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Contextual Note for Surveillance Performance Monitoring (SPM) Tools for Cooperative Systems (ADS-B, WAM, MLAT) (TRL6)

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Authors of the document

Beneficiary	Date
Thales	18 November 2022
Eurocontrol	18 November 2022
Coopans	18 November 2022
Enaire	18 November 2022

Reviewers internal to the project

Beneficiary	Date
Thales	18 November 2022
Eurocontrol	18 November 2022
Coopans	18 November 2022
Enaire	18 November 2022
Indra	18 November 2022
NAV Portugal	18 November 2022

Reviewers external to the project

Beneficiary	Date

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

Beneficiary	Date
Thales	18 November 2022
Eurocontrol	18 November 2022
Coopans	18 November 2022
Enaire	18 November 2022
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Rejected By – Representatives of beneficiaries involved in the project

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D12.5.950 CONTEXTUAL NOTE

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Abstract

This TRL6 Contextual Note provides SESAR Solution PJ.14-W2-84e description for industrialisation consideration. The SESAR Technological Solution PJ.14-W2-84e Surveillance Performance Monitoring (SPM) tools for Cooperative Sensors addresses the Cooperative part of the Surveillance Performance Monitoring at sensor level (ADS-B, WAM and MLAT) in En-Route & TMA (ADS-B, WAM - enabler CTE-S07a) and also for Surface (MLAT, ADS-B - enabler CTE-S07b). Within Wave 2 the solution evolved from an initial maturity level TRL4 to a maturity level TRL6 for both enablers CTE-S07a and CTE-S07b.

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1 Purpose

It is essential that the surveillance data output from new and emerging surveillance techniques and technologies can be seamlessly integrated into the ATM infrastructure. This implies (among other things) a trustworthy and accurate performance monitoring. PJ.14-W2-84e aims to develop mechanisms to elaborate on existing means for the performance assessment of sensors, using both off-line and quasi real-time processes. The tools intended to assess the performance have been developed and validated by THALES and EUROCONTROL to a TRL6 maturity level in the frame of PJ.14-W2-84e.

This solution copes with the performance monitoring of cooperative sensors (ADS-B, WAM and MLAT) in En-Route and TMA environments (ADS-B, WAM - enabler CTE-S07a) and also for Surface environment (MLAT, ADS-B - enabler CTE-S07b). The intention of this solution is first to reflect and detail the performance evaluation methods from emerging and evolving standards in line with the performance based surveillance (PBS) approach and second to obtain a harmonisation of methods for performance monitoring in general and across the SPM tool prototypes developed in PJ.14-W2-84e.

The objective is to evolve the enablers **CTE-S07a "Coop sensor SPM Tool – ER & TMA" and CTE-S07b "Coop sensor SPM Tool – Surface" to TRL6** enabling the new defined Performance Operational Improvement, **POI-0061-SUR "Surveillance performance monitoring for cooperative sensors".**

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2 Improvements in Air Traffic Management (ATM)

The PJ.14-W2-84e is a technological solution aiming at enabling an improved performance monitoring of surveillance systems in line with the Performance-Based Surveillance (PBS) approach. This solution focuses on the development of Surveillance Performance Monitoring Tools for cooperative sensors such as ADS-B, Wide Area Multilateration and airport Multilateration. Using off-line and quasi real-time processes the solution supports in ensuring the correct functioning of the ATM surveillance function. All phases of flight are covered by the solution: Terminal Maneuvering Area (TMA) & En-Route (ER) and Surface.

The objective is to evolve the enablers **CTE-S07a "Coop sensor SPM Tool – ER & TMA" and CTE-S07b "Coop sensor SPM Tool – Surface" to TRL6** enabling the new defined Performance Operational Improvement, **POI-0061-SUR "Surveillance performance monitoring for cooperative sensors".**

Two SPM Tool prototypes, namely THALES MAGS EXPLORER (CTE-S07a & CTE-S07b) and EUROCONTROL SASS-C/VERIF (CTE-S07a), have been developed and validated during the TRL6 phase.

The main activities of the solution include:

- The adaptation of the methods and tools to take into account the evolution of the emerging standards on cooperative sensor level following the performance based approach: (i.e. EUROCAE ED-117A for MLAT Surface, ED-142A for WAM and ED-129B/C for ADS-B);
- Introduction of quasi real-time monitoring capabilities allowing to assess system performance in close to real-time;
- Specification and development of related SPM tools and methods;
- SPM tools validation including harmonization cross-check between the tools;
- Provision of the results of tools verification are a potential input to the standardisation, in particular the EUROCAE documents and EUROCONTROL Specification, test or Conformity Assessment sections, for possible improvements.

The SPM tool is a separate tool for assessment of the performance of Surveillance sensors, typically delivering statistical reports related to the system performance. SPM tools are usually used for verifying and demonstrating that the performance requirements have been met (e.g. for system acceptance test) before putting a system into operation or for system maintenance and for in service performance compliance monitoring. This Solution provides a means to harmonise industry tools specifications for SPM, aligned with existing or developing Surveillance Standards (e.g. EUROCAE ED129 for ADS-B, ED142 for WAM and ED117 for airport MLAT).

SPM tools are not involved in the ATC operations and are used:

- by ATSEP (Air Traffic Safety Electronics Personnel), who are the engineers providing the support for maintaining a correctly functioning surveillance system;

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- by the project engineers at industry side responsible for verifying that the installed system performance satisfies the customer requirements for system acceptance.

SPM tools aim to demonstrate correct functioning of the ATM surveillance function at the individual sensor level (this solution Solution 84e) or at ATC end-to-end level (Solution 84f). The mount point for SPM Tools within the ATM Surveillance is shown in Figure 1. The herein described solution focuses on the monitoring of the cooperative sensors.

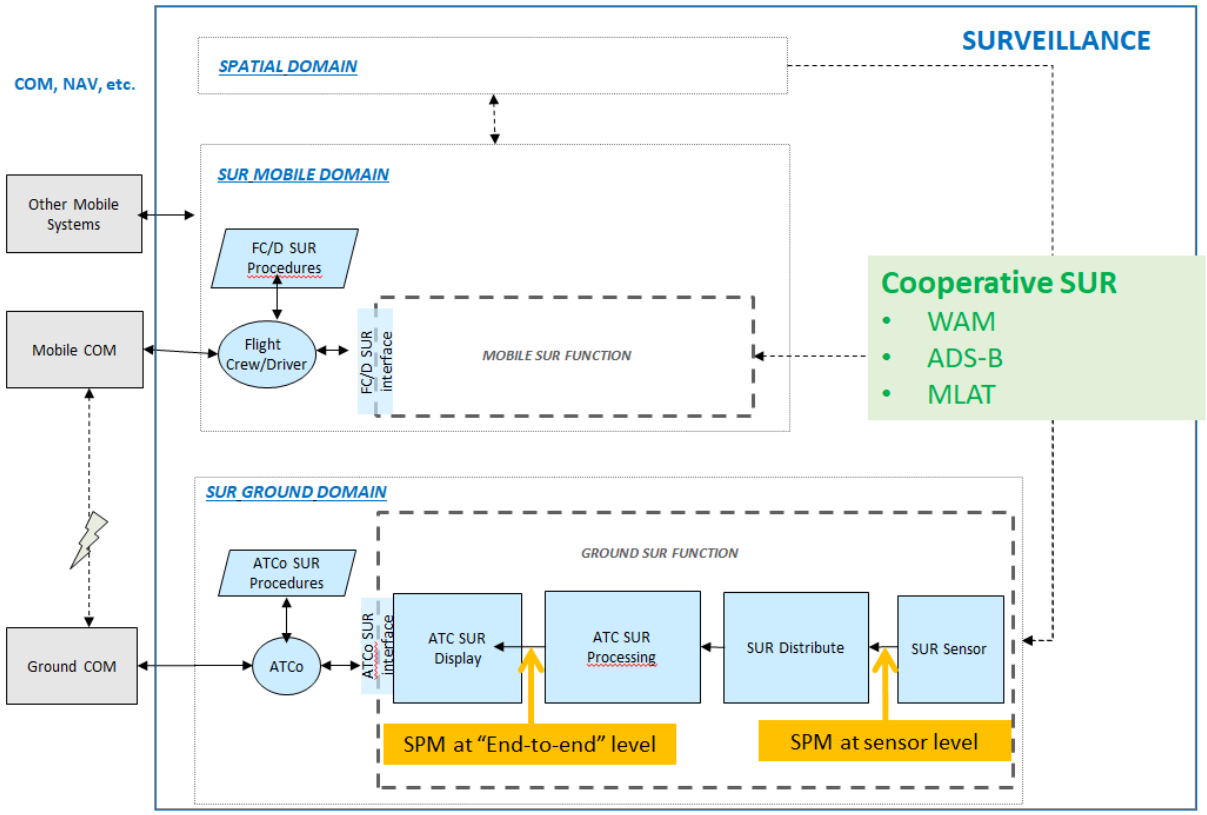

Figure 1: Surveillance Performance Monitoring Tool within Surveillance (84e for Sensor Level, 84f for End- to-End level).

The SPM tool has as the main input data from surveillance sensors whose performance will be assessed and monitored. There is additional input from external references like on-board GPS recordings or other data sources that can be used as reference.

Output interfaces are performance analysis reports and graphical displays for inspection. Performance analysis reports give a list of performance metrics and whether the metrics are within allowed limits. Graphical displays provide the mechanism to investigate the reasons for unexpected performance values and identify problematic regions and/or aircrafts.

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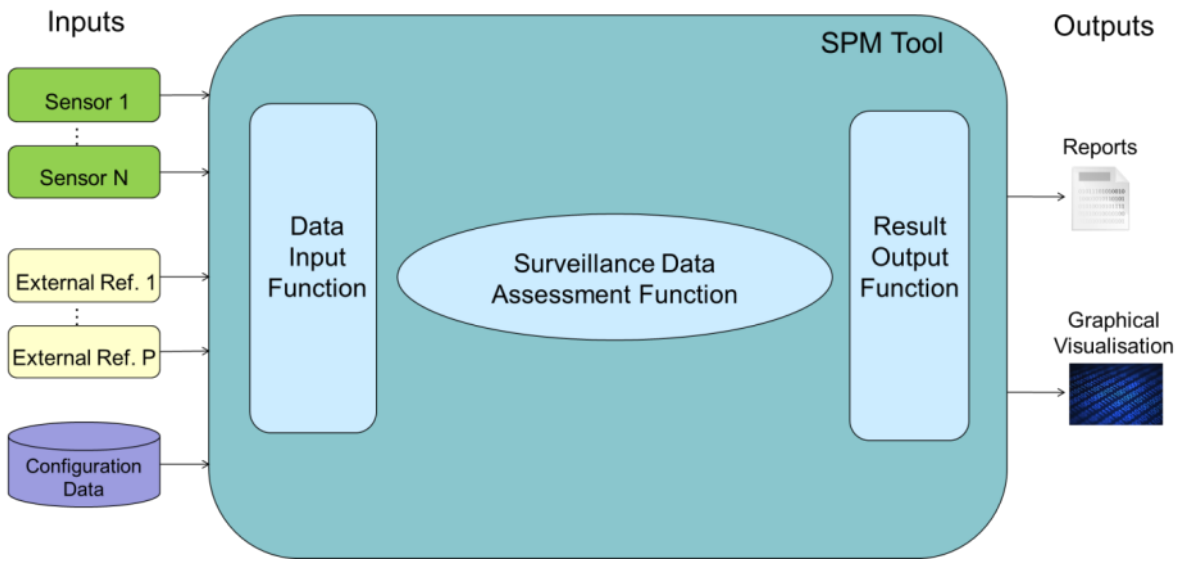

Figure 2: Functional architecture overview of a generic Surveillance Performance Monitoring Tool.

The offline assessment is linked to an interactive execution where after the processing phase the results and reports are produced. Performance results are obtained for the selected data set and are compared to the thresholds configured. The user has the possibility to manually refine the setup and re-run the execution and/or to investigate specific cases via the interface.

While the scope of this solution (started as Task 01 in PJ14-04-01) in Wave 1 was to proceed a step further from an offline tool towards a real-time monitoring approach by covering the steps of automation and the storage of performance results, the scope in Wave 2 was to cover also the trend visualization. An automated execution of an assessment of a data recording is established that produces results related to user configured time frames, which are distinctively saved in a database. The results related to the different time frames are visualized to demonstrate the performance trend over time. The trend is updated each time there is a new result available for the new time frames.

The benefits of the solution can be summarized as follows:

- SPM tools that are compliant to newest surveillance standards supporting the performance based surveillance approach.
- Harmonised SPM Tools enable lower cost through the economies of scale amongst the larger user community. By deploying the harmonized SPM-tools, the stakeholders will still have to invest, but they will invest less than with the current approach of deciding for a suitable SPM tool. Moreover, they will benefit from several trustworthy (and harmonized) SPM-tools defined and accepted by a larger community involving ANSP's and industry via the SESAR project.
- The "quasi real-time" capability also brings benefits both technically by easing the ATSEP work allowing automated performance evaluation and economically by reduction of operating costs. Furthermore, an early detection of performance degradation may support the activation of appropriate procedures.
- Competitiveness of European stakeholders is supported.

3 Operational Improvement Steps (OIs) & Enablers

This Technological Solution covers the enablers CTE-S07a: “Cooperative sensor SPM Tool at En-route & TMA” and CTE-S07b: “Cooperative sensor SPM Tool at Surface” and will support OI (Operational Improvement) step POI-0061-SUR: “Surveillance performance monitoring for cooperative sensors”. This solution is the only contributor to the enablers CTE-S07a and CTE-S07b and it has full coverage of these enablers. The main objective of these enablers is to provide a harmonised performance monitoring for the cooperative surveillance sensors ADS-B, WAM and MLAT following the Performance Based Surveillance (PBS) approach.

The applicable Integrated Roadmap dataset is DS22. During SESAR Wave 2, this solution will pass through TRL6 maturity.

This solution is not depending on other SESAR solutions, OI steps or enablers. Nonetheless, there is another Technological Solution (84f) targeting similar enablers and OI steps for the end-to-end surveillance chain counterpart in parallel.

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4 Background and validation process

In Wave 1, TRL4 was achieved by implementing and validating a large number of performance metrics introduced by the upcoming surveillance standards. Back then beside the MLAT standard ED117A and the ADS-B standard ED129B initial drafts of the not-yet published surveillance standard for WAM ED142A had been used, which followed the trend of Performance based surveillance started by the GENSUR (draft ED261). Furthermore, an initial step in the direction of a quasi real-time monitoring had been introduced allowing recurrent evaluations and automated evaluation result storage. The harmonization was focused on TMA & En-route and compared the results of the different SPM tools developed within the project.

In Wave 2, the TRL6 is achieved by improved specification given by more up-to-date and mature drafts of the surveillance standards (draft ED129C, draft ED142A) introducing additional performance metrics, fine tuning of performance metric calculation and harmonizing also the surface related requirements to the performance based surveillance approach where possible. Furthermore, the quasi real-time monitoring has been advanced in a way such that it completes the full loop from sensor data input, performance evaluation and result storage as well as the trend visualization and update over time in an automated manner.

The Solution has been validated to TRL6 through the development of THALES “MAGS Explorer” and EUROCONTROL “SASS-C/VERIF” SPM tool implementing the requirements developed in the TS/IRS. The development of these SPM tools has been verified and validated with a number of exercises using real traffic datasets.

The validation exercises performed in the solution are the following:

- Individual tests using real traffic dataset in order to check the implemented capabilities of each SPM tool separately;
- Additional exercise using a common dataset in order to check the harmonization of the results between the two SPM tools for the environments TMA & ER.

While the individual exercises have been completed for all of the environments TMA & ER and Surface, the harmonization exercise has been focused on TMA & ER only due to only THALES MAGS Explorer covering the Surface capabilities.

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5 Results and performance achievements

The main validation findings from the Industry point of view are that the solution supports:

- Competitiveness of European stakeholders through the harmonization of the SPM tools
- The acceptance of the SPM tool for usage for Site Acceptance Tests (SAT) since the specification is agreed and the tool is validated by a larger surveillance community involving ANSP's and industry
- An increased reliability of the SPM tool given through the cross check between the SPM tools facilitating bug detection
- Eased fine tuning of the surveillance sensor before putting it into operation offered by the trend visualization of the quasi real-time monitoring

The main validation findings from ANSP point of view are that the solution offers:

- SPM tool aligned with the latest surveillance standards
- SPM tool aligned with a detailed specification of performance assessment methods as agreed by a larger surveillance community involving ANSP's and industry
- an increased reliability of the SPM tool given the tools have been validated and cross checked between different manufactures
- automated performance monitoring capabilities that reduce the work load of the ATSEP and facilitate early detection of performance degradation and activation of appropriate procedures

The SPM tools developed and validated within this solution are the THALES MAGS Explorer and the EUROCONTROL SASS-C/VERIF. The harmonization between the tools has been proven for the En-route and TMA environments. The performance assessment of the surface environment has been aligned to the performance based approach where possible but could not be cross checked by the harmonization exercise due to only THALES MAGS Explorer covering the surface environment.

The main benefits of this Solution are the "avoided costs". By deploying the harmonized SPM-tools, the stakeholders will still have to invest, but they will invest less than with the current approach of deciding for a suitable SPM tool. Moreover, they will benefit from several trustworthy (and harmonized) SPM-tools defined and accepted by a larger community involving ANSP's and industry via the SESAR project, and also take advantage of the Quasi Real-Time functionality both technically (= flexible monitoring) and economically (= reduction of operating costs).

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6 Recommendations and Additional activities

During Wave 1 and Wave 2, an extensive validation has already been performed to demonstrate the performance monitoring capabilities of the THALES MAGS Explorer and the EUROCONTROL SASS-C/VERIF SPM tool for the different sensors and environments and for each of the various performance evaluations defined in the TS-IRS. Furthermore, the En-route and TMA environment have been extensively tested by the harmonization exercise between the two SPM tools developed in this solution. Although the THALES MAGS Explorer surface environment capabilities could not be tested for harmonization due to lack of a second SPM tool with surface capabilities, nevertheless they are expected to provide reliable results given performance metric calculations of the airport MLAT standard ED117A were aligned in the TS-IRS to the WAM/ADS-B standards following the performance based surveillance approach, where possible, with the latter being already additionally proven through harmonization in En-Route and TMA environments. Furthermore, even if the end performance metric for the MLAT surface case (e.g. Probability of False identification (FID)) may be computed differently to the En-route/TMA (e.g. Probability of Incorrect (POI)), the intermediate steps in THALES MAGS Explorer are aligned for both in keeping the consistency, wherever possible.

As the publication of the standards for WAM and ADS-B was delayed and the versions used were still drafts during the Wave 2 cycle, it is recommended to cross-check the finally published versions for any possible changes affecting the performance assessment metrics already implemented. As already initiated during the SESAR work it is recommended to maintain a close coordination with the Standardisation bodies also in future to ensure that the requirements related to the test methods for surveillance metrics developed by the Standards are fully unambiguous and not subject to interpretation when it comes to SPM TS/IRS specification and related software implementation.

For the industrialization a qualification process verifying all features of the SPM tool is recommended to exclude any potential not identified bugs. Furthermore, to support the qualification the quasi real-time feature could be executed for a longer period (e.g. up to 1 month) on real system data, in order to catch any corner cases that might be present in real data and to make sure the SPM tool is able to handle them.

Beside the completion of the product baseline documentation the user manual should be updated for the new functionalities. Finally, a training and corresponding material can be prepared to facilitate the deployment and usage of the SPM tools.

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7 Actors impacted by the SESAR Solution

SPM (Surveillance Performance Monitoring) Tools developed by both PJ.14-W2-84e for cooperative sensors and PJ.14-W2-84f for end-to-end surveillance will be used by ATSEP (Air Traffic Safety Electronics Personnel), who are the engineers doing the performance assessment of the ATC surveillance systems (individual sensors or trackers).

Furthermore, SPM tools will be used by project engineers at industry side to make sure the system performance meets the requirements before initiating a system acceptance test and additionally during the system acceptance test to demonstrate the performance requirements are satisfied. Neither ATSEP nor the project engineers are directly involved in active ATC Ops. They provide the back office type support for maintaining a correctly functioning surveillance system.

ATSEP and in general also the project engineers at industry side should already use a SPM Tool for performance assessment (either supplied by the surveillance system vendor or independently). However, PJ.14-W2-84e aims to develop SPM tools that are in line with the updated surveillance system standards enabling performance based surveillance and that allow a quasi real-time monitoring of the system performance.

The underlying goal of harmonisation and cross verification of the developed SPM tools within PJ.14-W2-84e solution will provide thoroughly tested, verified tools for trustworthy performance assessment of cooperative sensors. Furthermore, Quasi real-time (QRT) monitoring functionality will facilitate especially the task of ATSEP by providing automated reporting of the performance assessment of the surveillance system and trend visualization over time.

In this respect, QRT monitoring helps ATSEP to identify performance degradation early and take corrective action. Instead of ATSEP manually running SPM Tool at regular intervals for performance assessment, the monitored metrics are available through automated reports at a more frequent rate and through the trend visualization feature. If no degradation is identified, ATSEP may not need to take any other action. In case, performance degradation in one of the monitored metrics is identified, ATSEP can determine the problem directly or can use the SPM Tool to drill down and identify the source of the problem.

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8 Impact on Aircraft System

The PJ.14-W2-84e solution does not have any impact on the Aircraft System. The SPM tools are used for monitoring the performance of the cooperative surveillance system infrastructure.

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9 Impact on Ground Systems

The ground systems are not affected by the solution as the SPM Tools do not have an impact on the surveillance chain.

SPM tools aim to demonstrate correct functioning of the ATM surveillance function at the individual sensor level (PJ.14-W2-84e) or at ATC end-to-end level (PJ.14-W2-84f). The surveillance system data - in this solution the ADS-B and multilateration data - is captured from the surveillance chain (e.g. extracted from a SUR-data recorder) and used by the SPM tool to compute/derive performance metrics. SPM tools are not involved in the surveillance chain but present separate tools for monitoring the data of the surveillance chain and for providing statistical reports on the system performance.

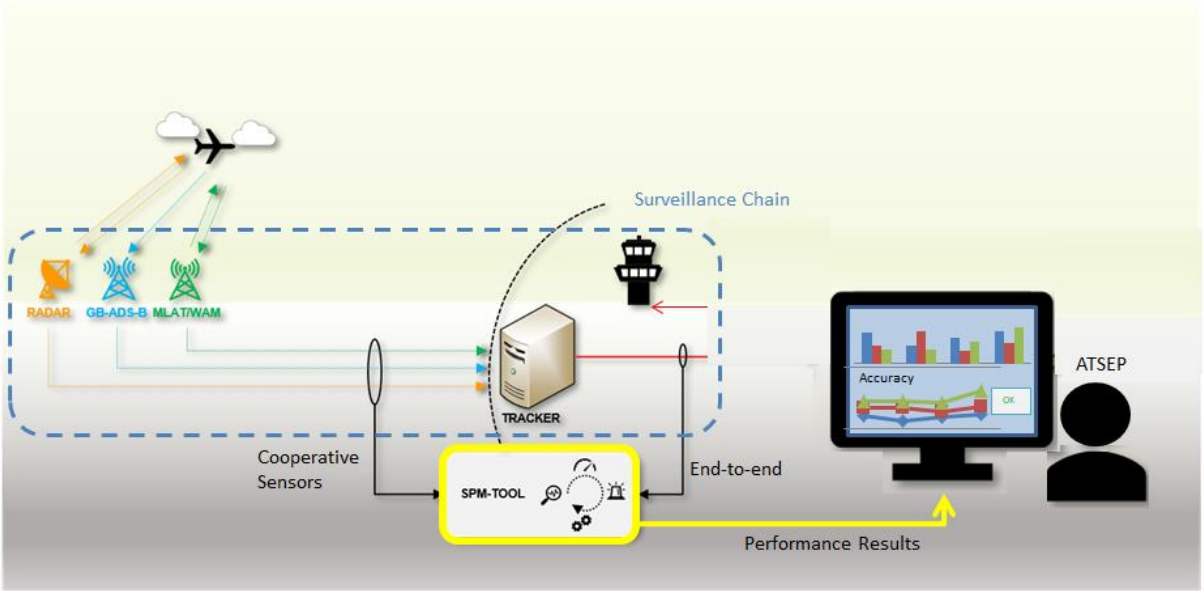

Figure 3: SPM Tool usage in operational context

The system performance results provided in numerical or graphical format are analysed by the user. SPM tools do not transmit any data to the air and do not affect or manipulate the rest of the surveillance chain in any way. The sole goal of the SPM tool is to provide insights on the system performance to the SPM tool user.

10 Regulatory Framework Considerations

This SESAR solution does not impact the SES nor the EASA regulatory framework as there are no changes introduced by the solution on the ground surveillance infrastructure or to on-board transponders.

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11 Standardization Framework Considerations

The main activities of the solution include the adaptation of the methods and tools to take into account the evolution of the emerging standards on cooperative sensor level following the performance based approach: i.e. EUROCAE ED-117A for MLAT Surface, ED-142A for WAM and ED-129B/C for ADS-B.

With respect to the performance-based approach reference EUROCAE ED-261 Safety and Performance Requirements Standard for a Generic Surveillance System - GEN-SUR may be considered. It represents an overarching standard providing background information regarding the performance metrics and their calculation, but is not directly applicable to the SPM tools.

The provision of the results of tools verification is a potential input to the standardisation, in particular the EUROCAE documents and EUROCONTROL Specification, test or Conformity Assessment sections, for possible improvements.

As the publication of the standards for WAM and ADS-B was delayed and the versions used were still drafts during the Wave 2 cycle, it is recommended to cross-check the finally published versions for any possible changes affecting the performance assessment metrics already implemented. As already initiated during the SESAR work it is recommended to maintain a close coordination with the Standardisation bodies also in the future to ensure that the requirements related to the test methods for surveillance metrics developed by the Standards are fully unambiguous and not subject to interpretation when it comes to SPM specification and related software implementation.

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12 Solution Data pack

The Data pack for this Solution includes the following documents:

- **TS/IRS**: D12.5.120 Final TS/IRS–Surveillance Performance Monitoring Tool for Cooperative Sensors (ADS-B, WAM, MLAT) at TRL6, Edition: 00.01.01, September 2022. It is the description of functional and non-functional requirements and of the architecture for the SPM tool for cooperative sensor assessment in line with the performance based surveillance approach covering the standards for WAM (ED142A), ADS-B (ED129C) and for the airport MLAT (ED117A). This document was the baseline for the development of the SPM tools THALES MAGS Explorer and EUROCONTROL SASS-C/VERIF.

- **TVALR**: D12.5.400 Technological Validation Report for Surveillance Performance Monitoring Tool for Cooperative Sensors (ADS-B, WAM, MLAT) at TRL6, Edition: 00.01.01, August 2022. It is the Final Technological Validation Report and provides the results of the technological validation activities of the SPM Tool prototypes, namely THALES MAGS Explorer and EUROCONTROL SASS-C/VERIF. The TVALR exists in two versions, one Public which will be included in the Data Pack, and another Confidential with the detailed validation results

- **CBAT:** D12.5.500 Cost Benefit Analysis for Surveillance Performance Monitoring (SPM) Tools for Cooperative Sensors (ADS-B, WAM, MLAT) at TRL6, Edition 00.01.02, November 2022. This document contains all identified costs and benefits related to the deployment of the SPM tools and the calculation of the economic value of the project.

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