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SESAR 2020 D12.1.120 - Multi Sensor Data Fusion - Final TS/IRS for TRL6

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Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Eurocontrol	Task Contributor	06.02.2023
Thales	Task Lead	06.02.2023
Thales	Solution 84 Lead	06.02.2023

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
Eurocontrol	Task Contributor	06.02.2023
Thales	Task Lead	06.02.2023
Thales	Solution 84 Lead	06.02.2023

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

Name/Beneficiary	Position/Title	Date
Eurocontrol	Task Contributor	06.02.2023
Thales	Solution 84 Lead	06.02.2023

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

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PJ.14 W2 I-CNSS

PJ.14-W2-84A-TRL6- NEW USE AND EVOLUTION OF COOPERATIVE AND NON-COOPERATIVE SURVEILLANCE - IMPROVED MULTI SENSOR DATA FUSION

This Final TS/IRS is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 874478 under European Union's Horizon 2020 research and innovation programme.

Abstract

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.

The solution PJ.14-W2-84a aims at adapting multi-sensor tracker systems for the new input data characteristics, especially MSPSR (CTE-S08a) and ADS-B data sourced from satellite (CTE-S08b) and implementing additional functionalities to improve Multi-Sensor Data Fusion (CTE-S08a). The solution will demonstrate the achievement and proposed improvements on several different platforms.

Solution PJ.14-W2-84a is part of a panel of six solutions defined in the scope of PJ14 surveillance solutions that progresses this solution from a maturity level TRL4 to a maturity level TRL6.

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1 Executive summary

Integration of new surveillance sources (ADS-B, WAM, enhanced Mode S and MSPSR) allows the use of additional data other than classical electromagnetic detection provided by the radar. In particular the new surveillance sources may deliver accurate position, speed and altitude data provided by on-board electronic equipment or (for the WAM) from reconstructed Time Difference of Arrival (TDOA).

It is essential that the surveillance data output from new and emerging surveillance techniques and technologies can be seamlessly integrated in to the ATM infrastructure. Mechanisms to elaborate on existing means to assess the performance of the new sensors are being developed within SESAR Solutions PJ.14-W2-84e and PJ.14-W2-84f.

Solution PJ.14-W2-84a is part of a panel of six solutions defined in the scope of PJ14 surveillance solutions that progresses this solution from an initial maturity level TRL4 to an intended maturity level TRL6.

Within Solution PJ.14-W2-84a has the focus of ensuring the interfaces between the sensors and subsequent processing stages, such as ARTAS and TTK multi-sensor tracker, are correct and fit for purpose.

The first component of the Solution PJ14-W2-84a is 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)

The second component of the Solution PJ14-W2-84a is to improve the multi-sensor data fusion (EN: CTE-S08a). This SESAR solution aims to develop a performance-based data fusion based on an advanced monitoring of the tracker coherence.

The aim of this document is to produce the consolidated technical requirements for the implementation of the multi-sensor data fusion capabilities previously described.

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2 Introduction

This project is part of the SESAR 2020 Multi Annual Program for the period 2020-2022. It is part of the Industrial Research & Validation phase, developed under the SJU Private Public Partnership. Solution PJ14-W2-84a is a continuation of the work initiated by PJ14-04-03 Task 3 which reached Maturity TRL4 at the end of Wave 1. The solution targets TRL6 at the end of Wave 2.

There are no changes with respect to the architecture representation that was defined and entered into EATMA in Wave 1 for PJ14-04-03 Improved Multi-Sensor Data Fusion.

Communications, Navigation and Surveillance (CNS) systems provide the invisible and often unappreciated infrastructure which is essential for Air Traffic Management. CNS enables efficient navigation and safe separation in all phases of flight.

In Surveillance, solutions will be developed to enhance, harmonize and integrate cooperative and emerging non-cooperative sensors, advanced multi-sensors data fusion capabilities, security related functionality together with the methods and tools for Surveillance Performance Monitoring. This is in line with a performance based Surveillance (PBS) approach.

The objective of the solution PJ14-W2-84a is to adapt multi-sensor tracker systems for the new surveillance technology characteristics.

2.1 Purpose of the document

This document provides Updated Technical Specifications and Interface Requirement Specifications (Final TS/IRS) related to Solution PJ14-W2-84a Improved Multi-Sensor Data Fusion, targeting Maturity TRL6 by the end of wave 2.

2.2 Scope

Integration of new surveillance sources (ADS-B, WAM, enhanced Mode S and MSPSR) allows the use of additional data other than classical electromagnetic detection provided by the radar. In particular, the new surveillance sources may deliver accurate position, speed and altitude data provided by on-board electronic equipment or in the case of WAM using reconstructed Time Difference of Arrival (TDOA).

It is essential that the surveillance data output from new and emerging surveillance techniques and technologies can be seamlessly integrated in to the ATM infrastructure. Mechanisms to elaborate on existing means to assess the performance of the new sensors are being developed within SESAR Solutions PJ.14-W2-84e and PJ.14-W2-84f.

Within SESAR PJ14, Solution 84a has the focus of ensuring the interfaces between the sensors and subsequent processing stages, such as TTK multi-sensor tracker, are correct and fit for purpose.

The first component of the SESAR PJ14 Solution 84a is 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)

The second component of the SESAR PJ14 Solution 84a is to improve the multi-sensor data fusion (EN: CTE-S08a). This SESAR solution aims to develop a performance-based data fusion based on an advanced monitoring of the tracker coherence.

2.3 Intended readership

The intended readership for this document is:

- The SESAR Joint Undertaking;
- The SESAR PJ14 Solution 84 project partners
- The SESAR PJ14 Solution 84a project partners:
    - THALES France
    - EUROCONTROL

2.4 Background

The first component of the SESAR PJ14 Solution 84a is to perform an INCS integration into an ATC SDPS. Technical studies have been performed in order to select candidate solution to meet the objective of developing an INCS. Results of these studies are available in the PJ.15-04-02 (SESAR1 project) technical studies report [51] and PJ.14-04-03 (SESAR2020 W1 Solution) Task 3 TS/IRS. Main conclusion addresses the development of a MSPSR based on several technologies that are FM, DVB-T and L-Band.

The second component of the SESAR PJ14 Solution 84a deals with the satellite-based ADS-B integration into an ATC SDPS. If available, the background for this integration - outside SESAR - is the demonstrated compliance with EUROCAE ED129B [40] and the delivery of the EASA Certification (approval as a Surveillance Data Service Provider).

2.5 Structure of the document

This document is structured as follows:

Chapter 1: Executive summary

Chapter 2: Introduction

Chapter 3: SESAR solution impacts on architecture

Chapter 4: Technical specifications

Chapter 5: Recommendation for Implementation

Chapter 6: Assumptions

Chapter 7: References and applicable documents

Appendix A: Service Description Document (SDD)

Appendix B: PJ14.04.03 Task 03 requirements removed in PJ14 Solution 84a

2.6 Glossary of terms

Term	Definition	Source of the definition
SENSOR DATA RECEPTION	The Sensor Data Reception consists of data acquisition and validation of the connected surveillance sources (sensors or systems). The received validated data is geographical and height filtered (configurable offline), taking into account the detection characteristics of each sensor type.	PJ14 Solution 84a
MULTI SENSOR DATA FUSION	The Multi-Sensor Data Fusion aims to associate target reports of an aircraft detected from different sources to a unique multi-sensor track. Once associated, the sensor report contributes to the multi-sensor track state in accordance with the estimated level of confidence of the related sensor.	PJ14 Solution 84a
MULTI SENSOR TRACK DISTRIBUTION	The Multi-Sensor Track Distribution aims to provide a track service management for the distribution of the Air Situation Picture.	PJ14 Solution 84a

Table 1: Glossary

2.7 Acronyms and Terminology

Term	Definition
ACC	Area control center or area control
ADD	Architecture Description Document
ADS-B	Automatic Dependent Surveillance - Broadcast

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ANSP	Air Navigation Service Provider
APP	Approach Control
ARTAS	Air traffic management surveillance tracker and server
ASTERIX	All Purpose STructured Eurocontrol SuRveillance Information Exchange
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
CC	Capability Configuration
CMB	Combined radar (PSR + SSR comounted radar)
COM	Communications
COMPOSITE	Characteristic of a surveillance system providing two independent surveillance technologies.
COMPOSITE PLUS	Characteristic of a surveillance system based on a composite SDPS which uses INCS outputted Cartesian plots to validate and/or improve secondary plots/tracks.
DOD	Detailed Operational Description
DVB-T	Digital Video Broadcast - Terrestrial
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
ESASSP	EUROCONTROL Specification for ATM Surveillance System Performance
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
IER	Information Exchange Requirement
INCS	Independent Non Cooperative Sensor

INTEROP	Interoperability Requirements
IP	Internet Protocol
IRS	Interface Requirements Specification
ISRM	Information Services Reference Model
MSPSR	Multi Static Primary Surveillance Radar
NAF	NATO Architecture Framework
NCS	Non Cooperative Sensor
NSOV	NAF Service Oriented View
NOV	NAF Operational View
NSV	NAF System View
OSED	Operational Service and Environment Definition
PSR	Primary Surveillance Radar
QoS	Quality of Service
R&D	Research & Development
Rx	Receiver
SDD	Service Description Document
SDPS	Sensor Data Processing System
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SoaML	Service Oriented Architecture Modelling Language
SPM	Surveillance Performance Monitoring
SPR	Safety and Performance Requirements
SWIM	System Wide Information Model
SQOS	Sensor Quality Of Service function
SQOSM	Sensor Quality Of Service Monitoring

SSR	Secondary Surveillance Radar
SUR	Surveillance
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level
TS	Technical Specification
TTK	Thales Topsky Tracker
TQOS	Tracker Quality of Service
TQOSM	Tracker Quality of Service Monitoring
UDP	User Datagram Protocol
UML	Unified Modelling Language
V&V	Validation and Verification
WAM	Wide Area Multilateration
WG	Working Group
WSDL	Web Services Definition Language
XSD	XML Schema Definition

Table 2: Acronyms and terminology

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3 SESAR Solution Impacts on Architecture

3.1 Target Solution Architecture

3.1.1 SESAR Solution(s) Overview

The objective of this solution is to ensure that the interfaces between the sensors and subsequent processing stages - in our case the multi-sensor trackers - are correct and fit for purpose. The two main components are:
- to adapt multi-sensor tracker systems for the new input data characteristics, especially MSPSR and ADS-B data sourced from satellite.
- to improve the multi-sensor data fusion. This SESAR solution aims to develop a performance-based data fusion based on an advanced monitoring of the tracker coherence.

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage	Open CR
PJ14-W2-84a: Multi sensor Data Fusion	Surveillance Chain Data Fusion	CTE-S08a	SUR Chain ER&TMA (MSPSR)	• **Fully**	CR 00244 Create CTE-S08a (PJ.14-W2-84A)
PJ14-W2-84a: Multi sensor Data Fusion	Surveillance Chain Data Fusion	CTE-S08b	SUR Chain ER&TMA (Space-based ADS-B)	• **Fully**	CR 00245 Create CTE-S08b (PJ.14-W2-84A)

Table 3: SESAR PJ14 Solution 84a Scope and related Functional Blocks/roles & Enablers

OI Step	OI description	Open CR

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POI-0007-CNS	Surveillance Chain Data Fusion	CR 05243

Table 4: SESAR Solution PJ14-W2-84a Operational Improvement Steps

3.1.1.1 Deviations with respect to the SESAR Solution(s) definition

No deviation.

3.1.1.2 Relevant Use Cases

The relevant 3 NM and 5 NM separation use cases are the one detailed within the ESASSP specification for cooperative and non-cooperative Surveillance [39].

The specific use cases for ADS-B are described in EUROCAE Technical Specification ED-129B [40] and are derived from ESASSP specification [39].

Potential use case for non-cooperative Surveillance sensors (INCS) were described in SESAR 15.4.2 as well as in the ESASSP. These are now subject to further development in both EUROCAE working groups WG-102 [41] and 103 [42].

System Process	Description
[NSV-4] T03 - ATC SUR Processing	This SESAR solution aims to support the integration of data from emerging surveillance techniques/technologies in to the wider ATM infrastructure. Of particular interest is ADS-B data sourced from satellites and NCS data presented in a system agnostic ASTERIX format. The main functional components of the ATC Surveillance Tracking system are: - Surveillance Data Acquisition - Data Association - Track Distribution The Surveillance Data Acquisition consists of data reception and validation of the connected surveillance sources (sensors or systems). The received validated data is geographical and height filtered (configurable offline), taking into account the detection characteristics of each sensor type. The Surveillance Data Acquisition uses the state-of-the-art interface standards (ASTERIX over UDP/IP) for sensor data reception. The Data association aims to associate target reports of an aircraft detected from different sources to a unique multi-sensor track. Once associated, the sensor report contributes to

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	the multi-sensor track state in accordance with the estimated level of confidence of the related sensor. The Track Distribution aims to provide a track service management for the distribution of the Air Situation Picture. The ATC Surveillance tracking function is represented schematically in the diagram which follows, wherein are identified the functional components of the ATC Surveillance Tracking system previously defined and other systems with which the ATC Surveillance tracking function exchanges data and the flows that this entails. An arrow identifies an interface. An interface can be with: - another Component of the system, - an external line, - A data store. The ATC surveillance tracking function is represented in the scope of the PJ.14-W2-84a solution. In Figure 3 – ATC SUR Processing System Functional presentation, the following interfaces are represented: - Secondary Radar Interface: for the reception of Secondary radar messages by Surveillance data acquisition function. - Primary Radar Interface: for the reception of Primary radar messages by Surveillance data acquisition function. - Space-Based ADS-B Interface: for the reception of space based ADS-B messages by Surveillance data acquisition function. - MSPSR Interface: for the reception of MSPSR messages by Surveillance data acquisition function. - ADS-B ground station interface: for the reception of ADS-B ground station messages by Surveillance data acquisition function. - APP/ACC interface: for the transmission of APP (approach) surveillance data messages and ACC (Air Control Center) surveillance data messages by the Track distribution function.
[NSV-4] T03 - Quasi real time performance monitoring	The second component of the SESAR PJ.14-W2-84a is to improve the multi-sensor data fusion. This SESAR solution aims to develop a performance-based data fusion which underlying objective is to improve the SDPS resilience based on an advanced monitoring of the tracker coherence. The quasi real time performance monitoring function is represented schematically in the diagram which follows, wherein are identified the functional components of the quasi

	real time performance monitoring system previously defined and other systems with which the quasi real time performance monitoring function exchanges data and the flows that this entails. An arrow identifies an interface. An interface can be with: - another Component of the system, - an external line, - A data store. The quasi real time performance monitoring function is represented in the scope of the PJ.14-W2-84a solution. In Figure 4 – Quasi real time performance monitoring System Functional presentation, the following interfaces are represented: - Secondary Radar Interface: for the reception of Secondary radar messages by Surveillance data acquisition function. - Primary Radar Interface: for the reception of Primary radar messages by Surveillance data acquisition function. - Space-Based ADS-B Interface: for the reception of space based ADS-B messages by Surveillance data acquisition function. - MSPSR Interface: for the reception of MSPSR messages by Surveillance data acquisition function. - ADS-B ground station interface: for the reception of ADS-B ground station messages by Surveillance data acquisition function. - Surveillance chain data fusion interface: for the reception of multi-sensor track messages by Surveillance data acquisition function. - SPM_CHAIN_TO_SPM_TOOLS interface: for the transmission of sensor and tracker data from the Surveillance Performance Monitoring chain to the Surveillance Performance Monitoring tools. - SPM_TOOLS_TO_SPM_CHAIN: for the transmission of sensor and tracker surveillance performance report from the Surveillance Performance Monitoring tools to the performance Monitoring chain.

Table 5: Relevant uses cases for the Solution PJ14-W2-84a

3.1.1.3 Applicable standards and regulations

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 [40]. (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) [51]
- EUROCAE WG-103 TBD (Technical Specification for NCS) [53]

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

3.1.2 Capability Configurations required for the SESAR Solution

T03 - Surveillance Chain Data Fusion				
CC	**Op Env**	**Capability**	**Node**	**Stakeholder**
APP ACC	Terminal Airspace;	Air Traffic Complexity Management; Air Traffic Flow Management; Airspace Configuration Management; Airspace Infringement Avoidance; Airspace Reservation Management; Arrival Sequencing; Arrival/Departure Routes Management; Clearance/Instruction Management; Coordination and Transfer; Crisis Management; CTA/CTO Management;	Air Traffic Flow and Capacity Management; Airspace Management; Airspace Organisation; En-Route/Approach ATS;	Civil ATS Approach Service Provider; Military ATS Approach Service Provider;

		Integrated Arrival/Departure Sequencing; Interval Management (IM); Mid-Air Collision Avoidance; Minimum Pair Separation Provision; Separation Provision (airspace); Separation Technique Management; Trajectory Conformance Monitoring; Trajectory Information Synchronisation; Trajectory Management; Trajectory Revision in Execution; Wake Turbulence Separation Provision; Weather-Dependent Separation Provision;		
Civil Aircraft	Airport; En-Route; Terminal Airspace;	Adverse Condition Operations Provision; ATSAW-Spacing Monitoring Execution; Clearance/Instruction Management; CTA/CTO Management; Ground Collision Avoidance; Interval Management (IM); Meteorological Observation and Forecasting Provision; Mid-Air Collision Avoidance; Optimised Climb Execution; Optimised Descent Execution; Optimised Take-Off / Landing Execution; PinS Operations Execution; RNP based Operations Execution; Separation Technique Management; Surface Route Management; Trajectory Information Synchronisation; Trajectory Revision in Execution; Wake Turbulence Separation Provision;	Airspace User Operations; Flight Deck;	Civil Scheduled Aviation;

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Communication Infrastructure	Airport; En-Route; Network; Terminal Airspace;	Communication;		Civil CNS Service Provider; Military CNS Service Provider;
Surveillance Infrastructure TMA (PJ.14-W2-84a)	Terminal Airspace;	Detection/Tracking of Mobiles (airspace) from Composite Surveillance and/or Alternative Sources;		Civil CNS Service Provider; Military CNS Service Provider;
Surveillance Performance Monitoring	Airport; En-Route; Terminal Airspace;	Separation Provision (airspace); Surface Guidance Provision;	Aerodrome ATS; En-Route/Approach ATS;	Civil CNS Service Provider; Military CNS Service Provider;
Telecom Service Providers (External)				

Table 6: List of Capability Configuration required for the Solution PJ14-W2-84a

3.2 Changes imposed by the SESAR Solution on the baseline Architecture

Enabler	Element type	Element name	Impact	Change
CTE-S08a (CR)	SUR Chain ER & TMA (MSPSR)			
	Function	Data association	Introduce	
	Function	Sensor Quality of Service	Introduce	
	Function	Sensor Quality of Service Monitoring	Introduce	

	Function	Surveillance performance monitoring	Introduce	
	Function	Track Distribution	Introduce	
	Function	Tracker Quality of Service	Introduce	
	Function	Tracker Quality of Service Monitoring	Introduce	
CTE-S08b (CR)	SUR Chain ER & TMA (Space-based ADS-B)			
	Function	Satellite-based ADS-B data acquisition	Introduce	

Table 7: List of changes due to the SESAR Solution

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4 Technical Specifications

4.1 Functional architecture overview (general introduction for all solutions)

This SESAR solution aims to support the integration of data from emerging surveillance techniques/technologies in to the wider ATM infrastructure, in particular ADS-B data sourced from satellites and NCS data presented in a system agnostic ASTERIX format.

This SESAR solution aims also to develop a performance-based data fusion based on an advanced monitoring of the tracker coherence. The achievement of this objective relies on the Surveillance Performance Monitoring (SPM) function, introduced as part of the PJ14 Solution 84a (see [16]) and a new Quasi real time performance monitoring function.

Functions required to perform needed Operational Activities can be allocated to Resources of a different type: Human Role, Infrastructure System or Functional Block.

Role	Functional Block	Function
[NSV-4] T03 - ATC SUR Processing		
	Chain data fusion	Data association; Satellite-based ADS-B data acquisition; Surveillance data acquisition; Track Distribution;
[NSV-4] T03 - Quasi real time performance monitoring		
	Quasi real time performance monitoring	Data association; Sensor Quality of Service; Sensor Quality of Service Monitoring; Surveillance data acquisition; Surveillance performance monitoring; Track Distribution; Tracker Quality of Service; Tracker Quality of Service Monitoring;

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

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Surveillance Chain Data Fusion aims to associate target reports of an aircraft detected from different sources to a unique multi-sensor track. Once associated, the sensor report contributes to the multi-sensor track state in accordance with the estimated level of confidence of the related sensor.

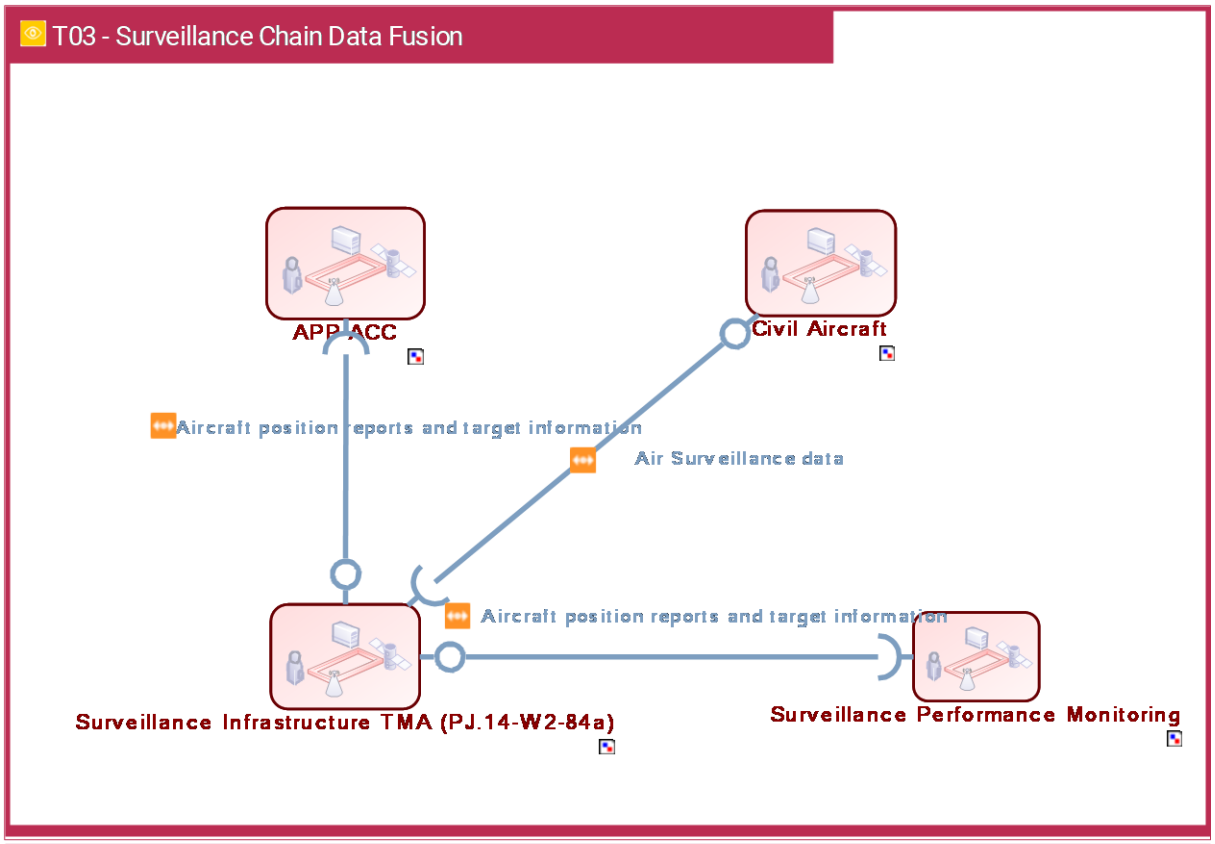

Figure 1 – Resource Connectivity Model

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4.1.1.1 Resource Infrastructure view (of the NSV-2)

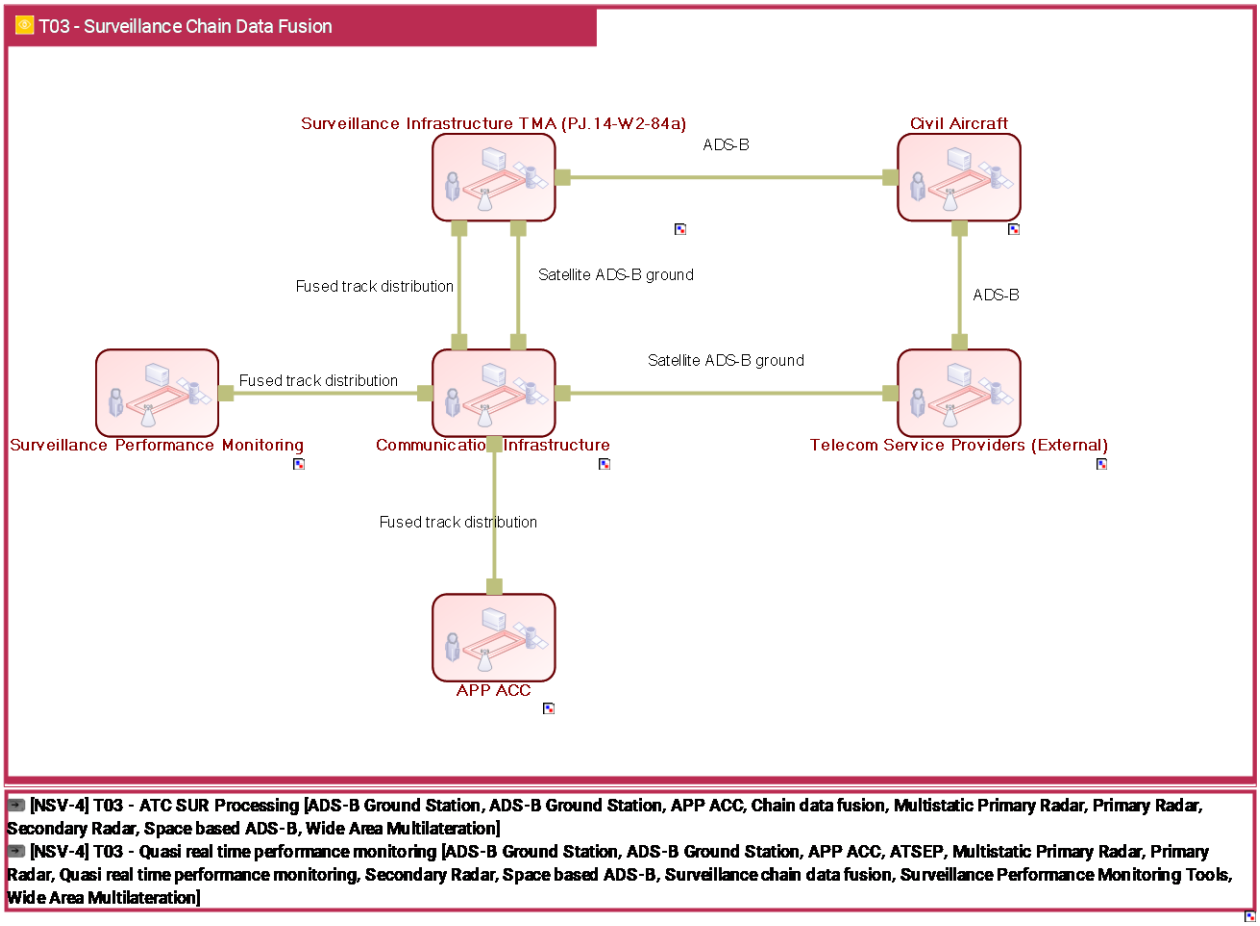

Figure 2 – Resource Infrastructure view

Infrastructure Connectivity view shows the Surveillance Chain Data Fusion connections to TMA Surveillance and Communication Infrastructure.**Resource Orchestration view (all NSV-4s linked to the NSV-1)**

4.1.1.2.1 ATC SUR Processing

This SESAR solution aims to support the integration of data from emerging surveillance techniques/technologies in to the wider ATM infrastructure, in particular ADS-B data sourced from satellites and NCS data presented in a system agnostic ASTERIX format.

The main functional components of the ATC Surveillance Tracking system are described in the table below:

Function	Description

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Data association	This function identifies a set of target reports as belonging to a specific aircraft to form a chain or trajectory.
Satellite-based ADS-B data acquisition	The purpose of the Function is to receive space-based ADS-B data.
Surveillance data acquisition	This function receives data from the optional input from surveillance sensors via the TCP/IP network and pre-recorded data files. This function uses standard service protocols in order to connect to the system LAN to acquire surveillance data that will be provided in standard ASTERIX format. Surveillance data received from different sensors, locally or remotely connected, will be provided in a unique system LAN where all the data flows shall be available. Surveillance data will be provided in standard ASTERIX format. In particular: · ASTERIX Cat 10 for SMR target reports; · ASTERIX Cat 10 for MLAT target reports; · ASTERIX Cat 20 for MLAT target reports; · ASTERIX Cat 21 for ADS-B target reports; · ASTERIX Cat 48 for Radar target reports.
Track Distribution	The Track Distribution function aims to provide a track service management for the distribution of the Air Situation Picture.

Table 8: Functional components of the ATC Surveillance Tracking system

The ATC Surveillance tracking function is represented schematically in the diagram which follows, wherein are identified the functional components of the ATC Surveillance Tracking system previously defined and other systems with which the ATC Surveillance tracking function exchanges data and the flows that this entails.
An arrow identifies an interface. An interface can be with:

- another Component of the system,
- an external line,
- A data store.

The ATC surveillance tracking function is represented in the scope of the PJ.14-W2-84a solution.

In the diagram below the following interfaces are represented:

- **Secondary Radar Interface**: for the reception of Secondary radar messages by Surveillance data acquisition function.
- **Primary Radar Interface**: for the reception of Primary radar messages by Surveillance data acquisition function.
- **Space-Based ADS-B Interface**: for the reception of space based ADS-B messages by Surveillance data acquisition function.
- **MSPSR Interface**: for the reception of MSPSR messages by Surveillance data acquisition function.
- **ADS-B ground station interface**: for the reception of ADS-B ground station messages by Surveillance data acquisition function.
- **APP/ACC interface**: for the transmission of APP (approach) surveillance data messages and ACC (Air Control Center) surveillance data messages by the Track distribution function.

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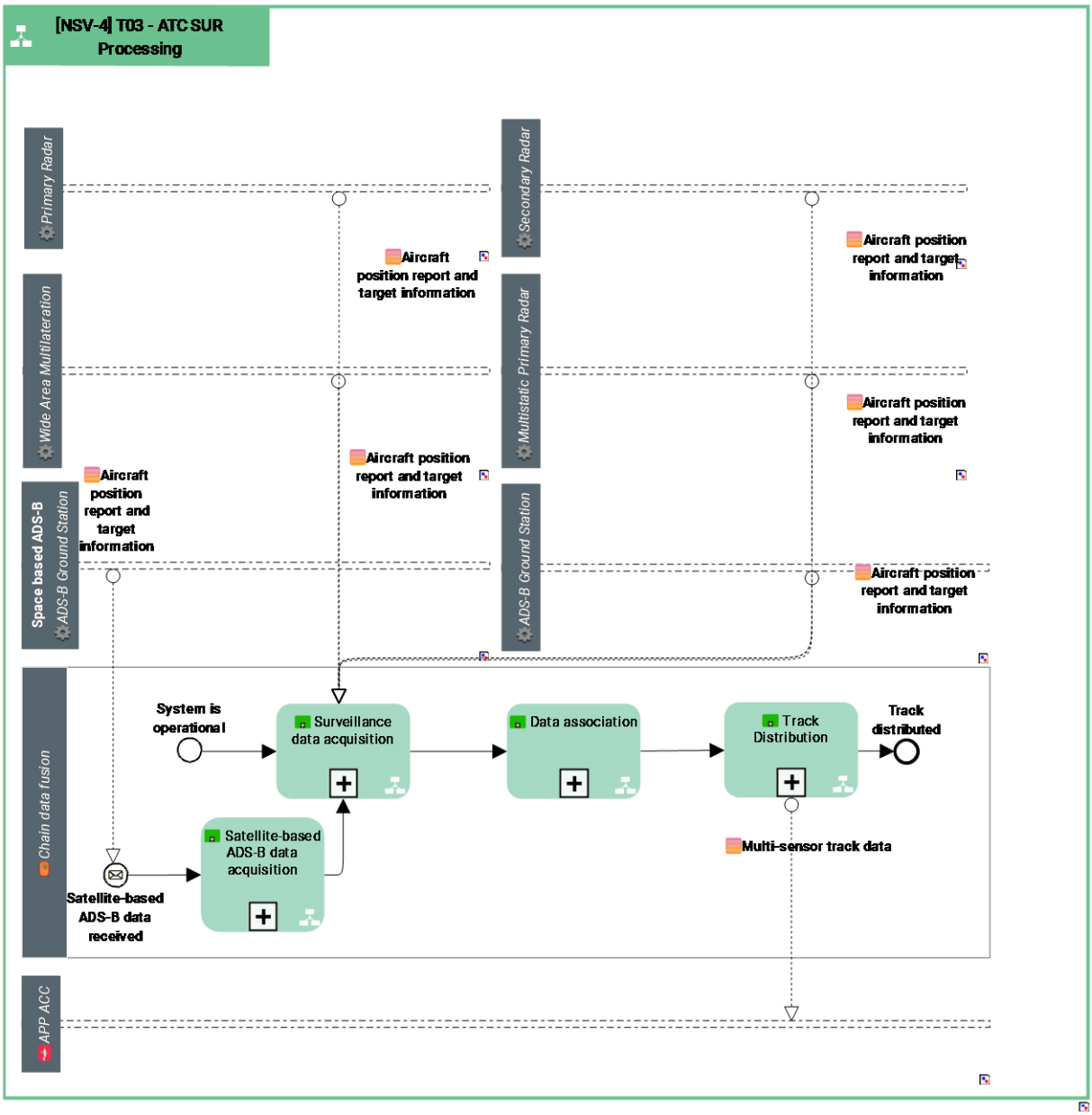

Figure 3 – ATC SUR Processing System Functional presentation

4.1.1.2.2 Quasi real time performance monitoring

The main functional components of the quasi real time performance monitoring system are described in the table below:

Function	Description
Data association	This function identifies a set of target reports as belonging to a specific aircraft to form a chain or trajectory.

Sensor Quality of Service	SQOS aims to evaluate the quality of service (QOS) from every sensor connected to an ATC SDPS based on qualitative criteria on SPM metrics.
Sensor Quality of Service Monitoring	SQOSM aims to monitor the quality of service (QOS) from every sensor connected to an ATC SDPS and to detect sensor performance degradation.
Surveillance data acquisition	This function receives data from the optional input from surveillance sensors via the TCP/IP network and pre-recorded data files. This function uses standard service protocols in order to connect to the system LAN to acquire surveillance data that will be provided in standard ASTERIX format. Surveillance data received from different sensors, locally or remotely connected, will be provided in a unique system LAN where all the data flows shall be available. Surveillance data will be provided in standard ASTERIX format. In particular: · ASTERIX Cat 10 for SMR target reports; · ASTERIX Cat 10 for MLAT target reports; · ASTERIX Cat 20 for MLAT target reports; · ASTERIX Cat 21 for ADS-B target reports; · ASTERIX Cat 48 for Radar target reports.
Surveillance performance monitoring	Surveillance Performance Monitoring (SPM) aims to evaluate performance metrics from every sensor connected to an ATC SDPS using both off-line and in continuous quasi real-time processes.
Track Distribution	The Track Distribution function aims to provide a track service management for the distribution of the Air Situation Picture.
Tracker Quality of Service	TQOS aims to evaluate the QOS of the Multi-sensor Tracking function based on qualitative criteria on SPM metrics.
Tracker Quality of Service Monitoring	TQOSM aims to monitor the quality of service (QOS) of the multi-sensor tracking function and to detect inconsistencies between TQOS and SQOS.

Table 9: Functional components of the quasi real time performance monitoring system

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The quasi real time performance monitoring function is represented schematically in the diagram which follows, wherein are identified the functional components of the quasi real time performance monitoring system previously defined and other systems with which the quasi real time performance monitoring function exchanges data and the flows that this entails.
An arrow identifies an interface. An interface can be with:

- another Component of the system,
- an external line,
- A data store.

The quasi real time performance monitoring function is represented in the scope of the PJ.14-W2-84a solution.

In the diagram below the following interfaces are represented:

- **Secondary Radar Interface**: for the reception of Secondary radar messages by Surveillance data acquisition function.
- **Primary Radar Interface**: for the reception of Primary radar messages by Surveillance data acquisition function.
- **Space-Based ADS-B Interface**: for the reception of space based ADS-B messages by Surveillance data acquisition function.
- **MSPSR Interface**: for the reception of MSPSR messages by Surveillance data acquisition function.
- **ADS-B ground station interface**: for the reception of ADS-B ground station messages by Surveillance data acquisition function.
- **Surveillance chain data fusion interface**: for the reception of multi-sensor track messages by Surveillance data acquisition function.
- **SPM_CHAIN_TO_SPM_TOOLS interface:** for the transmission of sensor and tracker data from the Surveillance Performance Monitoring chain to the Surveillance Performance Monitoring tools.
- **SPM_TOOLS_TO_SPM_CHAIN:** for the transmission of sensor and tracker surveillance performance report from the Surveillance Performance Monitoring tools to the performance Monitoring chain.
- **SQOS_TO_ATSEP:** for the transmission of Sensor Quality of Service to ATSEP.
- **TQOS_TO_ATSEP:** for the transmission of Tracker Quality of Service to ATSEP.
- **SQOSM_TO_ATSEP:** for the transmission of alert from SQOSM to ATSEP.
- **TQOSM_TO_ATSEP:** for the transmission of alert to TQOSM to ATSEP.

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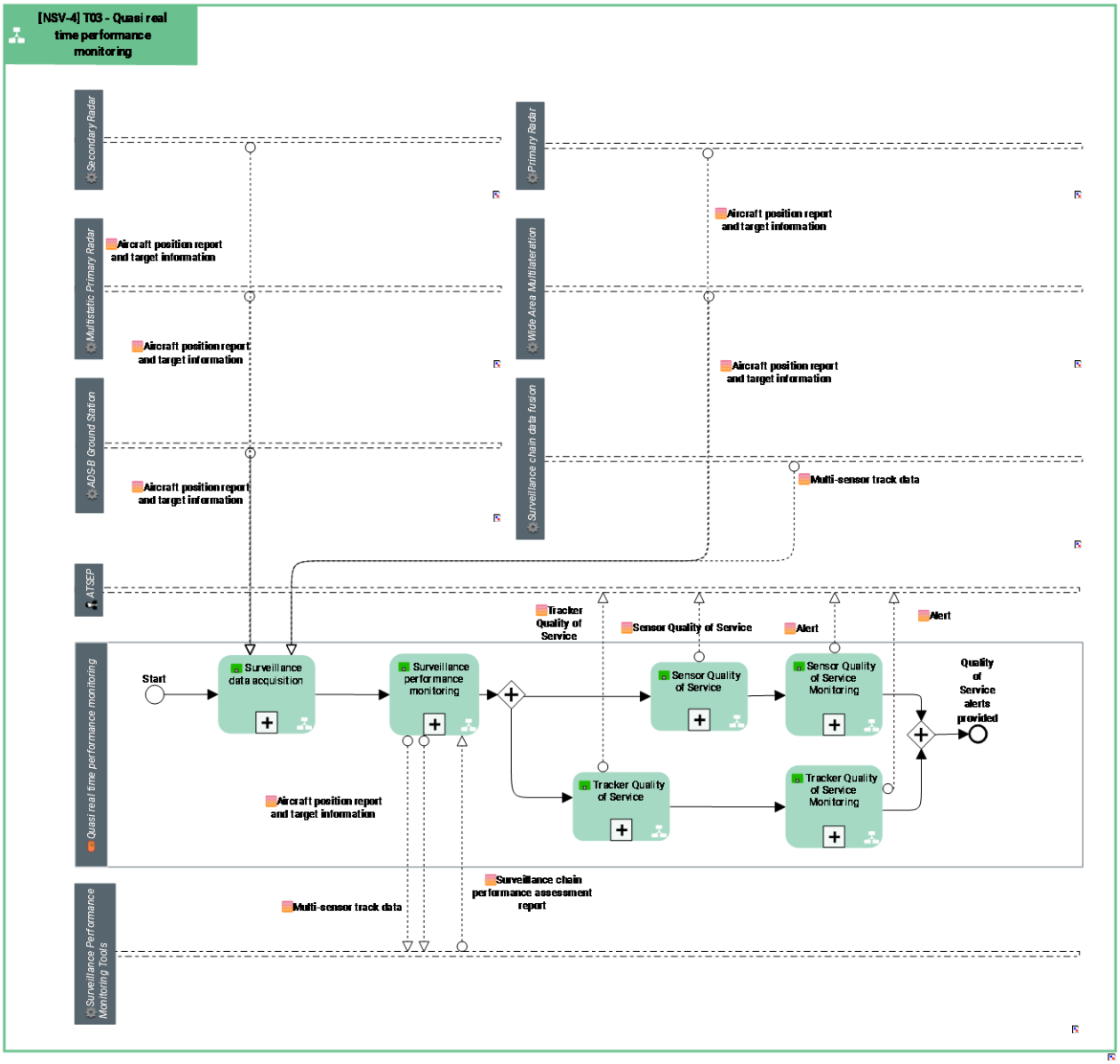

Figure 4 – Quasi real time performance monitoring System Functional presentation

4.1.2 Resource Composition

Not generated from EATMA by MEGA.

4.1.3 Service view

4.1.3.1 Service description

Service	Service description

4.1.3.2 Service Provisioning

Interaction	Consumer CC	Consumer System	Provider CC	Provider System
Air Surveillance data.Surveillance Infrastructure TMA (PJ.14-W2-84a)_CC and Civil Aircraft_CC	Surveillance Infrastructure TMA (PJ.14-W2-84a)	ADS-B Ground Station; Airport Multilateration; Secondary Radar; Wide Area Multilateration;	Civil Aircraft	Aircraft;
Aircraft position reports and target information.Surveillance Performance Monitoring_CC and Surveillance Infrastructure TMA (PJ.14-W2-84a)_CC	Surveillance Performance Monitoring	Surveillance Performance Monitoring Tools;	Surveillance Infrastructure TMA (PJ.14-W2-84a)	ADS-B Ground Station; Airport Multilateration; Multistatic Primary Radar; Primary Radar; Secondary Radar; Wide Area Multilateration; Surveillance chain data fusion;
Aircraft position reports and target information.APP ACC_CC and Surveillance Infrastructure TMA (PJ.14-W2-84a)_CC	APP ACC	En-Route / Approach ATC;	Surveillance Infrastructure TMA (PJ.14-W2-84a)	ADS-B Ground Station; Airport Multilateration; Multistatic Primary Radar; Primary Radar; Secondary Radar; Wide Area Multilateration; Surveillance chain data fusion;

Table 10: Services used and developed by PJ.14-W2-84a

4.1.3.3 Service Realization

4.1.3.3.1 Interaction Air Surveillance data.Surveillance Infrastructure TMA (PJ.14-W2-84a)_CC and Civil Aircraft_CC

System Port: SUR_ADS-B_AIR at Surveillance Infrastructure - TMA_CC

Protocol Stack	Protocol
ADS-B	

	DF17
	DF18
	DF19

System Port: ADS-B_OUT at Civil Aircraft_CC

Protocol Stack	Protocol
ADS-B	
	DF17
	DF18
	DF19

System Port: SUR_ADS-B_AIR at Telecom Service Providers (External) (PJ.14-04-03)_CC

Protocol Stack	Protocol
ADS-B	
	DF17
	DF18
	DF19

System Port: ADS-B_OUT at Civil Aircraft_CC

Protocol Stack	Protocol
ADS-B	
	DF17
	DF18
	DF19

System Port: SUR_ADS-B_SAT_GND at Surveillance Infrastructure TMA (PJ14.04.03)_CC

Protocol Stack	Protocol
Satellite ADS-B ground	
	IP
	UDP

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol

IP	

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: SUR_ADS-B_SAT_GND at Telecom Service Providers (External) (PJ.14-04-03)_CC

Protocol Stack	Protocol
Satellite ADS-B ground	
	IP
	UDP

4.1.3.3.2 Interaction Aircraft position reports and target information.APP ACC_CC and Surveillance Infrastructure TMA (PJ.14-W2-84a)_CC

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: SUR_TRACK_GND at APP ACC (Step 2)_CC

Protocol Stack	Protocol
Fused track distribution	
	Asterix Cat62
	UDP
	IP

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: SUR_TRACK_GND at Surveillance Infrastructure-TMA_CC

Protocol Stack	Protocol
Fused track distribution	
	Asterix Cat62
	UDP
	IP

4.1.3.3.3 Interaction Aircraft position reports and target information.Surveillance Performance Monitoring_CC and Surveillance Infrastructure TMA (PJ.14-W2-84a)_CC

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: SUR_TRACK_GND at Surveillance Infrastructure-TMA_CC

Protocol Stack	Protocol
Fused track distribution	
	Asterix Cat62
	UDP
	IP

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: SUR_TRACK_GND at Surveillance Performance Monitoring_CC

Protocol Stack	Protocol
Fused track distribution	
	Asterix Cat62

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	UDP
	IP

4.1.4 Modified Systems View

4.1.4.1 Surveillance chain data fusion

Surveillance Chain Data Fusion aims to associate target reports of an aircraft detected from different sources to a unique multi-sensor track. Once associated, the sensor report contributes to the multi-sensor track state in accordance with the estimated level of confidence of the related sensor.

4.1.4.1.1 Composition

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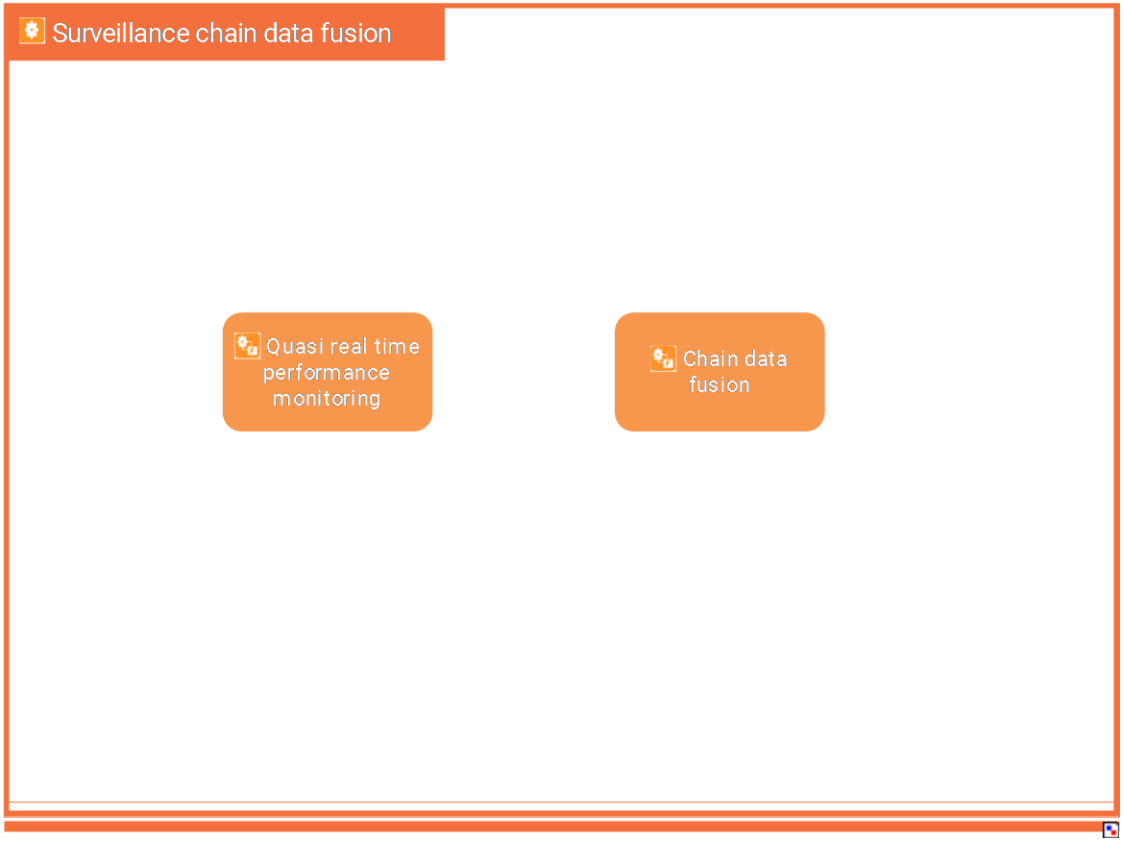

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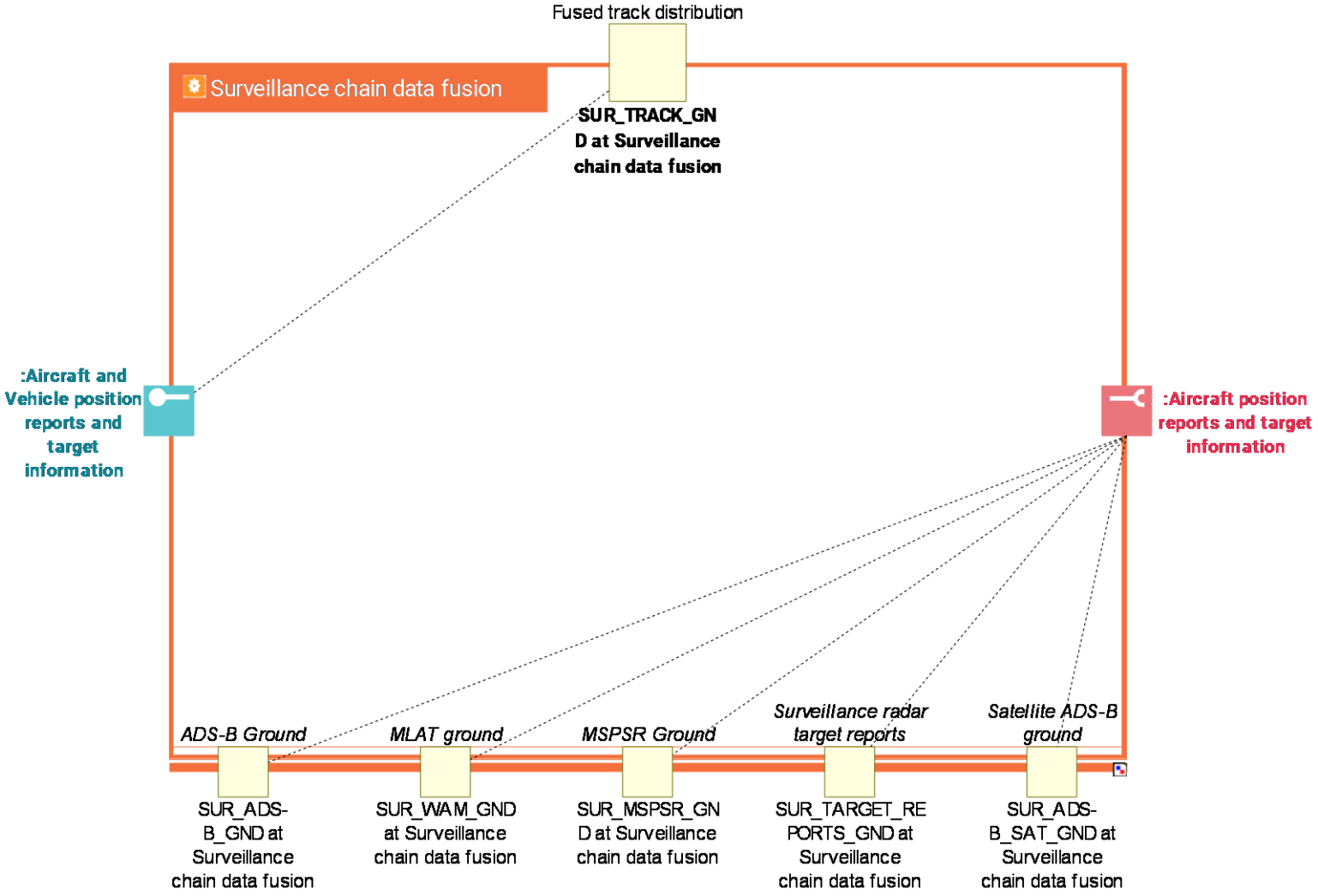
4.1.4.1.2 System Interfaces Diagram



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4.2 Functional and non-Functional Requirements

4.2.1 MSPSR and ADS-B space-based integration

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0006
Title	ASTERIX CAT 021 Input and Decode
Requirement	The SDPS software shall decode and process ASTERIX CAT 021 messages.
Status	<validated>
Rationale	The main function of a multi-sensor tracker is to process all surveillance data reports (classical radar, Mode-S, WAM and ADS) in order to provide its users with the best estimate of the current air traffic situation. In the case of ADS-B, the data are sent/presented to SDPS Tracking function as ASTERIX CAT021 messages.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08b
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0007
Title	Transformation of ADS-B Target Report Data in to a System Track
Requirement	The SDPS software shall transform the ASTERIX CAT 021 data, derived from satellite constellations, into a system track.
Status	<validated>
Rationale	The main function of a multi-sensor tracker is to process all surveillance data reports (classical radar, Mode-S, WAM and ADS) in order to provide its users

	with the best estimate of the current air traffic situation. This best estimate is a calculated multi-sensor track, also called system track.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08b
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0008
Title	Encoding of system track data in to ASTERIX CAT 062 messages
Requirement	The SDPS software shall encode and serve the system track data in ASTERIX CAT 062 messages.
Status	<validated>
Rationale	ASTERIX CAT062 describes the message structure for the transmission of System Track Data to a user. ASTERIX represents a state-of-the-art surveillance data format which is nearly being adopted by the world user's community as the universal standard for the exchange of air traffic services (ATS) information.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08b
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0009

Title	Confirmation of Correlation between ADS-B Target Report and System Track
Requirement	The ASTERIX CAT 062 SDPS Tracking function output shall be compared to the ASTERIX CAT 021 input to confirm it was processed correctly.
Status	<validated>
Rationale	This requirement aims to confirm that the ASTERIX CAT 021 data items are correctly populated and establish whether the tracking integrity is reinforced through the usability of the spaced-based ADS-B.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08b
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0010
Title	Tracking Performance when integrating space based ADS-B data within an extensive area of interest
Requirement	When integrating Space based ADS-B data within an extensive area of interest (4000NM * 4000NM square system), the SDPS Tracking function shall perform in the expected performance boundaries regarding the following ESASSP requirements [39]: - 5N_N-R1 - 5N_N-R2 - 5N_N-R3 - 5N_N-R4
Status	<validated>
Rationale	The rationale is to check that SDPS Tracking function is able to perform in the expected performance boundaries regarding ESASSP (See [16]) when integrating space based ADS-B data within an extensive are of interest.
Category	<Performance>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08b
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.1001
Title	Decoding of ASTERIX CAT015 messages
Requirement	The SDPS Tracking Function shall decode ASTERIX CAT 015 messages.
Status	<validated>
Rationale	The rationale is to check that SDPS Tracking function is able to decode ASTERIX CAT 015 messages dedicated to INCS data.
Category	<Functional>

REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.1002
Title	INCS Measurement Noise
Requirement	The SDPS Tracking Function shall apply the received INCS measurement noise for the update of the associated surveillance track tracking filter.
Status	<validated>
Rationale	The rationale is to check that SDPS Tracking function is able to process the received INCS measurement noise to estimate the position of the target.
Category	<Functional>

REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.1003
Title	INCS 3D Speed Doppler
Requirement	The SDPS Tracking Function shall update the state of the surveillance track using the INCS 3D speed Doppler when the surveillance track is associated to an INCS report.
Status	<validated>
Rationale	The rationale is to check that SDPS Tracking function is able to process the received INCS 3D speed Doppler to estimate the state of the target. The INCS 3D Speed Doppler refers to a Cartesian velocity derived from the radial Doppler velocity measured at MSPSR receiver level.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.1004
Title	Tracking Performance
Requirement	When integrating INCS data, the SDPS Tracking function shall perform in the expected performance boundaries regarding the following ESASSP requirements [39]: - 5N_N-R1

	- 5N_N-R2 - 5N_N-R3 - 5N_N-R4 - 3N_N-R1 - 3N_N-R2 - 3N_N-R3 - 3N_N-R4
Status	<validated>
Rationale	The rationale is to check that SDPS Tracking function is able to perform in the expected performance boundaries regarding ESASSP (See [16]) when integrating INCS data.
Category	<Performance>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

4.2.2 Multi-Sensor Data Fusion Improvement

4.2.2.1 Online SQOS construction

[REQ]

Identifier	REQ-14-84a-TS-FUSE.2001
Title	Sensor Performance Metrics per Trajectory Reception
Requirement	For each sensor and for each trajectory, SQOS shall receive from SPM the performance metrics attached to the sensor and the trajectory.
Status	<validated>
Rationale	For more details on SPM sensor performance metrics see [29].
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.2002
Title	Sensor Performance Metrics per cell
Requirement	For each sensor and for each cell of a pre-defined grid, SQOS shall receive from SPM the performance metrics attached to the sensor and the area.
Status	<validated>
Rationale	For more details on SPM sensor performance metrics see [15].
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.2003
Title	Sensor Quality of Service per Trajectory
Requirement	For each sensor and for each trajectory, SQOS shall be able to evaluate a quality of service expressed as a percentage.
Status	<validated>
Rationale	The rationale is to check that SQOS is able to evaluate a sensor quality of service.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A

<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.2004
Title	Sensor Quality of Service per cell
Requirement	For each sensor and for each cell of a pre-defined grid, SQOS shall be able to evaluate a quality of service expressed as a percentage.
Status	<validated>
Rationale	The rationale is to check that SQOS is able to evaluate a sensor quality of service.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.2005
Title	Quality of Service grid transmission
Requirement	For each sensor, SQOS shall be able to transmit a grid of quality of service.
Status	<validated>
Rationale	The rationale is to check that SQOS is able to evaluate a sensor quality of service.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a

<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.2006
Title	Trajectories Quality of Service transmission
Requirement	For each sensor, SQOS shall be able to transmit the quality of service for each trajectory.
Status	<validated>
Rationale	The rationale is to check that SQOS is able to evaluate sensor quality of service.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

4.2.2.2 Online TQOS construction

[REQ]

Identifier	REQ-14-84a-TS-FUSE.5001
Title	Tracker Performance Metrics per Trajectory Reception
Requirement	For each trajectory, TQOS shall receive from SPM the tracker performance metrics attached to the trajectory.
Status	<validated>
Rationale	For more details on SPM tracker performance metrics see [30].
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A

<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.5002
Title	Tracker Performance Metrics per cell
Requirement	For each cell of a pre-defined grid, TQOS shall receive from SPM the performance metrics attached to the area.
Status	<validated>
Rationale	For more details on SPM tracker performance metrics see [15].
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.5003
Title	Tracker Quality of Service per Trajectory
Requirement	For each trajectory, TQOS shall be able to evaluate a quality of service expressed as a percentage.
Status	<validated>
Rationale	The rationale is to check that TQOS is able to evaluate a tracker quality of service. Algorithm description: Rate criteria are computed for each ESASSP KPI using utility functions for normalization. Aggregation of the criteria are used for assessing quality of services using several rules such as continuity, monotonicity, and user preferences.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.5004
Title	Tracker Quality of Service per cell
Requirement	For each cell of a pre-defined grid, TQOS shall be able to evaluate a quality of service expressed as a percentage.
Status	<validated>
Rationale	The rationale is to check that TQOS is able to evaluate a tracker quality of service.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.5005
Title	Quality of Service grid transmission
Requirement	TQOS shall be able to transmit a grid of quality of service.
Status	<validated>
Rationale	The rationale is to check that TQOS is able to evaluate a tracker quality of service.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.5006
Title	Trajectories Quality of Service transmission
Requirement	TQOS shall be able to transmit the quality of service for each trajectory.
Status	<validated>
Rationale	The rationale is to check that TQOS is able to evaluate a tracker quality of service.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

4.2.2.3 Online supervision of the surveillance performance

4.2.2.3.1 Online SQOS Assessment

[REQ]

Identifier	REQ-14-84a-TS-FUSE.4001
Title	Sensor grid of Quality of Service
Requirement	For each sensor, SQOSM shall receive from SQOS a sensor grid of Quality of Service.
Status	<validated>
Rationale	The rationale is to check that SQOSM is able to receive a sensor quality of service.
Category	<Functional>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.4002
Title	Sensor Performance degradation per cell
Requirement	For each sensor and for each cell of a pre-defined grid, SQOSM shall be able to detect performance degradation.
Status	<validated>
Rationale	For more details on SPM sensor performance metrics see [15].
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.4003
Title	Sensor Performance Degradation per Trajectory
Requirement	For each sensor, and for each trajectory SQOSM shall be able to detect performance degradation.
Status	<validated>
Rationale	The rationale is to check that SQOSM is able to detect sensor performance degradation.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

4.2.2.3.2 Online TQOS Assessment

[REQ]

Identifier	REQ-14-84a-TS-FUSE.6001
Title	Tracker grid of Quality of Service
Requirement	TQOSM shall receive from TQOS a tracker grid of Quality of Service.
Status	<validated>
Rationale	The rationale is to check that TQOSM is able to receive a tracker quality of service.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.6003
Title	Tracker Performance degradation per cell
Requirement	For each cell of a pre-defined grid, TQOSM shall be able to detect performance degradation.
Status	<validated>
Rationale	For more details on SPM sensor performance metrics see [15].
Category	<Functional>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

Identifier	REQ-14-84a-TS-FUSE.6004
Title	Tracker Performance Degradation per Trajectory
Requirement	For each trajectory TQOSM shall be able to detect performance degradation.
Status	<validated>
Rationale	The rationale is to check that TQOSM is able performance degradation.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

4.2.2.3.3 QOS degradation explainability

[REQ]

Identifier	REQ-14-84a-TS-FUSE.7001
Title	SQOS degradation explainability
Requirement	The SQOSM function shall be able to identify the root cause of a SQOS degradation.
Status	<validated>
Rationale	The rationale is to check that SQOSM function is able to identify the root cause of a SQOS degradation.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

[REQ]

Identifier	REQ-14-84a-TS-FUSE.7002
Title	TQOS degradation explainability
Requirement	The TQOSM function shall be able to identify the root cause of a TQOS degradation.
Status	<validated>
Rationale	The rationale is to check that TQOSM function is able to identify the root cause of a TQOS degradation.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-W2-84A
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Quasi real time performance monitoring

[REQ]

5 Recommendation for Implementation

The improved data fusion solution does not affect the surveillance architecture except the introduction of new interfaces for the ASTERIX CAT 15.

The new functional requirements related to space based ADS-B and MSPSR integration and Surveillance Performance Monitoring function will be implemented as software updates of the existing SDPS components. These SDPS can already be adapted to meet local architectural requirements – fusing data at either a local, National or International level, and configured to meet the objectives of various operational performance criteria and separation minima across different coverage volumes. Their use therefore brings a degree of flexibility to the architecture and design of the ATM system.

Depending on the safety constraints of the system, potential architectural system requirements should or should not require the SPM function and the SDPS to be hosted on different servers.

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6 Assumptions

No assumptions identified for the Final TS/IRS.

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7 References and Applicable Documents

7.1 Applicable Documents

Content Integration

[1] EATMA guidance material and report, Dec 2019.

[2] EATMA Community pages.

Content Development

[3] Concept of Operations, Dec 2019.

System and Service Development

[4] Report of the progress on standardisation of Services, Information and Terminology, Oct 2019.

Performance Management

[5] Performance Framework, Dec 2019.

Validation

[6] Validation Strategy, Dec 2019.

[7] Validation Targets W2, Jun 2020.

System Engineering

[8] System Engineering - Methodology for the V&VP, V&VI and Demonstration Platform development, Jun 2019.

Safety

[9] SESAR Safety Reference Material, Dec 2018.

[10] Guidance to Apply SESAR Safety Reference Material, Dec 2018.

Human Performance

[11] Human Performance - Guidance Reference Material, Aug 2020.

Environment Assessment

[12] ENV - Guidance Reference Material, Dec 2019.

Security

[13] SecRAM, Sep 2017

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7.2 Reference Documents

[14]ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[1]

[15]PJ 14.04.01 TECHNICAL SPECIFICATION, TS_IRS

[16] EUROCONTROL Specification for ATM Surveillance System Performance (volume 1), EUROCONTROL-SPEC-0147, rev01

[17] EUROCAE ED-129B Technical Specification for a 1090 MHz Extended Squitter ADS-B Ground System Version dated March 2016.

[18] EUROCAE WG-102 TBD (GEN SUR SPR)

[19] EUROCAE WG-103 TBD (Technical Specification for NCS)

[20] ASTERIX Cat 015 NCS Target Reports Draft v0.8 Dated: TBD

[21] ASTERIX CAT 021 ADS-B Messages Edition 2.4 Dated 15/06/2015

[22] ASTERIX CAT 023 CNS/ATM Ground Station Service Message Edition 1.2 Dated 01/03/2009

[23] ASTERIX CAT 025 CNS/ATM Ground System Status Report Edition 1.1 Dated 09/11/2015

[24] ASTERIX CAT 062 System Track Data Edition 1.17 Dated 01/12/2014

[25] ASTERIX CAT 063 Sensor Status Messages Edition 1.3 Date 01/07/2007

[26] ASTERIX CAT 238 Service Prediction Reports Edition 1.1 Dated 24/10/2016

[27] ASTERIX CAT 247 Number Exchange (Part 20) Edition 1.2 Dated 01/02/2008

[28] PJ.15-04-02 technical studies report

[29] PJ.14-W2-84e TECHNICAL SPECIFICATION, TS_IRS

[30] PJ.14-W2-84f TECHNICAL SPECIFICATION, TS_IRS

Appendix A Service Description Document (SDD)

Not generated from EATMA by MEGA.

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Appendix B PJ14.04.03 Task 03 requirements removed in PJ14 Solution 84a

EUROCONTROL is no longer a stakeholder in the PJ14 84a solution, the following requirements relating to the integration of the MSPSR in ARTAS have been removed:

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0001
Title	ASTERIX CAT 015, NCS Target Report Data, Input and Decode
Requirement	The SDPS software shall decode and process reconstructed ASTERIX CAT 015 messages.
Status	<validated>
Rationale	This TS/IRS addresses the means to introduce INCS data, in ASTERIX Cat 015 format, into the ARTAS Multi-Sensor Tracker. As the associated sensor technology continues to evolve, and as the supporting ASTERIX category remains at a draft edition, this exercise is conducted on prototype ARTAS software and enables the possible future development of a production/operational ARTAS system and ASTERIX specification. The rationale for this particular requirement is to ensure that the necessary data items are contained within the draft ASTERIX CAT 015, they are defined appropriately and can be made available to the Tracker functions of the prototype ARTAS software.
Category	Enumerate <Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-04-03
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0002
Title	Transformation of NCS Target Report Data in to a System Track
Requirement	The SDPS software shall transform the reconstructed ASTERIX CAT 015 data into a mono sensor system track.
Status	<validated>
Rationale	This TS/IRS addresses the means to introduce INCS data, in ASTERIX Cat 015 format, into the ARTAS Multi-Sensor Tracker. As the associated sensor technology continues to evolve, and as the supporting ASTERIX category remains at a draft edition, this exercise is conducted on prototype ARTAS software and enables the possible future development of a production/operational ARTAS system and ASTERIX specification. The rationale for this particular requirement is to ensure that the draft ASTERIX CAT 015 data items input into ARTAS can be managed and integrated into a mono-sensor system track.
Category	<Functional>

REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-04-03
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0003
Title	Encoding of system track data in to ASTERIX CAT 062 messages
Requirement	The SDPS software shall encode and serve the system track data in ASTERIX CAT 062 messages.
Status	<validated>
Rationale	This TS/IRS addresses the means to introduce INCS data, in ASTERIX Cat 015 format, into the ARTAS Multi-Sensor Tracker. As the associated sensor technology continues to evolve, and as the supporting ASTERIX category remains at a draft edition, this exercise is conducted on prototype ARTAS

	software and enables the possible future development of a production/operational ARTAS system and ASTERIX specification. The rationale for this particular requirement is to confirm that the INCS data can be replicated in the ASTERIX System Track category.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-04-03
<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

[REQ]

Identifier	REQ-14-84a-TS-FUSE.0004
Title	Confirmation of Correlation between NCS Target Report and System Track
Requirement	The ASTERIX CAT 062 ARTAS output shall be compared to the ASTERIX CAT 015 input to confirm it was processed correctly to the limit of the tool availability.
Status	<validated>
Rationale	This TS/IRS addresses the means to introduce INCS data, in ASTERIX Cat 015 format, into the ARTAS Multi-Sensor Tracker. As the associated sensor technology continues to evolve, and as the supporting ASTERIX category remains at a draft edition, this exercise is conducted on prototype ARTAS software and is conducted to enable the eventual development of a production/operational ARTAS system and ASTERIX specification. The rationale for this particular requirement is to check that the output data (in ASTERIX CAT 062) is representative of the input INCS data.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.14-04-03

<ALLOCATED_TO>	<Enabler>	CTE-S08a
<ALLOCATED_TO>	<Functional block>	Chain data fusion

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Appendix C Safety Assessment

C.1 Safety Strategy

C.1.1 Scope of the Safety Assessment

1. Integrating INCS data into ATC-SUR function

The scope covers the assessment of safety aspects of PJ.14-W2-84a – Multi Sensor Data Fusion:

- Identify hazards linked to the technical components.
- Define safety drivers for the technical components: identify the design assurance levels.
- Validate that the technical performance is compliant with the safety needs of the intended operation.
- Define basis for detailed technical safety assessment in a later industrialization phase (certification).

Please note that a failure approach analysis is not applicable at this stage.

2. Integrating space based ADS-B data into ATC-SUR function

The scope covers the assessment of safety aspects of PJ.14-W2-84a – Multi Sensor Data Fusion:

- Identify hazards linked to the technical components.
- Define safety drivers for the technical components: identify the design assurance levels.
- Validate that the technical performance is compliant with the safety needs of the intended operation.
- Define basis for detailed technical safety assessment in a later industrialization phase (certification).

Please note that a failure approach analysis is not applicable at this stage.

3. Online supervision of the surveillance performance

TQOS and SQOS functions do not cover any safety assessment since the solution is considered to not have a safety impact.

C.1.2 Safety impact of the solution

The following functions of ATC-SUR are impacted by the integration of the MSPSR and space based ADS-B:

- **Surveillance Data Acquisition**
- **Data Association**
- **Track Distribution**

The safety assessment aims to validate the following services provided by the ATC-SUR is safe:

- ATC-SUR function performs in the expected performance boundaries regarding ESASSP 3N requirements when integrating INCS data in TMA (see REQ-14-84a-TS-FUSE.1004).
- ATC-SUR function performs in the expected performance boundaries regarding ESASSP 5N requirements when Integrating space based ADS-B data into ATC-SUR function (see REQ-14-84a-TS-FUSE.0010).

C.2 Safety Assessment Results

REQ-14-84a-TS-FUSE.1004 is covered by Technical Validation Objective OBJ-PJ.14-W2-84a-TRL6-TVALP-001.1.

REQ-14-84a-TS-FUSE.0010 is covered by Technical Validation Objective OBJ-PJ.14-W2-84a-TRL6-TVALP-001.2.

Below is a summary of Technological Validation Exercises Results related to safety requirements REQ-14-84a-TS-FUSE.1004 and REQ-14-84a-TS-FUSE.0010.

SESAR Technological Solution Technological Validation Objective ID	SESAR Technological Solution Technological Validation Objective Title	SESAR Technological Solution Success Criterion ID	SESAR Technological Solution Success Criterion	SESAR Technological Solution Validation Results	SESAR Technological Solution Technological Validation Objective Status

OBJ-PJ.14-W2-84a-TRL6-TVALP-001.1	Verification of multi-sensor data fusion integrating MSPSR	CRT-14.84a-TRL6-TVALP-001.003	The multi-sensor data fusion prototype meets the specification for primary reinforcement of cooperative targets using secondary sources by SDPS fusion while maintaining the conformance to the separation requirements based on ESSASP criteria as a mean of compliance.	The performance analysis based on the comparison between the reference air situation of the scenario and the output of the tracker is within the thresholds defined by the ESSASP standard for the following requirement: - 3N_N-R1 - 3N_N-R2 - 3N_N-R3 - 3N_N-R4	OK

OBJ-PJ.14-W2-84a-TRL6-TVALP-001.2		CRT-14.84a-TRL6-TVALP-001.005	The multi-sensor data fusion meets the specification of the ESSASP separation requirements integrating space based ADS-B data within an extensive coverage area (4000NM * 4000NM).	EXE#01 Test Case #05 results: The performance analysis based on the comparison between the reference air situation (reconstructed by AGATE) and the output of the tracker is within the thresholds defined by the ESSASP standard for the following requirement: - 5N_N-R1 - 5N_N-R2 - 5N_N-R3 - 5N_N-R4	OK

Table 11: Summary of Technological Validation Exercises Results

The implementation of a realistic testbed based on real data and a representative multi sensors configuration including common coverage areas between ADS-B, Radar and MSPSR sensors allowed to perform a statistical evaluation of the performance of the multi-sensor data fusion integrating MSPSR and space based ADS-B.

The statistical analysis performed as part of EXE#01 validated that the multi sensor data fusion performs in the expected performance boundaries, when integrated INCS data regarding the following ESASSP requirements ([16]):

- 3N_N-R1
- 3N_N-R2
- 3N_N-R3
- 3N_N-R4

The statistical analysis performed as part of EXE#01 validated that the multi sensor data fusion performs in the expected performance boundaries, when integrated space based ADS-B data regarding the following ESASSP requirements ([16]):

- 5N_N-R1
- 5N_N-R2
- 5N_N-R3
- 5N_N-R4

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