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Enhanced Flight Vision Systems: Uses, Regulations, and Benefits

White Paper

Doc No.: WHTP-2020-14-08
August 2020

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Executive Summary

For many years, descent below Decision Altitude (DA)/Decision Height (DH) or Minimum Descent Altitude (MDA) could only be accomplished using natural vision, resulting in costly delays or diversions due to inclement weather and other impairing factors. On January 9, 2004, the Federal Aviation Administration (FAA) published a rule permitting Enhanced Flight Vision Systems (EFVS) to be used in lieu of natural vision to continue descent below DA/DH or MDA to 100 feet above the Touchdown Zone Elevation (TDZE) on an Instrument Approach Procedure (IAP) that is flown using published straight-in landing minima. In December 2016, the FAA amended its regulations to allow operators to use EFVS to continue descent from 100 feet above the TDZE to land and rollout on certain straight-in IAPs under Instrument Flight Rules (IFR).

As the future of aviation becomes increasingly focused on safety and efficiency, understanding and implementing EFVS technology is vitally important for cargo aircraft operators, airlines, and business aviation.

EFVS and Enhanced Vision Systems (EVS)

The ability to simultaneously display real-time video topography overlaid with 2D flight symbology ,3D synthetic terrain and obstacles along with navigational guidance is rapidly becoming a demand in the field of aviation. These systems allow for increased situational awareness in darkness and inclement weather such as fog, haze, smoke, smog, and dust. Notably, there are differences between the terms EVS and EFVS.

An EVS, or Enhanced Vision System, produces a real-time image of the forward external scene topography using imaging sensors. An imaging sensor can be:

- Forward-looking infrared
- Millimeter wave radiometry
- Millimeter wave radar
- Low-light level image intensification
- Any other real-time imaging technology

Key EFVS Benefits

- Fewer delays and consequent travel disruption
- Reduction in fuel, noise, and emissions
- Improved situational awareness
- Enhanced safety and efficiency

Natural Vision

Enhanced Vision

EVS can be used tactically since it is created from real-time data sources and it allows pilots to see what is in front of the aircraft.

An EFVS combines flight symbology information, navigational guidance, and real-time sensor imaging of the forward external scene and presents them to the pilot on a Head-Up Display (HUD) or a HUD equivalent display, such as a Head-Wearable Display (HWD). For traditional HUDs, the imagery, information, and symbology must be clearly visible to the pilot flying in their normal position with the line of vision looking forward along the flight path.

An EFVS is eligible for regulatory operational credit that allows a reduction of landing minima and Runway Visual Range (RVR) to as low as 1000 feet, depending on what EVS system the aircraft has installed and what credit the FAA has granted that system. During an instrument approach, the enhanced vision image is intended to improve the pilot's ability to detect and identify the visual references required to land by the regulations. Although an EVS system is a good tool for enhanced situational awareness, it does not allow for any operational credit by itself.

Natural Vision

Enhanced Vision

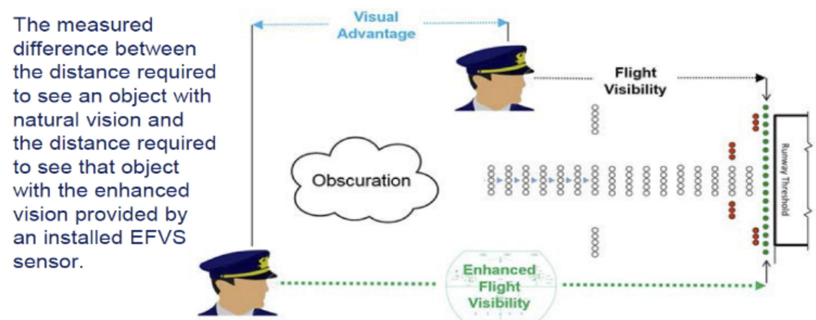
The following systems do not meet the equipment requirements of an EFVS eligible to conduct operations:

- An image presented on a Head-Down Display (HDD)
- An image displayed on a HUD without symbology or guidance information
- A Synthetic Vision System (SVS)
- A Synthetic Vision Guidance System (SVGS)
- A Night Vision Imaging System (NVIS) / Night Vision Goggles (NVG)

Equipping one of these systems alone will not allow operators to benefit from the features of a full EFVS system.

What is an EFVS Operation?

An EFVS operation is conducted using the enhanced image provided by an EFVS when flight visibility with natural vision does not meet the requirements to proceed with the visual segment of an instrument approach and landing. The visual advantage is the measured difference between the distance required to see an object with natural vision and the distance required to see that object with the enhanced vision provided by an installed EFVS sensor.



Per FAA published regulations, Part 121, 125, 129, and 135 operators can depart to a destination or begin an instrument approach when reported visibility is below the minimum visibility prescribed for the IAP by using a certified EFVS. Based on the demonstrated performance of the installed EVS sensor, the Flight Technologies and Procedures Division assisted by the Aircraft Evaluation Group (AEG) of the FAA finds the EVS sensor eligible for operational credit allowing the EFVS to account for no more than an approved percentage of IAP visibility requirements. Per the Operational Suitability Report, "the greater the visual advantage an EFVS sensor demonstrates may enable an operator to release a flight or begin an approach in lower forecast or reported visibilities. The authorization to use EFVS operational credit to release a flight or begin approaches is authorized through the operational application process for OpSpec C048."

There are two types of EFVS operations authorized for Straight In IAPs:

1. Operation to 100 feet above TDZE – 91.176 (b)
    a. Uses enhanced vision imagery alone to descend below DA/DH or MDA to 100 feet above the TDZE
    b. Uses a combination of enhanced imagery and natural vision to descend below 100 feet above the TDZE
    c. Pilot Flying should have enough flight visibility to conduct an unaided rollout to safe taxi speed
    d. Pilot Monitoring should have enough flight visibility below 100 feet above the TDZE to support PF
2. Operation to Touchdown & Rollout – 91.176(a)
    a. Uses enhanced vision imagery alone to descend below DA/DH to touchdown and rollout
    b. Pilot conducts entire visual segment of instrument approach, including the landing and rollout, using the EFVS to comply with the enhanced flight visibility and visual reference requirements of § 91.176(a)(3)
    c. Greater than or equal to 1,000 feet RVR with certified Approach or Landing System
    d. In case of EFVS failure (AC90-106A 4.1.1.8.1)

The term Slant Range Flight Visibility (SRFV) is defined as the range at which the unaided eye of the pilot can detect a visual reference listed in 91.176(a)(3) out-the-window during the approach.

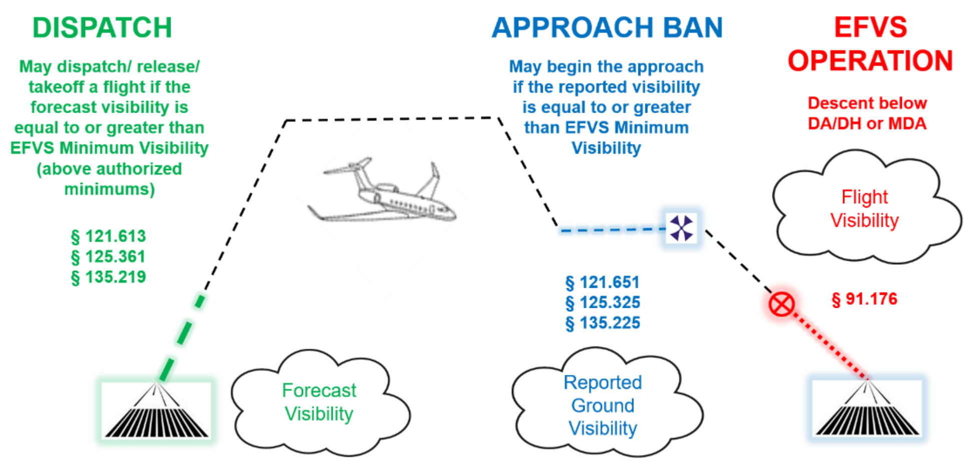
The term Slant Range Enhanced Flight Visibility (SREFV) is defined as the range at which the pilot can detect a visual reference listed in 91.176(a)(3) using the EFVS during the approach.

For determination of visual advantage, a data set demonstrating the in-flight relationship between SRFV and SREFV with the reported visibility needs to be created and analyzed. The required weather, test location, and methodology for EFVS quantified visual advantage determination is detailed in AC20-167B.

Operational Regulations for EFVS

The diagram below illustrates and specifies the operation regulations for:

- Dispatch and releasing aircraft for EFVS operations
- Approach and descent below DA/DH or MDA for EFVS operations



Worldwide Requirements & Mandates

EFVS capable HUDs will be mandated in Commercial aircraft operating in China by 2025, and HUD-EVS technology is expected to be mandated in Business aircraft in China by 2025. Any aviation operator who does business in China will need to begin preparing for these upcoming regulations.

System Components

EFVS system architectures typically include a HUD Computer Unit (HUD CU) which receives pertinent aircraft information such as Attitude Heading Reference System (AHRS), Air Data Computer (ADC), Global Positioning System (GPS), Very High Frequency Radio Navigation (VHF NAV), and more to generate flight display symbology and perform guidance functions. The EVS camera provides real-time video overlay on the 2D symbology via either an overhead-mounted HUD or a HWD/Helmet-Mounted Display (HMD), such as Universal Avionics' SkyLens™ HWD or SkyVis™ HMD, to form the EFVS.

For HWD/HMD units, the Line of Sight (LOS) low-latency tracking system is the function of the Optical Tracker Head sensors (OTH), the inertial tracking gyro mounted in the HWD's display module, the Optical Tracker fixed (OTF) mounted in a fixed position in front of the pilot, and the HUD CU. All the information gathered by the OTH, Inertial gyro and OTF is fed to the HUD CU which compiles the data and calculates where the pilot is looking. It then correlates the EVS or SVS imagery to the pilot head position and overlays that imagery with the flight and guidance symbology. This process happens automatically and continuously when the CVS is on and operational.

Summary

While EVS capabilities improve upon natural vision, a comprehensive EFVS product offers regulatory operational credit among many other benefits. EFVS components are designed to be minimally invasive and easily integrate with other avionics. While system configuration will vary according to aircraft type, options are available for most platforms, such as equipping HWDs/HMDs when cockpit space is limited.

Equipping for EFVS operations in advance of regulatory requirements can provide a substantial return on investment for aircraft dependent upon operating in those airspaces. Simply considering the reduction in delays and rerouting EFVS can provide in circumstances of reduced visibility due to weather or other acts of nature, the benefits are clear.

References

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Acronyms and Abbreviations

The following are industry standard acronyms, abbreviations, and terms used in this white paper.

- ADC Air Data Computer
- AHRS Attitude Heading Reference System
- CFR Code of Federal Regulation
- CVS Combined Vision System
- DA Decision Altitude
- DH Decision Height
- DME Distance Measuring Equipment
- EFVS Enhanced Flight Vision System
- EVS Enhanced Vision System
- FAA Federal Aviation Administration
- FAR Federal Aviation Regulation
- FMS Flight Management System
- GPS Global Positioning System
- HDD Head-Down Display
- HMD Helmet-Mounted Display
- HUD Head-Up Display
- HUD CU HUD Computer Unit
- HWD Head-Wearable Display
- IAP Instrument Approach Procedure
- IFR Instrument Flight Rules
- MALRS Medium Intensity Approach Lighting System
- MDA Minimum Decision Altitude
- NAV Navigation
- NVG Night Vision Goggles
- NVIS Night Vision Imaging System
- OTF Optical Tracker Fixed
- RVR Runway Visual Range
- SRFV Slant Range Flight Visibility
- SREFV Slant Range Enhanced Flight Visibility
- SVGS Synthetic Vision Guidance System
- SVS Synthetic Vision System
- TDZE Touchdown Zone Elevation
- VHF NAV Very High Frequency Radio Navigation

About Universal Avionics

Universal Avionics, an Elbit Systems Company, is a leading manufacturer of innovative commercial avionics systems offered as retrofit and forward-fit solutions for the largest diversification of aircraft types in the industry. To learn more, visit uasc.com.

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