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# SESAR PJ.14-W2-84a - Multi Sensor Data Fusion - Contextual Note - TRL6

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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Eurocontrol | Task Contributor | 26.10.2022 |
| Thales | Task Lead | 26.10.2022 |
| Thales | Solution 84 Lead | 26.10.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Eurocontrol | Task Contributor | 26.10.2022 |
| Thales | Task Lead | 26.10.2022 |
| Thales | Solution 84 Lead | 26.10.2022 |

### Approved for submission to the SJU By - Representatives of all beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Eurocontrol | Task Contributor | 26.10.2022 |
| Thales | Solution 84 Lead | 26.10.2022 |

### Rejected By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|

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# PJ.14 W2 I-CNSS

INTEGRATED COMMUNICATION, NAVIGATION AND SURVEILLANCE SYSTEMS

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## Abstract

This TRL6 Contextual Note provides the SESAR2020 Solution PJ.14-W2-84a description for industrialization consideration. This Solution addresses multi-sensor data fusion improvements.

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There are no figures in this document.



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# 1 Purpose

This contextual note introduces SESAR PJ.14-W2-84a Multi-sensor data fusion. It provides expected improvements to ATC, impact in the EATM Roadmap, main performance benefits.

The solution has achieved TRL6 maturity at the end of Wave 2 by integrating in the multi-sensor data fusion new surveillance sources and developing an advanced monitoring of tracker coherence.

The solution fulfilled the main objectives based on performance-based approach proving that emerging surveillance techniques and technologies can be seamlessly integrated into the ATM infrastructure.



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# 2 Improvements in Air Traffic Management (ATM)

The Solution PJ14-W2-84a has proved that the surveillance data output from new and emerging surveillance techniques and technologies can be seamlessly integrated in to the ATM infrastructure.

The Solution PJ14-W2-84a is applicable to TMA environment supporting 3 NM minima separation requirements and En-Route (ER) supporting 5 NM minima separation requirements.

The first part of the Solution PJ14-W2-84a was to adapt multi-sensor tracker systems for the new input data characteristics, especially MSPSR (EN: CTE-S08a) and ADS-B data sourced from satellite (EN: CTE-S08b)

In order to understand the issues related to the integration of these two new surveillance sensors, a short description of the characteristics of the MSPSR and the space based ADS-B is proposed below.

MSPSR (Multi-Static Primary Surveillance Radar) is an independent surveillance technology that uses a distributed transmitter and receiver architecture to detect aircraft (see Figure 1 MSPSR System description).

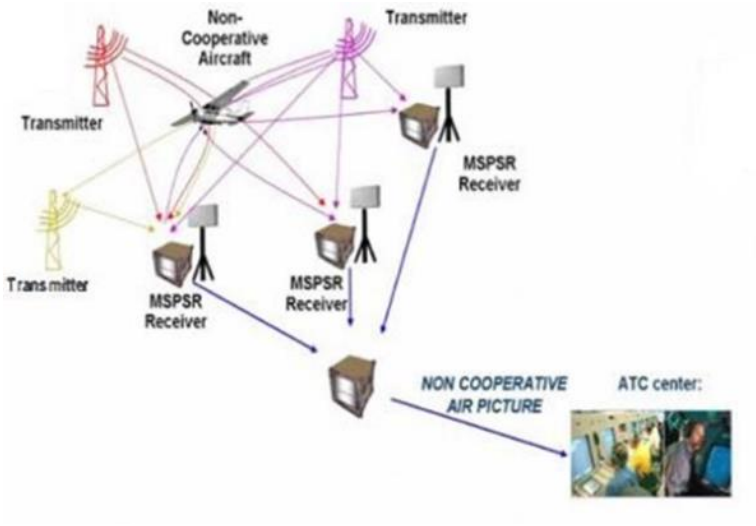


**Figure 1 MSPSR System description**

MSPSR main strength are:

- Improving the probability of detection in certain low-altitude coverage areas (TMA);
- Primary re-enforcement without degrading position accuracy.

Space-based ADS-B provides the same capabilities as conventional ground-based ADS-B. Space-based ADS-B relies on a constellation of satellites made up of 66 satellites (see Figure 2 Space based ADS-B description).



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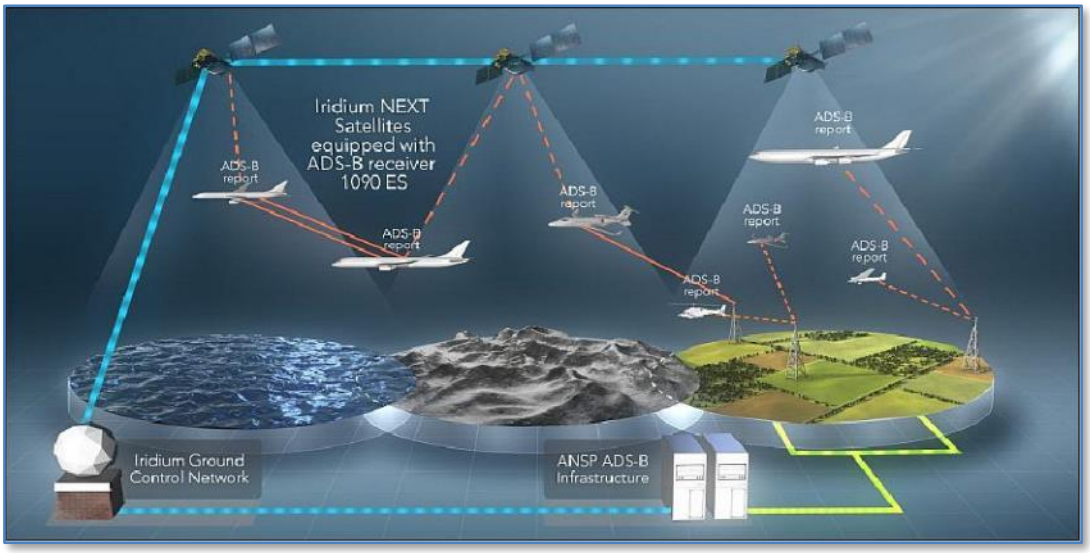


**Figure 2 Space based ADS-B description**

The main advantage of space based ADS-B is that it can considerably extend the coverage area with coverage areas greater than squares of 4000NM per side.

The second part of the Solution PJ14-W2-84a was to develop a performance-based data fusion based on an advanced monitoring of the tracker and sensor coherence.

The improvement for the ANSPs is to provide continuously the level of performance of the multi sensor data fusion for ATM system supporting 3NM horizontal separation for TMA application and 5NM horizontal separation for En Route application. The system is able to raise alerts on degradation of the Tracker Quality of Service (TQOS). The improvement is also to provide continuously the level of performance for each sensor. The system is able to raise alerts on degradation of Sensor Quality of Service (SQOS) for a given sensor.

The improvements foreseen for ATM system are:

- Improving the non-cooperative coverage in TMA areas integrating new independent non cooperative surveillance sources (MSPSR) in ASTERIX Category 015 for primary coverage in TMA ,
- Improving the surveillance coverage in oceanic areas integrating ADS-B data sourced from satellite for oceanic coverage;
- Cost efficiency and safety improvement through continuous evaluation of the sensors and tracker performance assessing their surveillance quality of service (QoS);
- Diagnose capacity for detecting sensor degradation causing tracking degradation;
- Increased automation.



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# 3 Operational Improvement Steps (OIs) & Enablers

SESAR2020 PJ.14-W2-84a Technological Solution covers the following enablers:

| Enabler ID | Enabler Title | Enabler coverage | Dataset |
|---|---|---|---|
| **CTE-S08a** | SUR Chain ER&TMA (MSPSR) | Full | 22 |
| **CTE-S08b** | SUR Chain ER&TMA (Space-based ADS-B) | Full | 22 |
| **SVC-063** | MultiSensorDataFusion Service | Full | 22 |
| **CTE-S03d** | Satellite based ADS-B technology | Full | 22 |

**Table 1. SESAR2020 PJ.14-W2-84a enablers list**

These enablers support the following OI steps:

| POI Code | POI Title | Dataset |
|---|---|---|
| • **POI-0057-SUR** | Enhanced Integrity Surveillance | 22 |

**Table 2. SESAR2020 PJ.14-W2-84a OI steps list**



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# 4 Background and validation process

Four validation exercises cover the Validation Objectives for PJ.14-W2-84a Solution:

- PJ.14-W2-84a EXE01 Verification of multi-sensor data fusion integrating emerging surveillance techniques and technologies (MSPSR and space based ADS-B) addresses validation objective OBJ-PJ.14-W2-84a-TRL6-TVALP-001.1 and OBJ-PJ.14-W2-84a-TRL6-TVALP-001.2. This exercise covers both the integration of MSPSR (EN: CTE-S08a) and the integration of Space-Based ADS-B (EN: CTE-S08b) into the tracker T-TK.
- PJ.14-W2-84a EXE02 Monitoring of the multi-sensor data fusion based on performance assessment addresses validation objective OBJ-PJ.14-W2-84a-TRL6-TVALP-002. This exercise covers the validation of the online tracker performance function TQOS.
- PJ.14-W2-84a EXE03 Monitoring of multi-sensor data fusion based on sensor performance assessment addresses Validation Objective OBJ-PJ.14-W2-84a-TRL6-TVALP-003. This exercise covers the validation of the online sensor performance function SQOS.
- PJ.14-W2-84a EXE04 Supervision of multi-sensor data fusion based on surveillance integrity addresses Validation Objective OBJ-PJ.14-W2-84a-TRL6-TVALP-004. This exercise covers the validation of the online supervision of the global tracking function SQOSM and TQOSM.

With the specific objective to increase the maturity towards TRL6, the validation strategy for these exercises consisted in evaluating the performance metrics defined by ESASSP Ed 1.2 standard for the multi-sensor data fusion function. The realization of this TRL6 went through the implementation of an adequate testbed with a representative multi-sensor configuration including common coverage areas between ADS-B, Radar and MSPSR sensors. The realization of this testbed enabled a statistical evaluation of the performance of the multi-sensor data fusion integrating emerging surveillance techniques and technologies.

**In summary, the results for TRL6 in this Wave 2 Solution were successful**.



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# 5 Results and performance achievements

The following results were achieved as part of PJ.14-W2-84a Solution:

- the ability for multi-sensor data fusion to integrate MSPSR and space based ADS-B.
- the elaboration of sensor quality of service for online monitoring.
- the elaboration of tracker quality of service for online monitoring.
- the elaboration of a root cause analysis function to help ATSEP diagnosis.

Performance assessments were based on real data and representative multi sensors configuration. It was demonstrated that the multi sensor data fusion performs in the expected performance boundaries, when integrated INCS data and space based ADS-B, regarding the ESASSP requirements. It was also demonstrated the ability of the surveillance quality of service functions to detect safety critical issues and weak signals of performance degradation and to identify the root cause of surveillance quality of service degradation.



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# 6 Recommendations and Additional activities

The recommendations from PJ.14-W2-84a Solution are:

- to assess the system impacts linked to the integration of space based ADS-B and MSPSR within ATC-System (Extended coverage Areas, in bound Flight Plan Management).
- to assess the system impacts linked to the implementation of surveillance quality of service functions into ATM System.

PJ.14-W2-84a Solution recommends also the creation of a new SESAR project dedicated to the study of quasi real time surveillance performance monitoring. This study will focus on the following topics:

- KPI in low sampling condition: the purpose is to shorten the re-new of KPI for a better detection of surveillance performance degradation.
- KPI computation in degraded mode: use resilient algorithm for performance assessment in degraded mode.
- Assess the system and safety impacts linked to the implementation of surveillance performance monitoring functions into ATM-System.





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# 7 Actors impacted by the SESAR Solution

The PJ.14-W2-84a Solution targets ANSPs operating in the TMA & En-route operational environments.

The principal impacts are on:

- Air Traffic Controller (ATCO) through improving the air situation awareness within TMA with the use of innovative non-cooperative sensors; and within En-route oceanic areas with the use of space based ADS-B;
- Air Traffic Safety Electronics Personnel (ATSEP) through automation of the surveillance performance monitoring.



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# 8 Impact on Aircraft System

The solution PJ14-W2-84a does not affect to the Aircraft Systems.



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# 9 Impact on Ground Systems

The main impacts on Ground systems for PJ14-W2-84a are:

- Upgrading the SDPS of the ATM system
- Upgrading ATM supervision systems
- Upgrading ATM sensor infrastructure



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# 10 Regulatory Framework Considerations

The solution PJ14-W2-84a does not identify impact on the regulatory framework.



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# 11 Standardization Framework Considerations

The solution PJ14-W2-84a was based on the use of ESASSP version 1.2 for the multi-sensor data fusion performance assessment and surveillance quality of service elaboration.

EUROCAE Specifications:

The following EUROCAE specifications are pertinent to the activities conducted in PJ14 Solution 84a:

- EUROCAE ED-129B Technical Specification for a 1090 MHz Extended Squitter ADS-B Ground System Version dated March 2016 . (Note that corrections and clarifications to ED-129B are being recorded within EUROCAE WG51 SG4 and that it is anticipated that the specification will be taken up to ED-129C in 2018)
- EUROCAE ED-261 (GEN SUR SPR)

ASTERIX Specifications:

Whilst ASTERIX specifications are not strictly standards they are included here as they represent an agreed Interface Control Document that will be used in the scope of SESAR 14.04.03:

- ASTERIX Cat 015 NCS Target Reports Draft v0.8 Dated June 2017, v1.2 Dated October 2017 and Edition 1.0 Dated 16/07/19
- ASTERIX CAT 021 ADS-B Messages Edition 2.4 Dated 15/06/2015
- ASTERIX CAT 023 CNS/ATM Ground Station Service Message Edition 1.2 Dated 01/03/2009
- ASTERIX CAT 025 CNS/ATM Ground System Status Report Edition 1.1 Dated 09/11/2015
- ASTERIX CAT 062 System Track Data Edition 1.17 Dated 01/12/2014
- ASTERIX CAT 063 Sensor Status Messages Edition 1.3 Date 01/07/2007
- ASTERIX CAT 238 Service Prediction Reports Edition 1.1 Dated 24/10/2016
- ASTERIX CAT 247 Number Exchange (Part 20) Edition 1.2 Dated 01/02/2008



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# 12 Solution Data pack

The Data pack for this Solution includes the following documents:

- **Final TS/IRS:** *SESAR 2020 PJ.14-W2-84a – Multi Sensor Data Fusion – Final TS/IRS for TRL6* (D12.1.120, Ed. 00.02.00, September 2022). This document provides the Updated Technical Specifications and Interface Requirement Specifications (Final TS/IRS) related to SESAR Solution PJ.14-W2-84a – Improved Multi-Sensor Data Fusion.

- **TVALR:** *SESAR 2020 PJ.14-W2-84a – Multi Sensor Data Fusion – TVALR – TRL6* (D12.1.400, Ed. 00.01.01, September 2022). This document describes the Technical Validation Report (TVALR) of the SESAR2020 Technological Solution PJ.14-W2-84a – Improved Multi-Sensor Data Fusion. Four validation exercises have been identified to progress from an initial maturity level TRL4 to an intended maturity level TRL6 for enablers CTE-S08a and CTE-S08b.

  **The performance results of surveillance systems related to objective OBJ-PJ.14-W2-84a-TRL6-TVALP-001.2, that are reported as part of this Technological Validation Report (TVALR) are confidential. Therefore, two versions of TVALR exist: a public one which is part of TRL6 Data Pack and a Confidential one (with sensitive ADS-B data) which shall be only accessible by Solution Members, PJ14-W2 coordinator and SESAR3 JU.**

- **CBAT:** *SESAR 2020 PJ.14-W2-84a – Multi Sensor Data Fusion - Technical Cost Benefit Analysis (CBAT) for TRL6* (D12.1.500, Ed. 00.02.00, September 2022). This document presents the Cost Benefit Analysis (CBA) for the deployment of the SESAR technological solution PJ.14-W2-84a targeting a maturity level of TRL6. Solution PJ.14-W2-84a has the OI step POI-0057-SUR and provides the enablers CTE-S08a (SUR Chain ER & TMA MSPSR), CTE-S08b (SUR Chain ER & TMA Space-based ADS-B) and SVC-063 (MultiSensorDataFusion Service). Moreover, the solution uses enabler CTE-S03d (Satellite based ADS-B technology). The solution targets ANSPs in TMA & En-route operational environments for deployment.





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