 CRT-REQ-SATERA-TRL2-ERP-015.002 CRT-REQ-SATERA-TRL2-ERP-015.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-015.004 CRT-REQ-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.001 CRT-OPT-SATERA-TRL2-ERP-015.002 CRT-OPT-SATERA-TRL2-ERP-015.003 CRT-OPT-SATERA-TRL2-ERP-015.004 CRT-OPT-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.006
OBJ-SATERA-TRL2-ERP-016	CRT-REQ-SATERA-TRL2-ERP-016.001	Fully covered	OBJ-SATERA-TRL2-ERP-016	CRT-REQ-SATERA-TRL2-ERP-016.001

	CRT-REQ-SATERA-TRL2-ERP-016.002 CRT-REQ-SATERA-TRL2-ERP-016.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-016.004 CRT-REQ-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.001 CRT-OPT-SATERA-TRL2-ERP-016.002 CRT-OPT-SATERA-TRL2-ERP-016.003 CRT-OPT-SATERA-TRL2-ERP-016.004 CRT-OPT-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.006			CRT-REQ-SATERA-TRL2-ERP-016.002 CRT-REQ-SATERA-TRL2-ERP-016.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-016.004 CRT-REQ-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.001 CRT-OPT-SATERA-TRL2-ERP-016.002 CRT-OPT-SATERA-TRL2-ERP-016.003 CRT-OPT-SATERA-TRL2-ERP-016.004 CRT-OPT-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.006
OBJ-SATERA-TRL2-ERP-017	CRT-REQ-SATERA-TRL2-ERP-017.001 CRT-REQ-SATERA-TRL2-ERP-017.002 CRT-REQ-SATERA-TRL2-ERP-017.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-017.004 CRT-REQ-SATERA-TRL2-ERP-017.005 CRT-OPT-SATERA-TRL2-ERP-017.001 CRT-OPT-SATERA-TRL2-ERP-017.002 CRT-OPT-SATERA-TRL2-ERP-017.003 CRT-OPT-SATERA-TRL2-ERP-017.004 CRT-OPT-SATERA-TRL2-ERP-017.005 CRT-OPT-SATERA-TRL2-ERP-017.006	Fully covered	OBJ-SATERA-TRL2-ERP-017	CRT-REQ-SATERA-TRL2-ERP-017.001 CRT-REQ-SATERA-TRL2-ERP-017.002 CRT-REQ-SATERA-TRL2-ERP-017.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-017.004 CRT-REQ-SATERA-TRL2-ERP-017.005 CRT-OPT-SATERA-TRL2-ERP-017.001 CRT-OPT-SATERA-TRL2-ERP-017.002 CRT-OPT-SATERA-TRL2-ERP-017.003 CRT-OPT-SATERA-TRL2-ERP-017.004 CRT-OPT-SATERA-TRL2-ERP-017.005 CRT-OPT-SATERA-TRL2-ERP-017.006

OBJ-SATERA-TRL2-ERP-018	CRT-REQ-SATERA-TRL2-ERP-018.001 CRT-REQ-SATERA-TRL2-ERP-018.002 CRT-REQ-SATERA-TRL2-ERP-018.003	Fully covered	OBJ-SATERA-TRL2-ERP-018	CRT-REQ-SATERA-TRL2-ERP-018.001 CRT-REQ-SATERA-TRL2-ERP-018.002 CRT-REQ-SATERA-TRL2-ERP-018.003

Table 2928: validation objectives addressed in validation exercise #2.2

5.4.4 Validation scenarios

5.4.4.1 Reference scenario

The reference scenario is defined in the North Atlantic corridor. According to the ICAO [1], in 2023 there were more than 2,000,000 flight hours in the NAT corridor. Assuming an average flight duration of 7 hours in the NAT corridor, 2 million flight hours would correspond to around 285,000 flights. Therefore, this scenario covers the En-route high complexity sub-operating environment.

The oceanic North Atlantic airspace is divided in six Oceanic Control Areas, as shown in Figure 5:

- Bodø
- Reykjavik
- Shanwick
- Gander
- Santa Maria, and
- New York

Westbound traffic (Europe → North America) typically occurs during daytime hours, whereas eastbound traffic (North America → Europe) predominantly takes place at night, as illustrated in Figure 6 & Figure 7. Figure 8 depicts ground-based surveillance coverage, showing the coverage gap in the NAT region (highlighted with a blue frame). Aireon's space-based ADS-B coverage largely fills this gap, as shown in Figure 9. However, the figure also indicates that Aireon's coverage over the NAT typically involves fewer than three simultaneous satellites, falling short of the minimum (disregarding DOP effects) needed to compute aircraft positions via multilateration. Other non-ADS-B surveillance sources that provide GNSS-independent data also offer limited coverage (see Figure 10), thereby constraining both the provision of an independent surveillance layer and the ability to verify ADS-B position integrity by cross-checking with non-GNSS-based fixes.

Integrity is a major issue with ADS-B, since reported positions can be affected by both jamming and spoofing. Although the NAT region is far from conflict zones where jamming is common, the current geopolitical situation in Europe, with documented jamming/spoofing attacks against state aircraft **¡Error! No se encuentra el origen de la referencia.** and unauthorised drone activity around major European airports **¡Error! No se encuentra el origen de la referencia.**, highlights the importance of hardening space-based surveillance systems with enhanced integrity checks against such threats. On a different note, even when aircraft are spoofed far from the NAT regions, commercial pilots have reported long-lasting effects on their navigation system. Figure 12 showcases this effect with an example taken form **¡Error! No se encuentra el origen de la referencia.**, reporting anomalous GNSS receiver behaviour of a commercial flight form *from Dubai DBX airport to San Francisco SFO in May 2024.* The figure shows that after crossing Russian airspace, the reported positions follow a fake sinusoidal pattern with huge errors when the aircraft crossed the Bodø and Reykjavik OCSs within the NAT region.

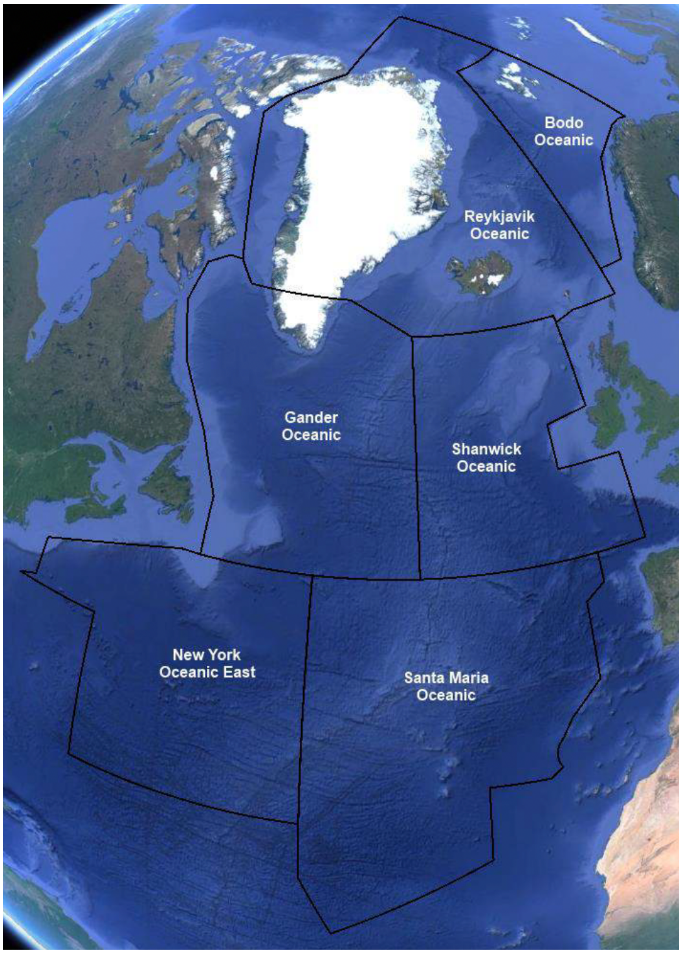

Figure 5. Oceanic Control Areas in the NAT region ¡Error! No se encuentra el origen de la referencia.

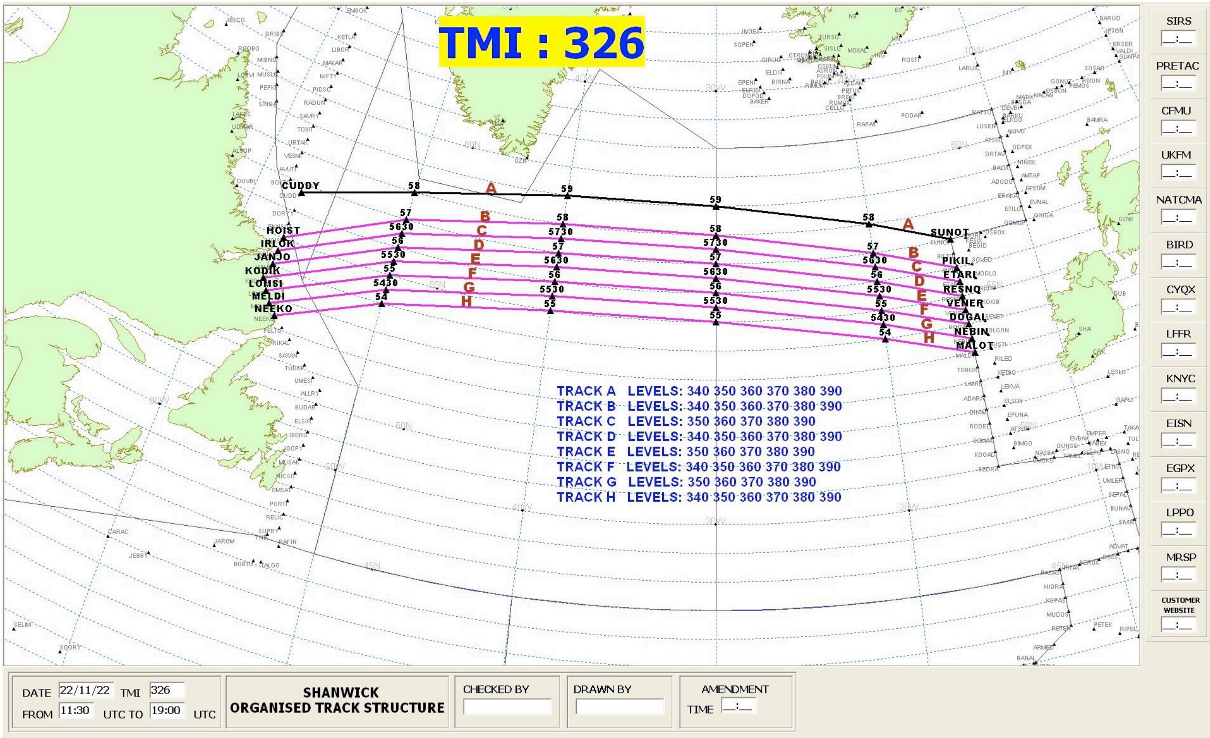

Figure 6. Westbound NAT corridor ¡Error! No se encuentra el origen de la referencia.

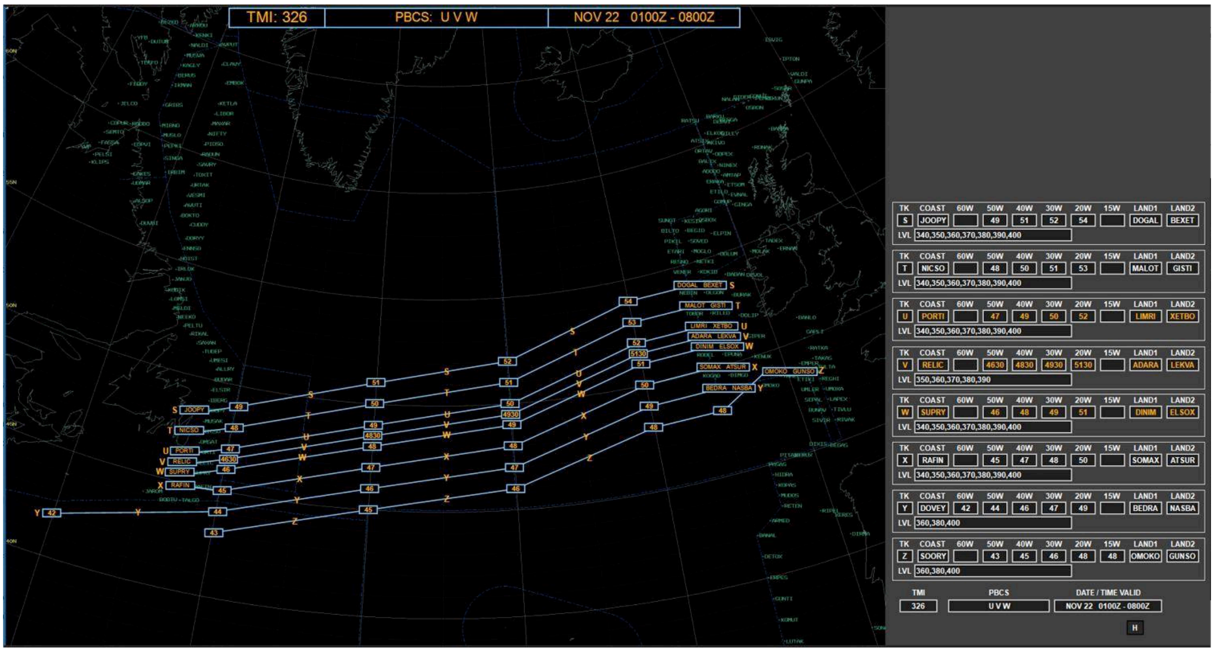

Figure 7. Eastbound NAT corridor ¡Error! No se encuentra el origen de la referencia.

Co-funded by the European Union

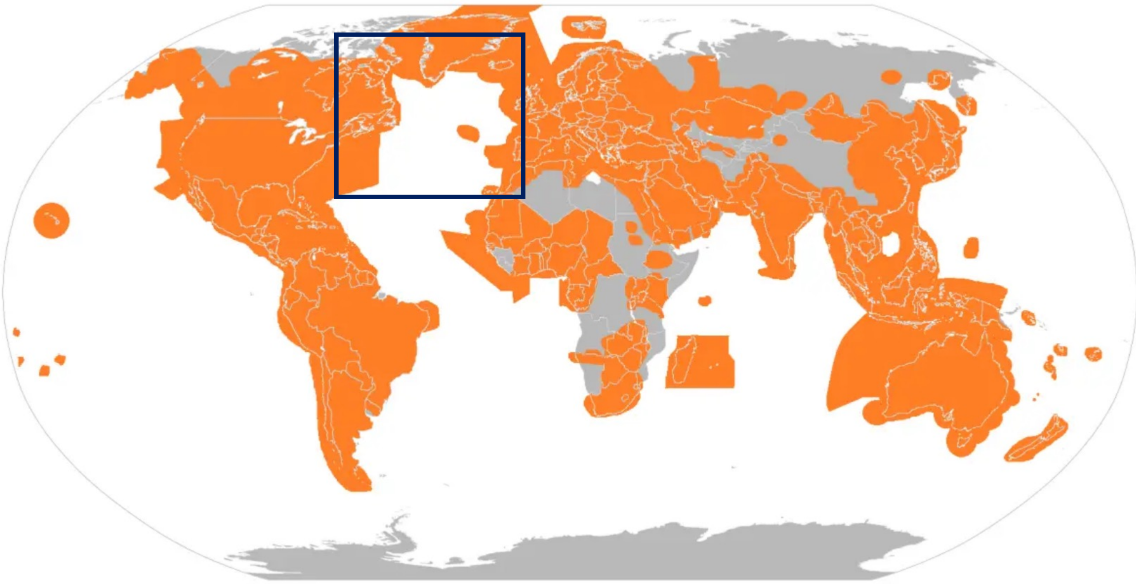

Figure 8. Ground-based ADS-B and SSR composite surveillance coverage, with the NAT region delineated by a blue frame ¡Error! No se encuentra el origen de la referencia..

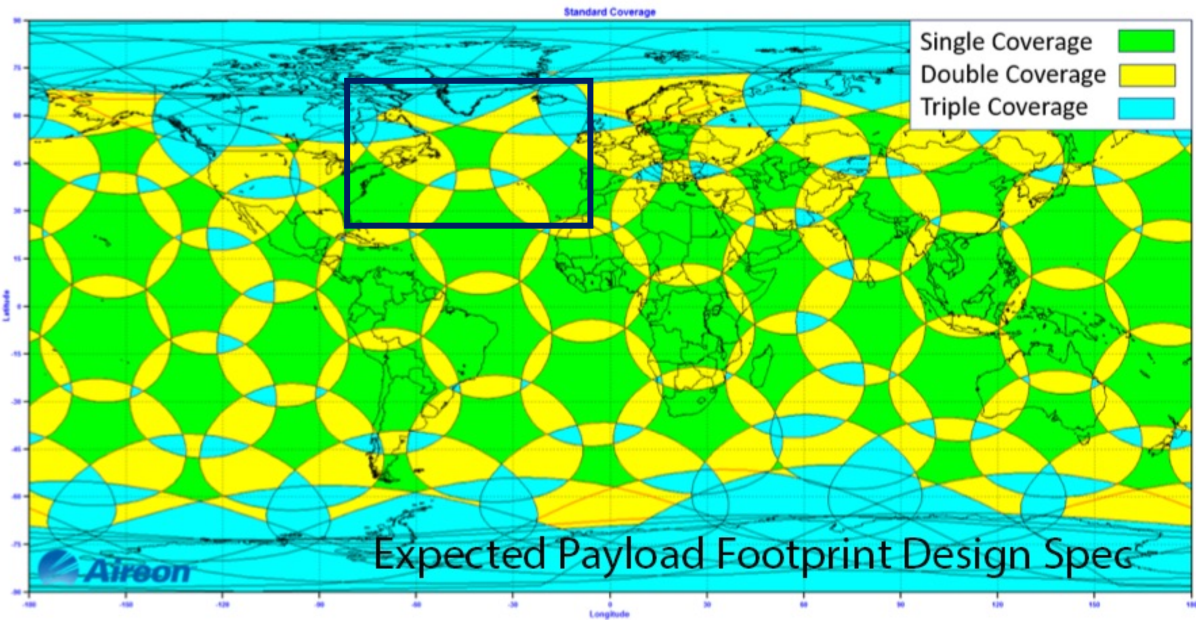

Figure 9. Aireon's Space-Based ADS-B coverage, with the NAT region delineated by a blue frame ¡Error! No se encuentra el origen de la referencia..

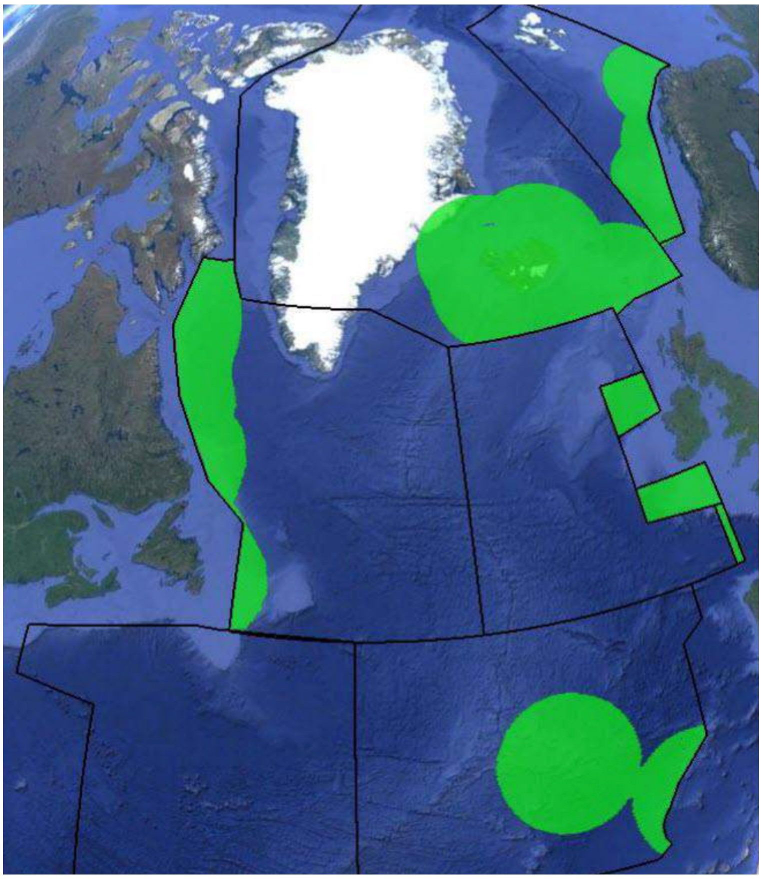

Figure 10. Non-ADS-B surveillance coverage (SSR+WAM) in the NAT region ¡Error! No se encuentra el origen de la referencia.**.**

EUROPEAN PARTNERSHIP

Co-funded by the European Union

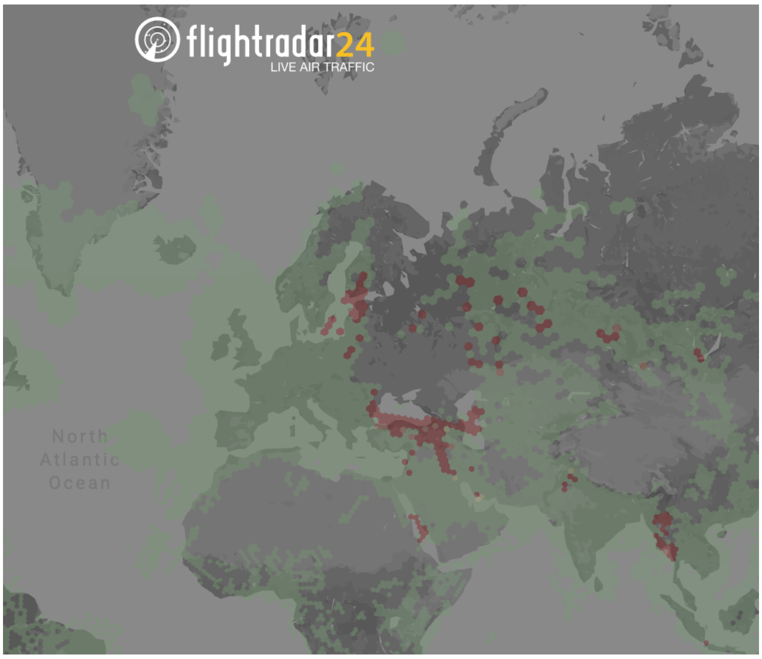

Figure 11. GNSS jamming map (affecting ADS-B reported positions) ¡Error! No se encuentra el origen de la referencia..

Figure 12. Example of permanent GNSS interference effects on ADS-B reported data, from ¡Error! No se encuentra el origen de la referencia.

Nominal conditions are assumed in all cases (See Section 4.4 for details).

5.4.4.2 Solution scenario(s)

Solution scenario will consist of the NAT region, as described in Section 5.2.4.1, but with the SATERA solution providing space-based multilateration surveillance. SATERA outcomes will consist of: (1) a GNSS independent surveillance layer, and (2) an integrity estimator based on the crosscheck of MLAT computed positions and ADS-B reported fixes.

Both normal and abnormal conditions, as described in Section 4.4 will be considered.

5.4.5 Exercise validation assumptions

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
ASSUMP-SATERA-TRL2-ERP-2.2-001	Per-OCA assessment	Assessing SATERA performance by OCA yields results like those of a comprehensive evaluation of the entire NAT region.	Evaluating SATERA performance across the entire region is prohibitively time-consuming.	Noncritical (from validation wxercise #2.1)

Table 29: validation exercise #2.2 assumptions

5.4.6 Limitations and impact on the level of significance

Neither the general assumptions in Section 4.4 nor the assumptions specific to validation exercise #1.2 listed in Table 18: validation exercise #1.1 assumptions

limit the significance of the results. Concerning assumptions Table 18: validation exercise #1.1 assumptions

:

- Conducting the assessment at OCA level pursues a trade-off between accuracy and computation time. validation exercise #2.1 will provide the relation of OCA assessment and NAT corridor wide ones enabling the extrapolation of results without loss of accuracy.
- The number of target report recorded within OCAs will suffice to obtain statistically sound results. In any case, SATERA SET will take into consideration the impact of the sample size on the significance of the computed metrics when assessing the compliance with the ESASSP requirements based on the method described in ED-129 and adopted in the ESASSP Ed. 1.3

5.4.7 Validation exercise platform / tool and validation technique

5.4.7.1 Validation exercise platform / tool characteristics

See Section 5.1.7.1.

5.4.7.2 Validation exercise technique

Validation exercise #2.2 will consist of non-real-time, large-scale simulations. This technique is commonly used in surveillance systems performance assessment, as there are no real time requirements and data recorded during several hours are usually needed to guarantee the statistical soundness of the results.

5.4.8 Data collection and analysis

5.4.8.1 Data and data collection methods

Validation exercise #1.2 will use both external data and data generated by the project. External data will consist of ADS-B data provided by E from FlightAware with the following data items:

- Pitr: Unix timestamp (in seconds) representing when the position record was processed.
- Type: Type of message. Normally, this field will say Position, meaning it has ADS-B position data.
- Ident: Flight identifier, usually the callsign.
- Air ground: Indicates whether the aircraft is airborne (A) or on the ground (G).
- Alt: Altitude (in feet) of the aircraft.
- AltChange: Rate or direction of altitude change. Often blank when altitude is stable.
- Atcident: Timestamp representing when the ADS-B data was generated by the aircraft. Normally, this field will be empty, meaning the aircraft is not broadcasting this timestamp. Most aircraft do not do so.
- Clock: Unix timestamp (in seconds) indicating when FlightAware recorded this message.
- Dest: Destination airport ICAO code.
- Facility hash: Identifier for the ADS-B receiving station. It is unique.
- Facility name: Name of the source that collected the data. Example: FlightAware ADS-B.
- Id: Message / track ID generated by FlightAware. It is unique.
- Gs: Ground speed (in knots).
- Heading: Aircraft heading (in degrees (0–359)).
- Lat: Latitude of the aircraft at that moment (in degrees).
- Lon: Longitude of the aircraft at that moment (in degrees).
- Orig: Origin airport ICAO code.
- Reg: Aircraft registration.
- UpdateType: Type of update. Usually A, for ADS-B update.

External data will be provided in CSV format. Data generated by the project will consist of MLAT target reports in ASTERIX CAT020 and performance monitoring reports produced by the UPV and UC teams using SATERA SET. A specific folder will be created in the SATERA SharePoint to share these data among the SATERA researchers involved in the validation exercise.

5.4.8.2 Analysis methods

UPV and UC teams will produce MLAT target reports applying the algorithms described in deliverables D.3.1, D4.2, D6.1 and D6.2 and will export them in ASTERIX CAT020. Performance metrics will be computed according to the procedures described in ESAASSP Ed. 1.3 Vol. 1. Performance assessment will be conducted for each OCA within the NAT corridor independently.

5.4.9 Exercise planning and management

5.4.9.1 Activities

Validation exercise #2.2 will consist of the following activities:

- Activity1: Preparation of FlightAware datasets (the FlightAware datasets needed for all validation exercises will be created and validated before the exercises kick-off).
- Activity 2: Assessment under normal conditions.
- Activity 3: Assessment under abnormal conditions: space weather.
- Activity 4: Assessment under abnormal conditions: jamming.
- Activity 5: Assessment under abnormal conditions: spoofing.

5.4.9.2 Roles and responsibilities in the exercise

The following roles and responsibilities have been identified in validation exercise #2.2.

- UPV and COLLINS will define the flights the dataset shall contain.
- UPV and UC will generate MLAT surveillance data for the flights in the data sets (one data set per OCA), both under normal and abnormal conditions.
- UPV will compute applicable 5/3 NM ESASSP performance metrics for the MLAT surveillance data using SATERA SET, both in normal and in abnormal conditions.
- UPV COLLINS will review the metrics and assess whether the applicable validation objectives have been achieved.

5.4.9.3 Time planning

Activity	2025	2026			
	W50	W6	W7	W8	W9
Activity 1	MS2.2-1				
Activity 2		MS2.2-2			
Activity 3			M2.2-3		
Activity 4				MS2.2-4	
Activity 5					MS2.2-5

Table 30: detailed exercise #2.2-time planning

Validation exercise milestones:

- MS2.2-1: Validated FlightAware ADS-B data for validation exercise #2.2 available in the project SharePoint.

- MS2.2-2 Results from validation exercise #2.2 under normal conditions have been generated.
- MS2.2-3 Results from validation exercise #2.2 under abnormal conditions (space weather) have been generated.
- MS2.2-3 Results from validation exercise #2.2 under abnormal (jamming) conditions have been generated.
- MS2.2-5 Results from validation exercise #2.2 under normal conditions (spoofing) have been generated.

5.4.9.4 Identified risks and mitigation actions

No risks affecting validation exercise #2.2 have been reported in STELLAR.

5.5 Validation exercise #2.3 plan

5.5.1 Validation exercise description and scope

Operational Scope

Validation exercise #2.3 primarily focuses on **validating the SATERA solution in the EUR/SAM** corridor. To this purpose, the research team will primarily assess the **compliance of SATERA with the ESASSP requirements in the EUR/SAM corridor**. The SATERA team will **proposal different service levels** based on the assessed performance. Finally, validation will **address integrity issues**, especially when the system operates **under abnormal conditions**.

The operational scope involves the following **actors and processes**:

- **COLLINS** – Provides FlightAware ADS-B surveillance data for a set of flights.
- **UPV/UC** – Generates MLAT surveillance data based on the FlightAware ADS-B data provided by COLLINS.
- **UPV** – Computes ESASSP performance metrics for the MLAT surveillance data generated using SATERA SET and using RTs generated from FlightAware ADS-B.
- **SATERA SET** – The system under validation, responsible for generating MLAT data for performance assessments and for the computation of ESASSP performance metrics.

Key Validation Objectives and Scenarios

The primary objective of Exercise #2.3 is to validate the **SATERA Solution** in the EUR/SAM corridor.

Validation Scenarios:

- Simulations will cover the **EUR/SAM corridor.**
- Separate simulation will be conducted in the following Oceanic Control Areas (OACs):
  - Canarias,
  - Sal Oceanic,
  - Dakar Oceanic,
  - Atlantic (Brazil), and
  - Recife
- Simulations will cover the busiest day in the EUR/SAM corridor in 2024.
- Only **En-route trajectory segments** will be analysed.
- Both normal and abnormal conditions are assumed in all cases (see Section 4.4 for details)
- Two validation scenarios will be addressed:

- Performance metrics will be computed for 3 NM surveillance applications.
- Performance metrics will be computed for 5 NM surveillance applications.

Validation Technique

The exercise applies a **quantitative benchmarking technique**, consisting of:

3. Generating MLAT surveillance data from FlightAware ADS-B data using SATERA SET. This process involves the generation of ground truth trajectories from ADS-B data using the techniques validated in validation exercise #1.1.
4. Generating ESASSP performance metrics for SATERA MLAT data in the methods defined in ESASSP Ed. 1.3 Vol. 1 implemented in SATERA SET, previously validated in validation exercise #1.2.

This approach ensures an objective, tool-supported comparison consistent with established surveillance validation practices.

Validation Platform

- **SATERA SET** is a validation platform, including both the MLAT data generation and the performance metrics computation functions.

Applicable TRL

This activity corresponds to **Technology Readiness Level (TRL) 2**, focusing on the analytical validation of key system concepts and methods - specifically, the feasibility and expected fidelity of RT generation based solely on ADS-B surveillance data.

5.5.2 Stakeholder's expectations and benefit mechanisms addressed by the exercise

Stakeholder	Involvement	Why it matters to the stakeholder
ANSP	ANSPs are Involved as the project partner and member of the advisory board.	The outcomes of the validation exercise will benefit the air traffic controllers through provision of reliable and accurate positioning data of the aircrafts to support safe and efficient air traffic management. ANSPs will exploit the validation results to analyse the new business model to offer new and economic benefit to end users. For ANSPs, KPAs of interest where the solution impacts positively include the operational efficiency, capacity and safety.
Scheduled airlines	No direct involvement	For airliners, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.

Military	No direct involvement	Like commercial airlines, the solution and the outcomes of the validation activities are relevant as it positively impacts the airlines in terms of operational efficiency and safety.
CNSaaS provider	No direct involvement	For this futuristic CNSaaS provider, the successful validation of the solution, along with other changes in the oceanic ATM procedure, will enable revenue from ANSPs, strategic role in CNS services. This will eventually enable high-performance surveillance globally. The realization of the whole system will require necessary infrastructure deployment (satellites, ground stations), development of data processing algorithms, service provision.

Table 31: stakeholders' expectations validation exercise #2.3

5.5.3 Validation objectives.

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #2.2	Exercise validation objective	Exercise success criteria
OBJ-SATERA-TRL2-ERP-006	CRT-REQ-SATERA-TRL2-ERP-006.001 CRT-REQ-SATERA-TRL2-ERP-006.002 CRT-REQ-SATERA-TRL2-ERP-006.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-006.004 CRT-REQ-SATERA-TRL2-ERP-006.005	Fully covered	OBJ-SATERA-TRL2-ERP-006	CRT-REQ-SATERA-TRL2-ERP-006.001 CRT-REQ-SATERA-TRL2-ERP-006.002 CRT-REQ-SATERA-TRL2-ERP-006.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-006.004 CRT-REQ-SATERA-TRL2-ERP-006.005

	CRT-OPT-SATERA-TRL2-ERP-006.001 CRT-OPT-SATERA-TRL2-ERP-006.002 CRT-OPT-SATERA-TRL2-ERP-006.003 CRT-OPT-SATERA-TRL2-ERP-006.004 CRT-OPT-SATERA-TRL2-ERP-006.005 CRT-OPT-SATERA-TRL2-ERP-006.006			CRT-OPT-SATERA-TRL2-ERP-006.001 CRT-OPT-SATERA-TRL2-ERP-006.002 CRT-OPT-SATERA-TRL2-ERP-006.003 CRT-OPT-SATERA-TRL2-ERP-006.004 CRT-OPT-SATERA-TRL2-ERP-006.005 CRT-OPT-SATERA-TRL2-ERP-006.006
OBJ-SATERA-TRL2-ERP-007	CRT-REQ-SATERA-TRL2-ERP-007.001 CRT-REQ-SATERA-TRL2-ERP-007.002 CRT-REQ-SATERA-TRL2-ERP-007.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-007.004 CRT-REQ-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.001 CRT-OPT-SATERA-TRL2-ERP-007.002 CRT-OPT-SATERA-TRL2-ERP-007.003 CRT-OPT-SATERA-TRL2-ERP-007.004 CRT-OPT-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.006	Fully covered	OBJ-SATERA-TRL2-ERP-007	CRT-REQ-SATERA-TRL2-ERP-007.001 CRT-REQ-SATERA-TRL2-ERP-007.002 CRT-REQ-SATERA-TRL2-ERP-007.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-007.004 CRT-REQ-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.001 CRT-OPT-SATERA-TRL2-ERP-007.002 CRT-OPT-SATERA-TRL2-ERP-007.003 CRT-OPT-SATERA-TRL2-ERP-007.004 CRT-OPT-SATERA-TRL2-ERP-007.005 CRT-OPT-SATERA-TRL2-ERP-007.006
OBJ-SATERA-TRL2-ERP-008	CRT-REQ-SATERA-TRL2-ERP-008.001 CRT-REQ-SATERA-TRL2-ERP-008.002 CRT-REQ-SATERA-TRL2-ERP-008.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-008.004	Fully covered	OBJ-SATERA-TRL2-ERP-008	CRT-REQ-SATERA-TRL2-ERP-008.001 CRT-REQ-SATERA-TRL2-ERP-008.002 CRT-REQ-SATERA-TRL2-ERP-008.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-008.004

	CRT-REQ-SATERA-TRL2-ERP-008.005 CRT-OPT-SATERA-TRL2-ERP-008.001 CRT-OPT-SATERA-TRL2-ERP-008.002 CRT-OPT-SATERA-TRL2-ERP-008.003 CRT-OPT-SATERA-TRL2-ERP-008.004 CRT-OPT-SATERA-TRL2-ERP-008.005 CRT-OPT-SATERA-TRL2-ERP-008.006			CRT-REQ-SATERA-TRL2-ERP-008.005 CRT-OPT-SATERA-TRL2-ERP-008.001 CRT-OPT-SATERA-TRL2-ERP-008.002 CRT-OPT-SATERA-TRL2-ERP-008.003 CRT-OPT-SATERA-TRL2-ERP-008.004 CRT-OPT-SATERA-TRL2-ERP-008.005 CRT-OPT-SATERA-TRL2-ERP-008.006
OBJ-SATERA-TRL2-ERP-009	CRT-REQ-SATERA-TRL2-ERP-009.001 CRT-REQ-SATERA-TRL2-ERP-009.002 CRT-REQ-SATERA-TRL2-ERP-009.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-009.004 CRT-REQ-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.001 CRT-OPT-SATERA-TRL2-ERP-009.002 CRT-OPT-SATERA-TRL2-ERP-009.003 CRT-OPT-SATERA-TRL2-ERP-009.004 CRT-OPT-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.006	Fully covered	OBJ-SATERA-TRL2-ERP-009	RT-REQ-SATERA-TRL2-ERP-008.001 CRT-REQ-SATERA-TRL2-ERP-009.002 CRT-REQ-SATERA-TRL2-ERP-009.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-009.004 CRT-REQ-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.001 CRT-OPT-SATERA-TRL2-ERP-009.002 CRT-OPT-SATERA-TRL2-ERP-009.003 CRT-OPT-SATERA-TRL2-ERP-009.004 CRT-OPT-SATERA-TRL2-ERP-009.005 CRT-OPT-SATERA-TRL2-ERP-009.006
OBJ-SATERA-TRL2-ERP-0010	CRT-REQ-SATERA-TRL2-ERP-010.001 CRT-REQ-SATERA-TRL2-ERP-010.002 CRT-REQ-SATERA-TRL2-ERP-010.003 ESASSP	Fully covered	OBJ-SATERA-TRL2-ERP-0010	CRT-REQ-SATERA-TRL2-ERP-010.001 CRT-REQ-SATERA-TRL2-ERP-010.002 CRT-REQ-SATERA-TRL2-ERP-010.003 ESASSP

EUROPEAN PARTNERSHIP
Co-funded by the European Union

	CRT-REQ-SATERA-TRL2-ERP-010.004 CRT-REQ-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.001 CRT-OPT-SATERA-TRL2-ERP-010.002 CRT-OPT-SATERA-TRL2-ERP-010.003 CRT-OPT-SATERA-TRL2-ERP-010.004 CRT-OPT-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.006			CRT-REQ-SATERA-TRL2-ERP-010.004 CRT-REQ-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.001 CRT-OPT-SATERA-TRL2-ERP-010.002 CRT-OPT-SATERA-TRL2-ERP-010.003 CRT-OPT-SATERA-TRL2-ERP-010.004 CRT-OPT-SATERA-TRL2-ERP-010.005 CRT-OPT-SATERA-TRL2-ERP-010.006
OBJ-SATERA-TRL2-ERP-011	CRT-REQ-SATERA-TRL2-ERP-011.001 CRT-REQ-SATERA-TRL2-ERP-011.002 CRT-REQ-SATERA-TRL2-ERP-011.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-011.004 CRT-REQ-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.001 CRT-OPT-SATERA-TRL2-ERP-011.002 CRT-OPT-SATERA-TRL2-ERP-011.003 CRT-OPT-SATERA-TRL2-ERP-011.004 CRT-OPT-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.006	Fully covered	OBJ-SATERA-TRL2-ERP-011	CRT-REQ-SATERA-TRL2-ERP-011.001 CRT-REQ-SATERA-TRL2-ERP-011.002 CRT-REQ-SATERA-TRL2-ERP-011.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-011.004 CRT-REQ-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.001 CRT-OPT-SATERA-TRL2-ERP-011.002 CRT-OPT-SATERA-TRL2-ERP-011.003 CRT-OPT-SATERA-TRL2-ERP-011.004 CRT-OPT-SATERA-TRL2-ERP-011.005 CRT-OPT-SATERA-TRL2-ERP-011.006
OBJ-SATERA-TRL2-ERP-012	CRT-REQ-SATERA-TRL2-ERP-012.001 CRT-REQ-SATERA-TRL2-ERP-012.002	Fully covered	OBJ-SATERA-TRL2-ERP-012	CRT-REQ-SATERA-TRL2-ERP-012.001 CRT-REQ-SATERA-TRL2-ERP-012.002

	CRT-REQ-SATERA-TRL2-ERP-012.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-012.004 CRT-REQ-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.001 CRT-OPT-SATERA-TRL2-ERP-012.002 CRT-OPT-SATERA-TRL2-ERP-012.003 CRT-OPT-SATERA-TRL2-ERP-012.004 CRT-OPT-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.006			CRT-REQ-SATERA-TRL2-ERP-012.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-012.004 CRT-REQ-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.001 CRT-OPT-SATERA-TRL2-ERP-012.002 CRT-OPT-SATERA-TRL2-ERP-012.003 CRT-OPT-SATERA-TRL2-ERP-012.004 CRT-OPT-SATERA-TRL2-ERP-012.005 CRT-OPT-SATERA-TRL2-ERP-012.006
OBJ-SATERA-TRL2-ERP-013	CRT-REQ-SATERA-TRL2-ERP-013.001 CRT-REQ-SATERA-TRL2-ERP-013.002 CRT-REQ-SATERA-TRL2-ERP-013.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-013.004 CRT-REQ-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.001 CRT-OPT-SATERA-TRL2-ERP-013.002 CRT-OPT-SATERA-TRL2-ERP-013.003 CRT-OPT-SATERA-TRL2-ERP-013.004 CRT-OPT-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.006	Fully covered	OBJ-SATERA-TRL2-ERP-013	CRT-REQ-SATERA-TRL2-ERP-013.001 CRT-REQ-SATERA-TRL2-ERP-013.002 CRT-REQ-SATERA-TRL2-ERP-013.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-013.004 CRT-REQ-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.001 CRT-OPT-SATERA-TRL2-ERP-013.002 CRT-OPT-SATERA-TRL2-ERP-013.003 CRT-OPT-SATERA-TRL2-ERP-013.004 CRT-OPT-SATERA-TRL2-ERP-013.005 CRT-OPT-SATERA-TRL2-ERP-013.006
OBJ-SATERA-TRL2-ERP-014	CRT-REQ-SATERA-TRL2-ERP-014.001	Fully covered	OBJ-SATERA-TRL2-ERP-014	CRT-REQ-SATERA-TRL2-ERP-014.001

Co-funded by the European Union

	CRT-REQ-SATERA-TRL2-ERP-014.002 CRT-REQ-SATERA-TRL2-ERP-014.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-014.004 CRT-REQ-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.001 CRT-OPT-SATERA-TRL2-ERP-014.002 CRT-OPT-SATERA-TRL2-ERP-014.003 CRT-OPT-SATERA-TRL2-ERP-014.004 CRT-OPT-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.006			CRT-REQ-SATERA-TRL2-ERP-014.002 CRT-REQ-SATERA-TRL2-ERP-014.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-014.004 CRT-REQ-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.001 CRT-OPT-SATERA-TRL2-ERP-014.002 CRT-OPT-SATERA-TRL2-ERP-014.003 CRT-OPT-SATERA-TRL2-ERP-014.004 CRT-OPT-SATERA-TRL2-ERP-014.005 CRT-OPT-SATERA-TRL2-ERP-014.006
OBJ-SATERA-TRL2-ERP-015	CRT-REQ-SATERA-TRL2-ERP-015.001 CRT-REQ-SATERA-TRL2-ERP-015.002 CRT-REQ-SATERA-TRL2-ERP-015.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-015.004 CRT-REQ-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.001 CRT-OPT-SATERA-TRL2-ERP-015.002 CRT-OPT-SATERA-TRL2-ERP-015.003 CRT-OPT-SATERA-TRL2-ERP-015.004 CRT-OPT-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.006	Fully covered	OBJ-SATERA-TRL2-ERP-015	CRT-REQ-SATERA-TRL2-ERP-015.001 CRT-REQ-SATERA-TRL2-ERP-015.002 CRT-REQ-SATERA-TRL2-ERP-015.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-015.004 CRT-REQ-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.001 CRT-OPT-SATERA-TRL2-ERP-015.002 CRT-OPT-SATERA-TRL2-ERP-015.003 CRT-OPT-SATERA-TRL2-ERP-015.004 CRT-OPT-SATERA-TRL2-ERP-015.005 CRT-OPT-SATERA-TRL2-ERP-015.006

EUROPEAN PARTNERSHIP
Co-funded by the European Union

OBJ-SATERA-TRL2-ERP-016	CRT-REQ-SATERA-TRL2-ERP-016.001 CRT-REQ-SATERA-TRL2-ERP-016.002 CRT-REQ-SATERA-TRL2-ERP-016.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-016.004 CRT-REQ-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.001 CRT-OPT-SATERA-TRL2-ERP-016.002 CRT-OPT-SATERA-TRL2-ERP-016.003 CRT-OPT-SATERA-TRL2-ERP-016.004 CRT-OPT-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.006	Fully covered	OBJ-SATERA-TRL2-ERP-016	CRT-REQ-SATERA-TRL2-ERP-016.001 CRT-REQ-SATERA-TRL2-ERP-016.002 CRT-REQ-SATERA-TRL2-ERP-016.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-016.004 CRT-REQ-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.001 CRT-OPT-SATERA-TRL2-ERP-016.002 CRT-OPT-SATERA-TRL2-ERP-016.003 CRT-OPT-SATERA-TRL2-ERP-016.004 CRT-OPT-SATERA-TRL2-ERP-016.005 CRT-OPT-SATERA-TRL2-ERP-016.006
OBJ-SATERA-TRL2-ERP-017	CRT-REQ-SATERA-TRL2-ERP-017.001 CRT-REQ-SATERA-TRL2-ERP-017.002 CRT-REQ-SATERA-TRL2-ERP-017.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-017.004 CRT-REQ-SATERA-TRL2-ERP-017.005 CRT-OPT-SATERA-TRL2-ERP-017.001 CRT-OPT-SATERA-TRL2-ERP-017.002 CRT-OPT-SATERA-TRL2-ERP-017.003 CRT-OPT-SATERA-TRL2-ERP-017.004 CRT-OPT-SATERA-TRL2-ERP-017.005 CRT-OPT-SATERA-TRL2-ERP-017.006	Fully covered	OBJ-SATERA-TRL2-ERP-017	CRT-REQ-SATERA-TRL2-ERP-017.001 CRT-REQ-SATERA-TRL2-ERP-017.002 CRT-REQ-SATERA-TRL2-ERP-017.003 ESASSP CRT-REQ-SATERA-TRL2-ERP-017.004 CRT-REQ-SATERA-TRL2-ERP-017.005 CRT-OPT-SATERA-TRL2-ERP-017.001 CRT-OPT-SATERA-TRL2-ERP-017.002 CRT-OPT-SATERA-TRL2-ERP-017.003 CRT-OPT-SATERA-TRL2-ERP-017.004 CRT-OPT-SATERA-TRL2-ERP-017.005

				CRT-OPT-SATERA-TRL2-ERP-017.006
OBJ-SATERA-TRL2-ERP-018	CRT-REQ-SATERA-TRL2-ERP-018.001 CRT-REQ-SATERA-TRL2-ERP-018.002 CRT-REQ-SATERA-TRL2-ERP-018.003	Fully covered	OBJ-SATERA-TRL2-ERP-018	CRT-REQ-SATERA-TRL2-ERP-018.001 CRT-REQ-SATERA-TRL2-ERP-018.002 CRT-REQ-SATERA-TRL2-ERP-018.003

Table 32: validation objectives addressed in validation exercise #2.3

5.5.4 Validation scenarios

5.5.4.1 Reference scenario

The reference scenario is defined in the EUR/SAM corridor. According to ENAIRE **¡Error! No se encuentra el origen de la referencia.**, the aggregate number of flights in the EURSAM exceeded 40,000 in 2019..Therefore, this scenario covers the En-route medium complexity sub-operating environment.

The oceanic Atlantic airspace is divided in five Oceanic Control Areas, as shown in Figure 13:

- Canarias,
- Sal Oceanic,
- Dakar Oceanic,
- Atlantic (Brazil), and
- Recife

Still in Figure 13, the Southbound routes use the flight levels FL300, FL320, FL340, FL360, FL380 and FL400. The Northbound routes use the flight levels FL290, FL310, FL330, FL350, FL370, FL390 and FL410. **¡Error! No se encuentra el origen de la referencia.** depicts ground-based surveillance coverage, showing the coverage gap in the EUR/SAM region (highlighted with a frame). Aireon's space-based ADS-B coverage largely fills this gap, as shown in Figure 15. However, the figure also indicates that Aireon's coverage over the EUR/SAM typically involves fewer than three simultaneous satellites, falling short of the minimum (disregarding DOP effects) needed to compute aircraft positions via multilateration. Other non-ADS-B surveillance sources that provide GNSS-independent data also offer limited coverage, thereby constraining both the provision of an independent surveillance layer and the ability to verify ADS-B position integrity by cross-checking with non-GNSS-based fixes.

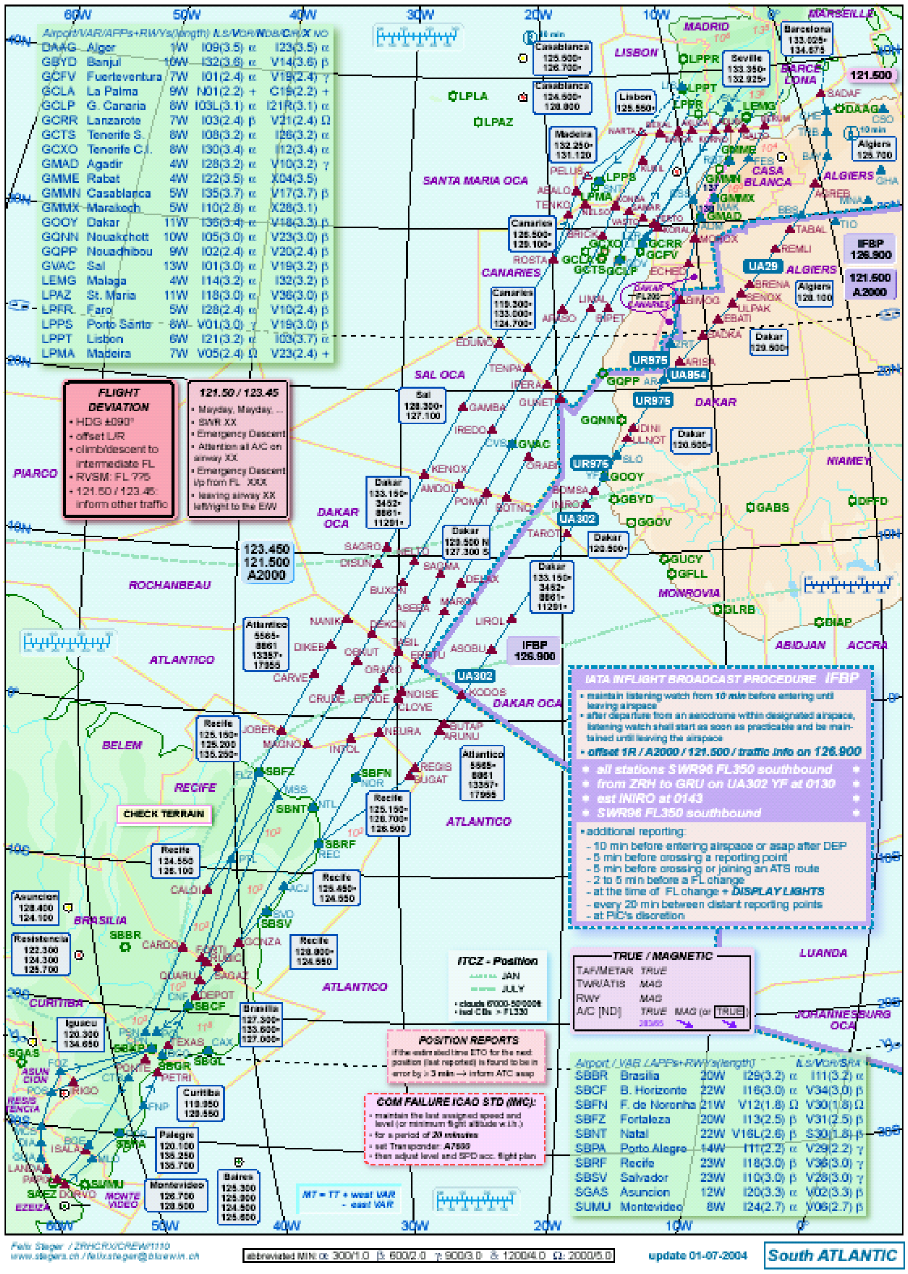

Figure 13. Oceanic Control Areas in the EUR/SAM corridor ¡Error! No se encuentra el origen de la referencia.

Co-funded by the European Union

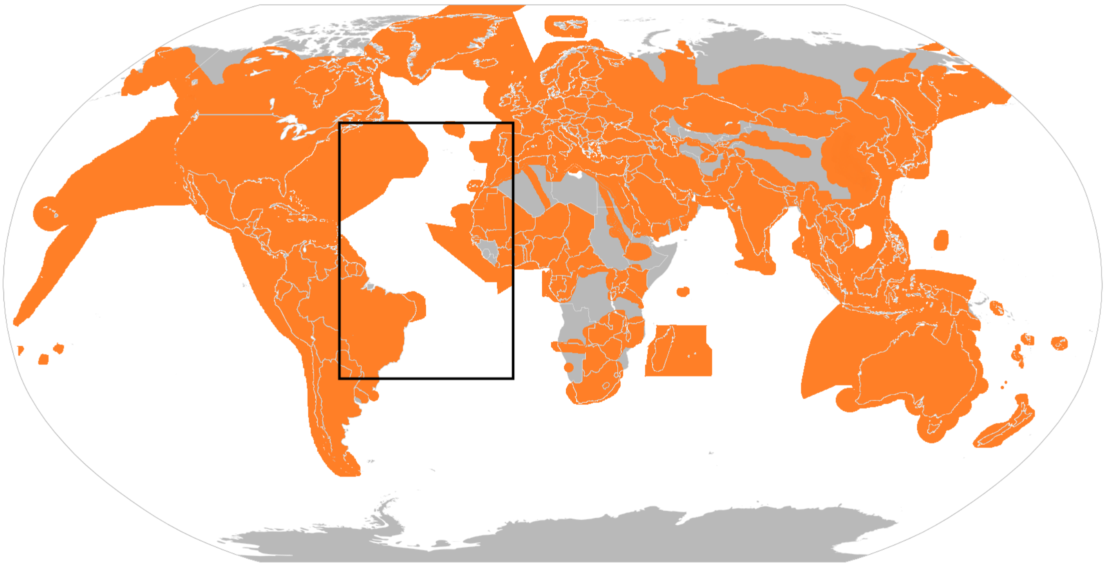

Figure 14 Ground-based ADS-B and SSR composite surveillance coverage, with the EUR/SAM region delineated by a blue frame ¡Error! No se encuentra el origen de la referencia..

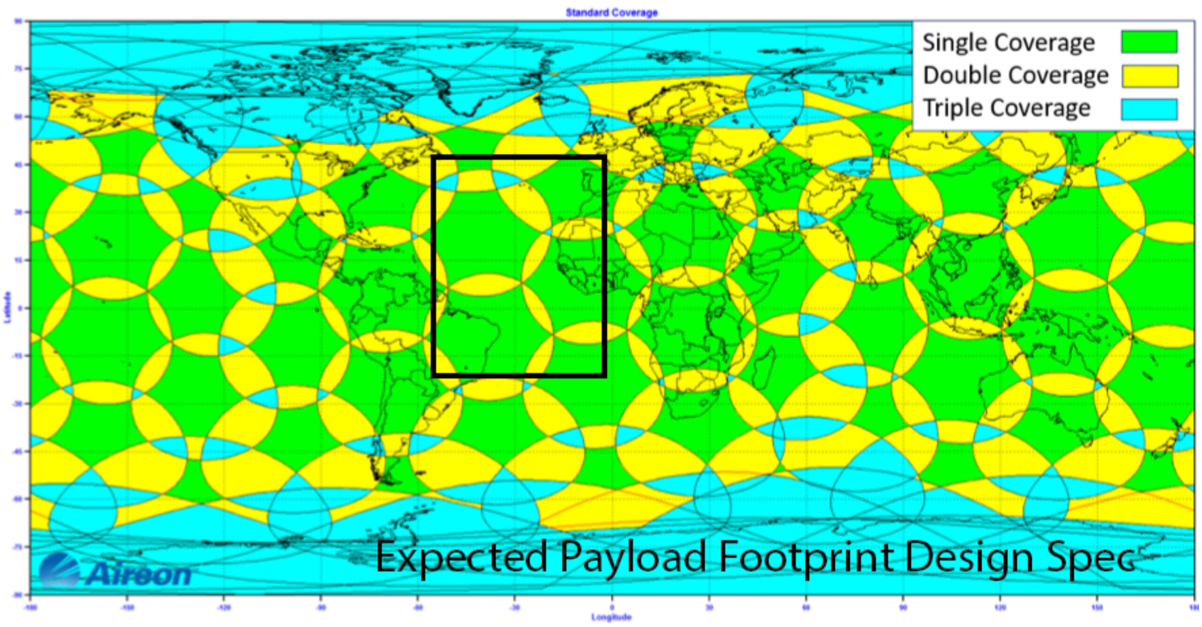

Figure 15. Aireon's Space-Based ADS-B coverage, with the EUR/SAM region delineated by a blue frame ¡Error! No se encuentra el origen de la referencia..

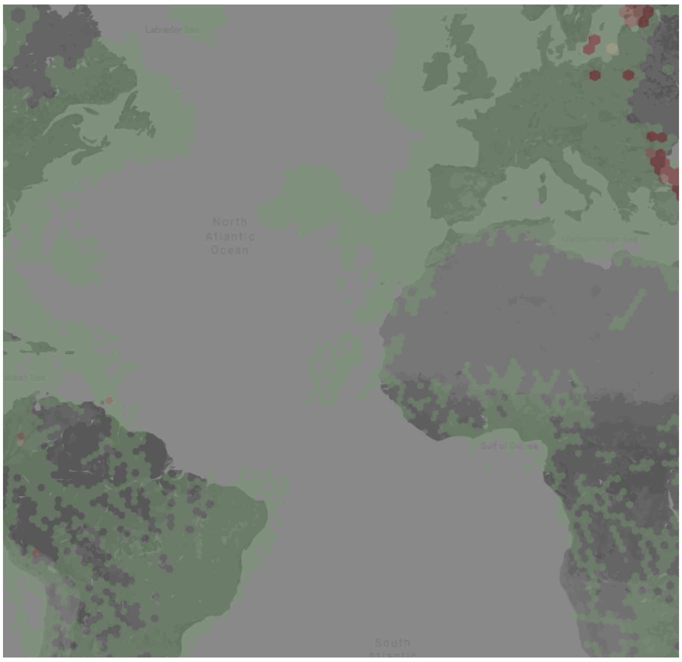

Figure 16. GNSS jamming map (affecting ADS-B reported positions) ¡Error! No se encuentra el origen de la referencia..

5.5.4.2 Solution scenario(s)

Solution scenario will consist of the EUR/SAM region, as described in Section 5.2.4.1, but with the SATERA solution providing space-based multilateration surveillance. SATERA outcomes will consist of: (1) a GNSS independent surveillance layer, and (2) an integrity estimator based on the crosscheck of MLAT computed positions and ADS-B reported fixes.

Both normal and abnormal conditions, as described in Section 4.4 will be considered.

5.5.5 Exercise validation assumptions

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
ASSUMP-SATERA-TRL2-ERP-2.2-001	Per-OCA assessment	Assessing SATERA performance by OCA yields results like those of a comprehensive evaluation of the entire NAT region.	Evaluating SATERA performance across the entire region is prohibitively time-consuming.	Noncritical (from validation exercise #2.1)

Table 33: validation exercise #2.3 assumptions

EUROPEAN PARTNERSHIP

Co-funded by the European Union

5.5.6 Limitations and impact on the level of significance

Neither the general assumptions in Section 4.4 nor the assumptions specific to validation exercise #1.2 listed in Table 18: validation exercise #1.1 assumptions

limit the significance of the results. Concerning assumptions Table 18: validation exercise #1.1 assumptions

:

- Conducting the assessment at OCA level pursues a trade-off between accuracy and computation time. validation exercise #2.1 will provide the relation of OCA assessment and NAT corridor wide ones enabling the extrapolation of results without loss of accuracy.
- The number of target report recorded within OCAs will suffice to obtain statistically sound results. In any case, SATERA SET will take into consideration the impact of the sample size on the significance of the computed metrics when assessing the compliance with the ESASSP requirements based on the method described in ED-129 and adopted in the ESASSP Ed. 1.3

5.5.7 Validation exercise platform / tool and validation technique

5.5.7.1 Validation exercise platform / tool characteristics

See Section 5.1.7.1.

5.5.7.2 Validation exercise technique

Validation exercise #2.3 will consist of non-real-time, large-scale simulations. This technique is commonly used in surveillance systems performance assessment, as there are no real time requirements and data recorded during several hours are usually needed to guarantee the statistical soundness of the results.

5.5.8 Data collection and analysis

5.5.8.1 Data and data collection methods

Validation exercise #1.2 will use both external data and data generated by the project. External data will consist of ADS-B data provided by COLLINS from FlightAware with the following data items:

- Pitr: Unix timestamp (in seconds) representing when the position record was processed.
- Type: Type of message. Normally, this field will say Position, meaning it has ADS-B position data.
- Ident: Flight identifier, usually the callsign.
- Air ground: Indicates whether the aircraft is airborne (A) or on the ground (G).
- Alt: Altitude (in feet) of the aircraft.
- AltChange: Rate or direction of altitude change. Often blank when altitude is stable.
- Atcident: Timestamp representing when the ADS-B data was generated by the aircraft. Normally, this field will be empty, meaning the aircraft is not broadcasting this timestamp. Most aircraft do not do so.
- Clock: Unix timestamp (in seconds) indicating when FlightAware recorded this message.
- Dest: Destination airport ICAO code.

- Facility hash: Identifier for the ADS-B receiving station. It is unique.
- Facility name: Name of the source that collected the data. Example: FlightAware ADS-B.
- Id: Message / track ID generated by FlightAware. It is unique.
- Gs: Ground speed (in knots).
- Heading: Aircraft heading (in degrees (0–359)).
- Lat: Latitude of the aircraft at that moment (in degrees).
- Lon: Longitude of the aircraft at that moment (in degrees).
- Orig: Origin airport ICAO code.
- Reg: Aircraft registration.
- UpdateType: Type of update. Usually A, for ADS-B update.

External data will be provided in CSV format. Data generated by the project will consist of MLAT target reports in ASTERIX CAT020 produced by the UPV and UC teams using SATERA SET. A specific folder will be created in the SATERA SharePoint to share these data among the SATERA researchers involved in the validation exercise.

5.5.8.2 Analysis methods

UPV and UC teams will produce MLAT target reports applying the algorithms described in deliverables D.3.1, D4.2, D6.1 and D6.2 and will export them in ASTERIX CAT020. Performance metrics will be computed according to the procedures described in ESAASSP Ed. 1.3 Vol. 1. Performance assessment will be conducted for each OCA within the NAT corridor independently.

5.5.9 Exercise planning and management

5.5.9.1 Activities

Validation exercise #2.3 will consist of the following activities:

- Activity1: Preparation of FlightAware datasets (the FlightAware datasets needed for all validation exercises will be created and validated before the exercises kick-off).
- Activity 2: Assessment under normal conditions.
- Activity 3: Assessment under abnormal conditions: space weather.
- Activity 4: Assessment under abnormal conditions: jamming.
- Activity 5: Assessment under abnormal conditions: spoofing.

5.5.9.2 Roles and responsibilities in the exercise

The following roles and responsibilities have been identified in Validation exercise #2.2.

- UPV and COLLINS will define the flights the dataset shall contain.
- UPV and UC will generate MLAT surveillance data for the flights in the data sets (one data set per OCA), both under normal and abnormal conditions.
- UPV will compute applicable 5/3 NM ESASSP performance metrics for the MLAT surveillance data using SATERA SET, both in normal and in abnormal conditions.
- UPV COLLINS will review the metrics and assess whether the applicable validation objectives have been achieved.

Co-funded by the European Union

5.5.9.3 Time planning

Activity	2025	2026			
	W51	W10	W11	W12/13	W13/14
Activity 1	MS2.3-1				
Activity 2		MS2.3-2			
Activity 3			M2.3-3		
Activity 4				MS2.3-4	
Activity 5					MS2.3-5

Table 34: detailed exercise #2.2-time planning

Validation exercise milestones:

- MS2.3-1: Validated FlightAware ADS-B data for validation exercise #2.3 available in the project SharePoint.
- MS2.3-2 Results from validation exercise #2.3 under normal conditions have been generated.
- MS2.3-3 Results from validation exercise #2.3 under abnormal conditions (space weather) have been generated.
- MS2.3-3 Results from validation exercise #2.3 under abnormal (jamming) conditions have been generated.
- MS2.3-5 Results from validation exercise #2.3 under normal conditions (spoofing) have been generated.

5.5.9.4 Identified risks and mitigation actions

No risks affecting validation exercise #2.3 have been reported in STELLAR.

6 References

[1] "SATELLITE-BASED ADS-B FOR LOWER SEPARATION-MINIMA APPLICATION (SALSA), Grant agreement ID: 699337," European Commission, Apr. 2016–Mar. 2018.

[2] "Satcom and terrestrial architectures improving performance, security and safety in ATM (SAPIENT), Grant Agreement ID: 699328," European Commission, Apr. 2016–Sep. 2017.

[3] EUROCONTROL, EUROCONTROL Specification for ATM Surveillance System Performance. Volume 1, EUROCONTROL-SPEC-0147, ed. 1.3, Jun. 26, 2023.

[4] https://www.enaire.es/es_ES/2019_01_25/ndp_planverano. [Accessed: Nov. 30, 2025]

[5] ICAO, North Atlantic Operations and Airspace Manual, v.2025-1, applicable from March 2025.

[6] ICAO North Atlantic Annual Safety Report, NAT Systems Planning Group, 2023 edition.

[7] Reuters, "EU says von der Leyen's plane GPS system was jammed, Russian interference suspected," Sept. 1, 2025. [Online]. Available: https://www.reuters.com/world/europe/eu-says-von-der-leyens-plane-gps-system-was-jammed-russian-interference-2025-09-01/. [Accessed: Nov. 30, 2025].

[8] The Brussels Times, "Majority of drone flights over sensitive areas in Belgium are unauthorised," Sept. 30, 2025. [Online]. Available: https://www.brusselstimes.com/843948/majority-of-drone-flights-over-sensitive-areas-in-belgium-are-unauthorised. [Accessed: Nov. 30, 2025].

[9] Sirigu, Giuseppe, John Dolan, and Michael A. Garcia. "Independent Estimation of Aircraft Positions Using Space-Based ADS-B Data for GNSS Anomaly Identification and Investigation." 2025 Integrated Communications, Navigation and Surveillance Conference (ICNS). IEEE, 2025.

[10] Airwaze Avionics, "ADS-B Components," *ADS-B Overview*. [Online]. Available: https://airwazeavionics.com/ads-b-overview/ads-b-how-it-works/ads-b-components/. [Accessed: Nov. 23, 2025].

[11] Aireon, "Satellite Wide-Area Multilateration Solution," 2025. [Online]. Available: https://aireon.com/wp-content/uploads/2025/05/Aireon-White-Paper-Satellite-Wide-Area-Multilateration.pdf. [Accessed: Nov. 30, 2025].

[12] Flightradar24, "GPS Jamming," [Online]. Available: https://www.flightradar24.com/data/gps-jamming. [Accessed: Nov. 23, 2025].

[13] ENAIRE, "ENAIRE surpasses 2.1-million flight mark in 2019," Jan. 10, 2020. [Online]. Available: https://www.enaire.es/en_GB/2020_01_10/enaire_surpasses_2.1-million-flight_mark_in_2019. [Accessed: Nov. 30, 2025].

[14] ENAIRE, EUR/SAM Corridor: 2016 Collision Risk Assessment, Code: NYVI-IDSA-INF-017-17-1.0, Prepared: 29 May 2017.

EUROPEAN PARTNERSHIP

Co-funded by the European Union