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SESAR SOLUTION PJ.02-W2-21.1 CONTEXTUAL NOTE V3

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AART

AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

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Abstract

This V3 contextual note describes the SESAR Solution PJ.02-W2-21.1 for industrialization considerations.

Solution PJ.02-W2-21.1 "Enhanced Airport Safety Networks for Controllers at A-SMGCS Airports" improves safety for airport operations by providing support tools for controllers at A-SMGCS airports to address potential and actual conflict situations, incursions, and noncompliance with procedures or ATC clearances, including mobile (and stationary) traffic on runways, taxiways, and in apron/staging/gate areas, and unauthorized/unidentified traffic. Controllers are provided with the appropriate predictive indications and alerts in all cases.

Solution PJ.02-W2-21.1 extends SESAR 1 Solution #02 which is part of CP1 S-AF2.3 — Airport Safety Nets.

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1 Purpose

This Contextual Note describes the Solution PJ.02-W2-21.1 with a summary of results from R&D activities that contributed to the provision of the Airport Safety Support Service[1].

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.

Additional activities to be conducted during the industrialization phase or as part of deployment are recommended.

It presents the technical data pack, which consists of a collection of deliverables proposed to support the industrialization/deployment Improvements in Air Traffic Management (ATM)

1.1 Solution description & Scope

The scope of Solution PJ.02-W2-21-1 covers the Aerodrome Movement Area as defined the EUROCONTROL Specification for A-SMGCS.

The A-SMGCS Airport Safety Support Service contributes to airside operations as a safety improvement, enabling controllers to prevent hazards/incidents/accidents resulting from controller, flight crew or vehicle driver operational errors or deviations. This Service depends on the Surveillance Service being in operation.

The Airport Safety Support Service supports controllers by:

- Anticipating potential conflicts (e.g., hazardous situations between aircraft or aircraft and vehicles);
- Detecting conflicts and incursions;
- Detecting mobiles that are not following given Clearances;
- Providing alerts.

The Airport Safety Support Service is designed based on one or more of the following three functions. These functions may be partially introduced depending on local requirements e.g., not all CATC or CMAC alerts may be suitable depending on the aerodrome layout:

- Runway Monitoring and Conflict Alerting (RMCA);
- Conflicting ATC Clearances (CATC);

[1] The term "Airport Safety Support Service" is an umbrella term that encompasses various terms commonly used to describe Airport Safety Nets and Airport Safety Support Tools.

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- Conformance Monitoring Alerts for Controllers (CMAC).

The RMCA function acts as a short-term alerting tool, whereas the CATC and CMAC serve to be more predictive tools that aim at preventing situations where an RMCA alert may be triggered.

For the CATC and CMAC alerts to function correctly, it is important the system receives the Controller's Clearances, therefore, the Controller shall be provided with an Electronic Clearance Input (ECI) means e.g., Electronic Flight Strips (EFS).

Some of the CMAC alerts work on the assumption that every mobile entering the Runway Protected Area (RPA) or Restricted Area shall have received Clearance from the Controller.

The Airport Safety Support Service may be partially introduced depending on local requirements e.g., not all CATC or CMAC alerts may be suitable depending on the aerodrome layout.

Solution PJ.02-W2-21.1 completely replaces SESAR 1 **Solution #02**. The Airport Safety Nets **Conflicting ATC Clearances (CATC)** and **Conformance Monitoring Alerts for Controllers (CMAC)** developed in Solution #02 have been incorporated into this solution and updated and expanded where necessary[2].

The improvements provided by the solution PJ.02-W2-21.1 are:

- **New CATC for ground operation**
    - Expansion of the use of the Safety Support Tools on taxiways and in the apron/stand/gate area.
- **Updated CATC for runway operation**
    - Support of reasonable assurance used by ATCOs at airports with high runway demand.
    - Consideration of potentially violated separation minima along SIDs for ±simultaneous take off clearances from different runways (TOF/TOF converging SIDs).
    - Detection of clearance conflicts with ongoing RMCA or CMAC alerts at the cleared runway.
- **CATC for ground and runway operation**
    - Support of conditional clearances for all clearances given by the controller.
- **Updated Predictive Indication**

[2] Replacing SESAR 1 solution #02 with solution PJ.02-W2-21.1 avoids potential implementation trade-offs versus deploying 21.1 on top of an already deployed solution #02.

- Prediction of the new and the updated CATC alerts, as well as RMCA/CMAC versus ATC Clearance alerts.

- **Runway Notifications**
  - Indication of the current integrated occupancy/conflict status of a runway.

- **New CMAC Stand Occupied alert**
  - Indication of a scheduling problem when a stand for an arriving aircraft is still occupied by another aircraft.

The solution targets traffic Safety on the entire Aerodrome Movement Area of medium, large and very large airports and during take-off and landing.

1.2 Relevant Operational Environments

OE	Sub Operating Environments	Definition
Airport	Very Large Airport	**APT-Very Large** A very large Airport Operating Environment corresponds to the aerodrome movement area and the volume of controlled airspace around an airport with a number of annual movements greater than 250000, where a movement is either an IFR departure or an IFR arrival.
	Large Airport	**APT-Large** A large Airport Operating Environment corresponds to the aerodrome movement area and the volume of controlled airspace around an airport with a number of annual movements greater or equal to 150000 and lower or equal to 250000, where a movement is either an IFR departure or an IFR arrival.
	Medium Airport	**APT-Medium** A medium Airport Operating Environment corresponds to the aerodrome movement area and the volume of controlled airspace around an airport with a number of annual movements greater or equal to 40000 and less than 150000, where a movement is either an IFR departure or an IFR arrival.

Table 1: Relevant Operational Environments

1.3 Expected Benefits

The benefits of Airport Safety Support Tools are evident in the following Key Performance Areas (KPA):

- **Safety**
  - Reduction in RWY collision accidents.
  - **R**eduction in TWY collision accidents.

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- **Resilience**
    - Loss of airport capacity avoided.
    - Minutes of delays avoided.
    - Number of cancellations avoided.
- **Human Performance**
    - Consistency of human role with respect to human capabilities and limitations.
    - Suitability of technical system in supporting the tasks of human actors.
    - Adequacy of team structure and team communication in supporting the human actors.
    - Feasibility regarding HP-related transition factors.

The benefits reported here are limited to airports equipped with A-SMGCS.

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2 Operational Improvement Steps (OIs) & Enablers

The SESAR Solution PJ.02-W2-21.1 covers the Operational Improvement AO-0104-B (see Table 2).

PJ.02-W2-21.1 extends Solution #02 and uses Solution #22 (see Table 3).

Applicable Integrated Roadmap Dataset is DS23.

Solution	**PJ.02-W2-21.1** Enhanced Airport Safety Nets for Controllers at A-SMGCS Airports	
Applicable OI Step	**AO-0104-B** Enhanced Airport Safety Nets for Controllers at A-SMGCS Airports	
Dependent OI Step	None	
Required Enablers	**AERODROME-ATC-06b** A-SMGCS incorporating the function that detects Conflicting ATC Clearances (CATC) on the entire airport surface	Required Fully covered
	AERODROME-ATC-07b A-SMGCS incorporating the function that provides an advanced set of Conformance Monitoring Alerts for Controllers (CMAC) on the movement area	Required Fully covered
	AERODROME-ATC-115 A-SMGCS incorporating the function that provides RMCA/CMAC vs ATC Clearance alerts	Required Fully covered
	AERODROME-ATC-116 A-SMGCS incorporating the function that provides Runway-Busy notifications	Required Fully covered

Table 2: SESAR Solution PJ.02-W2-21.1 Scope and related OI steps/enablers

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Solution	**Solution #02** Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances V3 maturity in SESAR 1 Relation to PJ.02-W2-21.1: **incorporated, updated and extended by PJ.02-W2-21.1**
Applicable OI Step	**AO-0104-A** Airport Safety Nets for Controllers at A-SMGCS Airports

Solution	**Solution #22** Automated Assistance to Controller for Surface Movement Planning and Routing V3 maturity in SESAR 1 Relation to PJ.02-W2-21.1: **routing information used by PJ.02-W2-21.1 for conflict detection**
Applicable OI Step	**AO-0205** Automated Assistance to Controller for Surface Movement Planning and Routing

Table 3: Pre-requisite SESAR Solutions for Solution PJ.02-W2-21.1

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3 Background and validation process

The development of the "Airport Safety Support Service" launched in SESAR 1 with Solution #02 (OI AO-0104-A, V3 maturity), was followed in SESAR 2020 Wave 1 by Solution PJ03b-01 (OI AO-0104-B, V2 maturity) and continued in Wave 2 by Solution PJ.02-W2-21.1 (OI AO-0104-B, V3 maturity).

Solution PJ03b-01 started in Wave 1 to reach V2 maturity for OI AO-014-B. The solution partners conducted four validation exercises as listed in Table 4.

Simulated Environment	Sub Operating Environment	Validation Technique	Organizations
Nice Airport	Medium airport	Real time simulation	DSNA
Prague Airport	Large airport	Real time simulation	EUROCONTROL, ANS-CR (B4),DLR
Düsseldorf Airport	Large airport	Real time simulation	DFS, DLR
Sofia Airport	Medium airport	Real time simulation	LEONARDO, BULTASA

Table 4: SESAR Solution PJ03b-01 validation exercises addressing AO-014-B

Solution PJ.02-W2-21.1 continued the work on OI AO-014-B in Wave 2 to reach V3 maturity. Solution PJ.02-W2-21.1 was validated through a series of activities, including a shadow mode trial exercise and two real-time simulation exercises listed in Table 5.

Simulated Environment	Sub Operating Environment	Validation Technique	Organizations
Düsseldorf Airport	Large airport	Shadow mode	DFS
Barcelona Airport	Very large airport	Real time simulation	ENAIRE Indra
Sofia Airport	Medium airport	Real time simulation	LEONARDO, BULTASA

Table 5: SESAR Solution PJ.02-W2-21.1 validation exercises addressing AO-014-B

The solution was validated by three validation exercises (see Table 5), each performed on its own validation platform. The trials in shadow mode used real traffic data (surveillance and flight plan data), for the real-time simulations the respective simulators provided the data required.

In the exercises, reference and solution scenarios were compared to determine the benefits of the improved safety support tools. Local ATC controllers from the respective target airports completed

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online and hands on training to become familiar with the validation platforms and the Airport Safety Support Tools before they carried out the validation runs.

Standard questionnaires (AIM-s for workload, SASHA for situation awareness) and specific questionnaires to answer the validation criteria collected the air traffic controllers' opinions. ATM operational experts, validation experts and safety experts accompanied the execution of the runs. In the subsequent debriefings, the overall impressions of the exercise participants were collected.

The results of the validation exercise were evaluated at the exercise level and summarized at the solution level. Conclusions and recommendations were derived from this.

The validations objectives mainly addressed the usability and utility of the new and updated alerts and indications, and the impact of the solution on Safety and Human Performance .

4 Results and performance achievements

4.1 Results

New CATC for ground operation expands the use of the Safety Support Tools on taxiways and in the apron/stand/gate area.

Updated CATC for runway operation at airports with high runway demand supports reasonable assurance used by ATCOs to implement reduced separation. It also accounts for potentially violated separation minima along SIDs for take-off clearances from different runways (TOF/TOF converging SIDs).

In case of an ongoing RMAC/CMAC alert, the system will trigger an RMCA/CMAC vs Clearance alert the moment the ATCO enters the clearance.

CATC support of conditional clearances for all clearances given by the controller.

Predictive indication of potential clearance conflicts, supported by solution #02 and PJ.02-W2-21.1 CATC detection for runway and ground operations, provides additional situational awareness support and results in increased resilience.

Runway Notifications and Predictive Indication for runway operation provide immediate runway status information and act as an additional safety barrier to avoid potential clearance conflicts or incidents related to current CMAC or RMCA alerts.

The new CMAC Stand Occupied alert indicates that this planning issue needs to be resolved.

4.2 Performance achievements

Solution PJ.02-W2-21.1 has successfully extended the use of SESAR 1 Solution #02 to the entire airport movement area and the support for runway operation is greatly improved, especially for airports with high runway throughput. The improvements compared to SESAR 1 Solution #02 outcomes as baseline have a very positive impact on Safety and Resilience:

- Network-level performance benefit expectations are 52.7% for SAF3.X (RWY collision accident) and 45.7% for SAF4.X (RWY collision accident) at the ECAC level, both with high confidence in the results.
- Resilience benefits were found to be 19.82% for RES1 (airport capacity loss avoidance), 1761.8 minutes for RES4 (minutes of delays), and 6.7 for RES5 (number of cancellations).
- The impact of the solution on Human Performance was evaluated to identify potential issues and appropriate remediation to provide air traffic controllers with the best possible Safety Support Service.

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5 Recommendations and Additional activities

The following activities are relevant once transitioned to industrialization (V4):

- Develop appropriate ATCO training. The ATCOs must know and understand the rules and parameters applied by the conflict detection. This helps to avoid misinterpretations, reduces the mental workload, and shortens the reaction time. Proper training is a key factor in improving safety.
- Determine the perfect alert timing. As part of the solution, an iterative process was devised to achieve the most perfect alert timing possible to avoid false alerts (nuisance alerts). A suitable approach for the necessary optimizations and calibrations was trialled in cooperation between local air traffic controllers and system engineers.
  The calibration of the conflict detection rules parameters is an essential part of the deployment process. One possible approach is to use recorded traffic data from the target airport, based on which the optimal alert trigger times are optimized using Artifical Intelligence. The optimized trigger times are verified by local air traffic controllers. This also contributes significantly to the acceptance of the Airport Safety Support Tools by the controllers.
- Perform a survey of the local airport layout and the local procedures to identify how the needs can be supported by the Airport Safety Support Tools. In particular, it is important to support the way the controllers work as much as possible (see example below for runway operations at airports with low or high runway demand). This should be worked out in collaboration with the local controllers to achieve the best possible results and to show the ATCOs that their needs are taken seriously. The acceptance of the local implementation of the solution is important to eliminate reservations about automation.
- Considering the Airport Safety Support Tools as a toolbox consisting of individual safety solutions that complement each other. The CATC and CMAC alerts in combination with RMCA should be well selected to adequately support safety according to the local operational requirements.
- The deployment of the PJ.02-W2-21.1 solution is considered a complex task. One possible approach to simplify this task is the specification of a Minimum Viable Product (MVP). This MVP provides an initial installation for a limited number of alerts on which the required deployment steps can be practiced.

The way the controllers work can be very different, depending on the given airport layout, the local procedures, but also on the volume of traffic.

Low runway demand

In Solution #02 the basic rule for CATC for runway operations was that only one clearance shall be active at a time on a runway. Consequently, a second clearance given triggers a CATC alert if the two cleared routes are in conflict. This approach is safe because it strictly avoids minimum separation violations.

High runway demand

The procedure used for low runway demand (see above) is not supporting air traffic controller in their service provision at airports with high runway demand. They either must closely monitor that the runway is vacated before they give the next clearance, or they must accept the high number of false alerts when using CATC for runway operations as specified in Solution #02. This causes additional mental workload for the ATCOs at airports with high runway demand and therefore this approach is not acceptable.

As described in ICAO Doc 4444 runway controllers at airports with high runway demand can make use of “reasonable assurance”, i.e., by estimating that the minimum separation will not be violated if a second clearance is given for a runway. To support this approach Solution PJ.02-W2-21.1 developed CATC support for ATCOs who apply “reasonable assurance”. This allows the ATCOs to work with reasonable assurance as usual and to be fully supported by the Safety Support Tools, i.e., without nuisance alerts.

To support controllers according to the specifics of local operations, CATC considers two different approaches to runway operations in solution 21.1: One for airports with low runway demand and the second for airports with high runway demand where reasonable assurance is applied to serve the high traffic volume.

The validation exercises have shown the importance of selecting Safety Support according to the ATCOs usual way of working. It avoids loss of situational awareness and reduces mental workload.

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6 Actors impacted by the SESAR Solution

Actors/roles directly affected by the SESAR Solution are:

- Tower Runway Controller
- Tower Ground Controller
- Apron Manager

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7 Impact on Aircraft System

The Airport Safety Support Tools have no impact on aircraft system.

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8 Impact on Ground Systems

A TWR-ATC system with A-SMGCS Surveillance Service, and Routing Services is required. An existing Airport Safety Support Service (Solution #02) is replaced by Solution PJ.02-W2-21.1. Additionally Electronic Controller Inputs (ECI) shall be available.

Apart from this, the impact to ground systems can be considered minimal because the provision of required data is already in place through the A-SMGCS. Since Solution PJ.02-W2-21.1 is the further development of Solution #02, it can be deployed on the same hardware. The HMI is essentially already available from Solution #02 and can be reused.

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9 Regulatory Framework Considerations

Since Solution PJ.02-W2-21.1 is the further development of Solution #02 no impacts have been identified that may require additional regulatory changes.

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10 Standardization Framework Considerations

The following specifications need to be updated:

- The EUROCONTROL Specification for Advanced-Surface Movement Guidance and Control System (A-SMGCS) Services (SPEC-171) contains specifications for A-SMGCS Safety Support Service. The A-SMGCS Task Force is updating the standard and the PJ.02-W2-21.1 solution is contributing to the update.

  Enabler STD-105 — Update of EUROCONTROL-SPEC-171

- The EUCOCAE ED-87E MINIMUM AVIATION SYSTEM PERFORMANCE STANDARD (MASPS) FOR ADVANCED SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS (A-SMGCS) is aligned with EUROCONTROL A-SMGCS Services (SPEC-171) edition 2.0.

  Enabler STD-016 — ED-87E MASPS for A-SMGCS including Airport Safety Support Service Routing Service and Guidance Service using airfield ground lighting infrastructure

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11 Solution Data pack

The Data pack for this Solution includes the following documents:

- **SPR-INTEROP/OSED** for V3, D6.1.002, Edition 00.02.02, 24/05/2023. The document presents the Safety, Security, Performance, and Interoperability requirements identified during the validation activities and describes the operational environment, the operational service, and procedures (includes part II SAR, part IV HPAR, part V PAR).**VALR** for V3, D6.1.006, Edition 00.01.02, 24/05/2023. The document collects and describes the results of the validation exercises.
- **TS/IRS** for V3, D6.1.008, Edition 00.02.00, 24/05/2023. The document collects and describes the Technical System Requirements.
- **CBA** for V3, D6.1.010, Edition 00.01.03, 24/05/2023. This document provides the Cost Benefit Analysis.

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