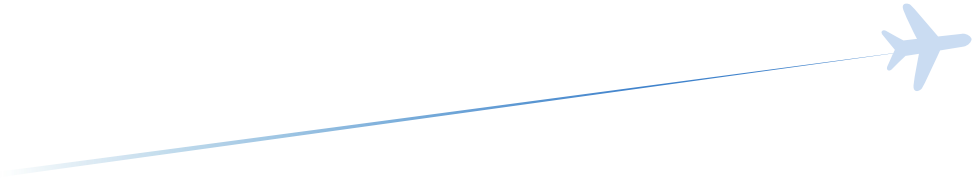

SESAR SOLUTION #120 "Enhanced Flight Vision System (EFVS) to land operations supported by IR and Visual based technology" CONTEXTUAL NOTE V3

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AAL2

AUGMENTED APPROACHES TO LAND 2

This Contextual Note is part of a project AAL2 that has received funding from the SESAR Joint Undertaking under grant agreement 783112 under European Union's Horizon 2020 research and innovation programme.

Abstract

This V3 Contextual note provides SESAR Solution #120 "Enhanced Flight Vision System (EFVS) to land operations supported by IR and Visual based technology" description for industrialisation consideration.

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1 Purpose

This contextual note introduces the SESAR Solution #120 “Enhanced Flight Vision System (EFVS) to land operations supported by IR and Visual based technology”. The solution represents a step beyond solution #117 “Reducing landing minima in low visibility conditions using enhanced Flight vision systems (EFVS)”.

Solution #117 focused on enhanced vision system (EVS) 100 ft operation as defined per EU No 965/2012 (2008) and addressed as EFVS-A in the future all-weather operations (AWO) regulation resulting from EASA notice of proposed amendment (NPA) AWO 2018-06 (published 15th of July 2018). This solution covers operational improvement (OI) step AUO-0403 “Reducing Landing Minima in Low Visibility Conditions using Enhanced Flight Vision Systems“ and is supported by system enabler (EN A/C-22 “Enhanced Flight Vision System (EFVS)”. It applies to infrared (IR) and visual based EVS technologies supported by head-up displays (HUDs) or equivalent systems such as head wearable displays (HWDs). Deployment of such operations is in progress. However, the applicable regulation does not provide any guidance material for ground segment. As a consequence, only a few airspace users have been approved by their national authorities after a long and heavy individual process.

The new SESAR Solution #120 addresses EFVS to land (EFVS-L) operation that will be introduced in Europe with the publication of the new AWO regulation resulting from EASA NPA AWO 2018-06.

This solution is already industrialized (therefore at a higher maturity level than V3) and some aircraft manufacturers have already been certified by EASA through a certification review item (CRI) process. Nevertheless, the deployment relies on the publication of the new EU AWO regulation.

According to EASA European Plan for Aviation Safety 2021-2025, the EFVS-L regulation is expected in Q2 2022. Therefore, initial operational capability (IOC) is targeted in 2023.

Solution #120 was delivered thanks to the results obtained in the WP3 of the SESAR very large demonstration (VLD) project “augmented approaches to land 2 (AAL2)”. This project allowed to bridge the gap with deployment from the aerodrome perspective in particular thanks to the execution of demonstration EFVS-L flights at some non-CAT II/III equipped aerodromes after the experimental approval from the competent national authorities.

2 Improvements in Air Traffic Management (ATM)

The solution addresses Enhanced Flight Vision System (EFVS) to land operations supported by IR and visual based technology.

The solution allows the pilot to descent below decision altitude (DA) / decision height (DH) and perform landing in runway visual range (RVR) as low as 300 m (without the need for transition to natural vision) taking credit of an EFVS system. The EFVS system is composed of a HUD system (or equivalent HWD) and a multispectral camera providing the capability to see in advance compared to naked eye in degraded weather conditions. This capacity of EFVS operation to provide a significant visual advantage in conditions such as fog or snow at DA/DH enables a successful landing, which would not be possible otherwise.

This EFVS advanced operation concept differs from other standard CAT II/III concepts (usually available at main airports and used by commercial airlines) as it allows operating in comparable adverse weather conditions, but at far more small and medium airports than just a few numbers of fully CATII/III equipped airports. The strength of the EFVS with operational credit concept is to take benefit of an advanced aircraft capacity based on technology rather than requiring a heavy and costly aerodrome infrastructure.

The intended function of an EFVS is to provide enhanced visibility allowing the flight crew to start an approach and descend below the DA/DH in low visibility conditions. EFVS operational credit can be granted on some suitable straight-in instrument approaches in reduced visibility as low as 300 m RVR (airworthiness requirement for allowing landing in case of EFVS failure. RVR 300 m is the lowest RVR value permitted for CATII and allows performing a safe manual and visual landing). Published DA/H is not changed during EFVS operations.

Compared to standard approach:

- Although the landing decision is the responsibility of the pilot-in-command, the flight crew may inform air traffic control (ATC) of their intention to perform an EFVS approach. This way, ATC will expect the aircraft to continue the approach and land while weather is below published minima, which is only possible using an EFVS; Crew may inform NM/ ATC of EFVS capacity mentioning it in the field 18 of the flight plan (this need has been shared with Eurocontrol-NM).

- The EFVS approach is flown using the same method as for standard non EFVS approach and phraseology is not changed. The approach has to be flown using HUD or HWD and the RVR considered for the check at 1000 ft will take credit of visual advantage provided by EFVS (typically30 %, performance based);

- At DA/ DH, the approach can be continued if visual cues are seen in HUD/EFVS or HWD/ EFVS (in lieu of in natural vision) and provided EFVS is consistent with the other HUD or HWD independent flight information used for the approach. Go around must be initiated otherwise;

- Below DA/ DH, the crew uses EFVS image in combination with HUD or HWD in lieu of natural vision to land and to perform the roll-out. During flare, prompt or guidance is provided to assist the pilot.

In summary, the EFVS to land operation:

- Can only be conducted on 3D straight in approaches, with offset limited to 3 degrees;
- Requires a minimum RVR of 300 m/ 1000 ft;
- Provides operational credit as demonstrated in certification. Operational credit is applied to reduce the RVR by typically one third of the published RVR (performance based demonstration);
- Requires a HUD or equivalent system such as HWD, a resolution advisory system, and a flare feature available to the pilot flying (PF);
- Requires an EVS image is displayed to the PF and to the pilot monitoring (PM) in case of multiple pilot operations

3 Operational Improvement Steps (OIs) & Enablers

New OI step **AUO-0403b "EFVS to Land operations allowing landing in RVR as low as 300 m using Visual and IR technologies" (CR 05090)**

The ability for the flight crew to descend below DA/DH and perform landing in RVR as low as 300 m (without the need for transition to natural vision) is allowed by taking credit of an EFVS system. The EFVS system is composed of a head-up display (HUD) system (or equivalent HWD) and a multispectral camera providing the capability to see in advance compared to the naked eye in degraded weather conditions. This capacity of EFVS operation to provide a significant visual advantage in conditions such as fog or snow at DA/DH will enable a successful landing in weather conditions it would not be possible otherwise.

New Enabler **A/C-22b Enhanced Flight Vision System to support EFVS to Land operations (CR 05091)**

An enhanced flight vision system (EFVS), combining enhanced vision (EV) of external environment with head-up display (HUD) (or equivalent HWD) and a multispectral camera, that facilitates approach and landing operations in low visibility conditions (as defined per NPA AWO 2018-06). It requires a flare feature available to the pilot flying.

4 Background and validation process

EFVS-L flights were successfully performed at the type of aerodromes where EFVS-L is intended to be deployed (CAT I controlled and uncontrolled airport flight information service (AFIS) aerodromes with instrument landing system (ILS) and/or global navigation satellite system (GNSS) approaches) and where an experimental approval had been granted by the authorities in the frame of the project AAL2 e.g. Antwerp, Belgium and Périgueux, France. Some demonstration flights were carried out in full operational environment and in real low visibility conditions corresponding to the maximum value of operational credit allowed by the regulation (and considering the state of art of EFVS technology available in 2020).

10 EFVS-L approaches were carried out at the two airports mentioned above (no flights were performed in Le Bourget, France due to the absence of adequate weather in the available period for the demonstrations. However, experimental approval for EFVS operation has been granted by national aviation authority for landing in RVR as low as RVR400m), including low visibility conditions and based on ILS as well as LPV. Some of the demonstrations had to be performed in simulated weather conditions due to the absence of adequate weather. An obscurant panel was placed on the windshield to simulate conditions on board and LVP were fully or partially simulated by aerodromes.

The demonstration activities involved business and regional aviation, scheduled and non-scheduled airspace users, with ATC familiarized and pilot trained for the EFVS-L operation and considering two different aircraft configurations (HWD on ATR; dual HUD on F8X).

5 Results and performance achievements

EFVS-L operation was assessed as feasible by both regional and business aviation end users' flight crews who participated in the demonstration flights.

For regional aviation:

- The ease of the operation is improved for approach and landing compared to non EFVS operations;
- No difficulty was perceived. The EFVS improves situational awareness for all phases of flight (approach and landing in particular);
- Decision making in case of aborted approach is equivalent and may be even improved by the use of EFVS;
- Crew coordination was assessed as acceptable.

For business aviation:

- The ease of operation is equivalent to non EFVS comparable operation;
- EFVS improved situational awareness. Workload was equivalent or slightly increased during landing phase mainly because of the short term of visual acquisition in these extreme weather conditions of the demonstration (EFVS allowed to acquire visual reference just before the DA/H where decision to continue the approach has to be taken). The pilot indicated this point could be improved by recommending the use of EFVS as much as possible in day to day operations. Training and experience will decrease the extra workload that may be perceived;
- Crew coordination and decision making to continue or go around are equivalent to other operations.

With respect to flight accuracy demonstration, lateral and vertical path accuracies were kept within one dot during all the EFVS-L approach and landing. No significant deviation of trajectory was observed. Approaches were stabilized well before the EFVS segment. The aircraft crossed the threshold close to 50 ft (as expected) and landing occurred in the expected area. All landing terminated close to the expected aiming point and well before the end of the touchdown zone.

Three successful approaches were achieved in actual RVR of 500 m although the minimum published RVR was 750 m for this approach. It demonstrates that the EFVS system used for the demonstration is capable of an operational credit of 1/3, which is the maximum visual advantage (30%) allowed by the current OPS regulation.

During the demonstration in Antwerp, while other aircraft needed to perform missed approaches at EBAW and EBBR due to the low visibility, the demonstration flight could continue.

Weather analysis focused on airport accessibility. A study demonstrated that the EFVS to land concept of operations would allow aerodromes to remain accessible in more than 78 % of the limiting weather conditions they faced in the 2008-2018 period.

6 Recommendations and Additional activities

The guidance manual produced by AAL2 should serve as an example for states / ANSPs to establish a list of similar aerodromes authorizing the use of EFVS in the perspective of a large deployment of the solution and as part of the promulgation of aerodromes for EFVS activity.

Extensive work conducted in Le Bourget and resulting in the issuance of experimental approval by authorities for SESAR demonstrations should serve as an example for the deployment of EFVS operations at those aerodromes with higher traffic density and where the traffic regulation constraints are shared with a hub airport.

The large scope weather analysis produced in AAL2 is a key input that should be considered to assist all the stakeholders in their assessment of the real benefit of that new operational capacity (i.e. States, airspace users, aerodrome operators, ANSPs).

All the recommended actions should support, ease, and speed up deployment of EFVS operations that are part of the regulation since 2008.

EFVS operation is an efficient and safe complement to existing GNSS based approaches as stated in GSA/GNSS Market Report | Issue 6, 2019. In order to expand ATM stakeholders' awareness of what EFVS is, and to prepare the deployment of the new AWO regulation (European Commission Decision targeted for Q2 2022 according to EASA's European Plan for Aviation Safety 2019-2023), the recommendation is that EFVS is addressed in performance based navigation (PBN) based approach activities and reflected in associated documentations.

In order to support the deployment of EFVS at non-controlled aerodromes (AFIS), AAL2 recommends the experimental approval process conducted at Périgueux to be deployed at one other AFIS aerodrome with higher traffic constraints.

7 Actors impacted by the SESAR Solution

Aerodrome operators, airspace users, ANSPs including (TWR ATC / AFIS), aircraft and avionics manufacturers, National Aviation Authorities.

Eurocontrol-NM for reflecting EFVS capability (RVR credit) in flight plan

8 Impact on Aircraft System

The EFVS-L operation supplements most of existing instrument approach procedures that are published.

The system is already certified according to requirements currently provided by EASA through standard a CRI process and soon described as part of AWO regulation.

Full AWO regulation is expected to be published by the EU in 2022.

9 Impact on Ground Systems

EFVS-L requires aerodromes to be declared as suitable for that AWO operation.

AAL2 conducted necessary safety assessments at some pioneer aerodromes and experimental approval was issued by two national authorities for SESAR demonstrations.

Full AWO regulation is expected to be published by the EU in 2022.

EFVS operation does not intend to change the airport infrastructure. Declaration of suitability of the aerodrome for EFVS consists in conducting appropriate safety analysis for determining at the end the min RVR required to guaranty safe EFVS operation on the airport (depends on availability of LVP procedures…).

The conclusions of AAL2 regarding ground segment are mentioned below.

In particular, AAL2 recommends promulgation of airports for EFVS operations. Based on the safety analysis performed, AAL2 stakeholders concluded that promulgation of EFVS operation at aerodrome level will guarantee the highest level of safety and it will give a very clear indication to the flight crew with respect to the limits of the EFVS operation at each aerodrome.

As a minimum requirement, in case airport is not promulgated for EFVS operation (current situation, since SESAR AAL2 is the first time aerodromes are promulgated for the EFVS operation) the information the air user needs for declaring the airport suitable for EFVS operation (required by regulation) should be published in the AIP.

AAL2 proposed the EFVS capability is reflected in the flight plan (Field 18) by air users.

EFVS qualification of aerodrome has been assessed by ANSP and aerodrome operators as a low complexity task compared to CATII/III. Economically, it has been assessed as affordable.

Guide has been produced by SKEYES to serve as example for other Belgium airports.

10 Regulatory Framework Considerations

EFVS operation is applicable and adds credit to 3D instrument approach procedures that are already published and satisfying the criteria defined in the EASA NPA 2018-06 and possibly in the aircraft flight manual.

The solution can be deployed in the near future thanks to the new EU AWO regulation resulting from EASA NPA AWO 2018-06. Some aircraft manufacturers have already been certified by EASA through a CRI process. The solution applies to aerodromes that have been declared as suitable for that EFVS-L operation.

Current situation (2020):

EFVS-L operation is currently defined in Europe as per EASA NPA AWO 2018-06.

Airworthiness aspects are currently addressed by EASA through a CRI process and will be defined as part of the CS AWO section of the future AWO regulation.

Aerodrome and operational aspects will be defined in the future AWO regulation expected to be published in 2022. AAL2 was a major contributor to this activity, providing recommendations and proposing guidance material based on the results of the demonstrations undertaken in this project.

2022:

The full regulation is expected to be published by the EU. Based on the regulation publication date, the initial operational capability (IOC) for EFVS-L operation is targeted in 2023.

There are two major recommendations for improving AWO EFVS regulation and allowing large deployment of the operation:

- The declaration of suitability of the aerodrome/ runway for EFVS should be made on the aerodrome side (i.e. aerodrome information publication – AIP) rather than letting each airspace user do it on its own. This will guaranty the highest level of safety and it will give a very clear indication to the flight crew with respect to the limits of the EFVS operation at each aerodrome;
- The RVR capabilities of an aircraft / flight crew resulting from EFVS should be mentioned in the flight plan for traffic regulation purpose. Field 18 of the flight plan was successfully used in the AAL2 demonstrations. Field 10 could also be envisaged.

11 Standardization Framework Considerations

EFVS-L operation (for airworthiness and operational aspects only) is addressed by the EUROCAE's minimum aviation system performance standard (MASPS) document ED-179B for enhanced vision systems and synthetic vision systems and combined vision systems and enhanced flight vision systems.

12 Solution Data pack

D1.9 SESAR 2020 VLD - AAL2 Demonstration Report, edition 01.00.00, 10 July 2020.


AUGMENTED APPROACHES TO LAND II


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