



SESAR Solution 03a-04 SPR/INTEROP-OSED for V3 - Part IV - Human Performance Assessment Report

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SUMO

ENHANCED VISUAL OPERATIONS

This Human Performance Assessment Report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 734153 under European Union's Horizon 2020 research and innovation programme.



Abstract

This document contains the Human Performance (HP) assessment report for the PJ03a-04 which consists of the HP assessment plan, the results of the HP activities conducted according to the HP assessment process, newly identified issues and the HP recommendations & requirements. It corresponds to the completion of the four steps of the Human Performance assessment process, namely: Step 1 – Understand the concept: Baseline, Solution and Assumptions, Step 2 – Understand the Human Performance Implications, Step 3 – Improve and Validate the concept and Step4 – Collate findings & conclude on transition to next V-phase.

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1 Executive Summary

This document describes the result of the activities conducted to date according to the Human Performance assessment process to derive the Human Performance Plan for the PJ03a-04. It corresponds to the completion of the four steps of the Human Performance assessment process, namely: Step 1 – Understand the concept: Reference, Solution and Assumptions and Step 2 – Understand the Human Performance Implications. The outputs of the two steps are described and used to scope and identify the Human Performance activities that should be performed given the level of maturity of the concept at this stage of the SESAR Solution V3. The recommended human performance activities identified form the basis for the Human Performance Plan presented in this document.

The HP assessment process uses an argument and evidence based approach and is structured according to four steps: (1) Understand the ATM concept, (2) Understand the HP implications, (3) Improve and validate the concept, and (4) Collate findings and conclude on transition to next V3-phase. For each step, recommended activities, required inputs, and expected outputs are described

The HP activities have focused on the two enablers studies in the frame of Pj03a-04: Head Mounted Display (HMD) and active sensor.

The HMD (providing a monocular coloured image with 360° field of view) has been assessed with regard to Human Performances during flight trials performed in February/March 2019 with a Dassault Falcon 8X. Human Performances evaluation was aiming at demonstrating that HMD could provide the same advantages in term of awareness and operational credit as Head-Up Displays.

The outcomes of the validation exercises have confirmed the V3 maturity level of HMD technology during taxi and landing operations despite some non-blocking limitations observed during EFVS flight trials. The validation exercise for active sensor in landing operations has not confirmed V3 maturity level, as expected during project timeframe, because of low sensor maturity.

The Real-Time simulations initially foreseen to assess HP for active sensor were not performed due to lower-than-expected maturity of the simulator. As a consequence, all related HP activities could not be conducted.

2 Introduction

2.1 Purpose of the document

This document is part of the SPR-INTEROP/OSED for Solution PJ.03a-04, describing operational services for combined vision for equivalent visual landing and taxi operations in LVC.

The purpose of this document is to describe the result of the activities conducted according to the Human Performance (HP) assessment process [1] in order to derive the HP assessment report for PJ03a-04 including requirements and recommendations.

The Human Performance (HP) assessment serves to ensure that HP aspects are systematically identified and considered in the SESAR operational and technical developments.

2.2 Intended readership

2.2.1 SESAR readership

The intended audience for this Validation Plan document is represented by the following solutions:

- PJ19 (Content Integration) responsible for managing the content integration process to ensure the needed coherency (in terms of operational concept, architecture) between the different SESAR 2020 projects.
- PJ20 (Master Plan Maintenance) responsible for ATM Master Plan maintenance
- PJ22 (Validation and demonstration engineering project) responsible for requirements management
- PJ02-06 (Improved access into secondary airports in low visibility conditions) for supporting the development of SPR-INTEROP/OSED from operational point of view and of secondary airports infrastructure, services and procedures proposed for low visibility operations.
- PJ.18-04a (Management and sharing of data used in trajectory (AIM, METEO)) as provider of aeronautical data necessary via AIXM format for aircraft vision system using active sensor
- PJ15 (Common Services) The Common Service approach, if it is proved to be successful, could be viewed as an essential means to improve the overall cost effectiveness of the ATM business in Europe. PJ15 encompasses air navigation service providers and ground industry covering both provider and consumer perspectives.

2.2.2 Other readership

Additional intended readership includes members of EUROCAE WG-79 and RTCA SC-213, which are in charge of the Enhanced Flight Visions Systems/Synthetic Vision Systems (EFVS/SVS).

2.3 Scope of the document

This document provides the Human Performance Assessment Report for SESAR Solution PJ03a-04 for V3.

The HP assessment process uses an argument and evidence based approach and is structured according to four steps: (1) Understand the ATM concept, (2) Understand the HP implications, (3) Improve and validate the concept, and (4) Collate findings and conclude on transition to next V3-phase. For each step, recommended activities, required inputs, and expected outputs are described.

2.4 Human performance work schedule within the Solution

Refer to chapter 4.2.

2.5 Structure of the document

This document consists of the following chapters:

- **Section 1 – Executive summary:** It describes the scope and purpose of the Solution PJ03a-04 as well as a summary of results, conclusions and recommendations.
- **Section 2 – Introduction:** It details the purpose and the scope of the document. This section is also intended to provide an overview of previous activities relevant for SESAR Solution PJ03a-04 and all the Solutions and Projects that could be interested in reading this document.
- **Section 3 – The Human Performance Assessment Process:** It provides an overview of the Human Performance Assessment process, the objective of it and the approach to be followed.
- **Section 4 – Human Performance Assessment:** it describes the ATM concept including the reference and solution scenarios, the HP maturity and the identification of the nature of the change.
- **Section 5 – References:** It identifies the main documentation that is considered as reference for the Validation Plan.
- **Appendix A – Additional HP activities conducted:** It summarizes the potential additional activities conducted in the frame of the solution exercises.
- **Appendix B – HP Recommendations register:** It summarizes the recommendations issued following the HP assessment performed during the solution exercises.
- **Appendix C – HP Requirements register:** It summarizes the potential requirements issued following the HP assessment performed during the solution exercises.
- **Appendix D – HP Log:** It summarizes the main Key Performance Indicators that are expected to be measured and collected during the execution of the described validation exercise.

2.6 Acronyms and Terminology

Term	Description
ADD	Architecture Description Document
AESA	Active Electronically Scanner Array
AIM	Aeronautical Information management
AOF	Airport Onboard Function
ATC	Air Traffic Control
ATM	Air Traffic Management
CC	Capability Configuration
CVS	Combined Vision system
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
EFVS	Enhanced Flight Vision System
EVS	Enhanced Vision System
FAA	Federal Aviation Administration
GBAS	Ground Based Augmentation System
HMD	Head Mounted Display
HUD	Head Up Display
Human Factors (HF)	HF is used to denote aspects that influence a human's capability to accomplish tasks and meet job requirements. These can be external to the human (e.g. light & noise conditions at the work place) or internal (e.g. fatigue). In this way,

	“Human Factors” can be considered as <i>focussing on the variables that determine Human Performance</i> .
Human Performance (HP)	HP is used to denote the human capability to successfully accomplish tasks and meet job requirements. In this way, “Human Performance” can be considered as <i>focussing on the observable result of human activity in a work context</i> . Human Performance is a function of Human Factors (see above). It also depends on aspects related to Recruitment, Training, Competence, and Staffing (RTCS) as well as Social Factors and Change Management.
HP activity	An HP activity is an evidence-gathering activity carried out as part of Step 3 of the HP assessment process. An HP activity can relate to, among others, task analyses, cognitive walkthroughs, and experimental studies.
HP argument	An HP argument is an HP claim that needs to be proven through the HP Assessment Process.
HP assessment	An HP assessment is the documented result of applying the HP assessment process to the SESAR Solution-level. HP assessments provide the input for the HP case.
HP assessment process	The HP assessment process is the process by which HP aspects related to the proposed changes in SESAR are identified and addressed. The development of this process constitutes the scope of Project 16.04.01. It covers the conduct of HP assessments on the Solution-level as well as the HP case building over larger clusters of Solutions.
HP benefit	An HP benefit relates to those aspects of the proposed ATM concept that are likely to have a positive impact on human performance.
HP case	An HP case is the documented result of combining HP assessments from Solutions into larger clusters (SESAR Projects, deployment packages) in SESAR.
HP issue	An HP issue relates to those aspects in the ATM concept that need to be resolved before the proposed change can deliver the intended positive effects on Human Performance.
HP impact	An HP impact relates to the effect of the proposed solution on the human operator. Impacts can be positive (i.e. leading to an increase in Human Performance) or negative (leading to a decrease in Human Performance).
HP recommendations	HP recommendations propose means for mitigating HP issues related to a specific operational or technical change. HF recommendations are proposals that require additional analysis (i.e. refinement and validation). Once this additional analysis is performed, HF recommendations may be transformed into HF requirements.

HP requirements	HP requirements are statements that specify required characteristics of a solution from an HF point of view. HP requirements should be integrated into the DOD, OSED, SPR, or specifications. HF requirements can be seen as the stable result of the HF contribution to the Solution, leading to a redefinition of the operational concept or the specification of the technical solution.
IER	Information Exchange Requirement
IMC	Instrument Meteorological Conditions
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
ISRM	Information Services Reference Model
LNAV	Lateral Navigation
LVC	Low Visibility Conditions
LWIR	Long-wavelength infrared
MCMF	Multi Constellation Multi Frequency
MMW	Millimetre Wave
MWIR	Medium-wavelength infrared
NAF	NATO Architecture Framework
NSOV	NAF Service Oriented View
NOV	NAF Operational View
NSV	NAF System View
OSED	Operational Service and Environment Definition
PESA	Passive Electronically Scanner Array
PF	Pilot Flying
PIRM	Programme Information Reference Model
PM	Pilot Monitoring
PNF	Pilot Non Flying
QoS	Quality of Service
RADAR	Radio Detection And Ranging

RVR	Runway Visual Range
SDD	Service Description Document
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking
SoaML	Service Oriented Architecture Modelling Language
SPR	Safety and Performance Requirements
SVS	Synthetic Vision System
SWIM	System Wide Information Model
SWIR	Short-wavelength infrared
TDZE	Touch Down Zone
TRL	Technology Readiness Level
TS	Technical Specification
UML	Unified Modelling Language
V&V	Validation and Verification
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
WSDL	Web Services Definition Language
XSD	XML Schema Definition

Table 1: Acronyms and terminology

3 The Human Performance Assessment Process: Objective and Approach

The purpose of the HP assessment process described in detail in [1] is to ensure that HP aspects related to SESAR technical and operational developments are systematically identified and managed.

The SESAR HP assessment process uses an ‘argument’ and ‘evidence’ approach. A HP argument is a ‘HP claim that needs to be proven’. The aim of the HP assessment is to provide the necessary ‘evidence’ to show that the HP arguments impacted have been considered and satisfied by the HP assessment process. This includes the identification of HP requirements and recommendations to support the design and development of the concept.

The HP assessment process is a four-step process that provides an overview of these four steps with the tasks to be carried out and the two main outputs (i.e. HP plan and HP assessment report). In addition, a HP Log is maintained throughout the lifecycle of the Solution in which all the data/ information obtained from all HP activities conducted as part of the HP assessment is documented. This HP Log is a living document and is updated and / or added to as the Solution progresses.

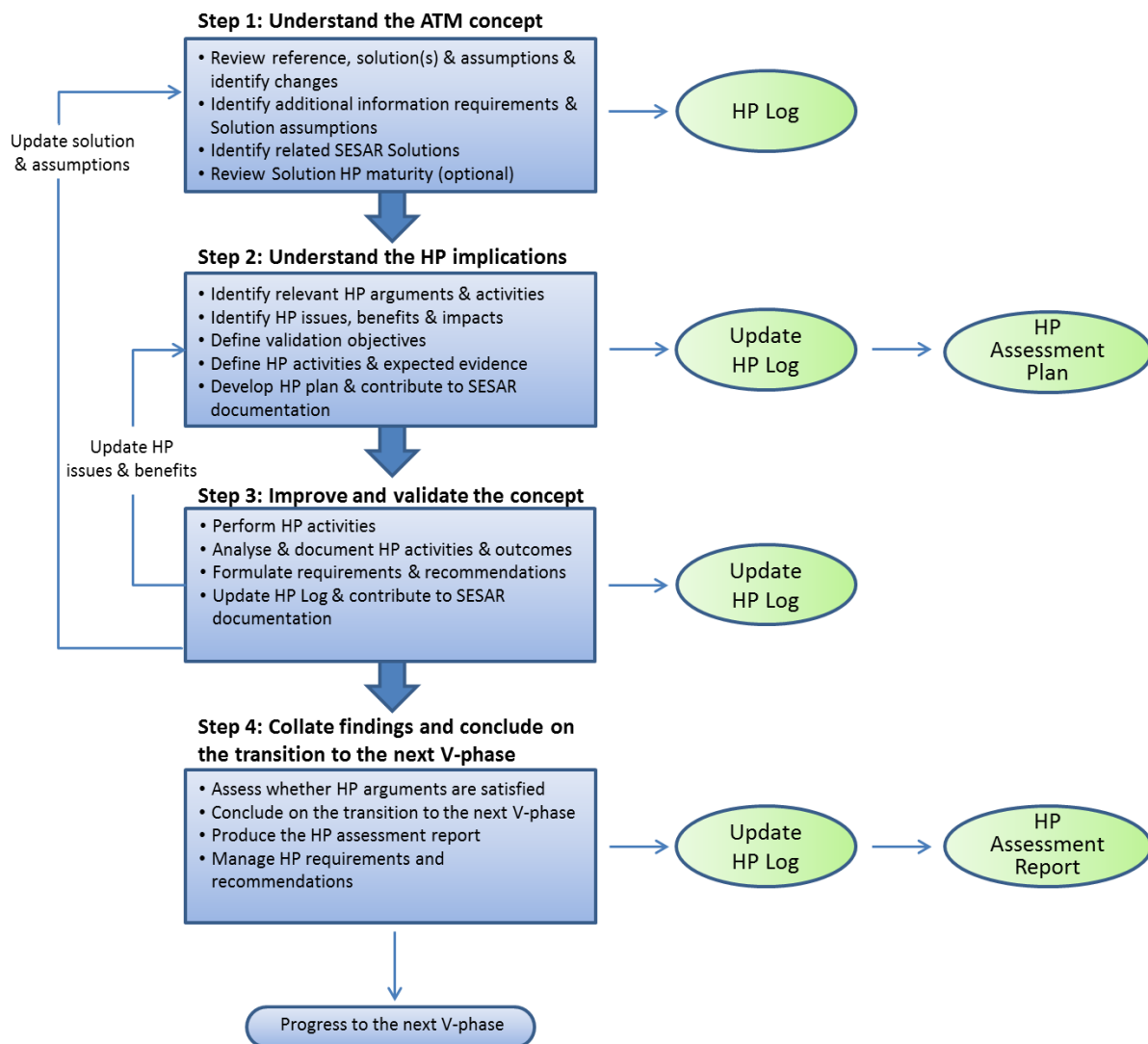


Figure 1: HP assessment process

4 Human Performance Assessment

4.1 Step 1 Understand the ATM concept

4.1.1 Description of reference scenario

Solution PJ03a-04 addresses landing and taxi operations and is therefore closely linked to the Airport operational environment.

Regarding the approach and taxi concepts of operations studied in the PJ03a-04:

- 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 operation on ILS 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 an **on board complementary solution for taxi**. This concerns mainly the main aerodromes due to usually complex taxi layout and busy nature of the traffic

4.1.1.1 Approach and Landing (CAT 1)

4.1.1.1.1 Standard instrument approach

The standard approach is flown as follows:

- At first contact, the ATC informs the crew of the runway in use (possibly propose an approach type) and pass the latest weather information if the crew doesn't confirm receiving of the ATIS information. If relevant, airport operator informs the crew that LVP are in force through ATIS or by radio by saying "Low Visibility Procedures in operation," reminds to "check the minima" and possibly communicate the missed approach procedure. Approach controller and tower runway controller start applying LVP criteria in their area of responsibility to the concerned flight crews,
- The crew selects an approach procedure in accordance with the information communicated by ATC and taking into account the aircraft limitations/ performances and crew qualifications,
- Crew establishes appropriate monitoring procedure for the type of approach, landing and missed approach that is in charge,

Down to the DA/ DH, the crew flies the approach procedure using **instruments** (flight and navigation information from different sources). Typical call-outs used for CAT 1 approach monitoring are included.

- No later than 1000ft HAT, call-out "1000ft" above the touchdown zone is accomplished, the crew must check that the actual RVR is greater than the RVR published for the approach that is flown. Otherwise, the pilot has to abort the approach, as the probability he would have visual

cues in sight at DA/ DH would be low. After the go around, the crew will decide to divert or to wait for weather improvement,

- Call-out “500ft” above the touchdown zone is announced,
- At alert height (usually 100ft above the DA/DH), call-out “approaching minimums,”
- At DA/ DH, call-out “minimums” is announced, required visual references¹ must be in sight and maintained to be authorized to continue into visual segment,

Below DA/ DH, visual references seen by natural vision is used as the primary mean to control or monitor (in case autopilot is used) the aircraft trajectory,

During the approach, the ATC monitors the trajectory (using radar, if available) and communicates by R/T with the crew.

4.1.1.1.2 Instrument approach with EFVS/ CVS operational credit

The intended function of an EFVS is to get credit to descent below the DA/DH on some suitable straight-in instrument approaches in reduced visibility as low as 300m RVR using of an approved EFVS in lieu of natural vision.

Compared to standard approach:

- Although the landing decision is the responsibility of the pilot-in-command, the crew may inform the ATC of his intention to perform an EFVS approach (see SESAR LSD.02.02). This way, the ATC will be not surprised when the aircraft will continue the approach and land while weather is below published minima, which is only possible using an EFVS,
- **Down to DA/ DH**, the EFVS approach is flown using the same method, except approach is conducted in HUD and the RVR considered for the check at 1000ft will take credit of visual advantage provided by EFVS,
- **At DA/ DH**, the approach can be continued if visual cues are seen in HUD/EFVS (instead of in natural vision), and provided EFVS is consistent with the other HUD flight information used for the approach. Go around must be initiated otherwise,
- **Below DA/ DH**, the crew uses **EFVS** image in combination with **HUD flight symbology** (such as FPV, guidance command, FPARC, conformal runway...). Depending on the EFVS concept certified, the crew may be requested to acquire the natural view of the runway without reliance to the EFVS at a certain altitude above runway. For concepts where natural vision

¹ Element of the Approach lighting system, or Threshold, or TDZE, or VGSI

acquisition² is not requested to be checked during approach (EFVS to landing and rollout), a flare cue and RA are mandatory,

CVS, when available, supplements the EFVS image in HUD by depicting runway environment regardless weather conditions.

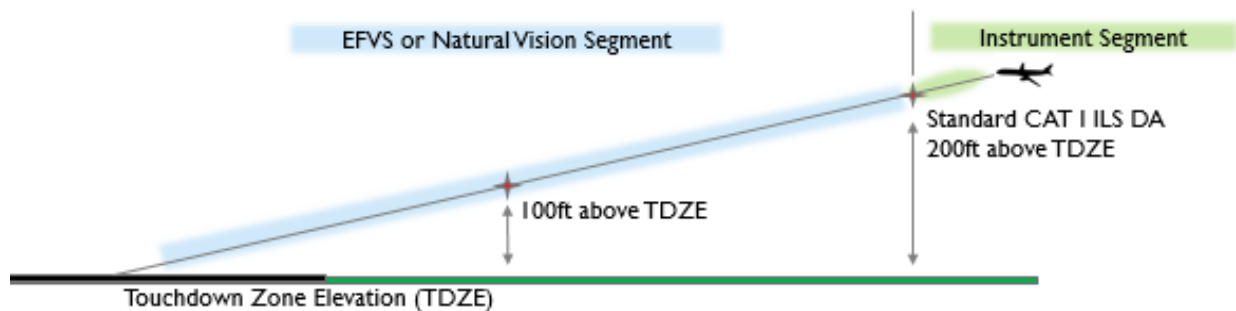


Figure 3: EFVS approach with operational credit

EFVS Operations to 100 Feet above the TDZE, as defined in (EU) 965/2012:

This operation:

- May be conducted on straight in approaches
- Operational credit is applied to reduce the runway visual range (RVR) by no more than one third of the published RVR
- At and below 100 feet above the TDZE, the pilot must transition to natural vision to identify the required visual references in order to continue descending. Below 100ft, natural vision is used as the primary mean.

4.1.1.2 Taxi Operations

The ATC gives clearance (routing, holding position...) to the flight crew and inform him of possible traffic by R/T.

At main airports, he monitors the A/C taxi using surface movement radar. When surface movement radar is not available, ATS is informed of aircraft position through R/T pilot's report.

Without Vision Systems (HMD or HUD), Flight crew taxi **visually** (primary mean) the aircraft according to ATC clearance and in accordance with the aerodrome procedures (AIP).

² Requested at 100ft for ILS or LPV, and at 200ft otherwise (per EU 965/2012)

- One Pilot (Pilot Flying) steers the aircraft along the taxi route assigned by ATC using natural vision and external references (panels, signs, lights, markings). He also looks outside to ensure the taxiway is clear of obstructions and identify potential conflicts. In LVC, pilot taxis the aircraft **slowly** (Ground speed is usually limited to 10kt per low visibility procedure during taxi in LVC) in order to be able to timely hold the aircraft in case of doubt, unexpected event, or if requested by ATC.
- The other pilot (Pilot Monitoring) usually scans alternately outside view and head down displays to monitor the progress of the taxi using more **strategic and exocentric view** such as “paper or aerodrome map” updated with real time aircraft position, or more advanced advisory AMM (either in EFB or integrated to avionics) systems directly aligned with the aircraft heading and possibly routing. PM is also in charge of the communication and surveillance of the systems.

In taxi, there are nearly no on board assistant systems supporting the crew to find their way and to avoid collisions (except the advisory RAAS, when available for the intended aerodrome). Particularly in low visibility and with dense traffic, navigation and collision avoidance becomes complicated and safety critical.

4.1.1.2.1 With EFVS

If the aircraft is equipped with EFVS, pilot flying uses EFVS in HUD to have enhanced vision in the forward field of view in addition to basic flight parameters (speed, heading). EFVS is only certified and used for situational awareness during Taxi.

At this time, there is no CVS with surface operation in service.

4.1.2 Description of solution scenario

4.1.2.1 Landing Operations with Vision Systems (EFVS)

Compared to:

- SESAR LSD02.02 dedicated to EFVS to land operation³ and based on monochrome HUD and on the latest generation of passive multispectral EFVS sensor,

³ Equivalent to *EFVS to touchdown and rollout* FAA concept

The PJ03a-04 solution will be the first attempt to assess:

- The feasibility and overall performance of the approach CVS making use of combination real-time scene capturing active sensor and database driven synthetic scene. The main advantages for approach and landing are:
 - to be less sensitive to variations of weather conditions and provide greater visual advantages in LVC
 - to be independent of lighting type (e.g. LED, incandescent)
 - to combine synthetic and sensor data thus provide additional information for improvement awareness of terrain, obstacles, and the runway environment.

All these new features should allow improved **performance** at any time and in all weather conditions.

4.1.2.2 Taxi with HMD

The solution PJ03a-04 aims at showing the benefit of a coloured HMD fitted with CVS for taxi operations.

In the proposed solution proposed, CVS is customised for taxi operation. In addition to HMD basic symbology, it contains:

- An EFVS image displayed in the forward field of view,
- The ground path according to ATC routing, displayed conformal
- Symbology/ signs indicating the next turn or hold on, displayed at a fixed position
- The traffic surrounding the aircraft, displayed conformally in the HMD. This capability is considered as an option and would require ADS-B IN receiver fitted onto the aircraft. This option is not present in the basic solution description (in EATMA).

The following scenario describes a nominal taxi operation from the gate to a runway threshold at a main airport with medium/ high traffic density, as intended to be performed during the SESAR solution flight tests

The mission is a commercial flight with passengers, departure from Paris CDG (LFPG) destination to New York (KJFK). The aircraft is located at a main airport (Paris CDG on parking D gate D12 for example). Doors are closed, engines on, pushback is over. The crew has entered in the AOF system the « expected routing » he received from ATC before pushback. Aircraft has received from ATC the authorization to taxi and initiate the manoeuvre.

An RVR greater than 150m and compliant with runway take off minima is reported by the ATC. Numerous traffics are reported, several being potentially on the aircraft trajectory.

Typical the taxi routing clearance (example) is:



Figure 4: Airport Onboard Function

The crew follows the route using the HMD 3D display. When an intersection or a turn is approaching, the crew is warned about it, as displayed below. Distance to next turn or intersection is also displayed.

Additionally, real time ground traffic can be displayed in the HMD enhancing crew situational awareness and ability to guarantee separation with other aircraft.

Thanks to HMD taxi symbology, the crew is able to more efficiently navigate to the runway threshold and with a reduced workload.

NB: The ground traffic display is part of the HMD symbology which requires additional block like airport database and algorithm for taxi routing that may be located inside or outside of the HMD.

4.1.3 Consolidated list of assumptions

Refer to Validation Plan Part I [5].

4.1.4 List of related SESAR Solutions to be considered in the HP assessment

Refer to Appendix A, HP Log, Section “Solution&Concept Info”. HP maturity of the Solution.

4.1.5 HP maturity of the Solution

The maturity of the solution overall is considered at V2 phase and targets V3 for both landing and taxing operations using HMD. The maturity of the approach operation using active sensor technology is considered at V2 phase and therefore targets V3 Maturity. Unfortunately, this part is not mature enough and will not be part of V3 maturity assessment of this solution. More details refer to Appendix A, HP Log, Section “Maturity-V3” which is relevant to HMD part of solution.

4.1.6 Identification of the nature of the change

Refer to Appendix A, HP Log, Section “Change&Argument Identification”⁴.

⁴ All ATM system represents “system” only.

4.2 Step 2 Understand the HP implications

4.2.1 Identification of relevant arguments, HP issues & benefits and HP activities

Refer to Appendix A, HP Log, Section “Issue-Objective-Outcome”.

Arg.	Issue ID	HP issue / Benefit	HP/Valid. ID	Obj. HP validation objective	recommended activity/ies
Arg. 1.2.5: Operating methods can be followed in an accurate, efficient and timely manner.	1.2.5.PJ03a-04_01	EFVS operations require the crew to carefully follow the approach path while relying on EVS image and symbology. The use of a monocular HMD instead of a conventional HUD may become challenging in this critical phase of flight.	OBJ-03a04-V3-VALP-HF.0000	The crew is capable of accurately and smoothly following the approach path in LVC conditions with the HMD symbology and EFVS image until 100ft.	Operational Trial
Arg. 1.2.5: Operating methods can be followed in an accurate, efficient and timely manner.	1.2.5.PJ03a-04_02	Taxi operations currently rely on visual references . Having a HMD capable of displaying conformal taxi routing may be new and uncomfortable for the crew to follow the taxiway centreline.	OBJ-03a04-V3-VALP-HF.0001	The crew is capable of accurately and smoothly following the taxiway centreline thanks to the HMD information in LVC or night conditions.	Operational Trial
Arg. 1.2.1: Operating methods cover operations in normal operating conditions.	1.2.1.PJ03a-04_03	In normal operating conditions, the system will add visual advantage in form of visual cues and enable to perform EFVS operation to 100 feet above the TDZE	OBJ-03a04-V3-VALP-HF.0002	Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods.	Operational Trial

Arg. 1.2.1: Operating methods cover operations in normal operating conditions.	1.2.1.PJ03a-04_04	In normal operating conditions, the system will provide increased environmental awareness during taxi phase	OBJ-03a04-V3-VALP-HF.0003	Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods.	Operational Trial
Arg. 1.2.2: Operating methods cover operations in abnormal operating conditions.	1.2.2.PJ03a-04_02	The operating method and HMI should cover abnormal operating conditions (abnormal conditions are those conditions the system may exceptionally encounter, e.g. severe weather, airport closure, etc.).	OBJ-03a04-V3-VALP-HF.0004	Identify/update situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists & check against the scope of operating methods	Operational Trial
Arg. 2.3.1: The type of information provided satisfies the information requirements of the human.	2.3.1.PJ03a-04_02	An adequate information should be presented to the pilot with acceptable latency and resolution as per SAE ARP6377 which refer to AC 25-11B applicable to displays such as HUD and equivalent displays.	OBJ-03a04-V3-VALP-HF.0005	The proposed HMI as designed is usable by flight crews	Operational Trial

Arguments related to the Real Time simulations were not addressed with respect fact mentioned above.

4.2.1 Description of HP activities for HMD validation

Regarding HMD concept, the performed HP Activities are the following:

HP activity	By when
Operational trials	2019/03

Table 2: Table of proposed HP activities and their priority

ACTIVITY 2.	
Description	HP support will be necessary prior to, during and after flight test. It will be required to prepare crew questionnaire and anticipate the potential HP issues that could be seen in flight. It will be necessary during flight to address blocking HP issues and tune the HMD accordingly It will be necessary after the flight to gather the crew feedback and provide a detailed synthesis.
Arguments & issues to be addressed	Arg. 1.2.1, Arg. 1.2.2., Arg. 1.2.5., Arg. 2.3.1.,
HP OBJECTIVES	OBJ-03a04-V3-VALP-HF.0000 The crew is capable of accurately and smoothly following the approach path in LVC conditions with the HMD symbology and EFVS image until 100ft. OBJ-03a04-V3-VALP-HF.0001 The crew is capable of accurately and smoothly following the taxiway centreline thanks to the HMD information in LVC or night conditions. OBJ-03a04-V3-VALP-HF.0002 Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods. OBJ-03a04-V3-VALP-HF.0003 Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods. OBJ-03a04-V3-VALP-HF.0004 Identify/update situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists & check against the scope of operating methods OBJ-03a04-V3-VALP-HF.0005 The proposed HMI as designed is usable by flight crews.

Required Evidence	A list of expected evidence related to each activity can be found in Appendix A HP log, section “Issue-Objective-Outcome” in column “Expected evidence.”
Tool selected out of the HP repository	Questionnaires designed internally for measuring the acceptability and performance of HMD from an HP point of view.
Planning and Approach	Refer to Part I. Section 5.2.9.1
resources	Refer to Part I. Section 5.2.9.2
timeline	Refer to Part I. Section 5.2.9.3

Table 3: Description of Activity 2-

4.2.2 Description of HP activities for active sensor Validation

Regarding active sensor concept, the planned HP Activities were the following:

HP activity	By when
Real Time Simulation	2019/02

Table 4: Table of proposed HP activities and their priority

ACTIVITY 1.	
Description	HP support will be provided to Real Time Simulation. This will ensure that appropriate evidence can be generated through these simulations, such that HP arguments and claims can be supported.
Arguments & issues to be addressed	1.2.1. PJ03A-04_02; 1.2.2. PJ03A-04_01; 1.2.3. PJ03A-04_01; 1.3.5 PJ03A-04_02; 2.2.1. PJ03A-04_01; 2.2.2. PJ03A-04_01; 2.3.1. PJ03A-04_02
HP OBJECTIVES	OBJ-03a04-V3-VALP-HF.0001 Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods. OBJ-03a04-V3-VALP-HF.0002 Identify/update situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists & check against the scope of operating methods OBJ-03a04-V3-VALP-HF.0003 Identify/update situations that constitute degraded modes of operation in cooperation with the safety and operational specialists & check against the scope of operating methods

	OBJ-03a04-V3-VALP-HF.0005 Assess sufficiency of the sensor imagery to provide aircraft position awareness to enter the visual segment at DH'. OBJ-03a04-V3-VALP-HF.0006 Assess information accuracy and acceptance in prototyping sessions or Real-Time Simulation or operational trials. OBJ-03a04-V3-VALP-HF.0007 Assess timeliness of actions in Real-Time Simulation or operational trials. OBJ-03a04-V3-VALP-HF.0009 Identify information needs/requirements of the human.
Required Evidence	A list of expected evidence related to each activity can be found in Appendix A HP log, section "Issue-Objective-Outcome" in column "Expected evidence."
Tool selected out of the HP repository	Questionnaires designed internally for measuring sufficiency of the sensor image depiction, usability and acceptability
Planning and Approach	Refer to Part I. Section 5.1.9.1
resources	Refer to Part I. Section 5.1.9.2
timeline	Refer to Part I. Section 5.1.9.3

Table 5: Description of Activity 1

4.3 Step 3 Improve and validate the concept

4.3.1 Description of HP activities conducted

4.3.1.1 HP activities - HMD (Activity 2)

HMD-related HP activity (Activity 2) has been performed as expected during Falcon F8X Flight trials in February and March 2019. Operational flight conditions for taxi (complex taxi route on Paris Charles de Gaulle Airport) and several IFR approaches (weather conditions ranging from CAVOK to LVC) including EFVS-100ft approaches on Treviso Airport have allowed to assess in real condition the usefulness of HMD.

Comparison with HUD could be performed in real time as the aircraft was also HUD equipped.

Extensive pilot feedback has been recorded using dedicated questionnaires filled by the crew after the flights.

ACTIVITY 2.	
Description	HP support will be necessary prior to, during and after flight test. It will be required to prepare crew questionnaire and anticipate the potential HP issues that could be seen in flight. It will be necessary during flight to address blocking HP issues and tune the HMD accordingly It will be necessary after the flight to gather the crew feedback and provide a detailed synthesis.
Arguments & related issues addressed	Arg. 1.2.1: 1.2.1.PJ03a-04_04, Arg 1.2.2: 1.2.2.PJ03a-04_02, Arg 1.2.5: 1.2.5.PJ03a-04_01, Arg. 2.3.1: 2.3.1.PJ03a-04_02
HP objectives	OBJ-03a04-V3-VALP-HF.0001 The crew is capable of accurately and smoothly following the taxiway centreline thanks to the HMD information in LVC or night conditions. OBJ-03a04-V3-VALP-HF.0002 Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods. OBJ-03a04-V3-VALP-HF.0003 Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods. OBJ-03a04-V3-VALP-HF.0004 Identify/update situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists & check against the scope of operating methods OBJ-03a04-V3-VALP-HF.0005 The proposed HMI as designed is usable by flight crews
Tools/Methods selected out of the hp repository	Questionnaires designed internally for measuring the acceptability and performance of HMD from an HP point of view.
summary of the hp activity	HP assessment activities for HMD use in approach and taxi phases have been performed as expected with the goal to extensively assess the capability of HMD to replace HUD from HP point of view. Every aspect

from ergonomics to possible discomfort and symbology conformity and latency has been carefully evaluated by the pilots during flight trials in representative LVC and taxi operations.

Table 6: Description of Activity 2

4.3.1.2 HP activities - active sensor (Activity 1)

The human performance assessment process relating to active sensor and validating the objective OBJ-AU00405-VALST2.002, was not performed. The HF evaluation was planned to consist of task analysis using a questionnaire technique, and HF Real Time Simulations in cockpit simulator. However, the simulations in cockpit simulator could not be run because the simulator tools were not mature enough to perform reliably and to bring relevant results. Due to the low maturity of active sensor model potential results would be affected and not relevant to intended goal of real time simulation. Therefore, this objective could not be validated. This issue is reported on Stellar under Issue ID 098 and was also reported in the periodic report 2018 and in the QPR 2019/Q1.

The validation exercise relating to active sensor did not aim to reach the V3 maturity level. Therefore, all reported deviations here have no impact on the intended solution maturity or other SESAR solutions.

Activity 1.

Description	HP support will be provided to Real Time Simulation. This will ensure that appropriate evidence can be generated through these simulations, such that HP arguments and claims can be supported. Brief description of the activity conducted and a reference if the description is already available in a different document.
Arguments & related issues addressed	1.2.1. PJ03a-04_02; 1.2.2. PJ03a-04_01; 1.2.3.PJ03a-04_01; 1.3.5 PJ03a-04_02; 2.2.1.PJ03a-04_01; 2.2.2.PJ03a-04_01; 2.3.1.PJ03a-04_021.2.1. PJ03a-04_02; 1.2.2. PJ03a-04_01; 1.2.3.PJ03a-04_01; 1.3.5 PJ03a-04_02; 2.2.1.PJ03a-04_01; 2.2.2.PJ03a-04_01; 2.3.1.PJ03a-04_02
HP objectives	OBJ-03a04-V3-VALP-HF.0001 Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists & check against the scope of the operating methods. OBJ-03a04-V3-VALP-HF.0002 Identify/update situations that constitute abnormal operating conditions in cooperation with the

	safety and operational specialists & check against the scope of operating methods OBJ-03a04-V3-VALP-HF.0003 Identify/update situations that constitute degraded modes of operation in cooperation with the safety and operational specialists & check against the scope of operating methods OBJ-03a04-V3-VALP-HF.0005 Assess sufficiency of the sensor imagery to provide aircraft position awareness to enter the visual segment at DH'. OBJ-03a04-V3-VALP-HF.0006 Assess information accuracy and acceptance in prototyping sessions or Real-Time Simulation or operational trials. OBJ-03a04-V3-VALP-HF.0007 Assess timeliness of actions in Real-Time Simulation or operational trials. OBJ-03a04-V3-VALP-HF.0008 Identify information needs/requirements of the human by performing Task Analysis and focus groups with end users OBJ-03a04-V3-VALP-HF.0009 Identify information needs/requirements of the human
Tools / Methods selected out of the hp repository	Questionnaires designed internally for measuring sufficiency of the sensor image depiction, usability and acceptability
Summary of the hp activity	N/A, Real Time Simulation was not conducted

Table 7: Description of Activity 1

4.4 Step 4 Collate findings & conclude on transition to next V-phase

4.4.1 Summary of HP activities results & recommendations / requirements

The feedback from the pilots (recovered through questionnaires) has highlighted the fact the perception of the environment with the HMD was not accurate enough during EFVS operation.; As a result one recommendation concerning HMD is issued regarding some additional technical enhancements that need to be performed for operational use in approach phase. No dedicated requirement is associated since the current requirements are deemed sufficient: meeting them will be acceptable to reach the objective.

The fact that no Real Time simulation activity was conducted for active sensor did not allow issuing recommendation or requirement for this enabler. The results are presented in the table below.

Issue ID	HP issue / Benefit	HP Issue/ Benefit Status	HP/ Valid. Obj. ID	activity conducted	results / evidence	recommendations	requirements
Arg. 1.1.1: The description of roles & responsibilities cover all affected human actors.							
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arg. 1.1.2: The description of roles & responsibilities cover all tasks to be performed by a human actor.							
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arg. 1.1.3: Roles and responsibilities are clear and consistent (in V1: non-contradictory).							
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arg. 1.2.1: Operating methods cover operations in normal operating conditions.							

1.2.1.PJ03a-04_03	In normal operating conditions, the system will add visual advantage in form of visual cues and enable to perform EFVS operation to 100 feet above the TDZE	Closed	OBJ-03a04-V3-VALP-HF.0002	Operational Trial	Several normal IFR approach operations in LVC (EFVS) or VMC conditions have been conducted to assess the relevancy of HMD use during normal operations. Real time comparison between HMD and HUD could be performed by the pilot monitoring with HUD in the left seat. Apparition of runway visual clues in EVS image or natural vision has been shown to occur simultaneously on HMD and HUD.	N/A	N/A
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1.2.1.PJ03a-04_04	In normal operating conditions, the system will provide increased environmental awareness during taxi phase	Closed	OBJ-03a04-V3-VALP-HF.0003	Operational Trial	The taxi exercise conducted in Paris Charles de Gaulle airport with a Dassault Falcon F8X during flight F465 occurs only in day conditions and good weather conditions. Voluntarily complex taxi clearances have been issued by the ground control at landing and take-off to exhaustively test the concept.	N/A	N/A
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Arg. 1.2.2: Operating methods cover operations in abnormal operating conditions.

1.2.2.PJ03a-04_02	The operating method and HMI should cover abnormal operating	Closed	OBJ-03a04-V3-VALP-HF.0004	Operational Trial	Interrupted EFVS operations (ending up in a go around) have been performed to assess the use of HMD	N/A	N/A
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	conditions (abnormal conditions are those conditions the system may exceptionally encounter, e.g. severe weather, airport closure, etc.).				during abnormal approach operations which actually consisted in a Runway Visual Range lower than 550m. By regulation such a RVR value prevents the crew from performing an EFVS approach. This level of degraded weather conditions may happen in real life (especially during winter time) but are considered as abnormal for the project since it is expected that the crew would not have started the flight, knowing that a go around and a diversion where		
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					extremely likely with these conditions. No additional HMD improvements compared to the one reported during normal operation have been found necessary. No specific abnormal taxi operation was identified nor tested.		
Arg. 1.2.3: Operating methods cover degraded modes of the ATM system.							
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arg. 1.2.5: Operating methods can be followed in an accurate, efficient and timely manner.							

1.2.5.PJ03a-04_01	EFVS operations require the crew to carefully follow the approach path while relying on EVS image and symbology. The use of a monocular HMD instead of a conventional HUD may become challenging in this critical phase of flight.	Open	OBJ-03a04-V3-VALP-HF.0000	Operational Trial	Several EFVS approaches have been conducted in actual LVC conditions on Treviso Airport with a F8X Dassault aircraft on March 6th allowing assessing the benefit and HP of HMD in normal operations. Pilot feedback and questionnaires have concluded that additional technical improvement of the HMD is necessary before fully satisfying the performance level required to conduct EFVS operations	HMD-RECOM-001-Design	N/A (The HMD must be compliant with existing requirements)
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					with acceptable workload.		
1.2.5.PJ03a-04_02	Taxi operations currently rely on visual references. Having a HMD capable of displaying conformal taxi routing may be new and uncomfortable for the crew to follow the taxiway centreline.	Closed	OBJ-03a04-V3-VALP-HF.0001	Operational Trial	Complex taxi routing clearance has been performed in CAVOK conditions on Paris Charles de Gaulle Airport with a F8X Dassault aircraft on March 7th allowing assessing the benefit and HP of HMD in normal operations. Pilot feedback and questionnaires have concluded that the HMD was fully usable in taxi conditions without increasing pilot workload and that it was adding	N/A	N/A

					significant gains in efficiency and HP.		
Arg. 1.3.5: Human actors can maintain a sufficient level of situation awareness							
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arg. 2.2.1: The accuracy of information provided by the system is adequate for carrying out the task.							
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arg. 2.2.2: The timeliness of information provided by the system is adequate for carrying out the task.							
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arg. 2.3.1: The type of information provided satisfies the information requirements of the human.							
2.3.1.PJ03a-04_02	An adequate information should be presented to the pilot with acceptable latency and resolution	Open	OBJ-03a04-V3-VALP-HF.0005	Operational Trial	During the EFVS approaches conducted in Treviso Airport the pilots have reported that an improvement of HMD characteristics would be need to	HMD-RECOM-001-Design	N/A (The HMD must be compliant with existing requirements)



					provide performances fully in line with human expectations.		
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Table 8: Summary of the HP results and recommendations/ requirements for each identified issue & related argument

4.4.2 Maturity of the Solution

4.4.2.1 Maturity of HMD

Based on the outcome of flight trials and following the conclusions from the Maturity Gate it can be stated that HMD has reached V3 for approach and taxi phases of flight.

4.4.2.2 Maturity of Active Sensor

Active sensor Maturity V3 regarding HP has not been assessed in the frame of the solution.

5 References

Human Performance

- [1] 16.04.01 Evolution from the ATM HF case to a HP Case Methodology for SESAR, HP assessment process for projects in V1, V2 or V3. D10-001, 00.01.00
- [2] 06.09.03 D05.1 Single Remote Tower Validation Plan – Appendix Human Performance Assessment Plan
- [3] 16.06.05 D 27 HP Reference Material D27
- [4] 16.04.02 D04 e-HP Repository - Release note
- [5] Pj03a-04: D4.025 Validation Plan (VALP)
- [6] Pj03a-04: D4.060 Validation Report (VALR)

Appendix A – Additional HP activities conducted

No Additional HP activities have been conducted.

Appendix B – HP Recommendations Register

HP Recommendations Register									
Reference	Type of recommendation	Recommendation	Rationale	Assessment source + Reference report	Scope (Air, Air/Ground, Ground)	Concept/solution Involved	Recommendation status	Rationale in case of rejection	Comments
<i>HMD-RECOM-001-Design</i>	System design	Improve the design of the HMD to make it fully compliant with the performances required for EFVS operation	The limitations observed by the pilots during the flight tests, (compared to EFVS certified HUD solution) have to be removed.	D4.060-PJ03a-04 Validation Report	Air	EFVS approach with HMD	Accepted		

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Table 9: HP recommendations

Appendix C – HP Requirements Register

HP Requirements Register									
Reference	Type of requirement	Requirement	Rationale	Assessment source + Reference report available if	Scope (Air, Air/Ground, Ground)	Concept/solution Involved	Requirement status	Rationale in case of rejection	Comments
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 10: HP Requirements

Appendix D – HP Log



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