INDUSTRIAL RESEARCH

SESAR JOINT UNDERTAKING

PJ.14 W2 - D12.2.950 - PJ14-W2-84b TRL6 MRT-SUR CONTEXTUAL NOTE

Deliverable ID:	D12.2.950
Dissemination Level:	PU
Project Acronym:	PJ.14 W2 I-CNSS
Grant:	874478
Call:	H2020-SESAR-2019-1
Topic:	SESAR-IR-VLD-WAVE2-12-2019
Consortium Coordinator:	Leonardo
Edition date:	30 November 2022
Edition:	00.01.02
Template Edition:	02.00.04

Authoring & Approval

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Eurocontrol	30 November 2022
Indra	30 November 2022
Enaire	30 November 2022

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Approved for submission to the S3JU By - Representatives of all beneficiaries involved in the project

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Frequentis	30 November 2022
Eurocontrol	30 November 2022
Indra	30 November 2022
Enaire	30 November 2022

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date

Document History

Edition	Date	Status	Beneficiary	Justification
00.01.00	15 October 2022	final	Thales	Release for submission to SJU
00.01.01	04 November 2022	final	Thales	Release addressing SJU comments
00.01.02	30 November	final	Thales	Release covering additional SJU comments from Maturity Gate

PJ.14 W2 I-CNSS

PJ.14-W2-84B - TRL6 - MULTI REMOTE TOWER SURVEILLANCE MODULE

This Contextual Note is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874478 under European Union's Horizon 2020 research and innovation programme.

Abstract

This TRL6 Contextual note provides SESAR Solution PJ.14-W2-84b Multi Remote Tower Surveillance module description for industrialisation consideration.

PJ.14-W2-84b covers the development of an adequate and economically reasonable surveillance solution for Multi Remote Tower Control – Surveillance (CTE-S10). The envisaged enabling solution is composed of data fusion of ADS-B and a mini-MLAT / non-rotating ranging with an electro-optical sensor in addition to the existing / already available surveillance infrastructure.

The scope covers to establish a surveillance performance class below the performance specified in the applicable ground surveillance standard. The required performance for the output of a tracker of an A-SMGCS System is specified in the EUROCAE standard ED-87C (Minimum Aviation System Performance Specification for Advanced Surface Movement Guidance and Control Systems (A-SMGCS)). To achieve this performance, sensors according to ED-116 (SMR) and ED-117 (MLAT) are necessary. From an economical point of view, these sensors are not suitable and from operational perspective not necessarily needed for the designated target airports for multi remote tower operations.

The multi-remote surveillance solution defines a set of requirements for the technical solution enabling surveillance for multiple remote tower control. These requirements address the electro-optical sensor, the non-rotating Mode-S ranging component as well as the data fusion component. All three components are closely connected with one another to establish a logical surveillance layer.

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1 Purpose

This contextual note introduces the SESAR Solution PJ.14-W2-84b Multi Remote Tower Surveillance module 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 for increasing the level of maturity. This contextual note complements the technical data pack comprising the SESAR deliverables.

The goal of solution 84b is to provide an adequate and economically reasonable surveillance solution for Multi Remote Tower Control – Surveillance (CTE-S10). Depending on the operational concept as defined by PJ 05 solution 35 for multiple remote tower control, a surveillance sensor is an optional part of the concept in order to enhance the controllers' situational awareness. Multiple remote tower control is envisaged for small and other aerodrome environments with low traffic density.

The core objective of PJ.14-W2-84b is to establish a surveillance performance class below the performance specified in the applicable ground surveillance standard. The main driver is to offer a cost efficient tailored-performance solution for providing an appropriate air and ground situation for small airports as beneficial for Multi Remote Tower Control.

The required performance for the output of a tracker of an A-SMGCS System is specified in the EUROCAE standard ED-87C (Minimum Aviation System Performance Specification for Advanced Surface Movement Guidance and Control Systems (A-SMGCS)). To achieve this performance, sensors according to ED-116 (SMR) and ED-117 (MLAT) are necessary. From an economical point of view, these sensors are not suitable and from operational perspective not necessarily needed for the designated target airports for multi remote tower operations.

The envisaged enabling solution is composed of data fusion of ADS-B and a mini-MLAT / non-rotating ranging with an electro-optical sensor in addition to the existing / already available surveillance infrastructure. The non-cooperative surveillance coverage is addressed by the electro-optical sensor using Cat015 as data container for azimuth and elevation angle data. For non-ADS-B equipped targets, the secondary coverage relies on a mini-MLAT system with a performance below the specified values of ED-117 (Minimum Operational Performance Specification for Mode S Multilateration Systems for Use in Advanced Surface Movement Guidance and Control Systems (A-SMGCS)). In addition to WGS-84 position solutions, this mini-MLAT is capable of providing range and range difference measurements directly to the ATC tracking system. The ADS-B performance is fully compliant with ED-129B (Technical specification for a 1090 MHz extended squitter ADS-B ground system).

The ATC tracking system is enhanced to be capable to process these partial (incomplete) measurements of ranges, range differences or angles directly. Furthermore the simulation and analysis infrastructure is upgraded to handle this new kind of data.

Solution 84b is part of a panel of surveillance solutions defined in the scope of PJ.14-W2-84 that aims to reach TRL6 maturity.

2 Improvements in Air Traffic Management (ATM)

Composite surveillance solutions have the potential to lower implementation costs and deliver appropriate levels of performance to meet the needs of regional airports or remote tower environments. This solution aims to provide a surveillance service to increase situational awareness for the multi remote tower controller in a cost-effective way. It provides a basic surveillance service for a small to medium sized airport below the performance specified in ED-87D within a range of around 20 nautical miles by augmenting the performance of existing surveillance equipment.

SESAR research aims to enhance the video camera plot extraction used as a non-cooperative source for the tailored multi-remote tower surveillance layer, consisting of video and infrared cameras, multilateration (MLAT) and multi-sensor data fusion (MSDF). The multi-remote surveillance module enables the event generation for multi-remote tower center (MRTC) operation. A key element is the monitoring of stop bars between the taxiway system and the runway. The solution also enables enhanced control of a pan tilt zoom (PTZ) camera.

The multi-remote surveillance solution defines a set of requirements for the technical solution enabling surveillance for multiple remote tower control. These requirements address the electro-optical sensor, the non-rotating Mode-S ranging component as well as the data fusion component. All three components are closely connected with one another to establish a logical surveillance layer.

The MRT-SUR defines a set of requirements for the technical solution enabling surveillance for multiple remote tower control. These requirements address the electro-optical sensor, the non-rotating Mode-S ranging component as well as the data fusion component. In difference to what is currently understood as a surveillance layer, all three components are closely connected with one another to establish a surveillance layer.

Due to the novelty of the MRT-SUR application no standard whatsoever is currently available to address this type of application. Therefore, an initial OSED is provided in the appendix of the solutions TS/IRS. Due to cost constraints, a classic A-SMGCS system with sensors specified according to ED-116 (SMR) and/or ED-117 (MLAT) will not be an option to establish a surveillance layer for MRTC applications.

Furthermore it should be noted that partially the currently existing ASTERIX categories are not sufficient for all data transfer proposes. While the novel Cat015 as container for non-rotating primary sensors is meanwhile available as a released version, with respect to non-rotating Mode-S ranging, Cat020 will be used as basic container in addition to Cat020/SP as defined in the appendix. After proving the concept of MRT-SUR these consideration are expected to form the base for standardization activities.

Detailed Relevant use cases are given in the solutions TS/IRS, Appendix **Error! Reference source not found.** on Use Cases as part of the OSED for MRT-SUR.

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3 Operational Improvement Steps (OIs) & Enablers

The PJ.14-W2-84b covers New use and evolution of Cooperative and Non-Cooperative Surveillance for ATM and A-SMGCS purposes with CTE-S10 MRTC – Surveillance (Multi Remote tower Control – Surveillance). This solution establishes a cost-effective surveillance for multi remote tower control (CTE-S10) as an optional enabler for SDM-0210 Flexible allocation of aerodrome. The applicable Integrated Roadmap Dataset is (draft) DS23.

The solution addresses interfaces, simulation & analysis infrastructure as well as data generation & processing. The feasibility has been demonstrated using a prototype in a real environment of a low traffic single runway airport.

The Multi Remote Tower Module is complemented with a cost efficient surveillance solution that integrates new combinations of NCS and CS sensors. Data fusion of electro-optical sensor, mini-MLAT, non-rotating Mode S ranging and ADS-B will be investigated.

In EATMA the enabler CTE-S10 is related to following operational improvements

POI-0058-SUR Surveillance sensors for Multiple Remote Tower Controlled operations: Increase in the efficiency and cost effectiveness of the Multiple Remote Tower Controlled operations at small and regional airports through the use of low cost/tailored performance surveillance sensors providing air and ground surveillance information for situational awareness of ATCOs.

SDM-0210 Highly Flexible Allocation of Aerodromes to Remote Tower Modules: The provision of remote ATS service to the remote aerodromes can be dynamically assigned (over time) to any other Remote Tower Module (RTM) within a Remote Tower Centre (RTC). RTC planning tools supporting the RTC supervisor enable an efficient usage of all RTMs and staff in an RTC.

STD-129 — Update of EUROCAE ED-87: Update of the EUROCAE ED-87 standard to cover a performance class below current A-SMGCS.

SVC-062 — Remote aerodrome track service: The Remote aerodrome track service is used to provide multi-sensor track data to Multi Remote Tower Module.

4 Background and validation process

The aim of this solution PJ.14-W2-84b, is to achieve the maturity level of the new enabler CTE-S10 (Multi Remote Tower Control – Surveillance) to a TRL6.

In order to achieve this level of maturity the development within PJ.14-W2-84b of providing a surveillance for multi-remote tower (MRT-SUR) was performed and validated as defined in the TVALP with the deviation that the non-cooperative sub-sensor was not assessed due to its unavailability. The TVALR documents the achievements by validating the development according to the validation objectives as per TVALP.

In order to achieve this level of maturity, several Validation Objectives were defined in the Technical Validation Plan document with their corresponding success criteria.

The predecessor Solution PJ14-04-03 has achieved maturity level TRL4 at the end of SESAR2020 Wave 1. In Wave 2, the target maturity level is TRL6.

With the goal to establish new performance classes for airport surveillance, the following validation was performed:

- PJ.14-W2-84b EXE01 – TRL6: In-field validation of Cooperative Sub-sensor
- PJ.14-W2-84b EXE02 – TRL6: In-field Validation of Non-Cooperative Sub sensor
- PJ.14-W2-84b EXE03 – TRL6: Overall Sensor technical validation based on operational experience

The approach followed in the validation was to determine

- The performance of the sub-sensors (cooperative and non-cooperative) expressed by respective KPI's and against tentative performance quantification expressed by the intermediate PJ.14-W2-84b TS/IRS
- Assessment of the impact of the sub-sensor performance to the overall sensor performance
- Determination of the overall sensor performance
- Acquisition of operational feedback based on shadow mode operation and real time simulation performed in PJ.05 and relating it to the achieved system performance
- Drawing conclusions with respect to suitability of the sensor to support the services identified in the PJ.14-W2-84b TS/IRS.

The validation as performed using the MRT-SUR prototype installed on the International Airport of Erfurt in Germany.

Erfurt airport (EDDE) is a small international airport controlled by DFS with a comparably low number of aircraft movements and is the second German airport introducing remote tower control (RTC). The RTC is not part of SESAR research. However, the MRTC extension is part of SESAR.

The airport has a single runway with a simple taxiway layout.

It provides ILS approaches to both runway ends. Direction 10 is CAT IIb, while direction 28 is CAT I. The airport is operated under low visibility conditions. The operations currently are conducted without ground surveillance.

The validation is linked to the operational validation performed by the Multi-Remote-Tower-Control project (Pj05, Sol. 35, DFS exercise)

Specifically the exercises covered following scope:

PJ.14-W2-84b EXE01:

This exercise is related to the determination of the technical performance of the Mini-MLAT for supported services in defined coverage volumes.

The approach followed in the validation is to determine

- The performance of the cooperative sub-sensor expressed by respective KPI's and against the performance quantification expressed by the intermediate PJ.14-W2-84b TS/IRS
- Assessment of the impact of the sub-sensor performance to the overall sensor performance
- Drawing conclusions with respect to suitability of the sub-sensor to support the services identified in the PJ.14-W2-84b TS/IRS.

The validation was performed using the MRT-SUR cooperative sub-sensor prototype installed on the platform Airport of Erfurt.

The SUT used for the in-field validation of the cooperative Sub-sensor is based on:

- Thales validated ADS-B (see also PJ.14-W2-84c)
- Mini-MLAT (5 GS reference plus central processing and monitoring)
- T(D)oA-ranging; non-rotating Mode-S radar

PJ.14-W2-84b EXE02:

This exercise is related to the determination of the technical performance of the Camera for supported services in defined coverage volumes.

The performance of the related sub-sensor could not be determined since the prototype was not available for the validation in the MRT-SUR context.

PJ.14-W2-84b EXE03:

This exercise is related to the determination of the technical performance of the Overall MRT-SUR sensor for supported services in defined coverage volumes (with the associated risk that Validation does not provide expected results since prior on-site verification of the non-cooperative sensor was not feasible, see also section 3.2).

The approach followed in the validation includes

- Determination of the overall sensor technical performance with focus on the cooperative sub-sensor with the data fusion
- Determination of the overall sensor technical performance with including the non-cooperative sub-sensor with the data fusion based on the recorded data.
- Provision of overall sensor MRT-SUR data based on replayed on-site data to the Multi-Remote Tower Controller Working Position.

- Acquisition of operational feedback & linking to given technical performance: validate the intended operation can be performed with the performance of the SUR-sensor

The SUT used for the PJ.14-W2-84b EXE03 – TRL6: Overall Sensor technical validation is based on:

- Cooperative Sub-sensor
- Data Fusion and track distribution

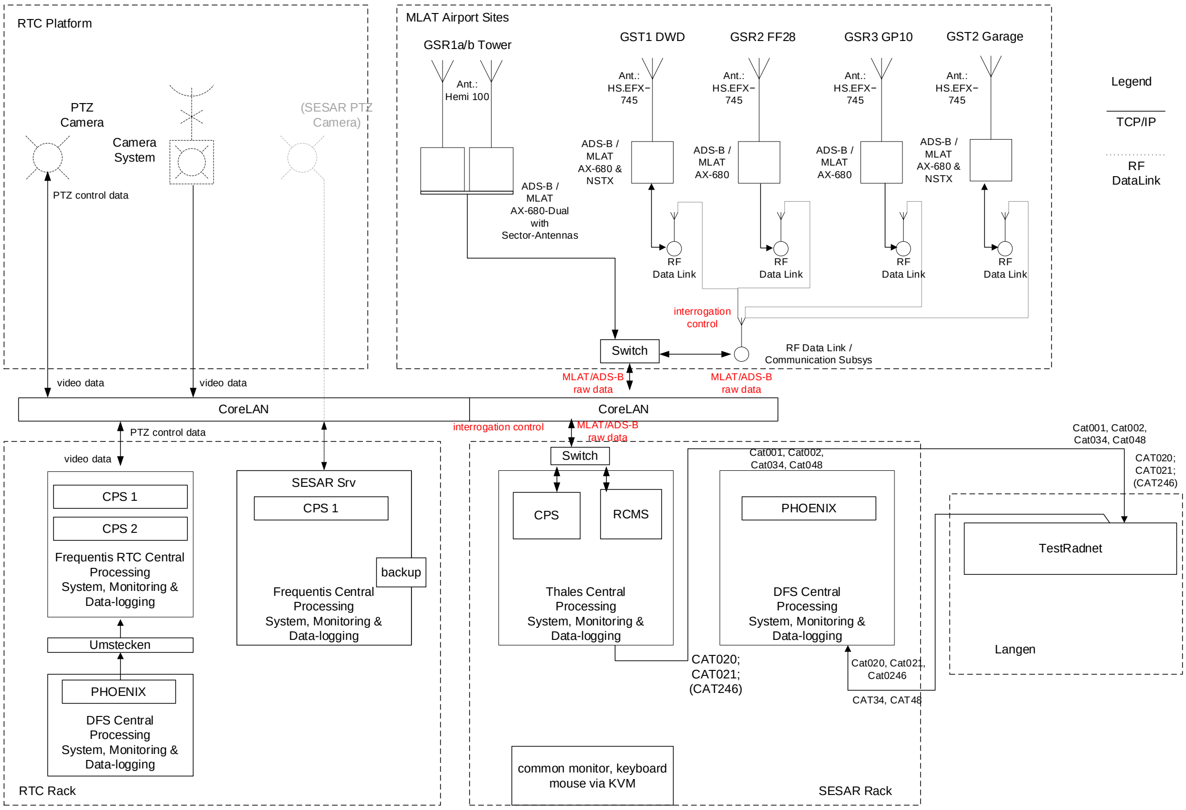

Figure 4-1: MRT-SUR infrastructure

Figure 4-2: Mini-MLAT Sites at airport of Erfurt (same as during Wave 1)

Figure 4-3: Mini-MLAT Equipment used at airport of Erfurt

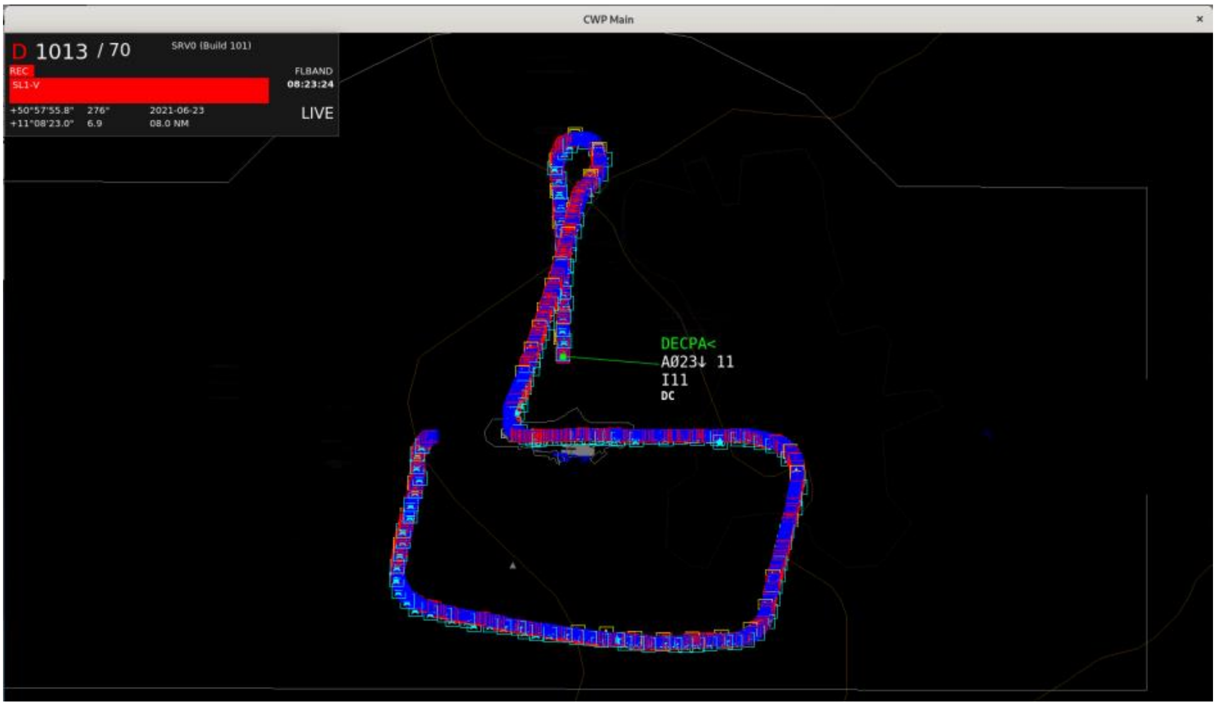

Figure 4-4: Example tracker output for off-airport locations incl. approach region

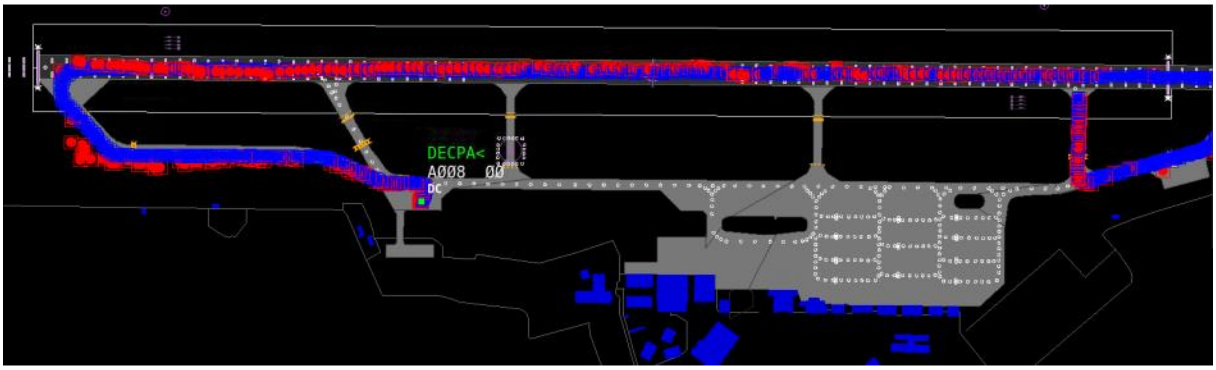

Figure 4-5: Example tracker output for on-airport locations

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5 Results and performance achievements

The validation results were achieved with a HW&SW prototype installed in a relevant operational environment. The development followed the same rules and processes as the product development.

The prototype was implemented in operated in a representative environment. The results were achieved with the prototype installed in airport environment and with real traffic representative for the envisaged operational environment.

The prototype missed inputs from the non-cooperative sub-sensor.

The specific MRTC surveillance sensor capabilities were developed according to processes and methodologies as also applied in product development.

The prototype was continuously operated over a long timeframe and in real on-airport environment. Hence the obtained results are seen to be representative and of good quality.

The results achieved with the prototype of the MRT-SUR sensor using only cooperative sub-sensor input data provide a comparably clear picture of the expectable performance and specific functions of the MRTC-SUR sensor.

The data collection on-site at the airport of Erfurt allowed to collect enough data even though the traffic density is low there. Based on the available data collected over a longer period of time a statistical evaluation was feasible with a good confidence.

The technological feasibility of an MRT-SUR has been proven using cooperative sub-sensor input data.

Regarding the addition of the non-cooperative sub-sensor to the overall MRT-SUR no assessment on technological feasibility has been performed in wave 2 due to the unavailability of the respective inputs. During wave 1 the technological feasibility has been proven with synthetic data.

The results of the validation exercises show that the maturity level of TRL6 can only partially be reached, simply due to some missing validation results. The concept of MRT-SUR has been completely tested under laboratory conditions and reached TRL4 in wave 1.

The present validation was performed totally in the envisaged operational environment on a candidate airport, representative for airports for MRTC. The international airport of Erfurt is already operated via RTC and in the future via MRTC.

The key validation results of this task are:

- Cooperative Sub-sensor: The performance provided by the Mini-MLAT / validated ADS-B conforms to the expectations and to the specification and is in-line with the intended operation. The performance is tailored compared to a typical airport MLAT as per ED-117.
- Non-cooperative sub-sensor: An assessment was not feasible since the sub-sensor was unavailable for the validation. This part is missing.

Overall sensor: Assessments by expert judgement and feedback from ATCOs on the MRT-SUR with only the cooperative sub-sensor providing input data confirm that the performance is suitable for the intended operation and that the MRT-SUR is able to ensure the situational awareness of an ATCO when controlling multiple airports simultaneously from remote.

The obtained experience will be used for future discussions with EUROCAE WGs for standardization purposes. With the specific objective to increase the maturity towards TRL6, a specific focus is laid on standardization including the establishment of a performance class below current A-SMGCS definitions (ED-87C) and definition of according equipment standards in MLAT MOPS (ED-117).

The technological performance assessment was complemented by a technological cost-benefit analysis (CBAT).

The CBAT was established from the perspective of a technological solution. It compares the cost of surveillance sensor implementations in context of the introduction of Multi-Remote Tower Control. The primary underlying assumption is that a surveillance is needed when applying MRTC operations.

The resulting benefit is cost saving resulting from applying MRT-SUR compared to state-of-the-art existing technology, i.e. A-SMGCs as defined by ED-87C.

Based on the performed analysis significant cost-savings would result by applying the solution scenario compared to the reference scenario. This holds also true if influencing factors (discount rate, cost per unit estimate, number of units) vary.

6 Recommendations and Additional activities

The following recommendations for the further development of the MRT-SUR are made:

- Performance refinement: An additional assessment of the inclusion of non-cooperative sub-sensor is recommended. The assessment should focus on non-transponder targets.
- In this context the following is clearly recommended: During industrialization of MRT-SUR a performance assessment of the non-cooperative sub-sensor of an MRT-SUR shall be performed. This is especially related to the use of an object detection running on camera data to validate the specified performance is achieved and to further detail the operational use.
- This clear recommendation on further activities (on the non- cooperative sub-sensor) during industrialisation is seen as a part of solution implementation and prerequisite for the operational use.
- Industrialization: Perform Industrialization of the MRT-SUR to bring it to operation and fulfil an operational need when MRTC operations are introduced operationally.
- Standardisation: The development of an applicable MASPs for the MRT-SUR is recommended. This is seen to be covered by future activities by EUROCAE WG-41 with a evolution of ED-87x to cover a “A-SMGCS light”.

The recommendation towards operational projects aiming on implementation of MRTC is to consider the MRT-SUR as surveillance sensor instead of a ‘classic’ A-SMGCs, when a surveillance is deemed necessary in order to ensure the situational awareness of an ATCO controlling multiple airports simultaneously from remote.

7 Actors impacted by the SESAR Solution

Actors impacted by the solution are:

- Multiple Remote Tower Air Traffic Controller (MRTC ATCO):
  - MRTC ATCO uses the MRT-SUR to maintain an awareness of the traffic situation at the respective airport. This is especially important when switching from one airport to another.
  - Needs to be trained with the operation using the MRT-SUR and be aware of the differences of an MRT-SUR compared to a 'classic' A-SMGCS
- ATC Maintenance personal (member of CNS department)
  - Maintains the MRT-SUR and needs to be trained with the sensor from maintenance parspective
- Data processing manufacturer
  - Industrialize the extended data fusion sub-sensor data processing of the solution and implement into products.
- MLAT manufacturer (provision of cooperative system components)
  - Industrialize the cooperative sub-sensor (Mini-MLAT/ADS-B) of the solution and implement into products.
  -
- RTC camera component provider (provision of non-cooperative system components)
  - Industrialize the object detection as non-cooperative sub-sensor of the solution and implement into products.
  -
- Military ATC
  - Could be interested in the solution as cost-effective surveillance mean and especially if Multi-Remote Tower operations would be introduced in military context. In this case to implement the industrialized solution and bring into operation.

8 Impact on Aircraft System

This SESAR solution has no impact on Aircraft systems.

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9 Impact on Ground Systems

The following impact on Ground Systems was identified:

- Upgrading the Remote Tower Control Cameras setup by adding a plot extractor unit to become a non-cooperative surveillance sensor.
- Adapt ADS-B/MLAT system to support MRT-SUR (system design, system siting, operation)
- Upgrading the SDPS for the processing of partial measurements and applying validated ADS-B (see SESAR solution PJ.14-W2-84c).
- Upgrading of the analysis infrastructure.

10 Regulatory Framework Considerations

The regulatory processes themselves remain untouched. The equipment is approved according to the applicable rules. The applicable rules have to reflect the tailored performance of the surveillance sensor.

The applicable rules are derived from the standards and the system demonstrates the applicable standards are fulfilled. Needed standardisation updates to bring MRT-SUR into operation are described in the following section. In this context it shall be made clear that ASTERIX CAT-15 has no need for update but performance of the non-cooperative part needs to be covered, presumably in ED-240 (Minimum Aviation System Performance Standard for Remote Tower Optical Systems). The future work plan of the related EUROCAE working group is recommended to cover the related activities.

11 Standardization Framework Considerations

The following standardization activities have been identified:

- Standardization of the SDPS output similar to ED-87D by establishing of a Minimum Aviation System Performance Standard (MAPS) system concept for MRT-SUR).
- Standardization of Mini-MLAT performance (derivation of the Minimum Operational Performance Standards (MOPS) based on the MAPS for MRT-SUR) similar to ED-117.
- Standardization of the usage of video cameras as surveillance sensor in the ATC context. From an interface perspective, CAT 015 has officially been released in July 2019 by the ASTERIX Maintenance Group (AMG). EUROCAE WG-100 already specified in ED-240A the usage of cameras for RTC purposes, but not as surveillance sensors providing a CAT 015 output.
- A central goal of this task was to provide a situation awareness regarding Mode-S aircraft for small and medium airports without ADS-B equipage. Nevertheless aircraft which are ADS-B equipped can be detected with a much greater performance, but for them, the security issue regarding ADS-B has to be covered. CAT 021 contains currently only a single flag regarding the confidence level. The usage of partial measurements like range, range differences or angular measurements provides much more information, than can currently be covered by this single flag. Therefore it is recommended to start a standardisation initiative regarding a new ASTERIX category as transponder deviation report.
- Interface standardization for the exchange of partial measurements for non-rotating Mode-S ranging especially the standardization of ASTERIX category which enables the transmission of range and range difference data. This might become part of CAT 020 (Mini-MLAT) and CAT 021 (ADS-B), but seems not to be necessarily limited to the enhancement of CAT 020 and CAT 021.

12 Solution Data pack - D12.2

The solution data pack D12.2 - PJ14-W2-84b -TRL6 Data Pack Multi Remote Tower Surveillance module will include:

- D12.2.130 PJ14-W2-84b -TRL6 Final TS/ IRS– Multi Tower Remote Tower Surveillance (MRT-SUR), ed 00.01.01, 26 October 2022
    - Composed by Part I: TS/IRS and Part II: Safety Assessment Report
    - Part I provides the requirements specification, covering functional, non-functional, interface and intermediate performance requirements related to SESAR Solution PJ.14-W2-84b – Multi Remote Tower Surveillance (MRT-SUR). It is complemented by part II providing the technical safety assessment report, which describes the performed safety activities, among which the derivation of the performance values for the MRT-SUR was performed.
    - Part II describes the safety activities performed for the SESAR Solution PJ.14-W2-84b – Multi Remote Tower Surveillance (MRT-SUR): SAP. It describes the safety assessment approach and activities performed as part of the MRT-SUR requirement derivation and validation.
- D12.2.400 PJ14-W2-84b -TRL6 TVALR - Multi Remote Tower Remote Surveillance (MRT-SUR), ed 00.01.01, 26 October 2022:
    - This document describes the Technical Validation Report for the SESAR Solution Pj.14-W2-84b – Multi-Remote Tower Surveillance Module, D12.2.400: TVALR. It describes the validation approach and the validation activities performed in order to validate the validation objectives associated to their corresponding success criteria and requirements. The requirements to be verified are defined in the Technical Specification D12.2.120 Intermediate Technical Specification (TS/IRS). For each requirement or set of requirements, validation objectives are formulated. The validation approach including the validation exercises, with respect to scope, expectations and procedures, are provided for the validation objectives in the Technical Validation Plan D12.2.200.
- D12.2.500 PJ14-W2-84b -TRL6 CBAT - Multi Remote Tower Surveillance (MRT-SUR), ed 00.01.01, 12 October 2022
    - This document provides the Technical Cost Benefit Analysis related to SESAR Solution PJ 14-W2 84b addressing the Multi-Remote Tower Surveillance sensor.