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)

The SESAR Solution "Enhanced Visual Operations" focuses enhanced vision systems (EVS), synthetic vision systems (SVS) and their innovations, which are developed to have more aircraft capable of LVC operations and to enable more efficient approach, landing and taxi and operations in LVC. This is applicable to all platforms, even if the main airline platforms have auto land capabilities to facilitate approaches in LVC. The solution consists in 3 development activities focusing on:

- HMD fitted with taxi routing and traffic information for easing taxi operation in degraded weather conditions.
- HMD equipment as an alternative to HUD equipment for EFVS operations using legacy EFVS sensors.
- Use of active sensor with improved performance to overcome the observed limitation of EVS legacy sensors.

The benefits of CVS fed with surface traffic and routing/ ATC clearance information in a coloured and monocular HMD, which the main advantages are the unlimited field of regard offering new HMI possibilities, the reduction of CVS display clutter (use of colour), the depiction of coloured aerodrome lighting, the depiction of traffic information.

The main advantages for approach operation using active sensor are to be less sensitive to variations of weather conditions and provide greater visual advantages in LVC and to be independent of lighting type (e.g. LED, incandescent).

From an ATM perspective, the PJ03a-04 solutions will make head up concept accessible to more aircraft types and EFVS/CVS operations more attractive financially and more efficient in terms of resilience to adverse weather.

The Vision based System is an on board alternative solution to heavy and expensive ground infrastructures for approach in LVC. The operational credit they provide through EFVS for landing operation on CAT1 and RNAV approaches concerns mainly the medium and small aerodromes where heavy ground infrastructures are neither available, nor affordable. The Vision based System is a on board complementary solution for taxi. This concerns mainly the main aerodromes due to usually complex taxi layout and busy nature of the traffic.

Operational Improvement Steps (OIs) & Enablers

The following Operational Improvement is under the scope of SESAR Solution PJ03a-04:

- AUO-0405: Equivalent Visual Landing operations in Low Visibility Conditions with Head Mounted Display.
- AUO-0406: Equivalent Visual Taxi operations in Low Visibility Conditions. Main focus on integration of HMD.

Equivalent Visual operations take benefit from an augmented vision of the external world based on a dedicated IR or multispectral sensor providing an Enhanced Vision System (EVS).

In addition, information from database used to recreate the 3D external world (Synthetic Vision System) may also be used. The combination of EVS and SVS bring a significant advantage and is called Combined Vision System (CVS). CVS is the corner stone of AUO-0405 and AUO-0406. Whatever the phase of flight, the presentation of an EVS image requires dedicated symbology.

For Equivalent Visual Landing operations (AUO-0405), the synthetic runway, Flight Path Vector or Flight Path Angle Reference Cue are some of the required symbology element to help pilot better understand its trajectory with regard to the image.

For Equivalent Visual Taxi operations (AUO-0406) the guidance symbology presentation on top of the EVS image is a improvement to allow the crew better interpreting the environment in low visibility conditions (where the IR camera performances may be insufficient).

Conformal 3D traffic display is an option which can be used in any phase of flight. It has been tested during taxi phase during PJ03a-04 Validation Exercise and has demonstrated to provide additional awareness by helping the crew to spot surrounding traffics with a 360° FOV.

AUO-0405 aims at increasing cost efficiency and safety (linked to increased equipage rate) for EFVS operations. Indeed, HMD targets a selling price much lower than HUD enabling more operators to equip.

AUO-0406 targets improved safety and resilience during taxi operations where no operational credit is currently brought by HUD or EVS.

Figure 1 – Picture from AUO-0406 validation exercise at CDG airport

AUO-0410 (not in DS19): Equivalent Visual Approach and Landing operations providing improved resilience to LVC. Focus on approach operation with active sensor replacing or supplementing current IR sensor with limited performances in target environment. Improved performances of EFVS/CVS lead to improved resilience to LVC. It does not plan to achieved target maturity.

The following required enablers are supporting SESAR Solution PJ03a-04:

- A/C-23b1: Combined Vision for Equivalent Visual Landing operations in LVC with HMD, enabling AUO-0405, partially covered.
- A/C-23b2: Combined Vision for Equivalent Visual Taxi operations in LVC is required enabler, enabling AUO-0406, fully covered.
- A/C-23b4 (not in DS19): Combined Vision for Equivalent Visual Approach operations using active sensor, enabling AUO-0410, it does not plan to support target maturity.

Applicable Integrated Roadmap Dataset is DS19 except AUO-0410 and A/C-23b4.

Note: AUO-0410 and A/C-23b4 plan to continue in Wave 2 and appropriate change requests are in the pipeline.

Note: PJ03a-03 is preferable to PJ.03a-04 as is in Data pack SPR-INTEROP-OSED Part V. Appropriate enabler is not listed as optional and not validated enabler within operation validation.

Background and validation process

The SESAR Solution has validated operations through a fast-time simulation, data collections and a series of live trials for approach and taxi. The validation activities were executed in Europe and North America with respect to different exercises.

Both validation exercises with HMD were based on live flight trials and pilot questionnaires. The live trial for taxi routing using HMD has been performed in CDG airport to validate environmental awareness improvements by displaying non-conformal taxi route indication to the crew as well as conformal traffic information on a 360° field of view. The live trial for approach operation using HMD has been performed in one airport on EFVS approaches to validate the same operational gain (EFVS down to 100ft) as for HUD.

The validation exercise with active sensor was based on data collection with Honeywell's experimental aircraft (Helicopter ASTAR AS350) and on using Honeywell's proprietary PC simulation framework. The simulator is a very complex system of tools which enables performing low-level signal simulations of the sensor model, scene and environment and operational scenarios.

Results and performance achievements

Validation exercise validated mandatory enablers via simulations and in a real environment. The above-mentioned validation exercises of both technologies for equivalent visual operations have provided the following main findings.

Taxi operations with HMD:

- Taxi operation with HMD has been shown to be feasible.

- The workshare between PM and PF is unchanged compared to current baseline.
- The display of taxi guidance information has been shown to be extremely valuable in large airport environment.
- The 3D depiction of surrounding traffic was considered as a very interesting feature by the crew

Landing operation with HMD:

- The use of HMD as a HUD alternative for landing operations has been considered acceptable from a symbology display point of view.
- EFVS operations (using CVS and IR image) with HMD have however not achieved the same level of performance as HUD: with the flight-tested HMD design, the tests crew did not manage to have the same symbology and image behaviour as with HUD.
- Additional work on HMD design is required to authorize operational credit with HMD in the future.

Landing operation with active sensor:

- Initial proof of weather penetration by active sensor model
- Initial proof of ground structures detection by active sensor prototype

The following potential benefits have been identified:

- By itself HMD has been considered as a promising concept.
- The addition of traffic display, taxi touting and CVS are improvement that significantly improve pilot environmental awareness.
- The use of a light and potentially lower-cost HMD as HUD equivalent solution could help democratize the eyes-out concept in the cockpits in the future

Recommendations and Additional activities

The following activities are relevant once transitioned to industrialization (V4) for HMD approach and taxi operations:

- Minor remaining technical work is required to improve the HMD design in order to achieve EFVS operational credit. These improvements will allow to fully take benefit of the HMD to perform EFVS operations, and are more at development side rather than further R&T work.

The following activities are relevant for achieving V3 maturity of EFVS/CVS approach operation using active sensor:

- Develop and validate radar data representation cover overall EFVS/CVS concept. Alignment of active sensor data representation with forward scene and pilot expectations. Combination and fusion definition of active sensor for CVS.
- Performance validation in flight tests with mature prototype on various environments in terms of runway parameters, equipment and surroundings and weather conditions
- Definition of Visual Advantage measurement method

Actors impacted by the SESAR Solution

Airspace Users (Pilots).

Impact on Aircraft System

Vision based systems are on-board solutions containing sensors (e.g. passive Infrared, active radar), processing unit and display units (HUD, HMD).

Impact on Ground Systems

There is no impact on ground systems.

Regulatory Framework Considerations

NPA 2016-08 has been deployed at the “pioneer aerodromes”. Flights in real weather conditions and full Ops environment are in progress. Feedback from users on this “NPA experimental implementation” will be collected as part of SESAR AAL2 results and communicated to EASA rulemaking for improving AWO/ EFVS regulation considerations.

Standardization Framework Considerations

There is no standardization issue with respect operation using HMD.

Standardization activities for Active sensor

- To permit the use of advanced active sensor technology for Enhanced Flight Vision System as those studied, it is necessary to amend regulation to define spectrum band allocation for this radio navigation service.
- EFVS spectrum allocation shall be introduced at European Level and then harmonized worldwide as much as possible to maximize interoperability.
- The using active sensor data instead of EVS image is not explicitly allowed by regulation for EFVS operation. Future work shall support validation of active sensor as EVS sensor for the approach operation and discussion results with appropriate organizations and bodies (RTCA SC-213 & EUROCAE WG-79) if necessary.

Considerations of Regulatory Oversight and Certification Activities

The introduction of operation supporting by new alternative technologies is something to be considered by EASA and/or National Authorities.

Solution Data pack

The Data pack for this Solution includes the following documents:

- D4.010 SESAR PJ03a-04 SPR-INTEROP-OSED for V3 - Part I 00.01.03, 16/12/2019
- D4.010 SESAR PJ03a-04 SPR-INTEROP-OSED for V3 - Part II 00.01.02, 16/12/2019
- D4.010 SESAR PJ03a-04 SPR-INTEROP-OSED for V3 - Part IV 00.01.03, 10/12/2019
- D4.010 SESAR PJ03a-04 SPR-INTEROP-OSED for V3 - Part V 00.01.03, 10/12/2019
- D4.020 SESAR PJ03a-04 TS-IRS for V3- 00.01.07, 10/12/2019
- D4.070 SESAR PJ03a-04 CBA for V3 00.01.03, 10/12/2019

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