



SESAR Solution PJ03a-04 SPR-INTEROP/OSED for V3 - Part I

Deliverable ID:	D4.010
Dissemination Level:	PU
Project Acronym:	PJ03a SUMO
Grant:	734153
Call:	H2020-SESAR-2015-2
Topic:	SESAR.IR-VLD.Wave1-05-2015 Integrated Surface Management
Consortium Coordinator:	ENAV
Edition Date:	16 Dec 2019
Edition:	00.01.03
Template Edition:	02.00.02

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Document History

Edition	Date	Status	Author	Justification
00.00.01	14 Dec 2017	Final Draft	DASSAULT, THALES, HONEYWELL	Preliminary Definition of Previous and new operating method
00.01.00	25 January 2018	First Version	DASSAULT, THALES, HONEYWELL	First delivery to SJU
00.01.01	04 oct 2019	Final Delivery	DASSAULT, THALES, HONEYWELL	Final delivery based on SJU comments
00.01.02	21 Oct 2019	Final Delivery	DASSAULT, THALES,	Final delivery based on

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			HONEYWELL	SJU additional comments
00.01.03	10 Dec 2019	Final Document	DASSAULT, THALES, HONEYWELL	Version updated with comments from SJU following Maturity Gate

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PJ.03a SUMO

Enhanced Visual Systems

This OSED/SPR/INTEROP document 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 is the Final version of the V3 OSED/SPR/-INTEROP for the “Enhanced Visual Operations” solution (PJ.03a-04).

This document describes the Operational Requirements which shall guide the development and implementation of prototypes for assessing in flight and through simulations the benefits of:

- the use of **Head-Worn Display** (also called as **Head Mounted displays**) fitted with SVS and using EVS legacy sensors to improve access to airports and provide EFVS operational credits on published approach minima as well as surface navigation management in degraded weather conditions (night and low visibility).
- the use of CVS using **active sensor** with less dependency to adverse weather conditions than existing legacy sensors and allowing to operate in “*all weather*” conditions to provide EFVS operational credit on published minima.

The outcomes of the PJ03a-04 validation exercises have confirmed the V3 maturity level of HMD technology for taxi and landing operations despite some non-blocking limitations observed during EFVS flight trials.

The validation exercise for active sensor landing operations cannot confirm V3 maturity level, as expected during project time being due to lower sensor maturity.

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The SPR/INTEROP-OSED Template includes the following parts:

- **SPR/INTEROP-OSED Template – Part I (this volume)**
- SPR/INTEROP-OSED Template – Part II Safety Assessment Report (SAR)

- SPR/INTEROP – OSED Template – Part III Security Assessment Report (SeAR)
- SPR/INTEROP – OSED Template – Part IV Human Performance Assessment Report (HPAR)
- SPR/INTEROP – OSED Template – Part V Performance Assessment Report (PAR)

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1 Executive Summary

PJ03a-04 “enhanced visual operations” addresses the feasibility of the new vision based systems to increase accessibility and improve taxi to all airports in low visibility conditions and without ground infrastructure requirements. The PJ030-04 consists in 3 activities:

- evaluation of the HMD fitted with taxi routing and traffic information for easing taxi operation in degraded weather conditions (AUO-406 Equivalent Visual Taxi operations in Low Visibility Conditions). These evaluations are based on flight tests at complex airport with high density of traffic.
- evaluation of HMD equipment as an alternative to HUD equipment for EFVS operations (using legacy EFVS sensors) as described in solution 117 (AUO-405 Equivalent Visual Landing Operations in Low Visibility Conditions). These evaluations are based on flight test in real low visibility conditions using Combined Vision system (EFVS combined with SVS).
- evaluation of the use of active sensor with improved performance to overcome the observed limitation of EVS legacy sensors (used in solution 117). Exercises were based on the use of fast time simulations as well as data collection flights with the Advanced Combined Vision System.

HMD evaluations are focused on human factor aspect.

The outcomes of the PJ03a-04 validation exercises have confirmed the V3 maturity level of HMD technology for taxi and landing operations despite some non-blocking limitations observed during EFVS flight trials.

The validation exercise for active sensor landing operations cannot confirm V3 maturity level, as expected during project time being due to lower sensor maturity.

The solutions of the PJ03a-04 will contribute to expand EFVS operations in Europe. On one hand, the additional use of HMD will make more aircraft capable of EFVS operation and on the other hand the use of new sensors based on emerging and promising technologies will make EFVS operation more efficient. For taxi, and in particular at large airport with complex layout and high density of traffic, HMD with 360° routing and traffic information capacity will provide enhanced situational awareness contributing to increase safety margin and to decrease workload.

Note: ATM aspects related to EFVS operations (Aerodrome/ ATC impacts) are addressed by SESAR AAL1 and AAL2 projects. From airworthiness standpoint, HMD is considered as HUD equivalent solution in regulation.

2 Introduction

2.1 Purpose of the document

Over the next decade, air traffic in the Europe is expected to significantly increase. In addition, according to the EASA Annual Safety Review 2017, perception/ situational awareness and decision making are among the top 5 safety issue ¹

In response, industrials are developing a number of advanced technologies among which the Vision Systems to

- **increase the traffic-handling capacity and the safety of surface operations at the existing key main airports**
- **and retain traffic at secondary aerodromes in degraded weather conditions.**

With respect to surface operations, aviation safety reports contain numerous incidents triggered by pilots becoming disoriented while taxiing under low-visibility conditions. The consequences of disorientation include deviating from the cleared route, increased interaction with ATC, and conflicts with other traffic. In extreme cases, route deviations can seriously disrupt the traffic pattern across the entire airport. For example, a misplaced aircraft forced the closing of a runway for several hours at Chicago O'Hare in US. It is clear from these incidents that surface navigation, particularly at night or under low visibility, poses a major challenge to the efficiency of terminal area operations. Concepts based on the use of solutions such as Head Up Display (HUD) or Helmet Mounted Display (HMD) equivalent display combined with Combined Vision System (CVS) that brings the pilot's eyes out the cockpit are studied and tested since few years with the goal to enable pilots to achieve the level of taxi performance normally seen VMC in IMC.

With respect to landing operations in low visibility conditions at other than CATII/III aerodromes, the European PBN regulation (EU) 2018/1048 requires the publication of LNAV, LNAV/VNAV and LPV minima by 2020 at runways served by non-precision approaches, and by 2024 at other runways.

EFVS operation will fully supports and will complement this PBN strategy expanding access at all airports.

Although EFVS concepts already exist (possibly combined with SVS), the technology on which sensors are based shows variable and unpredictable performances. The use of advanced active sensor at affordable cost is studied with the goal to increase the performances and improve the reliability of the EFVS landing operations to make EFVS “all weather operations” concepts a reality.

2.2 Scope

¹ based on the past performance of the system by counting high risk occurrences, or the number of fatalities or through the aggregated risk score.

This is the OSED / SPR / INTEROP for Solution PJ03a-04 for V3 phase describing the operational services for combined vision for equivalent visual landing and taxi operations in LVC (A/C-23b1 and A/C-23b2 enablers) for which they are intended, and reporting the requirements which are expected to be validated and, then, consolidated through planned validation activities.

These requirements will cover safety, performance, operational aspects as well as the interoperability ones related to specific technologies supporting the SESAR Solution PJ03a-04.

To clearly highlight the perimeter of the V3 maturity of the solution (HWD/HMD), and because the use of CVS using active sensors with less dependency to adverse weather conditions than existing legacy sensors for EFVS operations cannot confirm V3 maturity level, as expected during project time being due to lower sensor maturity, all the requirements related to active sensor are moved in B.

2.3 Intended readership

This document is intended for various stakeholders in the SESAR Programme:

The intended audience for this OSED document is represented by the main Solutions and Projects related to the Solution PJ03-SUMO (Surface Management Operation):

- PJ03a-04 for prototype development, V3 Validation Plan and trials
- 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. PJ15-10 and PJ15-11 could bring accurate and up-to date airport map in order to fulfil the database needs required for taxi guidance with HMD.
- 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 OSED/SPR-INTEROP from operational point of view and of secondary airports infrastructure, services and procedures proposed for low vis operations.
- PJ.18-04a (Management and sharing of data used in trajectory (AIM,)) as provider of aeronautical data necessary via AIXM format for aircraft vision system using active sensor
- The AAL2 project (on going as part of H2020 VLD1) addresses increased access to airports for low visibility mixed fleet operations using EFVS. It builds upon the results from the former award winning SESAR project AAL and has for main objective to conduct experimental approval of 4 pioneer non CATII-III aerodromes applying NPA 2018-06 requirements related to aerodrome/ ATC/ ATM in advance. Flight demonstration will be also performed in full

operational environment and in real weather condition to fully validate the concept of EFVS operation at secondary aerodromes. AAL2 is demonstrating EFVS to land operation using Head Up (HUD) as well as Helmet Mounted Display (HMD), with operational credit in non-CAT II/III airports (addresses medium-sized and small airports). To achieve these objectives and prepare large deployment of EFVS operation over Europe in the coming years, the AAL2 project brings together ANSPs, aerodrome operators and air users of 3 European countries. Feedback from each ATM users (ATC, aerodromes and air operators) will be collected and reported to EASA rulemaking office for considerations in update of regulation.

2.4 Background

Enhanced Visual Operations has already been addressed through SESAR1 project 9.28 “Enhanced Vision Solutions (Head-Down and Head Up)” as well as project 9.29 “Combined Vision System” as well as SESAR AAL demo project.

The goal of the WP9.28 was to develop head-up and head down Enhanced and synthetic vision systems concepts to enable more efficient approach, landing and taxi in low visibility conditions. More exactly, this work package dealt with solution analysis, mock-up development and testing in relevant environments of:

- ✓ EVS image and Synthetic symbols displayed on HUD and HDD
- ✓ SVS on HDD improved by external vision sensors
- ✓ CVS fusion on HUD
- ✓ EVS sensors performances analysis

The 09.29 project has worked on the development of on-board solutions combining Enhanced and Synthetic Vision Systems in order to improve pilots’ ability to conduct landing operation in low visibility conditions. To achieve these goals, the 9.29 project identified all relevant requirements, evaluated available database technologies and formats, defined a system concept, developed business and regional aircraft mock-ups, performed initial concept evaluation through modelling and simulation means and performed technical verification and validation to achieve V2 maturity level of the proposed solutions.

The AAL project demonstrated the feasibility, analysed the benefit of the EFVS to land and addressed the impact from an aerodrome/ATM standpoint. The recommendations of the projects were brought to EASA RMT0379 to support the drafting of the new AWO/ EFVS regulation.

The benefits and feasibility analysis have only been assessed for HUD/HDD and for legacy sensors in SESAR1. The main goal of SESAR2020 PJ 03a-04 is to complete this assessment with the introduction of both HMD and new active sensors as candidate solutions.

Solution 117 has been introduced in SESAR in 2018 to reflect the existing capability of aircraft equipped with EFVS technology to access to non CATII/III airport in degraded weather conditions. Although a significant part of jets are EASA certified for EFVS operation as per (UE) n° 965/2012 regulation since 2010, SESAR AAL projects were set up either to address ATM/ ATC/ aerodrome aspects to support regulation improvement and speed up large deployment of current EVS and future EFVS to land operations, or to continue research on new sensor technologies for enhance performances (PJ03a-04), or even to assess the potential of HMD as an alternative to HUD in the perspective to have more aircraft/ users capable of that EFVS operation (PJ03a-04).

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2.5 Structure of the document

The structure of this document is as follows:

- **Section 1** proposes an executive summary usable as-is for communication purposes,
- **Section 2** (this chapter) introduces the document and provides general information including glossary,
- **Section 3** is devoted to the Operational Service and Environment Definition, including the operational characteristics, roles and responsibilities, technical characteristics, applicable regulation and operating methods
- **Section 4** list the Safety, Performance and Interoperability Requirements with their description and traceability.
- **Section 5** reports the References and Applicable Documents,
- **Appendix A** exposes the Cost and Benefit Mechanisms involved in the concept, as well as stakeholders' expectations.
- **Appendix B** exposes the requirements for active sensor

2.6 Glossary of terms

Term	Definition	Source of the definition
AIR-REPORT	A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting.	ICAO Annex
EFVS	An Enhanced Flight Vision System is an electronic means to provide the flight crew with a real-time sensor-derived or enhanced display of the external scene topography (the natural or manmade features of a place or region especially in a way to show their relative positions and elevation) through the use of imaging sensors; an EFVS is integrated with a flight guidance system and is implemented on a head-up display or an equivalent display system. The term EFVS is introduced in RMT0379 to describe a system that can be used for operational credits as opposed to 'EVS', which refers to a system to be used only for improved situational awareness (see definitions in Annex I).	EASA NPA 2018-06 (RMT0379)
HUD	An head-up display (HUD) or equivalent display system' means a display system which presents flight information to the pilot's forward external field of view and which does not significantly	EASA NPA 2018-06 (RMT0379)

	restrict the external view	
CVS	Combined Vision Systems (CVS) combine a real-time imaging sensor and display with a synthetic image generated using a terrain and obstacle database utilising a precision navigation position. Where EFVS is part of a CVS, it is only the EFVS element that should provide the operational credits. The other part of the CVS, the SVS, should not provide operational credits	EASA NPA 2018-06 (RMT0379)
HWD/ HMD	An HMD (Head Mounted Display) also called HWD (Head-Worn Display) is a display system worn on the pilot's head that projects primary flight information (e.g. attitude, air data, and guidance) in alphanumeric and/or symbolic form to one or both pilot's eyes on a transparent screen (i.e., visor) along the pilot's dynamically changing line of sight. An HWD/HMD might also display vision system imagery. An HWD/HMD that is to be used as a HUD equivalent includes a head tracking function (HTF) to monitor the pilot's head location and line of sight so that the display can adjust in real time with head movements and enable the effective display of information over a wide field of regard	SAE ARP 6377 (draft)

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
AAL	Augmented Approach to Land
AESA	Active Electronically Scanner Array
AFIS	Advisory Flight information Service
AFM	Airplane Flight Manual
AFIS	Aerodrome Flight Information Service
AHRS	Attitude and Heading Reference System
AIP	Aeronautical Information Publication
AOF	Airport Onboard Function
APV	Approach with Vertical Guidance

A/T	Autothrottle
ATC	Air Traffic Controller
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
ATS	Air Traffic Service
AWO	All Weather Operation
CLL	Centreline Light
CNS	Communication Navigation and Surveillance
CONOPS	Concept of Operations
CPDLC	Controller-Pilot Data Link Communication
CR	Change Request
CVS	Combined Vision System
DEM	Digital elevation Model
DH	Decision Height
EASA	European Aviation Safety Agency
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
EFVS	Enhanced Flight Vision System
EMM	Electronic Moving Map
FD	Flight Director
FLIR	Forward Looking InfraRed
FOR	Field of Regard
FOV	Field of View
FPARC	Flight Path Angle Reference Cue
FPV	Flight Path Vector
HAT	Height Above Threshold
HDD	Head Down Display
HPAR	Human Performance Assessment Report
HMI	Human Machine Interface
HMD	Helmet Mounted Display
HUD	Head Up Display
HWD	Head Worn Display

IAP	Instrument approach Procedure
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
IMC	Instrumental Meteorological Conditions
IMU	Inertial Measurement Unit
INTEROP	Interoperability Requirements
IR	InfraRed
KPA	Key Performance Area
LCD	Liquid Cristal Display
LED	Light Emitting Diode
LNAV	Lateral Navigation
LPV	Localizer Performance with Vertical Guidance
LVC	Low Visibility Conditions
LVP	Low Visibility Procedure
LSD	Large Scale demo
METAR	MET Aviation routine Reports
NDB	Non Directional Beacon
NVG	Night Vision Google
OI	Operational Improvement
OPAR	Operational Performance Assessment Report
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PESA	Passive Electronically Scanner Array
PBN	Performance Based Navigation
PF	Pilot Flying
PFD	Primary Flight Display
PIRM	Programme Information Reference Model
PM	Pilot Monitoring
QoS	Quality of Service
RA	Radio Altimeter
RAAS	Runway Awareness Alert System
RADAR	Radio Detection And Ranging

RNAV	Area Navigation
RVR	Runway Visual Range
RMT	Rulemaking Task
R/T	Radio Telephone
RTCA	Radio Technical Commission for Aeronautics
RVR	Runway Visual Range
RWSL	Runway Status Light
SAC	Safety Criteria
SAR	Safety Assessment Report
SecAR	Security Assessment Report
SESAR	Single European Sky ATM Research Programme
SMGCS	Surface Movement Guidance Control system
SJU	SESAR Joint Undertaking
SPR	Safety and Performance Requirements
SVS	Synthetic Vision system
SWIM	System Wide Information Model
TAF	Terminal Aerodrome Forecast
TDZ	Touchdown Zone
TDZE	Touchdown Zone Elevation
TS	Technical Specification
VGSI	Visual Glide Slope Indicator
VNAV	Vertical Navigation
VMC	Visual Meteorological Conditions
VOR	Visual Omni Range

Table 2: List of acronyms

3 Operational Service and Environment Definition

3.1 SESAR Solution PJ3A-04: a summary

The concept proposed in SESAR consists in taking credit of emerging visual based technologies such as EFVS and SVS combined through CVS and displayed in coloured HMD in order to **increase the operational efficiency in both taxi and landing while significantly improving situational awareness**.

A unique advantage of the **solution is that it is mainly supported by the aircraft system instead of airports** and the need of complex and costly ground **infrastructures**.

From a global ATM network standpoint, the vision systems will **increase accessibility at most of secondary aerodromes providing operational credit at most of runways end with precision or non-precision landing minima** (LPV, LNAV/ VNAV, ILS CAT1...).

In addition, as Vision Systems provide the crew with a simple and comprehensive image of the situation, they require less mental effort and **potentially allow for alleviated crew training** and reduced operator constraints.

These advantages will make the Vision Systems a key operational capability especially for the business aviation community that is mainly composed of small/ medium operators with limited resources and operating frequently at small/medium airports. The Vision Systems are beneficial also for other types of aircrafts operating at small/medium airports.

Beyond operational credit, the Vision Systems will boost situational awareness in all weather conditions for all operators at all airports contributing to **increase safety margin** all the time.

SESAR Solution ID	SESAR Solution Title	OI Steps ID ref. (coming from EATMA)	OI Steps Title (coming from EATMA)	OI Step Coverage
PJ3a-04	Enhanced Visual Operations	AUO-0405	Equivalent Visual Landing operations in Low Visibility Conditions with Head Mounted Display	Full
		AUO-0406	Equivalent Visual Taxi operations in low Visibility Conditions	Full
		AUO-0410 (not in DS19, in	Equivalent Visual Approach	N/A

		pipeline)	and Landing operations providing improved resilience to LVC	
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Table 3: SESAR Solution PJ03a-04 Scope and related OI steps

High CONOPS Requirement ID	Level	High Level CONOPS Requirement	Reference to relevant CONOPS Sections e.g. Operational Scenario applicable to the SESAR Solution
S03-a4-HLOR-01		Enhanced Visual Operations shall increase landing capacity in LVC : - by augmenting flight crew vision during landing, taxi through the use of: - legacy, and new higher performance active sensors - Heads up and Heads down displays - While : - Defining requirement for sensors, displays and human factors. - Studying the opportunity for new MET observations and MET needs for the safe operation of these systems.	§B3.4.2.1 §B3.3.2.1

Table 4: Link to CONOPS

SESAR ATM Solution	OIs	Initial Maturity level	Target Maturity level at the end of Wave 1
Solution PJ.03a-04 — Enhanced Visual Operations	AUO-0405 HMD as alternative for EFVS operations	V3	achieved V3
	AUO-0410 EFVS operation with active	V2	Not achieved V3

SESAR ATM Solution	OIs	Initial Maturity level	Target Maturity level at the end of Wave 1
	sensor		
	AUO-0406 Taxi with HMD	V2	V3

Table 5: SESAR Solution PJ03a-04 initial and target maturity level

The outcomes of the PJ03a-04 validation exercises have confirmed the V3 maturity level of HMD technology for taxi and landing operations despite some non-blocking limitations observed during EFVS flight trials.

The validation exercise for active sensor landing operations cannot confirm V3 maturity level, as expected during project time being due to lower sensor maturity.

3.1.1 Deviations with respect to the SESAR Solution(s) definition

The approach part of solution originally covered OI AUO-0405 Equivalent Visual Landing operations in Low Visibility and Enabler A/C-23b1 Combined Vision for Equivalent Visual Landing operations in LVC. These elements didn't distinguish between different technologies Head-Mounted display and active sensor considered under the solution.

Because these technologies bring significantly various benefits and active sensor was on different maturity the solution decided to split two technologies under two different operational improvement steps and enablers. Therefore, original OI AUO-0405 and EN A/C-23b1 were updated and define HMD as supporting technology. Simultaneously, change requests CR 02774 and CR 02775 proposing a creation of OI AUO 410 and EN A/C-23b2 for active sensor are in the pipeline for future development.

3.2 Detailed Operational Environment

The detailed operational environment is the same as for existing HUD operations.

3.2.1 Operational Characteristics

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-4:

- 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 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 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

3.2.1.1 Main aerodromes

All main airports have extensive and costly infrastructures:

- Full ATC service (control tower with Controller given clearance)
- At least 2 runways (instrument precision runways), and complex taxiway layout including runway crossing
- Full lighting facilities (900m Approach Lighting System, CLL, TDZ light, stop bar light, clearance bar lights and new RWSL)
- CATII/III ILS navigation infrastructure (sensitive to interferences caused by vehicles or objects or aircrafts...)
- Full weather facilities and services (2 or 3 RVR sensor are available, TAF, ATIS)
- LVP in force below 550m RVR
- Surface movement radar or A-SMGCS installed.

With respect to **landing operations**, main airports are capable of Type B landing operations (CATII or CATIII) which allows facing to most adverse weather conditions that can be encountered in day to day operations. Separation between successive aircrafts on approach is increased to prevent interferences with the ILS beam, and to cope with the time needed for aircrafts to vacate the runway (depending on the airport taxiway/ runway layout).

With respect to **taxi**, surface movements, routing and spacing between aircrafts on ground are regulated using **surface movement radar** (SMR) or A-SMGCS at main airports. Taxi operation is based on ATC – Flight crew communications and takes mainly benefit of ground lighting/ marking/ signs and panels available at the airport. **A follow me** vehicle may be requested if necessary (Visibility may be lower at some parts of taxiways of large aerodrome).

During LVC conditions, as it cannot be assumed that the ATC can see the aircraft and manoeuvring areas from the control tower, **LVP are put in place at the aerodrome**. LVP at main aerodrome (equipped with CATII/III infrastructures) consist in procedures to regulate and limit traffic of vehicles, aircrafts and persons at the surface of the aerodrome. To make taxi safer, the use of preferred routes (best equipped, with limited intersections) may be recommended in addition to ground speed limitations (in general 10kt). In addition, CATII/III radio navigation beams must be protected against interferences. Spacing of aircrafts in air must be increased and sensitive areas on ground must not be penetrated while another aircraft is on final approach. Specific lightings such as stop bar or segments of taxiway centreline are turned on to assist pilot in progressive taxi.

As the **main airports** are the sole to remain accessible in the most adverse weather conditions, they are designed to be **capable of medium/ high traffic density** and **with a good level of continuity of service**. These operational objectives are reached by requiring very heavy infrastructures and procedures.

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PJ03a-04 taxi solutions flight validations will be mainly performed at main aerodromes.

3.2.1.2 Small/ Medium aerodromes:

Most of Small/ medium airports fitted with instrument procedures have limited ground infrastructures:

- limited ATS service. Significant number of small medium aerodrome is not controlled (or not full time controlled) and has only AFIS. AFIS provides only information and assistance services (see note in 3.2.2 for further information).
- Single runway with a single or only few taxiways (Non Precision Instrument Runway, no TDZ marking)
- Reduced lighting facilities (reduced Approach Lighting System, no CLL, no TDZ light, no stop bar or clearance bar lights, increased light spacing)
- Standard navigation means (ILS, RNAV, but also VOR or NDB)
- Limited weather facilities and services (a single RVR sensor is usually available. TAF may be not broadcasted)
- No LVP, or local LVP (usually for take-off use)

With respect to **landing operations**, most of small/ medium airports are capable of Type A landing operations and more and more are capable of type B CAT1 operations along with the PBN plan deployment. This potentially limits landing at a significant number of airports, in general during winter period and early in the morning (see SESAR AAL LSD02.02). At this time, **landing at these airports in LVC are only possible through EFVS with operational credit** operation permitted by AIR OPS regulation.

With respect to **taxi**, these airports are not² equipped with surface movement radar. Therefore, a minimum visibility is usually considered as sufficient to steer the aircraft along the taxi route and see and avoid potential obstructions. As it is for take-off, such values are consistent with CATII minima.

During LVC conditions, it is assumed that ATS cannot see the aircraft and manoeuvring areas from the tower, and then **LVP must be put in place at the aerodrome**. LVP at secondary aerodrome (not equipped with CATII means) consist in procedure to limit traffic of vehicles, aircraft and persons at the surface of the aerodrome. To make taxi safer, the use of preferred routes (best equipped, and with a unique direction of circulation and limited or no intersections) are recommended in addition to ground speed limitations. At secondary aerodromes, the spacing between aircraft is often increased. **Traffic may be reduced to one movement at one time** to mitigate the reduced installations (no surface movement radar, no stop bar, no taxiway centre line lights...).

² Except rare cases in Norway or Denmark for example

At secondary aerodromes, ground staff is often limited to few people having several responsibilities (the fireman may be also the marshaller...).

PJ03a-04 landing solutions flight validations will be mainly performed at small/ medium aerodromes

3.2.2 Roles and Responsibilities

3.2.2.1 General

During EFVS landing or taxi operations, nothing is specific to ATC or Crew responsibilities or their mixed roles compared to standard respective operations. Therefore, the following roles and responsibilities are provided as reminder.

At **controlled aerodromes**, **ATC** provides the 3 following services:

- air **control traffic clearance** service,
- flight **information** service
- and **alerting** service.

ATC gives air control traffic clearance as necessary to the flight crew to **prevent collisions**, separate aircrafts, **expedite and maintain an orderly flow of traffic**. Clearances are issued based on known traffic conditions which affect safety in aircraft operation. Such traffic conditions include:

- aircraft in the air,
- and also aircrafts on the manoeuvring area over which control is being exercised,
- and concerns any vehicular traffic or other obstructions not permanently installed on the manoeuvring area in use.

ATS determines location of the aircraft, convey information on essential local traffic or routing, and provides assistance in case of emergency.

Although the Flight crew has to acknowledge and follow ATC clearance, and adhere to the general and local (aerodrome AIP) traffic rules, the pilot-in-command of an aircraft has final authority as to the disposition of the aircraft while in command. He remains responsible for the safety and control of aircraft. The pilot-in-command of an aircraft shall inform ATC if he considers an air traffic control clearance is not satisfactory. In such cases, ATC will issue an amended clearance, if practicable. **The ATM procedures do not relieve pilots of their responsibility to ensure that any clearances issued by air traffic control units are safe in this respect.**

Note about **uncontrolled but AFIS** aerodromes: At some small aerodromes where a control service (ATC) is not clearly justified (or not justified on a 24h basis) by the complexity, density of air traffic, topographic and prevailing meteorological conditions, AFIS may be selected for a service between aerodrome control service and no service at all. **AFIS will provide flight information and alerting services, but no Control service to traffic.** AFIS officers only pass information and warning to pilot.

Founding Members



Pilots are therefore wholly responsible for maintaining proper spacing in conformity with the rule of air.

Node	Responsibilities
Aerodrome ATS	Performs all the aerodrome ATS operations. [RELATED ACTORS/ROLES] Runway controller, ground controller, etc.
Aeronautical Information Service Provision	Responsible for the timely collection, processing, storing, integration, exchange and delivery of quality-assured aeronautical data and aeronautical information within the air traffic management (ATM) system.
En-Route/Approach ATS	Performs all the en-route and approach ATS operations. [RELATED ACTORS/ROLES] Executive controller, planning controller, etc.
Flight Deck	Performs all the on-board AU operations including flight execution/monitoring according to agreed trajectory, compliance with ATC clearances/instructions, etc. [RELATED ACTORS/ROLES] Flight Crew

Operational interactions per context (NOV-2)		Operating Environment
[NOV-2] Enhanced Visual Operations		Airport;
Node	Node instance	Node instance description
Aeronautical Information Service Provision	Aeronautical Information Service Provision	
En-Route/Approach ATS	Approach Control	
Flight Deck	Flight Deck Enhanced Visual Operations	
Aerodrome ATS	Ground Control	

3.2.2.2 Taxi operations

Standard operation

Founding Members



With respect to taxi operations, while datalink technology/ CPDLC is clearly the path to the future especially for non-time/ safety critical information, **the importance of aural communications and its criticality still cannot be dismissed.**

Under low visibility conditions (LVC), specific procedure called as LVP and based primarily on the principle “see and be seen, or see and avoid” are **activated by ATC** to maintain spacing between aircraft and/or vehicles on the aerodrome movement area.

Crew is informed by R/T or ATIS broadcast (if exist) that LVP are in force. There are no prescribed separation minima, and **controllers, pilots and vehicle drivers share the responsibility that operations will not create a collision hazard.**

The cleared route is not displayed on the A-SMGCS or in the cockpit and is usually not even recorded on the paper or the EFS. **Flight crew and Vehicle Drivers** will generally write down the route in order to correctly read back the clearance and then follow the route using aerodrome maps and surface signage. From the **Flight Crew’s** point of view, receiving guidance information via a shared radio frequency requires a continuous monitoring of the radio calls in order to filter out relevant information which may increase workload, thus distracting attention from the primary task. **On large airports, the frequency can be overloaded, understanding Tower Controller clearances and ad-hoc communication can be difficult and lead to errors.** According to ICAO, pilots and vehicle drivers find that their ability to operate “see and be seen, see and avoid” are severely impaired and the number of accidents and incidents during surface movements, including runway incursions is increasing. Except where the total number of aircraft and vehicles permitted to operate on the movement area at any one time is kept very low, which is the case of small and part of medium airports, such tasks are beyond the capability of a controller. Therefore, **advanced capabilities are needed to ensure spacing when classical visual means are not adequate and to maintain aerodrome capacity in all weather conditions.**

- On one hand, A-SMGCS (supported by new RWSL) or alternative systems such as those studied in SESAR solution PJ02-06 must be envisaged depending on the aerodrome constraints.
- On the other hand, especially **in limited visibility conditions associated to time critical decisions, it is important that vigilance for the purpose of detecting potential collisions be exercised on board of aircraft.** Alerting systems which provide warnings directly to pilots³ have proved more effective than those which automatically alert controllers who then have to respond rapidly with effective mitigation. In addition to an inevitable delay using such a method, there is a risk that an automatic (i.e. routine) instruction to an aircraft to stop may not necessarily be appropriate if that aircraft is already crossing ahead of an aircraft approaching at speed when clearance is received. Advanced vision system proposed in PJ03a-04 is then an efficient and economically affordable solution to these time critical situations.

With Vision System

³ For example the RAAS or the aerodrome lighting systems like RWSL

Vision system will be a on board complementary system to A-SMGCS, especially at aerodromes where visibility, traffic density, layout complexity and any combination of these factors do present a problem for the ground movement of aircraft and vehicles. This simple solution will provide through an image an intuitive view to pilots:

- to have a **good situational awareness of the A/C position**, and to follow the assigned routes.
- to **detect potential ground collision**,
- to be capable of accepting a change of route at any time; be capable of seeing routes and areas that are either restricted or not available for use
- to potentially **reduce ATC-crew voice communication** asking for confirmation or further information

Vision systems solution of PJ03a04 will provide flight crew with CVS, which is made of SVS combined with EFVS:

- Whereas the **EFVS is a real time image** showing situation in the **forward field of view** with **enhanced visibility**,
- **SVS** is a **computed** image based on a digital elevation model (DEM) depicting possibly the **360°** surrounding environment **regardless of how poor the visibility** is outside.

In addition, CVS can be supplemented by ATC assigned routes information, ATC clearance information, aerodrome permanent or temporary restrictions information and surrounding traffic information.

The combination of all the needed information in a unique and comprehensive **CVS mode will reduce mental resources** required from the crew and as a consequence will increase safety margins.

The display of **CVS in a conformal way (scale and aligned with real world) in Head Up** will **maintain the pilot “eyes out”** avoiding to continuously scan from outside to inside reinforcing attentional getting, and improving decision making in critical situations.

At least, the use of an **HMD system with unlimited Field of Regard (FOR)** will provide enhanced information also in periphery, reducing routing errors and collision risk at runway/ taxiways intersections.

In conclusion, Vision Systems for taxi will increase short and Mid-term situational awareness while reducing workload, i.e the capacity of the crew to understand and to anticipate an unexpected⁴ surrounding situation in complex environment. This on board solution will assist the crew during taxi **avoiding misunderstanding**, and **limiting routing deviations**, **clearance infringement** and potential collision due to traffic flow and voice communication high density. **It will make the crew prompt to detect and to react to evolving situation and improve crew decision making.** Vision system will **contribute to safety and efficiency in surface operations.**

3.2.2.3 Landing operations

⁴ For example due to ATC error or accepted ATC clearance not followed...

Standard operation

With respect to approach and landing in low visibility conditions (LVC):

- During descent, **the crew** prepares the approach and landing by reviewing the navigation documentation. The crew get the latest airport information (ATIS), if available
- At first contact, **ATC** informs the crew of the runway in service (see note here below) and communicates by R/T the latest weather information such as wind, RVR/ visibility and ceiling. Pilots are then formally requested to “check their minima”.
- The **crew** selects an instrument approach procedure compliant with aircraft limitations (AFM), operator approval and crew qualification and satisfying as much as possible the actual weather conditions for the in service runway.

When in LVC, although LVP information is usually communicated by the ATC, it is also the responsibility of the pilot to check such procedures are well “*in force*”.

After being cleared for the approach by ATC, the crew starts the approach:

- **Down to DA/ DH**, the approach procedure is conducted using **instrument means** such as LOC/GS, LNAV/VNAV deviation scale, FD guidance...
- **No later than 1000ft** HAT, it is the responsibility of the pilot in command to check the consistency between the actual RVR and the minimum RVR for the approach flown. Approach must be **interrupted** by the crew **in case RVR is insufficient**.
- **Approaching the DA/ DH**, the required **visual references** such as approach light or threshold marking must be acquired by the crew. The crew must accomplish this obtaining required visual reference to be allowed to continue the approach to landing. **Below DA/ DH**, the approach and landing must be performed using **visual reference as the primary mean**.

During the approach, especially when in low visibility conditions, the pilot controls and monitors the trajectory of the aircraft using mainly **raw** and **multiple** isolated **information**, usually without any direct correlation to the external scene.

Note: In general, when several types of approaches are available for a runway (for ex an ILS and an RNAV), the ATC will recommend an approach type to all aircrafts for traffic sequencing reason.

With Vision System (EFVS)

An EFVS vision system displays a real-time image of the external scene that may significantly improve the pilot’s capability to detect required visual references that may not otherwise be visible using natural vision in some degraded weather conditions. The image of external scene delivered by the **EFVS** is displayed **conformal** (scale and aligned) to the real world on **Head Up Display or equivalent solution**.

The main benefit of the EFVS consists in **operational credit** granted by EASA EU 965/2012 (and 14-CFR FAA) regulations for other than CATII/III approaches. Per EASA regulation:

- Operational credit is applied to reduce the Runway Visual Range (RVR) by no more than one third of the published RVR
- a crew having visual reference in sight at DA/ DH in EFVS can continue the approach below DA/ DH (for example down to 100ft). **EFVS is then used in lieu of natural vision and in supplement to the instrument approach.**

Such an operational credit will allow certified aircraft and properly qualified and trained crews to **operate in lower than CAT1 weather conditions** (min RVR 350m for an unrestricted CAT1 RVR 550m approach). This potentially expands the low visibility operational capacity to **most of secondary aerodromes, and not just the few hundreds of key main airports** that are fully equipped with heavy CATII/III infrastructures. This operational credit is particularly important regarding secondary aerodromes because they have usually **higher than CAT 1 RVR – DA/DH minima** and are then potentially more frequently impacted by adverse weather conditions (see weather analysis of SESAR LSD 02.02).

Beyond landing operational credit, a Visual System, especially when EFVS is combined with SVS, will provide the crew with a **simple and comprehensive image** of the situation improving significantly situational awareness at any time, and regardless the weather conditions.

EFVS is not intended to change the roles and responsibilities of Air Navigation Services Providers (ANSPs) for spacing and separation from other traffic.

Operator responsibility

As EFVS with operational credit permits to descent below published minimum and in weather conditions lower than those usually practiced at these aerodromes, it is the **responsibility** of the **operator** to check that the aerodrome is suitable for such operations. Operators shall pay attention:

- to potential obstacle in the EFVS segment,
- to performance limitations of go around manoeuvre below DA/ DH
- and the presence of LVP.

Performance based concept

Concepts using sensors such as EFVS and CVS are **performance based** and the success of the landing operation with operational credit is mainly dependant from to the performance of the sensor. Existing EFVS sensors based on visual/ **Infrared spectral band**, however:

- may have **varying performances** in some conditions such as snow, or inhomogeneous fog.
- may have performance **difficult to predict** due to the very limited weather information the crew can get through TAF or METAR to support this task.

At least, passive **infrared only** sensors are not capable to see **LED lights**, as no energy is emitted in this spectral band.

3.2.3 Technical Characteristics

This section describes the type of technical aspects that are assumed to be in place for the HMD or active sensor solutions to be deployed

3.2.3.1 HMD system

Solution based on HMD assessed in PJ03a-04 requires following new features:

- an HMD product is available to support the concept in taxi or in landing
 - associated to controls for adjusting contrast/ brightness and display of information
 - capable of colour
 - capable to display CVS scaled and aligned with external world
 - Dynamic compensation mechanisms are usually necessary to be implemented to limit latency.
 - capable to display conformal (scale and aligned to the real world) symbology
 - An exact positioning of the conformal symbology on the helmet display is a real challenge since it requires an accurate knowledge of the helmet localisation and orientation inside the cockpit, as well as aircraft attitude parameters. As an example a 2° projection error (corresponding to an AHRS heading standard error) will look totally unacceptable to the crew. Several technologies may be used to provide accurate head tracking, based on embedded IMUs, magnetic field or optical trackers
- an aerodrome database is available for taxi routing information
 - Aerodrome database contains essential data about important runway parameters and aerodrome surface lightings are essential.

note: there is no need for METEO data other than existing METAR data.



Figure 4: Example of HWD/ HMD

3.2.3.2 Active sensor

Solution based on active sensor assessed in PJ03a-04 requires following new features:

- an active sensor product such as a radar:
 - capable of runway feature detection in all weather conditions
 - compatible with LED light use
- a modification of AIM to support acquisition of the runway

Some system implementations can also require runway features information to support acquisition of the runway features and coming from a modification of AIMX (PJ18-04) or other database.

More technical details about active sensor are in the technical specification.

Figure 1. Honeywell IntuVue™ RDR-84K Band Radar System

3.2.4 Applicable standards and regulations

The necessary regulations and standard describing vision systems and related operations are:

EASA Regulations:

- **EASA NPA 2018-06**, 2018 (in progress under RMT0379)

The EASA NPA No 2018-06 attempts to update the All Weather Operations (AWO) rules in all aviation domains, as regards possibility of applying safety performance principle in redrafting of current rules with the aim of allowing a better integration of **new and future technologies** supporting AWOs, as e.g. enhanced flight vision systems (EFVSs), synthetic vision systems (SVSs), synthetic vision guidance systems (SVGs), combined vision systems (CVSs), and head-up displays (HUDs).

In the context of the RMT0379 in charge of the NPA, the operations with **EFVS/CVS** and the special approval (SA) CAT I operations are **primarily addressed** as operations with **operational credits**.

As a result of the task, the European industry should be enabled to take full advantage of **safety** and **economic benefits** generated through new technologies and operational experience.

Per standard EASA rulemaking process described here below, the RMT0379 has started in 2015 and will end in 2020 for airworthiness requirements and in **2020** for Operational requirements (opinion).



Figure 1 EASA regulation process milestone

- EASA current Regulation (EU) 965/2012 on air operations rev 8, 2017. Will be replaced by NPA 2018-06, when published

ICAO standard documents:

- ICAO Annex 6 (Operation of Aircraft, including EFVS operations) to the Chicago Convention on International Civil Aviation, 9th Edition, July 2016
- ICAO Annex 3 (Meteorological Service for International Air Navigation) to the Chicago Convention on International Civil Aviation, 6th Edition, July 2007
- ICAO Annex 11 (Air Traffic Services) to the Chicago Convention on International Civil Aviation, 13th Edition, July 2001
- ICAO Document 9365, DOC — Manual of All-Weather Operations, 3th Edition, 2013
- ICAO Document 4444, PANS — Air Traffic Management, 15th Edition, 2007
- ICAO EUR Doc 013 — European Guidance Material On Aerodrome Operations Under Limited Visibility Conditions

RTCA/ EUROCAE standard documents (SC213/ WG79 Working group):

- EUROCAE ED-179 — Minimum Aviation System Performance Standards (MASPS) for Enhanced Vision Systems, Synthetic Vision Systems, Combined Vision Systems and Enhanced Flight Vision Systems, 2008
- RTCA DO-315A — Minimum Aviation System Performance Standards (MASPS) for Enhanced Vision Systems, Synthetic Vision Systems, Combined Vision Systems and Enhanced Flight Vision Systems, 2010
- RTCA DO-359 — Minimum Aviation System Performance Standard (MASPS) for Synthetic Vision Guidance Systems, 2015
- RTCA DO-341 — Minimum Aviation System Performance Standards (MASPS) for an Enhanced Flight Vision System to Enable All-Weather Approach, Landing and Roll-Out to a Safe Taxi Speed, 2012

SAE International document

- SAE International ARP-5677 — Human Engineering Considerations for Airborne Implementation of Enhanced Synthetic Vision Systems, 2012
- SAE International ARP-5288 — Transport Category Airplane Head Up Display (HUD) Systems
- SAE International ARP 6377 - Head Worn Display (HWD) Systems
- SAE International AS 8055A - Minimum Performance Standard for Airborne Head Up Display (HUD)

- SAE International AS 5703 - Minimum Performance Standard for Enhanced Vision System

FAA documents

- 14-CFR § 91.176 Straight-in landing operations below DA/DH or MDA using an enhanced flight vision system (EFVS) under IFR , dec 2016
- FAA Advisory circular AC 90-106A Enhanced Flight Vision Systems, 2017
- FAA Advisory circular AC 20-167A Airworthiness Approval of Enhanced Vision System, Synthetic Vision System, Combined Vision System, and Enhanced Flight Vision System Equipment, 2010

Standardization and regulation needs resulting from PJ03a-04:

- **To permit the use of advanced active sensor technology for Enhanced Flight Vision System as those studied in PJ03a-04 (V2), 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.

3.3 Detailed Operating Method

3.3.1 Previous Operating Method (CAT1)

This section describes the existing operating method related to:

- CAT1 approach and landing, including those with EFVS operational credit using HUD,
- Taxi operations.

3.3.1.1 Approach and Landing (CAT 1)

3.3.1.1.1 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 references⁵ 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 a radar, if available) and communicates by R/T with the crew.

3.3.1.1.2 Instrument approach with EFVS/CVS operational credit using HUD

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,

⁵ Element of the Approach lighting system, or Threshold, or TDZE, or VGSI

- **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 acquisition⁶ 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.

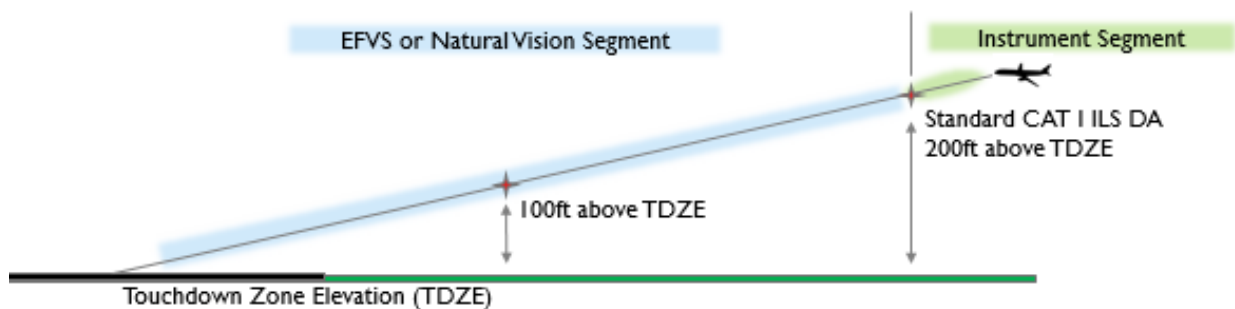


Figure 2: EFVS approach with operational credit

With respect to existing EFVS operations, the current US regulation, and the future EASA AWO regulation which the drafting is in progress describes two types of EFVS operations with operational credit:

- **EFVS Operations to Touchdown and Rollout**
- **EFVS Operations to 100 Feet Above the TDZE**

Historically only EFVS Operations to 100 Feet above the TDZE were permitted by EU 965/2012 (EASA) and 14-CFR §91.175 (FAA). Since December 2016, EFVS Operations to Touchdown and Rollout are also allowed by FAA through 14-CFR §91.176⁷. Same kind of operation (named as EFVS-L) is being to

⁶ Requested at 100ft for ILS or LPV, and at 200ft otherwise (per EU 965/2012)

⁷ Supported by AC 20-167A and AC 90-106A guidance materials

be introduced in the new EASA AIR Ops regulation expected to be published in 2018 (see §3.2.4, EASA NPA 2018-06) EFVS-L operation was also demonstrated in SESAR LSD02.02 (AAL) using a Dual HUD display/ CVS configuration/ multispectral IR sensor based. Both operations mandate the use of HUD or equivalent display (such as HMD) with an EVS image superimposed to flight symbols.

In addition, both types of operations are restricted to straight-in approaches.

EFVS Operations to 100 Feet above the TDZE, as defined in current (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.

EFVS Operations to Touchdown and Rollout:

The main differences compared to EFVS to 100ft (according to FAA regulation) are:

- It may only be conducted on precision or APV approaches,
- It requires a minimum of 300m/ 1000ft RVR and the performance (visual advantage provided by the EFVS) must be demonstrated in certification,
- An RA must be installed, and a flare prompt or a flare guidance must be displayed,
- An EVS image must be displayed both in the primary field of view of the PF and PM in case of dual-pilot operations,
- A pilot who conducts an EFVS operation to touchdown and rollout can continue to descend below 100 feet relying on the EFVS sensor image (used in combination with HUD flight information) to acquire requested visual cues,

3.3.1.2 Taxi

3.3.1.2.1 Standard operation

The ATC gives clearance (routing, holding position...) to the flight crew and informs them about possible traffic by R/T.

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

Without Vision Systems, Flight crew taxi **visually** (using primary means of navigation) the aircraft according to ATC clearance and in accordance with the aerodrome procedures (AIP).

- 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 identifies 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 react 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 or paper charts to monitor the progress of the taxi using more **strategic and exocentric view** such as “paper or electronic airport 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 monitoring of the systems.

During taxi, there are nearly no on board assistant systems supporting the crew to find their way and to avoid collisions (except the AMM with displayed ownship position or 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.

3.3.1.2.2 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 certified and used for situational awareness during Taxi only.

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

3.3.2 New SESAR Operating Method

Compared to:

- SESAR LSD02.02 dedicated to EFVS to land operation⁸ and based on monochrome HUD and on the latest generation of passive multispectral EFVS sensor,
- the other taxi studies performed in SESAR1 9.13 and 9.14 dedicated to the display of the taxi clearance and some taxi alerts on an HDD airport moving map,

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

- The feasibility of the **EFVS 100ft approach** operation using coloured HMD displaying **CVS**. CVS depicts SVS with terrain and obstacle information in addition to EFVS

⁸ Equivalent to *EFVS to touchdown and rollout* FAA concept

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**⁹
- the reduction of CVS display **clutter (use of colour)**,
- the depiction of **coloured aerodrome lighting**¹⁰
- the depiction of traffic information
- 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 will allow greater **performance**, better performance at any time and in all weather conditions.

From an **ATM perspective**, the PJ03a-04 solutions will make **head up** concept **accessible** to more aircraft types and **EFVS/CVS** operations more **efficient** and more **attractive** financially. The will lead to contribute to the large deployment of these operations in all the aviation segments.

3.3.2.1 Use Cases [NOV-2] Enhanced Visual Operations

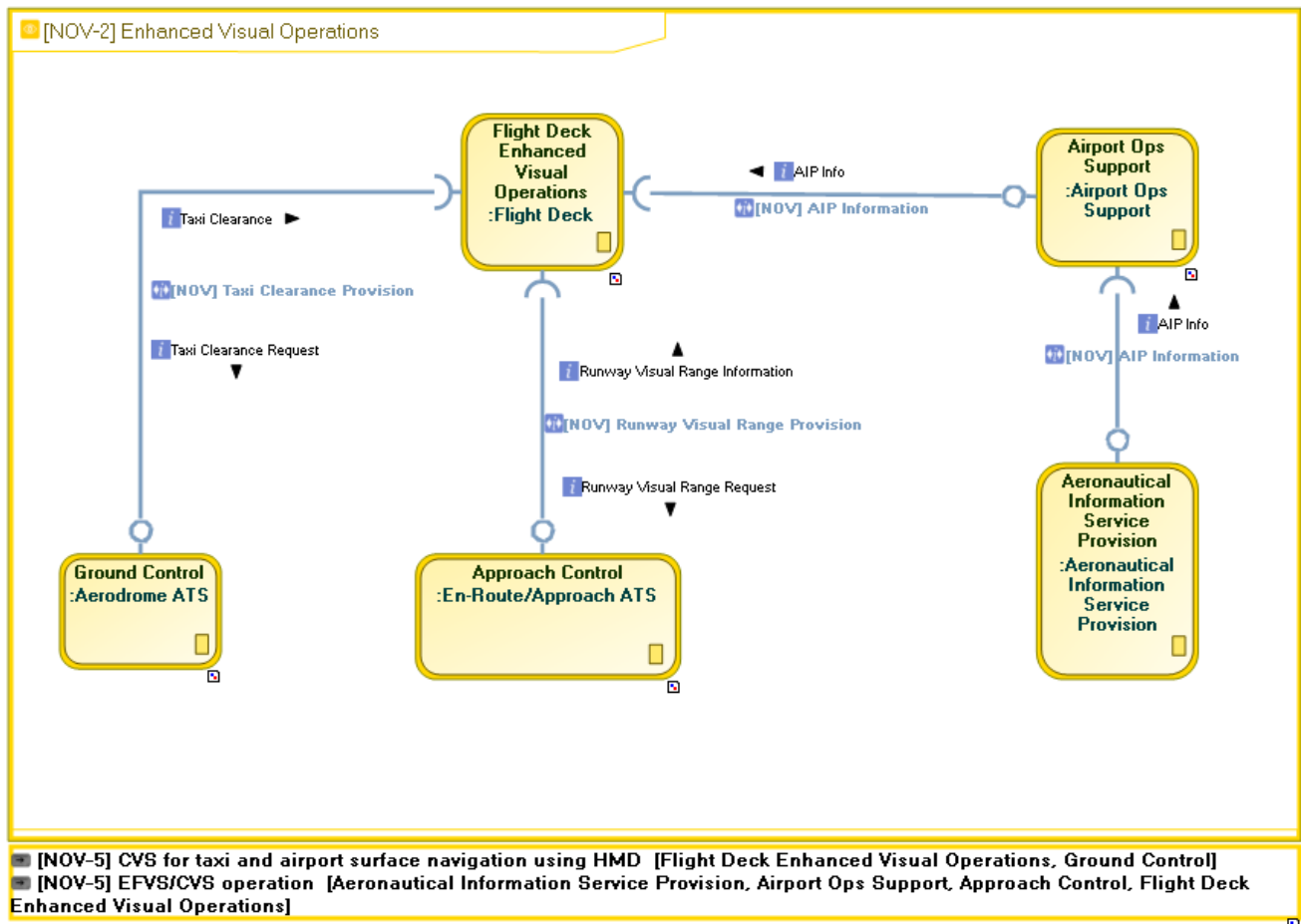
Enhanced Visual Operations Node Connectivity View is provided here below.

The Enhanced visual operation is described by two use cases

- [NOV-5] CVS for taxi and airport surface navigation using HMD
- [NOV-5] EFVS/CVS operation

⁹ such as the display of information in part of the display usually not used in operation (in the sky when on ground for example), but remaining easy accessible through head movement.

¹⁰ PAPI lights, or red displaced threshold lights or red runway centreline lights or red Runway Status Lights (RWSL)...



3.3.2.1.1 [NOV-5] EFVS/ CVS operation Landing operation with HMD

Normal operation

The following scenario describes a nominal CVS operation to **100ft**.

The use case proposed is based on the CVS operation to 100ft based on EFVS operation to 100 feet above TDZE as permitted by (EU) 965/2012 regulation, and intended to be performed during the SESAR solution flight tests using HMD.

Use Case Environment

- The aircraft is in approach and ready for landing at small or medium airport taking credit of EFVS regulation. A published IAP will be selected. Continuation of the approach below the published DA/H will be achieved using EFVS in HMD (equivalent HUD system).

Assumptions

- The aircraft is fitted with an Head-Mounted Display(HMD) and associated controls
- The aircraft is fitted with an EVS camera and associated controls

Pre-conditions

Founding Members

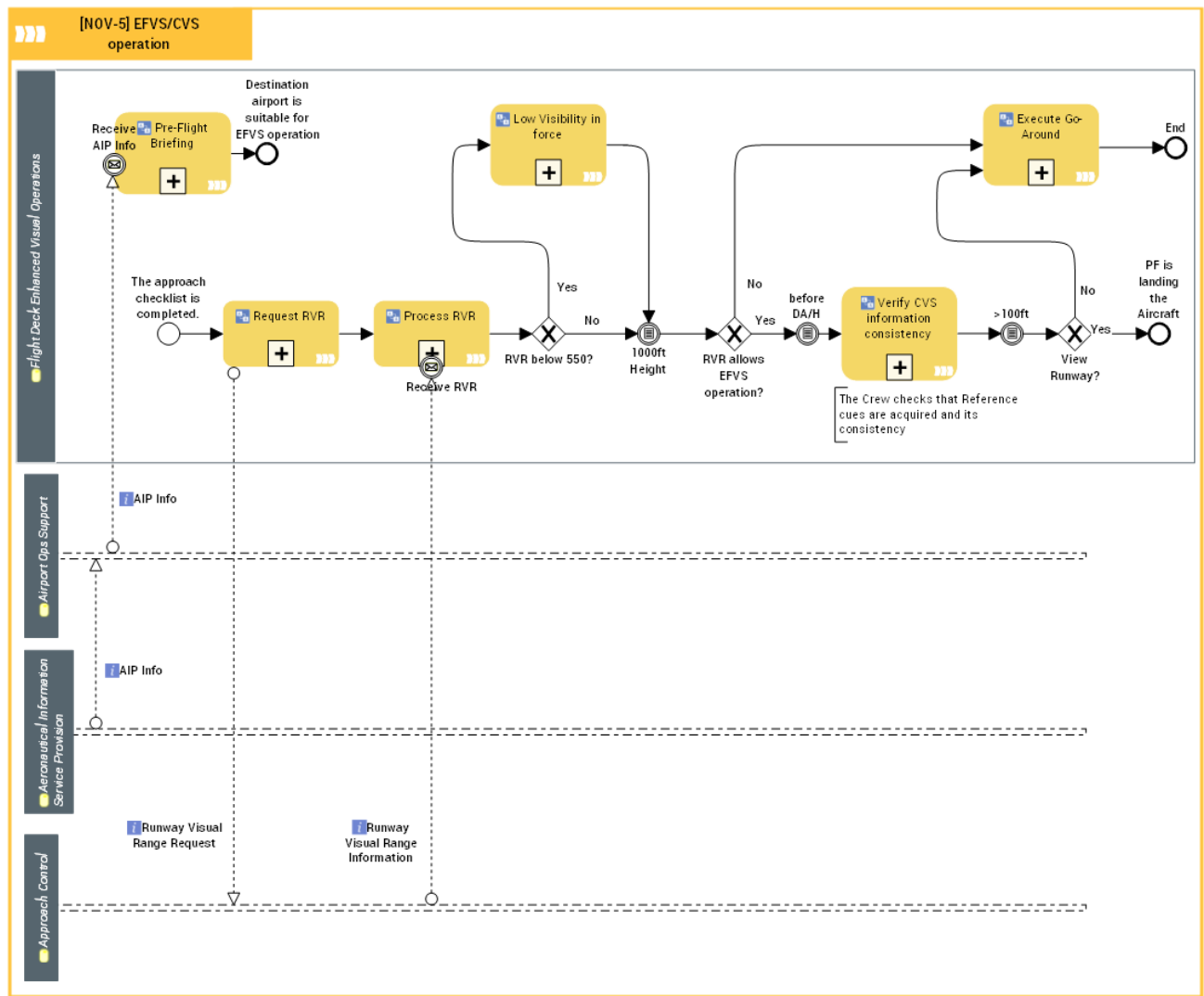


- The aircraft is in the air and stabilized in final instrument segment of a published Instrument Approach Procedure
- The PF is using the HMD with EFVS/CVS and basic flight information displayed
- The airport and the Instrument Approach Procedure have been checked as suitable for the EFVS operations with operational credit (during flight preparation) using AIP, Aircraft limitations and aircraft performances (AFM)
- The actual RVR measurement announced by the ATC is in accordance with operational credit granted during EFVS operational approval

Post-conditions Success End State

- The PF is continuing the approach below published DA/H and down to 100ft taking credit of EFVS in HMD.
- The PF is acquiring natural vision at 100ft and land the aircraft

Note: EFVS operation can be performed manually or using automatisms (Autopilot and Autothrottle). Per Dassault flight crew procedure, use of automatism is recommended to reduce workload during EFVS operations.



Activity	Description
Execute Go-Around	The Flight crew executes and follows the missed approach as defined in the approach chart.
Low Visibility in force	Flight Crew ensures Low Visibility procedures are in force
Pre-Flight Briefing	Flight Crew receives pre/fight Briefing info
Request RVR	Flight Crew requests Runway Visual Range
Process RVR	Flight Crew processes Runway Visual Range
Verify CVS information consistency	At DA/H, the Flight crew checks that visual cues are acquired through HMD in EFVS and that EFVS and HMD are consistent.
Verify natural vision cues	At 100ft, the Flight Crew check that visual cues are acquired in natural vision and aircraft is in position to land

Issuer	Info Flow	Addressee	Info Element
--------	-----------	-----------	--------------

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Issuer	Info Flow	Addressee	Info Element
Flight Deck Enhanced Visual Operations	Request RVR --> Approach Control	Approach Control	Runway Visual Range Request
Approach Control	Approach Control -> Receive RVR	Flight Crew Enhanced Visual Operations	Runway Visual Range Information
Aeronautical Information Service Provision	Aeronautical Information Service Provision --> Receive AIP Info	Flight Crew Enhanced Visual Operations	AIP Info (Aerodrome suitability or criteria allowing to declare the suitability of the aerodrome/ runway/ IAP for EFVS operations)

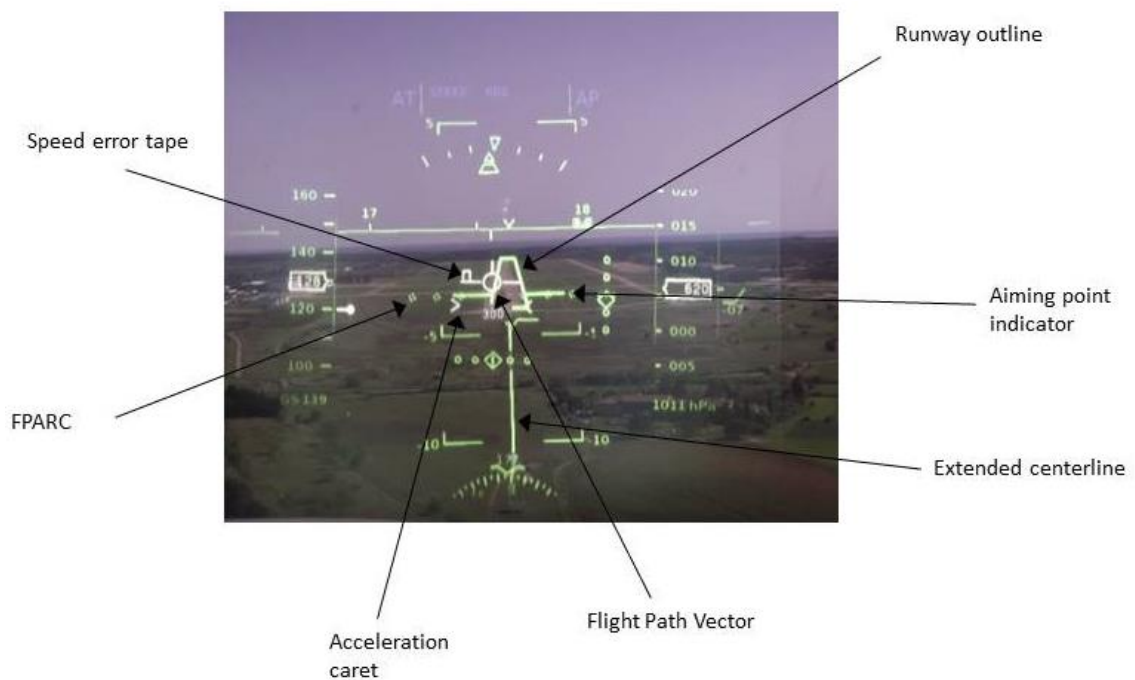


Figure 3 Head-Mounted Display with conformal symbology (white) and non-conformal symbology (green).



Figure 4: Example of decentred display of the destination runway, aiming point and extended centerline)

Non-normal operation

The following scenario describes a non-nominal **EFVS/CVS to 100ft Operations** as permitted by 14-CFR, described in AC-90-106A and intended to be performed during the SESAR solution flight tests using HMD.

Compared to normal operation described in here above section, the non normal scenario at ATM level is:

- **At and below DA/ DH:** PF aborts the approach and executes an immediate go around manoeuvre in case of lack of visual references requested to be acquired in CVS due to insufficient EFVS sensor performance or insufficient visibility,
- **At 100ft above TDZE:** PF aborts the approach and executes an immediate go around manoeuvre in case of lack of visual references requested to be acquired at 100ft HAT in natural vision due to insufficient real visibility caused for example by unpredictable inhomogeneity of atmosphere.

During go around, published missed approach is flown. Nothing is specific from ATC point of view.

Activity	Description
Execute Go-Around	The Flight crew executes and follows the missed approach as published in the approach chart. Sufficient aircraft climb gradient performance for go around manoeuvre at 100ft has been checked by the crew.

3.3.2.1.2 [NOV-5] CVS for taxi and airport surface navigation using HMD

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

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

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- An EFVS image displayed in the forward field of view,
- Symbology/ signs (taxi routing information) indicating the next turn or hold on, displayed at a fixed position
- The traffic surrounding the aircraft, displayed conformal (i.e scale and aligned to the real world)

Use Case Environment

The aircraft is ready for departure at the gate on a large airport with numerous runways/taxiways and dense traffic.

Assumptions

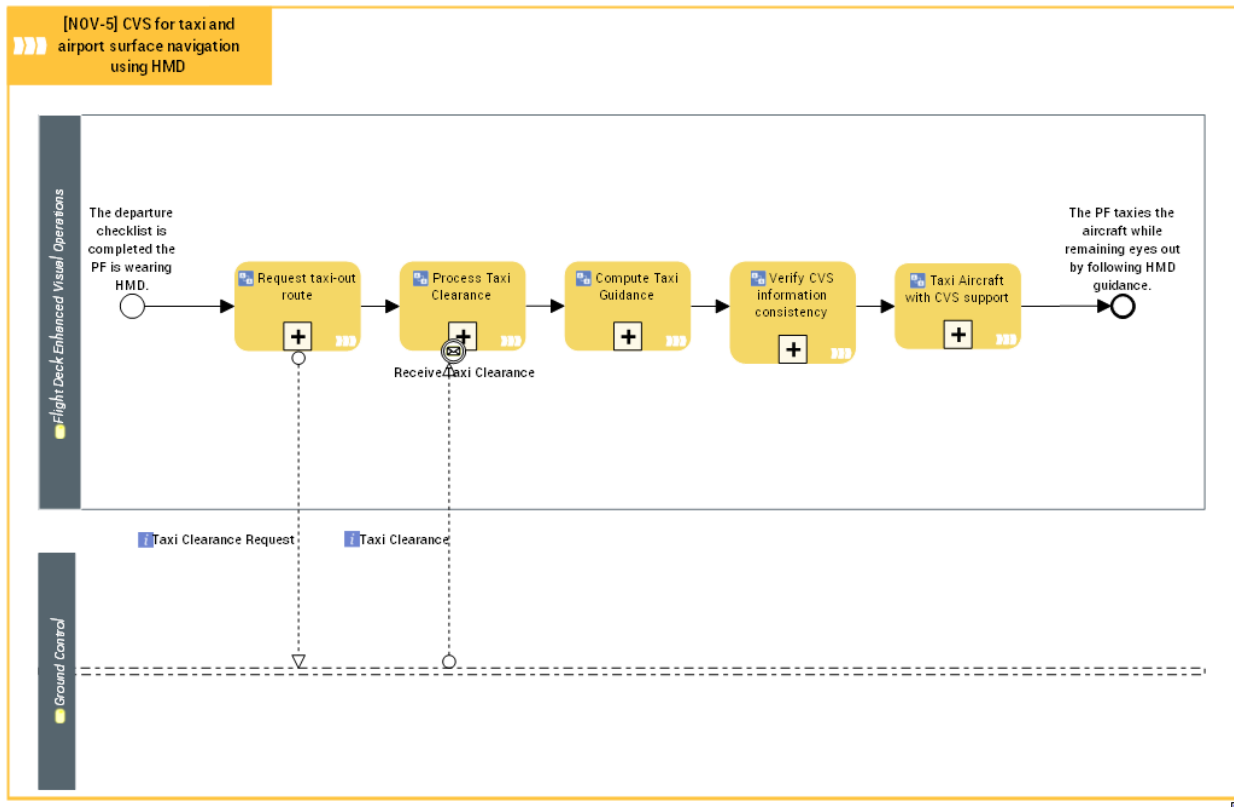
- The aircraft is fitted with an Head-Mounted Display(HMD)
- The aircraft avionics is either:
 - 1.Providing a crew interface to input the taxi clearance into the system
 - 2.Capable of directly recovering digital taxi clearance information through CPDLC
- The aircraft is fitted with an up-to-date A816-2 compliant airport database,
- The aircraft is fitted with an ADS-B receiver capable of forwarding the surrounding traffic information to the HMD.

Pre-conditions

- The aircraft is at the gate, ready for push-back and departure, in radio contact with ground control.
- The PF is using an HMD with taxi route guidance and traffic display capability enabled.
- A GPS position of the aircraft is available.

Post-conditions Success End State

- The PF is taxiing the aircraft along the cleared taxi route while keeping its eyes-out during all taxi



Activity	Description
Compute Taxi Guidance	Based in the different inputs, Flight Deck computes taxi guidance
Process Taxi Clearance	Flight Crew processess Taxi Clearance
Request taxi-out route	The Flight Crew requests ATC Departure Clearance and Planned Taxi-out route via data link.
Taxi Aircraft with CVS support	Flight Crew taxis Aircraft using the information available in the CVS
Verify CVS information consistency	The flight crew checks that visual cues are acquired through HMD in EFVS and that EFVS and HMD are consistent.

Issuer	Info Flow	Addressee	Info Element	Info Entity
Flight Deck Enhanced Visual Operations	Request taxi-out route --> Ground Control	Ground Control	Taxi Clearance Request	PilotRequest
Ground Control	Ground Control --> Receive Taxi Clearance	Flight Deck Enhanced Visual Operations	Taxi Clearance	TaxiClearance

Issuer	Info Flow	Addressee	Info Element	Info Entity
Ground Control	Ground Control --> Receive Taxi Clearance	Flight Deck Enhanced Visual Operations	Taxi Clearance	TaxiInClearance
Ground Control	Ground Control --> Receive Taxi Clearance	Flight Deck Enhanced Visual Operations	Taxi Clearance	TaxiOutClearance

As an example, 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 manoeuver.

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:

- Departure from Terminal 2 D, gate D12
- Taxi to west
- Via taxiways G, N, B, DB, D, BD4
- Taxi up to holding point Y3 (1)
- Take off on runway 09R

The expected taxi route is also displayed in AOF providing a complementary strategic 2D view to the crew.



Figure 5: Airport Onboard Function

The crew follows the route using the direction information displayed in HMD. When an intersection or a turn is approaching, the crew is warned about it. Distance to next turn or intersection is also displayed.

Additionally, real time ground traffic is 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

3.3.3 Differences between new and previous Operating Methods

Considering EFVS operations already exist in EASA and FAA regulations there is only small difference between previous and new operating methods:

First of all, the HMD studied in PJ03a-04 solution are not changing the operated method and have to be considered as HUD equivalent solution.

With respect to landing,

- EFVS 100ft operation is done using monocular and coloured HMD prototype as an alternative to HUD equipment (not always installed on aircraft due to technical constraints or due to extra cost it often requires).
- New advanced sensors such as active radar will allow detecting visual references required by the regulation in advance compared to legacy sensors, and will be less sensitive to variations of weather conditions providing greater visual advantages in LVC in more weather conditions.

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With respect to taxi operation,

- 360° Taxi routing indications and conformal (scale and aligned to the real world) traffic information is available to the crew allowing support to decision making process. HMD is monocular and coloured while HUD is monochrome.

Colour reduces display clutter and makes easier the understanding of the information by the pilot. It is particularly beneficial for advanced systems where EFVS, SVS and new set of information such as traffic or taxi routing are presented in addition to basic flight information.

The appropriate procedures should be established to guide the crew how to proceed the flight in situation of possible failure of the Head-Worn Display or active sensor failure in various descend phases.

Activities (in EATMA) that are impacted by the SESAR Solution	Current Operating Method	New Operating Method
EFVS landing operation	Use of Monochrome HUD fitted with EVS legacy sensor and CVS display	Use of multicolour HMD fitted with EVS legacy sensor and CVS display
Taxi operation	Use of HUD	Use of HMD fitted with traffic and taxi routing information

Table 6: Difference between new and previous Operating Method for V3 activities

4 Safety, Performance and Interoperability Requirements (SPR-INTEROP)

As the validation exercise for active sensor landing operations cannot confirm V3 maturity level, as expected during project time being due to lower sensor maturity, requirements relevant to active sensor are in appendix B.

In accordance with the objective of the project, TAXI using HMD and EFVS landing using HMD has been assessed as an operational standpoint and focusing on human factor aspect. Key requirements cited here and associated status results from the analysis of human factor questionnaire. Human factor questionnaire addresses all relevant topics (ergonomics, visual comfort, symbology, usability and operation). It contains more than 70 detailed requirements such as use of FPV, FD, FPARC, synthetic runway, assessment of lateral deviation, acquisition of visual cues and assessment of consistency with the EVS, latency and quality of the EFVS/ CVS image, capacity to fly the aircraft, crew coordination, situational awareness and workload. The questionnaire was defined by human factor expert and using human factor method used for certification purpose (scales, multiple choice...).

As the solution PJ03a-04 was non-prioritized solution, there is no necessity to address Security requirement at V3 stage of development as defined in Security Risk Assessment methodology for SESAR 2020.

4.1 Requirements for HMD during taxi

HMDT requirements are set to “in progress” because low visibility conditions were not encountered during trials at CDG.

However, as the use of HMD has been assessed as very helped to taxi on complex platform in good weather conditions, we can reasonably expect that it would have been even more beneficial in reduced visibility conditions. So, we can consider that V3 is achieved for HMD in taxi.

Identifier	REQ-03a.04-SPRINTEROP-HMDT.0001
Title	non-interference of HMD on existing method
Requirement	When pilot uses the HMD, it shall not interfere with the normal duties.
Status	<validated>
Rationale	In all phases of flight the head mounted display shall not distract the crew, or excessively increase workload or mask some important flight data. This point is part of Basic HUD certification requirements.

Category	<Operational>
----------	---------------

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Taxi Route Instruction
<Function>	Airport surface Navigation
<Activity>	Modify Taxi clearance
<Functional Block><role>	<u>Airport Surface Navigation</u> /Flight Crew
<Sub-Operating Environment>	Airport/ Large
<Sub-Operating Environment>	Airport/ Very Large

Identifier	REQ-03a.04-SPRINTEROP-HMDT.0002
Title	Safety benefit of HMD during taxi operations
Requirement	The HMD, as an onboard solution shall assist the crew in routing following, traffic detection and ATC clearance execution when at large and complex airports with high density of traffic.
Status	<validated>
Rationale	HMD on board solution provides the crew with a direct and complementary view to the SMGCS used by the ATC on ground. It will contribute to support the pilot in command responsibility during taxi and regarding ATC clearance.
Category	<safety>

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Taxi Route Instruction
<Function>	Airport surface Navigation
<Activity>	Modify Taxi clearance
<Functional Block><role>	<u>Airport Surface Navigation</u> /Flight Crew
<Sub-Operating Environment>	Airport/ Large
<Sub-Operating Environment>	Airport/ Very Large

Identifier	REQ-03a.04-SPRINTEROP-HMDT.0003
Title	HMD performance during taxi operation in all condition
Requirement	The HMD system shall provide clear and non-ambiguous view of the outside world whatever the external conditions (all weather conditions and ambient lighting conditions). It shall depict the situation without any significant degradation.
Status	<In Progress>
Rationale	HMD does not significantly distort, mask or change the colorimetry of the external scene when viewed in natural vision. This point is part of basic HUD certification requirement.
Category	<Performance>

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Taxi Route Instruction
<Function>	Airport surface Navigation
<Activity>	Modify Taxi clearance
<Functional Block><role>	<u>Airport Surface Navigation</u> /Flight Crew
<Sub-Operating Environment>	Airport/ Very Large

Identifier	REQ-03a.04-SPRINTEROP-HMDT.0004
Title	HMD performance during taxi operation in all condition
Requirement	The HMD with the presentation of traffic and routing information shall improve situational awareness and possibly reduce voice communications with ATC in high traffic density and complex environments.
Status	<In Progress>
Rationale	Crew may have limited situational awareness in degraded weather conditions and possibly deviate from the route communicated by ATC
Category	<Human Performance>

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Taxi Route Instruction
<Function>	Airport surface Navigation
<Activity>	Modify Taxi clearance
<Functional Block><role>	<u>Airport Surface Navigation</u> /Flight Crew
<Sub-Operating Environment>	Airport/ Large
<Sub-Operating Environment>	Airport/ Very Large

4.2 Requirements for HMD during Equivalent landing operation

For HMDL some requirements are set as “in progress” because some improvements are needed for having fully HMD capable of EFVS operation as indicated in part IV of OSED.

Identifier	REQ-03a.04-SPRINTEROP-HMDL.0001
Title	Processes & Procedures
Requirement	The landing operations (i.e the task described in detail in use case) with the new on-board feature that provides advanced vision (EVS & SVS) in LVP shall be operationally feasible.
Status	<In Progress>
Rationale	The use of HMD instead of HUD shall be acceptable for EFVS-100ft operations.
Category	<Human Performance>

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Airport and approach information
<Function>	Fly Aircraft during approach
<Activity>	Decide for landing or missed approach
<Sub-Operating Environment>	Airport/ Medium
<Sub-Operating Environment>	Airport/ Small

Identifier	REQ-03a.04-SPRINTEROP-HMDL.0002
Title	Human-technology integration
Requirement	The relationship and interactions between human and EVS & SVS for landing operations in LVC shall be operationally feasible
Status	<validated>
Rationale	The different controls and command of the HMD shall allow the crew to quickly and easily select between the different EVS/SVS settings.
Category	Human Performance

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Airport and approach information
<Function>	Fly Aircraft during approach
<Activity>	Decide for landing or missed approach
<Sub-Operating Environment>	Airport/ Medium
<Sub-Operating Environment>	Airport/ Small

Identifier	REQ-03a.04-SPRINTEROP-HMDL.0003
Title	Related Enablers
Requirement	The crew efficiency during visual landing operations in LVC shall be similar with HMD or HUD.
Status	<In Progress>
Rationale	HMD shall not degrade the runway visual reference depiction compared to existing HUD products.
Category	Human performance

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Airport and approach information
<Function>	Fly Aircraft during approach
<Activity>	Decide for landing or missed approach
<Sub-Operating Environment>	Airport/ Medium
<Sub-Operating Environment>	Airport/ Small

4.3 Information Exchange Requirements (IER)

See in Appendix B.

5 References and Applicable Documents

5.1 Applicable Documents

Content Integration

- [1] [1] PJ19 D5.1 EATMA Guidance Material Version 2018
- [2] [1] EATMA Community pages
- [2] SESAR ATM Lexicon

Content Development

- [3] [3] SESAR2020 PJ19-02 D2.5 Concept of Operations Edition 2019 – ed.00.01.00 - July 2019

System and Service Development

- [4] [4] 08.01.01 D52: SWIM Foundation v2
- [5] [5] 08.01.01 D49: SWIM Compliance Criteria
- [6] [6] 08.01.03 D47: AIRM v4.1.0
- [7] [7] 08.03.10 D45: ISRM Foundation v00.08.00
- [8] [8] PJ19 ADD 2018
- [9] [9] B.04.05 Common Service Foundation Method

Performance Management

- [10] [10] PJ19-04 D4.4 Performance Framework (2018) ed.01.00.00 – 24/08/2018
- [11] [11] 16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model
- [12] [12] 16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA
- [13] [13] 16.06.06 D26 [Method to assess cost of European ATM improvements and technologies, EUROCONTROL \(2014\)](#) ATM Cost Breakdown Structure_ed02_2014
- [14] [14] Standard Inputs for EUROCONTROL Cost Benefit Analyses
- [15] [15] 16.06.06_D26-08 ATM CBA Quality Checklist
- [16] [16] 16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms

Validation

- [17] [17] D3.6 PJ22 Updated platform development methodology

Founding Members



- [18] [18]Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational Federating Projects
- [19] [19]PJ19.02 D2.4 - PJ19: VALS (2018)
- [20]European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]
- [Ref] PJ19-04 D4.8 Validation Targets (2019) – ed.00.01.00 – 09/04/2019

System Engineering

- [20] [21]SESAR Requirements and V&V guidelines

Safety

- [21] [22]SESAR, Safety Reference Material, V00.04.01, December 2018
- [22] [23]SESAR, Guidance to Apply the Safety Reference Material, Edition 3.1, December 2018
- [23] [24]SESAR, Resilience Engineering Guidance, May 2016

Human Performance

- [24] [25]PJ19HP HP Guidance Reference Material , V00.02.00, April 2018

Environment Assessment

- [25] [26]SESAR, Environment Reference Material, alias, “Environmental impact assessment as part of the global SESAR validation”, Project 16.06.03, Deliverable D27,2016

Security

- [26] [27]PJ 19-03 Security Prioritisation CST FEB 2019

5.2 Reference Documents

- [27] ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.¹¹
 - [28] SESAR LSD 02.02 Final demonstration report (B2), 16/11/2016, ed 02.00.00
 - [29] SESAR 09.28 Final project report, 31/08/2011, ed 00.01.00
 - [30] SESAR 09.29 Final project report, 26/09/2016, ed 00.02.00
-

[31] SESAR Solution PJ03a-04 SPR-INTEROP/OSED for V3 - Part I, D4.070, ed 00.01.00

Appendix A Cost and Benefit Mechanisms

A.1 Stakeholders identification and Expectations

Stakeholder	Involvement	Why it matters to stakeholder
ANSP	No (no ANSP in the project)	AUO-405: extend of existing published instrument approach procedures. Increase efficiency of the aerodrome network allowing access at more airports and relive large airports in degraded weather conditions. AUO-406: improve situational awareness and then safety during taxi. Decrease misinterpreting situation and possibly alleviate communications between crew s and ATC
Airport operator	No	AUO-405: increase accessibility of aerodrome in degraded weather conditions
Scheduled number of delayed, diverted and canceled flights	No	AUO-405: relieve HUB in degraded weather conditions and allow access at secondary aerodrome
Business aviation	Yes	AUO-405: increase access in degraded weather conditions, especially at secondary airports AUO-406: improve taxi at complex airports with high density of traffic
Left column		

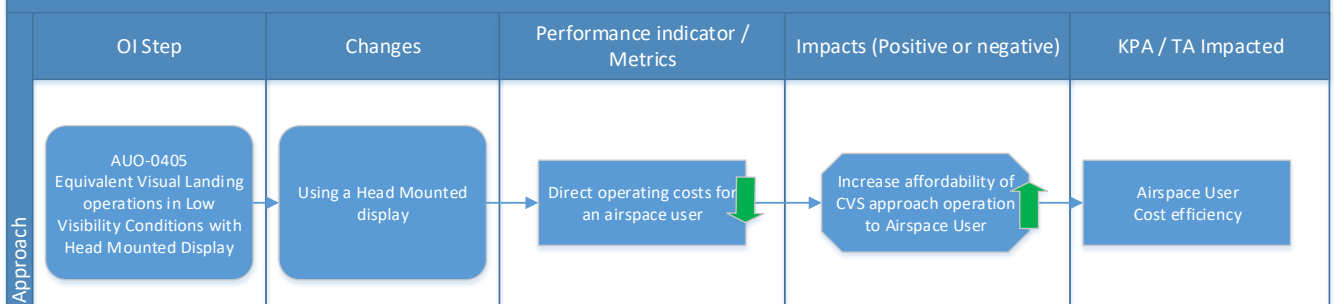
Table 7: Stakeholder's expectations

A.2 Benefits mechanisms

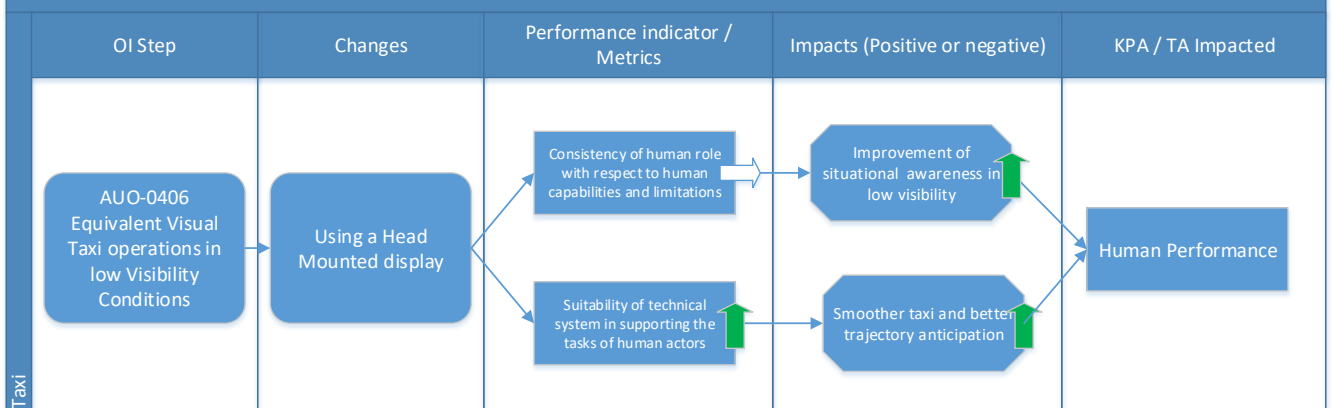
Founding Members



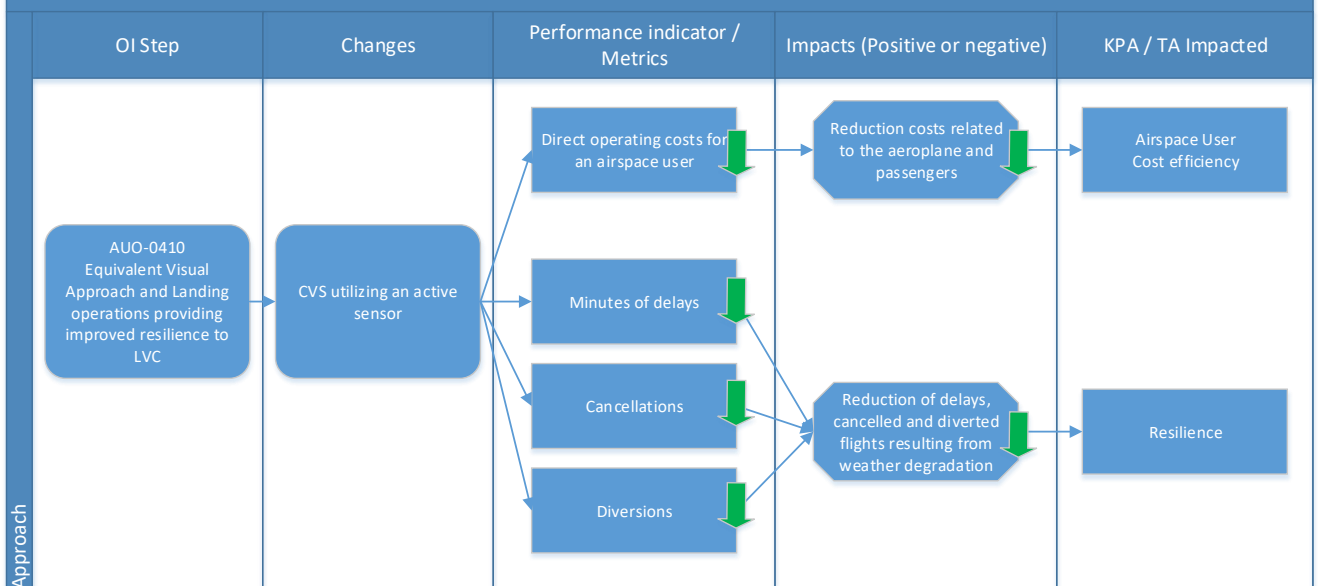
AUO-0405



AUO-0406



AUO-0410



A.3 Costs mechanisms

Costs assessment is in CBA chapter 5. Cost mechanism was not defined because costs are simply summed all costs for airspace users considering system acquisition and maintenance and pilots training.

Appendix B Active Sensor

B.1 CVS approach operation requirements

Identifier	REQ-03a.04-SPRINTEROP-SENS.0001
Title	Feasibility of operation using active sensor
Requirement	The equivalent visual approach operation in LVC using active sensor shall be operationally feasible.
Status	<In progress>
Rationale	Active sensor provides data in different way than current passive sensors. The provided sensor data to pilot shall support feasibility of operation.
Category	<Operational>

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Airport and approach information
<Function>	Fly Aircraft during approach
<Activity>	Decide for landing or missed approach
<Sub-Operating Environment>	Airport/ Small
<Sub-Operating Environment>	Airport/ Medium

Identifier	REQ-03a.04-SPRINTEROP-SENS.0002
Title	Operation performance improvement
Requirement	The equivalent visual approach operation in LVC using active sensor shall provide improved resilience to LVC compare to current operations using passive sensors.
Status	<In progress>

Rationale	LVC do not allow successfully approach and landing operation in all EFVS/CVS operations due to limited LVC penetration of current passive sensors.
Category	<Performance>

Linked Element Type	Identifier
<SESAR Solution>	PJ03a-04
<Information Exchange>	Airport and approach information
<Function>	Fly Aircraft during approach
<Activity>	Decide for landing or missed approach
<Sub-Operating Environment>	Airport/ Small
<Sub-Operating Environment>	Airport/ Medium