Release 5 SESAR Solution ID #114

Composite surveillance (ADS-B/WAM)

Contextual note – SESAR Solution description form for deployment planning

Purpose:

This contextual note introduces a SESAR Solution (for which maturity has been assessed as sufficient to support a decision for industrialization) with a summary of the results stemming from R&D activities contributing to deliver it. It provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR Solution in terms of scope, main operational and performance benefits, relevant system impacts as well as additional activities to be conducted during the industrialization phase or as part of deployment. This contextual note complements the technical data pack comprising the SESAR deliverables required for further industrialization/deployment.

Improvements in Air Traffic Management (ATM)

Air traffic surveillance systems use both cooperative and non-cooperative techniques to locate aircraft. While non-cooperative techniques rely on the reflection of energy directed at the aircraft, cooperative techniques require the carriage of a transponder or transmitter device on board the aircraft. Systems using the signals broadcast from such transponders / transmitters are classified as a cooperative independent technology, as the ground surveillance systems derive all surveillance information from the decoded message content to determine aircraft identity and 3D position. Systems, such as ADS-B, in which the aircraft transmits it own position are classified as a cooperative dependent technology.

The table below summarises the categories that the various existing and new ground-based air traffic Surveillance sensors fall into:

		Air traffic surveillance sensor
Independent Non cooperative		Primary Surveillance Radar (PSR) Multi-Static Primary Surveillance Radar (MSPSR) (Under development)
Cooperative	Independent	Secondary Surveillance Radar (SSR) (Mode A/C and Mode S) Wide Area Multilateration (WAM) system MultiLATeration (MLAT) system
	Dependent	Automatic Dependent Surveillance Broadcast (ADS-B)

Figure 1: Categories of air traffic surveillance sensors

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Composite surveillance (ADS-B/WAM)

Within a Cooperative Independent Surveillance System signals are broadcast from the transponders / transmitter devices of a cooperative aircraft as a result of a trigger interrogation or in support of ACAS or automatically in ADS-B. The ground surveillance system both decodes message content and uses measured parameters to determine aircraft identity and horizontal position, the horizontal position measurement process is 'independent' of aircraft derived information.

SSR, ADS-B (Automatic Dependent Surveillance – Broadcast) and WAM (Wide Area Multilateration) systems are 'Cooperative Surveillance Systems', as they are reliant on signals broadcast from aircraft transmitters/transponders.

The SESAR Solution "**Composite Cooperative Surveillance**" is a surveillance system that exploits the similarities between the two surveillance techniques and combines them into a single system. The term composite is used to signify that various system components and data items are shared whilst ensuring that the required degree of channel autonomy/independence is retained. ADS-B information received by WAM system is evaluated and if matching with WAM information extracted by others methods, then it´s used in the WAM output. Information is then periodically re-evaluated.

The exploitation of synergies between the two surveillance techniques into a "composite surveillance system" supports a number of benefits and performance enhancements. These include:

- ***cost savings***, achieved through the co-mounting of system components into a single unit and the associated savings in terms of site costs, communications and efficient utilization of certain common components

- Use of ADS-B message information to support passive acquisition of an aircraft, ***reducing the 1030/1090 MHz footprint*** of a WAM surveillance system, especially a reduction in the number of 1030 MHz interrogations.

- ***cost effective security mitigation*** techniques, based on the use of additional 'raw' RF and timing data (not available in other components of a surveillance infrastructure), which can be used to derive additional indicators, such as Ground based 'confidence/credibility' measure enabling e.g. the early identification of anomalous avionic behaviour, or spoofed 'ADS-B transmissions'.

- Means for ***performance monitoring*** and alerting of faults in the system, by supplementing the WAM channels BITE with the comparison between the ADS-B position and WAM channel data as a way to detect failure conditions.

- **Improvement of the performance** of the ADS-B channel, e.g. by enabling the allowance of temporary reductions in ADS-B quality indicator values, by resolving

ADS-B data-to-track association issues related to non-unique 24-bit addresses, by reducing the effects on the resulting along-track horizontal position error.

Operational Improvement Steps (OIs) & Enablers

"Composite surveillance solution" is based on the next enablers (DS16):

- CTE-S06: Composite Surveillance

This enabler comprises the different combinations of data at surveillance sensor level (e.g. MODE-S/ADS-B, WAM/MSPSR, WAM/ADS-B, MSPSR/ADS-B) in order to achieve better performances and reducing the environmental impact of the sensors.

Within the scope of this contextual note, we refer only to the WAM/ADS-B combination.

It´s proposed that as for other CTE-S enablers, a sub level of ENs is created to diferenciate the different combinations of composite surveillance. In this case, it´s porposed to create a CTE-S06a "Composite ADS-B / WAM" surveillance system.

- CTE-S05: Gradual rationalisation of conventional surveillance infrastructure (ADS-B/WAM vs SSR and MSPSR vs PSR)

Gradual integration of more recent technologies to complement the conventional surveillance sensors (ADS-B/WAM vs SSR and MSPSR vs PSR)

The following Enablers are considered predecessors and aree necessary for composite ADS-B / WAM surveillance system:

- CTE-S03a: ADS-B station for NRA surveillance
- CTE-S03b: ADS-B station for RAD and APT surveillance
- CTE-S04a — Wide Area Multilateration (WAM)

- Performance improvement (DS16): Evolution of the surveillance technology with the use of composite surveillance is not only led by operational factors, but also by rationalization in the use of systems and the provision of better performance. In this sense, new OIs called "performance improvements" were created in the masterplan and were linked to the ADS-B systems developed in this project.
  - CNS-0003-A: Rationalisation of SUR functionalities and/or technologies for CNS systems supporting cost efficiency, spectrum efficiency, etc. for Step 1.

Background and validation process

The SESAR Solution has been validated through a series of activities including 2 Real-Time live Flight Trials (one in the UK and one in Spain), focusing on a range of objectives and to assess of the abovementioned benefits.

UK platform:

To undertake the verification and validation activities exploring the potential for a combined WAM and ADS-B system to offer 3NM separation services in High Density airspace within the CASCADE CRISTAL RAD HD project a WAM system providing coverage over the London Terminal Manoeuvring Area (LTMA) was used. The receiver / interrogator configuration of the CRISTAL system was modified from the base configuration used within the CRISTAL RAD HD project validation activities.

The modification made under the auspices of project 15.04.02 included:

- The re-installation of decommissioned receivers , to improve low level coverage and improve the WAM DOP through an improved geometry of contributing receiver solutions.
- The redeployment of the interrogator from a site with a sectorial antenna to an omni antenna to facilitate range aided multilateration testing.

These modifications were mainly implemented to improve the DOP of the WAM system and improvement of the low level coverage within the LTMA. Furthermore the redeployment of the interrogator was undertaken to facilitate the assessment of range aided mulitlateration to extend the volume of coverage, which would not have been possible with the directed sectorial antenna of the base configuration

The UK platform was used to collect a large dataset of overlapping CAT021 ADS-B and CAT020 WAM messages covering the London Terminal Manoeuvring Area.
The following assessments compared the values of the CAT020 WAM messages with CAT021 ADS-B messages.

The V&V activities conducted using the UK platform include:

- Range-aided multilateration assessments with comparison to passive WAM,
- DAP extraction assessments,
- ADD comparison and population assessment
- Performance assessment for 3NM, 2NM and 2.5NM separation
- User acceptance trials,

Madrid Platform

To evaluate the performances and behaviour of a composite WAM-ADSB surveillance system, a WAM Surveillance System was installed to provide coverage over the Madrid (TMA). WAM system is composed of five receiver stations, one of them with interrogation capability. For the deployment of the stations, the criterion of selection of the sites was performed according to the availability of manufacturer facilities in the Area. In many cases, locations are not optimal by Line of Sight, or for DOP calculations, but this will help to

evaluate the improvements provided by a Composite system against a standard WAM system.

The modification made under the auspices of project 15.04.02 included:

- Update of existing receiving stations.
- Installation of one interrogator

Due to the existence of SSR in the surroundings, WAM system previously operated in passive configuration. It has been analized the differences between passive & active configurations. For some of the validation use of interrogator is necessary, so the redeployment of the interrogator was undertaken to facilitate the assessment of range aided validation and information extraction.

Madrid system has been used to collect a large dataset of overlapping CAT021 ADS-B and CAT020 WAM messages covering the Madrid TMA. CAT021 produced a “enhanced ADS-B dataflow” including the results of each of the performed data validations. CAT020 WAM output was composed by two different streams, WAM only and “composite” channel, in order to analize the differences.

The following assessments compared the values of the CAT020 WAM messages with CAT021 ADS-B messages.

The V&V activities conducted using the Madrid platform include:

- TDOA validation (with at least 2 receiver stations).
- Range validation with active WAM.
- Full-WAM validation.
- Position comparison between ADS-B and WAM results, both vertical and horizontal cases.
- Track association through the ICAO 24 bit address.
- Study of uncompensated latency cases.
- Altitude validation
- Identification validation
- Automatic performance monitoring

Results and performance achievements

The verification activities performed demonstrated the potential of the Composite Surveillance to support ATC services in the different types of airspace considered (Airport, TMA, En-Route) and for both nominal and non-nominal conditions investigated.

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By allowing the use of ADS-B data that has been validated against data derived in parallel by a WAM system the Composite Surveillance System configuration can help to reduce the 1030/1090 MHz RF load. It achieves this through the integration of validated data items in to the WAM channel thereby preventing a need to reinterrogate for the data item.

Furthermore, the use of the system contributes to an improved security by successfully mitigating associated ADS-B threats.

This SESAR Solution will contribute to benefits in the following KPA:

- Cost Efficiency: System provides two surveillance layers sharing HW components, whit the associated cost reduction.
- Security: Increases security of ADS-B surveillance layer by verification of received information

Other KPAs are benefit by the performance improvements of this solution:

- Spectrum efficiency: Due to the reduction of number of interrogations and also number of replies. Information is obtained via ADS-B only, and not as interrogations & replies.
- Safety, capacity, fuel efficiency: due to the performance achieved by the system this aspects are benefit from the solution in comparison to the sensors used as baseline.

As result of this valiation activities it´s proposed to propose the solution with TRL6.

Recommendations and Additional activities

It is recommended that in the transition towards and through industrialisation and deployment, including possible Large Scale Demonstration projects, a detailed description of the functionalities has to be produced. Emerging standards (e.g. EUROCAE) and Specifications as well as exercises of the applications to be implemented and their reachable benefits at generic and local levels, should be included.

Integration with security functionalities developed by other SESAR projects, such as 15.04.06 should be further elaborated.

Standardisation activities should take into account the results of the project. This includes Composite surveillance functionality to be included in new ED142 and/or ED129 standards as well as ASTERIX change proposals for Categories 21 and or 23 should be considered by the relevant stakeholder groups

Enablers for composite surveillance should be split to cover the different possibilities i.e. ADS-B/WAM, MSPSR/WAM/ADS-B, ….

Actors impacted by the SESAR Solution

ANSPs, Airport authorities, ATM system manufacturers, Member States.

Impact on Aircraft System

The solution envisaged is a Ground system so it does not include avionic functionality. However, in order to support operations in radar airspace and for airport surveillance, the aircraft systems are assumed compliant with the EU Regulation 1207/2011 (Surveillance Performance and Interoperability Implementing Rule - SPI IR) and associated EASA certification material (CS-ACNS). The equipage process is ongoing as part of the Rule applicability incl. any amendments.

Impact on Ground Systems

The Ground system will have to be upgraded in terms of composite WAM-ADSB functionality , including sensors, SDPD and ASTERIX interfaces. The specific parts of the developed functionality to be transferred to the industrialised and operational systems will be decided by the relevant stakeholders and their groups.

Regulatory Framework Considerations

Full text of IR Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky

Commission Implementing Regulation (EU) No 1028/2014 of 26 September 2014 amending Implementing Regulation (EU) No 1207/2011 laying down requirements for the performance and the interoperability of surveillance for the single European skyEU Regulation 1207/2011, 1028/2014 and any further amendment
EASA CS-ACNS
EASA RMT.0679

Revision of surveillance performance and interoperability (SPI)

The current SPI Regulation (Regulation (EU) No 1207/2011) details the requirements for the carriage and operation of airborne surveillance equipment by both civil and State registered aircraft, and the dates by which qualifying aircraft must be equipped.

EASA NPA -2017 Q2

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EASA Opinion- 2018 Q2

Standardization Framework Considerations

The SESAR projects have contributed to the progress of the following standards:

- EUROCAE Technical Specifications for ADS-B Ground system (ED-129B)
  - Published
- EUROCAE ED142A: Technical Specification for Wide Area Multilateration (WAM) systems
  - Work In Progress within EUROCAE WG51 SG4
- ASTERIX Interface Specifications not defined for composite use.
  - Update is necessary ASTERIX categories relevant for ADS-B (ASTERIX CAT021 for Target reports and ASTERIX CAT023-025 for System Status reports). Proposals have been produced but are still under definition by EUROCAE.

Considerations of Regulatory Oversight and Certification Activities

The provisions of the EU Regulation 1207/2011 (including safety case, monitoring etc.) and amendments as well as the associated provisions of EASA and/or National Authorities should be taken into account.

Solution Data pack

The Data pack for this Solution includes the following documents:

15.04.02 D06: Technical report, composite cooperative surveillance studies

This document includes the list of requirements that constitute the vision of “composite surveillance” in the EUROCAE framework. Participans of this project used drafts of EUROCAE WAM TS and included the relevant requirements as baseline for this SESAR project.

15.04.02 D08: Technical report, composite cooperative surveillance prototype

This document analises the “High level” requirements produced in D06 and produces more precise requirements necessary to perform the validations used in the project.

15.04.02 D11 Verification Report, composite cooperative surveillance

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This document contains the results of the verification activities performed in the project.

Intellectual Property Rights (foreground)

Deliverables consists of SJU foreground.