



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

**MINIMUM AVIATION SYSTEM PERFORMANCE STANDARDS
(MASPS) For
ENHANCED VISION SYSTEMS, SYNTHETIC VISION SYSTEMS,
COMBINED VISION SYSTEMS And ENHANCED FLIGHT VISION
SYSTEMS**

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ED-179B

September 2011

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CHAPTER 1

PURPOSE AND SCOPE

1.1 INTRODUCTION

ED-179/DO-315 addressed Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS), and Combined Vision Systems (CVS) technologies. Currently, only EVS technology incorporating an approved Head-Up Display (HUD) is eligible for operational credit under Title 14 US Code of Federal Regulations (CFR) §91.175 with the Federal Aviation Administration (FAA). An approved combination of EVS and HUD is termed an Enhanced Flight Vision System (EFVS) by the FAA. The European Aviation Safety Agency (EASA) uses the term “EVS” as equivalent to the FAA description of EFVS. While further definitions are in Appendix A, it is important to understand this distinction before reading this document. This document adds performance standards for operational credit to touchdown in visibility as low as 1000ft RVR (or 300M if applicable), by use of an approved EFVS. Performance standards for this new operational capability are delineated throughout this document in order to maintain the unique characteristics of ED-179/DO-315 and ED-179/DO-315A. Performance standards for EFVS to landing (ED-179/DO-315A) include performance standards for EFVS approaches to 100 ft height above threshold elevation (THRE), formerly height above touchdown zone elevation (TDZE) (ED-179/DO-315). See notes below regarding change in terms of reference in ED-179/DO-315A.

The operational scenarios and concepts discussed in this document are written to describe the intended use of the proposed systems and from this context, associated minimum performance standards are derived. They do not define current or future operational regulations or limitations of these technologies.

Section 1 provides information needed to understand the rationale for system characteristics and requirements. This section also contains typical applications and envisioned operational goals and assumptions necessary to establish a basis for the subsequent sections. It describes typical applications and operational goals, as envisioned by members of RTCA Special Committee 213 and EUROCAE Working Group 79, and establishes the basis for the standards stated in Sections 2 through 4. Definitions and assumptions essential to proper understanding of this document are also provided in this section.

Section 2 describes minimum system performance requirements.

Section 3 contains the minimum performance standards and subsystem/function that is a required element of minimum system performance in Section 2.0. These standards specify the required performance under the standard environmental conditions described.

Section 4 discusses performance evaluations with applicable FAA and EASA regulations, describing the minimum system test procedures to verify system performance compliance (e.g., end-to-end performance verification).

Compliance with these standards is recommended as one means of assuring that the system and each subsystem will perform its intended function(s) satisfactorily under conditions normally encountered in routine aeronautical operations for the environments intended. The Minimum Aviation System Performance Standards (MASPS) may be implemented by one or more regulatory documents and/or advisory documents (e.g., certifications, authorizations, approvals, commissioning, orders, advisory circulars, and notice.) and may be implemented in part or in total. Any regulatory application of this document is the sole responsibility of appropriate governmental agencies.

In this document, the term “shall” is used to indicate requirements. An approved design should comply with every requirement, which can be assured by inspection, test, analysis, or demonstration. The term “should” is used to denote a recommendation that would improve equipment, but does not constitute a requirement.

NOTE 1: 14 CFR § 91.175(l) refers to decision height (DH); however, this document uses DA/DH. For the purposes of ED-179A/DO-315A, the terms DA and DH are interchangeable.

NOTE 2: 14 CFR § 91.175(l) refers to descent to 100 feet height above touchdown zone elevation (TDZE). The FAA has recently instituted changes in the determination of instrument procedure minima to stop using TDZE to determine minima.

Future instrument approach minima (MDA or DA/DH) will be referenced to threshold elevation (THRE). The height value specified as MDA(H) or DA(H)/DH will be referenced to THRE for approaches with minima published after August 10, 2010. Existing published IFR approach minima and charting will gradually be changed to reference THRE and be displayed as a height above threshold (HATh). DO315A has adopted the use of THRE for all text whether 14 CFR § 91.175(l) "to 100 feet" or to touchdown. The former terms HAT or TDZE and new terms HATh or THRE are considered interchangeable relative to the requirements of this document and the intent of ED-179/DO-315.

1.1.1

EVS/SVS/CSV Introduction

This MASPS provides the high level system requirements for Enhanced, Synthetic, and Combined Vision Systems when installed in aircraft with the expressed purpose of gaining no additional operational credit. The implication of the term "no additional operational credit" as used throughout this MASPS is that the applicant cannot take advantage of the existing regulations in the Federal Aviation Regulations/EASA regulations for the various phases of flight through the installation certification of these systems. Refer to the EFVS sections of this MASPS for EVS to gain operational credit. For the FAA, EVS for operational credit is called "EFVS", and the term "EFVS" is used in this document.

The EVS/SVS/CSV subsections of the MASPS focuses on the concept that no additional capability with existing minima will be granted via EVS/SVS/CSV display systems as described within this portion of the MASPS. For example, the IFR approach minima or reduced vision taxi capability are the same for the aircraft regardless if EVS, SVS or CSV is installed.

In order for the following "no additional operational credit" guidelines to apply, the applicant shall be able to qualify the proposed EVS/SVS/CSV installation's intended function in terms that do not change the airplane's existing operational capability or certification basis. This will be one of the key parameters to be scrutinized by FAA during EVS/SVS/CSV flight evaluations when presented with a "No additional operational credit" installation certification.

In this document, the term Terrain Awareness and Warning System (TAWS) is used to indicate both TAWS for fixed-wing aircraft and Helicopter TAWS (HTAWS) for rotary-wing aircraft. TAWS is defined in TSO-C151b and HTAWS in DO-309. Installation of TAWS is defined in FAA/AC 23-18 and AC 25-23. Installation of HTAWS is defined in AC 29-2C.

1.1.2

EFVS Introduction

1.1.2.1

The EFVS subsections of this MASPS provide the high level system requirements for Enhanced Flight Vision Systems when installed in aircraft with the expressed purpose of gaining additional operational credit.

1.1.2.2

The requirements of this MASPS may be global in nature and have international implications; however, they are written to meet the definitions, intended functions, and operational application defined in 14 CFR §1.1, §91.175 (l) and (m), §121.651, §125.381, and §135.225 as of Amendment 91-281 (69 FR 1620, January 9, 2004). Similar references are found in EU Ops Subpart E, Appendix 1 to OPS 1.430 (h). It should be noted that the European Aviation Safety Agency's (EASA) terminology and operational credit may differ from that of the United States. EASA uses the term Enhanced Vision System (EVS) to describe a system that has the same elements, features and characteristics as an Enhanced Flight Vision System (EFVS) certified by the FAA for use in the United States. EASA's operational concept and corresponding requirements may also be slightly different from those of the FAA.

- 1.1.2.3 The EFVS subsections of this MASPS specifically focus on standards to meet existing and emerging FAA and EASA requirements for an Enhanced Flight Vision System. Other guidance material is available (see References). This MASPS is intended to be complementary to these other materials, and is not meant to replace or conflict with these other materials. Conflicts between this MASPS and other material should be resolved on a case-by-case basis.

1.1.3 SVS for Lower than Standard (LTS) Minima Operations: Introduction

An SVS for operations in Lower than Standard minima is based on an existing SVS system as defined in Section 1.2.1.2 below. When combined with display of the landing runway, and trajectory reference information, including flight path vector (FPV) and flight path angle reference cue (FPARC), the system will provide the pilot with information that indicates that the trajectory is projected to the runway touchdown zone. In systems designed to support operations in which additional credit is sought, such as reduced visibility or decision altitude, the system must be designed to meet integrity, accuracy and reliability requirements, appropriate to the target level of safety required.

The initial operational credit is envisioned to be authorization to operate to lower than standard approach minima during a Category I ILS approach. In the US, the initial authorization may be in accordance with the provisions of a future amendment of FAA Order 8400.13D. This order defines the operational requirements for a Special Authorization Category I ILS approach for which a DH as low as 150 ft height above THRE, and visibility as low as RVR 1400 may be authorized. A comparable operation is defined by EASA as a Lower than Standard Category I ILS. Such an approach may be conducted to decision heights no lower than 200 ft height above THRE, with visibility not less than 400m.

For convenience, in the balance of this document a synthetic vision system designed for lower than standard Category I ILS minima will be referred to as an SVS for Lower than Standard Minima system.

The SVS for Lower than Standard Minima subsections of this MASPS provide the high level system requirements for systems installed in aircraft for the purpose of gaining additional operational credit. The credit is expected to be in the form of a lower decision height (DH) and/or reduced minimum visibility than that available in conventional ILS approaches. The safety of the proposed operation will be established through safety analysis methods. Each operational authority will determine the type of credit according to their approval processes.

1.2 EVS/SVS/ CVS

1.2.1 EVS/SVS/ CVS Overview

Notional system diagrams accompany the EVS/EFVS and SVS descriptions. It is important to note the flight guidance system (FGS) contribution is not part of this MASPS, but an integral part of the overall display system. This distinction will be portrayed in the succeeding diagrams. FGS criteria may be found in documents such as FAA Advisory Circular (AC) 25.1329A and EASA Accountable Means of Compliance (AMC) 25.1329.

1.2.1.1 EVS Overview

An Enhanced Vision System (EVS) is an electronic means to provide the flight crew with a sensor-derived or enhanced image of the external scene through the use of imaging sensors such as forward looking infrared, millimeter wave radiometry, millimeter wave radio, and/or low light level image intensifying. A notional diagram for EVS is shown below. In this example, EVS does not have to be integrated with a flight guidance system.

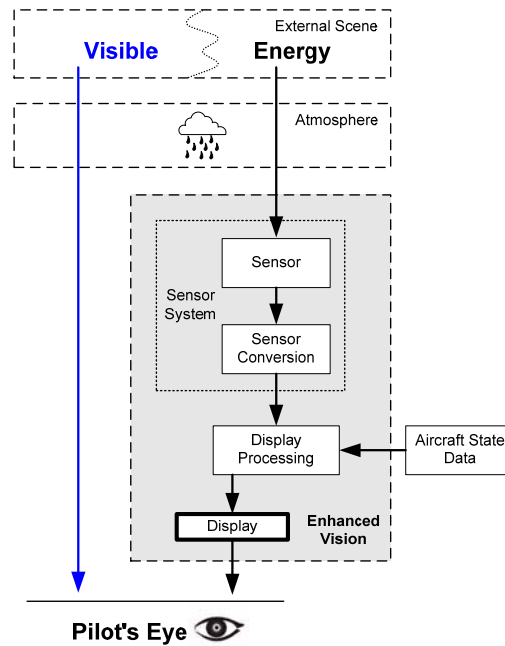


FIGURE 1: EVS DIAGRAM

(Dashed lines indicate individual system boundaries.)

NOTE: Aircraft state data, e.g., pitch attitude, is not a basic requirement for an EVS or EFVS. However, some applicants may utilize such data in their installations to enhance the E(F)VS image.

1.2.1.2 Synthetic Vision System Overview

A Synthetic Vision System (SVS) is an electronic means to display a computer-generated image of the applicable external topography from the perspective of the flight deck that is derived from aircraft attitude, altitude, position, and a coordinate-referenced database. Currently, the application of synthetic vision systems is through a primary flight display and from the perspective of the flight deck (egocentric). This MASPS also addresses exocentric views with respect to secondary displays. A notional diagram for SVS is shown in Figure 2.

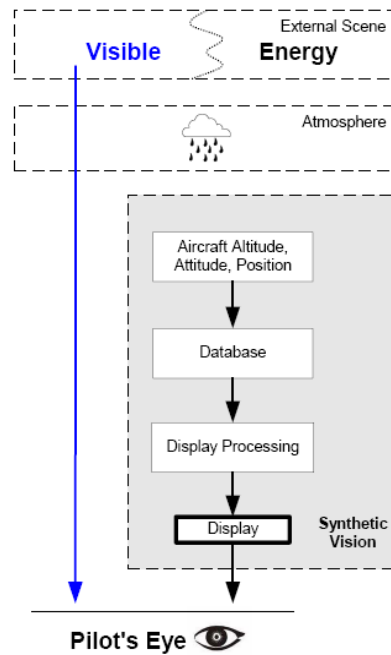


FIGURE 2: SVS DIAGRAM

(Dashed lines indicate individual system boundaries.)

External scene visible image is not affected by SVS.)

1.2.1.3 Combined Vision System Overview

A Combined Vision System (CVS) is a combination of synthetic and enhanced vision systems. The current integration concepts typically utilize a synthetic picture for higher altitudes and enhanced for lower altitudes down to the ground. For example, on an approach, most of the arrival and/or the procedure turn would utilize the SVS picture, but somewhere between the final approach fix and the runway, the picture would gradually transition from SVS to EVS either for SVS picture validation or simply to “see” the runway environment earlier.

Some examples of a CVS could include, but are not limited to, database driven synthetic vision images combined with real-time sensor images superimposed and correlated on the same display. This could also include selective blending of the two technologies based on the intended function of the Combined Vision System seeking certification.

1.2.1.4 EVS/SVS/CVS Installed Displays (EFIS, MFD, Class 3 EFB)

This MASPS breaks down the EVS, SVS and CVS into three general categories of display systems as installed on FAA and EASA certified aircraft. These categories include but are not limited to the following:

1.2.1.4.1 EVS/SVS/CVS Primary Displays: EVS, SVS, or CVS functionality superimposed on the Electronic Flight Instrument System (EFIS), for example the Primary Flight Display (PFD) as installed in the flight deck. In this configuration for example, the EVS, SVS, or CVS image could be merged into the sky/ground shading of the Attitude Direction Indicator as one implementation. In addition to the traditional HDD (Head-Down Display) PFD, this type of superimposed display could also be associated with a HUD or equivalent display system using EVS, SVS, or CVS capabilities.

1.2.1.4.2 EVS/SVS/CVS Secondary Displays: EVS, SVS, or CVS functionality that can be selected on a Multi-Function Display (MFD) or Navigation Display (ND) as one of many stand-alone type formats available in the flight deck. In other words, an EVS, SVS, or CVS image could be one selection on the MFD, while an Electrical Synoptic, for example, could be another selection on the same MFD.

- 1.2.1.4.3 EVS/SVS/CSV Electronic Flight Bag: EVS, SVS, or CSV functionality installed on Class 3 Electronic Flight Bag (EFB) displays. While similar in concept to the MFD, these EFB systems are, in general, limited due to the nature of the installation constraints of these devices. EFB using EVS technologies may present unique certification challenges such as alignment or positioning concerns relating to the EFB installation.

1.2.2 EVS/SVS/CSV General Operation

The pilot's ability to see and use the required primary flight display information e.g. primary attitude, airspeed, altitude, command bars, shall not be hindered or compromised by the EVS/SVS/CSV image. Great care should be exercised when adding additional features or symbology as well as the placement of required primary flight display information.

1.2.3 EVS/SVS/CSV Intended Function

The intended function of EVS/SVS/CSV is to provide a supplemental view of the external scene to provide the crew with an awareness of terrain, obstacles, and relevant cultural features (which may include the runway and airport environment). Additional intended functions (for example, terrain alerting) may be defined according to AC 25-11A, AMJ 25-11, AC 23-26, and 14 CFR §23.1301.

1.2.4 EVS/SVS/CSV Assumptions

Since no additional operational credit is allowed with this equipment, crews are expected to follow the existing operational procedures and adhere to all published minimums.

NOTE: *The system and safety criteria for each specific part and class of aircraft provide the necessary guidance for the required level of safety for each phase of flight and by type of operation.*

1.3 EFVS

1.3.1 EFVS Overview

- 1.3.1.1 Under FAA regulations, an Enhanced Flight Vision System (EFVS), as defined in 14 CFR §1.1, is "an electronic means to provide a display of the forward 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, such as a forward looking infrared, millimeter wave radiometry, millimeter wave radio, low light level image intensifying." For the purposes of the present document, all of these sensors will be categorized as either active or passive.

Under EASA regulations, the Enhanced Vision System (EVS) consists, for the purpose of this guidance material, of an electronic means of displaying a real-time image of the external scene through the use of external sensors. The image will also be repeated on a certified display on the pilot not-flying side.

Both systems incorporate HUD / FGS technologies, which have guidance criteria in other documents and are not repeated in this MASPS. A notional diagram for EFVS is shown in Figure 3.

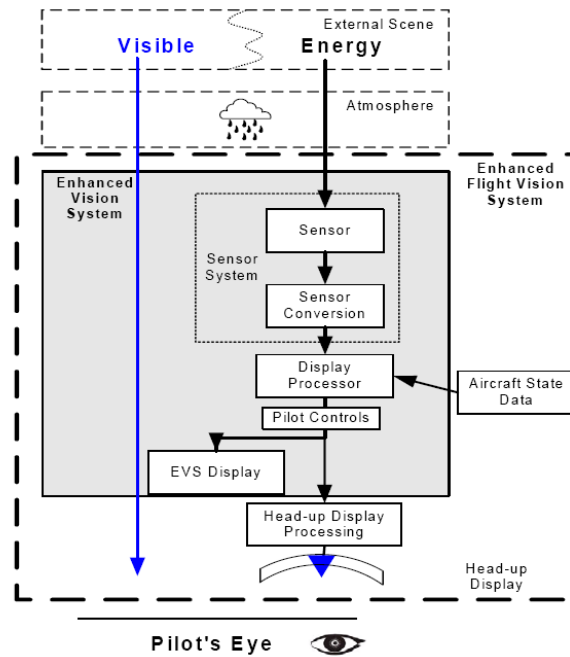


FIGURE 3: EFVS DIAGRAM

(Aircraft state data provides information for required flight instrument data.)

NOTE: Aircraft state data, e.g., pitch attitude, is not a basic requirement for an EVS or EFVS. However, some applicants may use such data in their installations to enhance the E(F)VS image.

1.3.1.2 Under FAA regulations, Amendment 91-281 to Title 14 of the CFR also introduced the term “Enhanced Flight Visibility.” Enhanced Flight Visibility is defined in 14 CFR §1.1 as the “average forward horizontal distance, from the cockpit of an aircraft in flight, at which prominent topographical objects may be clearly distinguished and identified by day or night by a pilot using an enhanced flight vision system.” An EFVS, then, is the means by which the pilot meets the enhanced flight visibility requirement.

Under EASA regulations (EU-OPS Sub-Part E), the term Enhanced Flight Visibility is not used. Operational credit is achieved by reducing the RVR required to commence the approach.

1.3.1.3 Under US regulations, an EFVS used to conduct operations under 14 CFR §91.175(l) and (m), §121.651, §125.381, and §135.225 shall have an FAA type design approval, or for a foreign-registered aircraft, the EFVS shall comply with all of the EFVS requirements of the U.S. regulations. Under 14 CFR §91.175(m), an EFVS is an installed airborne system that includes:

- The display element, which is a Head-Up Display (HUD) or an equivalent display, that presents the features and characteristics required by the regulations plus the out-the-window view such that they are clearly visible to the pilot flying in his or her normal position and line of vision looking forward along the flight path
- Sensors that provide a real-time image of the forward external scene topography, as described above
- Computers and power supplies
- Indications
- Controls

Under EASA regulations, an EVS used to conduct operations under EU-OPS Sub-Part E shall have an EASA type design approval or for a foreign-registered aircraft, the EVS shall comply with all of the EVS requirements of the European regulations.

- 1.3.1.4 For the purpose of EFVS only approved to 100 ft above the THRE, the HUD is assumed to be the display used per current regulations. For an equivalent display other than a HUD, a proof of concept demonstration would have to be conducted to determine the operational and airworthiness criteria. This document is not intended to be a HUD-approval document. The HUD is separately certified and shall remain subject to all applicable rules and guidance for the category of aircraft and operation. This MASPS pertains only to those items particular and unique to EFVS operations. For an equivalent display other than a HUD, a proof of concept demonstration would have to be conducted to determine the operational and airworthiness criteria.
- 1.3.1.5 In addition to the sensor imagery, for EFVS only approved to 100 ft above the threshold elevation, at least the following specific aircraft flight information shall be displayed:
- Airspeed;
 - Vertical speed;
 - Aircraft attitude;
 - Heading;
 - Altitude;
 - Command guidance as appropriate for the approach to be flown;
 - Path deviation indications;
 - Flight path vector; and
 - Flight path angle reference cue.
- 1.3.1.6 For the purpose of EFVS approved for landing and rollout (i.e., from DA through roll-out at not less than 1000 ft. (or 300 M if applicable) RVR visibility, the HUD is approved as a primary flight reference. This document does not define all HUD approval criteria. In addition to paragraph 1.3.1.5, the following specific aircraft flight information shall also be displayed:
- Radio altitude, and
 - Flare prompt, unless not adequate for the specific landing criteria required by paragraph 4.2.2 through 4.2.4. In this case, flare guidance is required.
- 1.3.2 EFVS Operational Application**
- 1.3.2.1 EFVS from DA/MDA to 100 ft:
- 1.3.2.1.1 Under FAA regulations, the use of EFVS for flight operations in instrument meteorological conditions (IMC) where operational credit is desired has been defined in 14 CFR §91.175(l) and (m), §121.651, §125.381, and §135.225. These regulations provide the basis for using an FAA-approved EFVS to operate below Decision Height/Decision Altitude (DH/DA) or Minimum Descent Height/Minimum Descent Altitude (MDH/MDA) down to 100 feet height above THRE, based on the pilot determining that the enhanced flight visibility is not less than that published for the instrument approach being used, and that the visual cues specified in §91.175 (l) can be seen using the EFVS display. The "operational credit" that is possible with an FAA-approved EFVS is that such approaches can be conducted even when actual flight visibility is less than prescribed in the instrument approach procedure being used.
- 1.3.2.1.2 Under EASA regulations (EU-OPS Sub-Part E), the use of EVS for flight operations in IMC is defined. These regulations provide the basis for using an EASA-approved EVS to operate below DH/MDH/DA/MDA down to 100 feet height above THRE in reduced visibility conditions.
- 1.3.2.1.3 Under FAA regulations, published approach minima remain unchanged in this operations concept.
- 1.3.2.1.4 Under European regulations, published approach minima are adjusted by a reduction in the required RVR in accordance with the table in EU-OPS Sub-Part E (this equates to an approximate reduction of 1/3 RVR compared to approaches not utilizing EVS).

1.3.2.2 EFVS from DA through landing and roll-out with not less than 1000 ft. (or 300 M if applicable) RVR: For EFVS approved for landing and rollout in visibility not less than 1000 ft. (or 300 M if applicable) RVR visibility, minimum requirements are defined for using an approved EFVS to operate below the published DH/DA down to touchdown and roll-out to a safe taxi speed, in actual visibility of not less than 1000 ft RVR (or 300M if applicable).

1.3.2.3 The operational credit possible with an FAA-/EASA-approved EFVS enables approaches and landings even when actual flight visibility is less than prescribed in the instrument approach procedure being used. Take-off and surface movement credits may also be provided by an EFVS, if the respective civil aviation authority's operational and safety requirements can be met.

1.3.3 EFVS General Operation

EFVS may be used in all phases of flight, including surface movement, to improve a pilot's ability to see objects and features in the surrounding environment. The operational applications and goals described in this section address two applications for other than Category II or III straight-in landing instrument approach procedures.

One application is for EFVS-equipped aircraft approved to 100 feet height above THRE. This portion of the approach phase of flight is where operational credit for EFVS is given under 14 CFR § 91.175 (l) and (m), 121.651, 125.381, and 135.225. An "other than Category II or III straight-in landing instrument approach procedure" may be offset up to 30 degrees from the extended runway centerline depending on the type of instrument approach procedure (up to 3 degrees for ILS, 15 degrees for GPS, and 30 degrees for VOR or NDB). The instrument portion of an instrument approach procedure ends at DH/DA or MDH/MDA, and the visual segment begins just below DH/DA or MDH/MDA and continues to the runway. Under the current regulations, there are two means of operating below DH/DA or MDH/MDA down to 100 feet height above THRE from other than a Category II or III straight-in landing instrument approach procedure: by natural vision or by using an FAA-certified (or EASA, as applicable) EFVS.

Another application is for EFVS-equipped aircraft to operate below DH/DA to landing and rollout in as low as 1000ft (or 300M if applicable) RVR visibility.

1.3.3.1 Instrument approach operations without EFVS

1.3.3.1.1 When natural vision is used, an operator conducts the instrument approach procedure down to DH/DA or MDH/MDA in accordance with the published instrument approach procedure and that operator's approved procedures and callouts. A pilot may either be head down or head up, depending on how the aircraft is equipped. Prior to reaching DH/DA or MDH/MDA, the pilot's primary references for maneuvering the airplane are the aircraft instruments, displays, and onboard navigation system.

1.3.3.1.2 At DH/DA or MDH/MDA, if no HUD is installed in the airplane, the pilot transitions from using head down displays of aircraft state and flight path information to looking outside along the flight path. The steps in this task sequence include head and eye movement from cockpit displays to the outside environment, visual accommodation, visual search for relevant objects in the outside visual scene, and allocation of attention to various elements in the visual scene. If a HUD is installed, the pilot continues looking through the HUD, eliminating head down to head up movement and visual accommodation. Visual search through the HUD and allocation of attention between HUD symbology and other elements in the outside visual scene are still part of the pilot task sequence. At DH/DA or MDH/MDA, the pilot makes a decision whether to continue descending below DH/DA or MDH/MDA.

Under FAA regulations, based on the requirements of 14 CFR §91.175(c), §121.651, §125.381, and/or §135.225, as applicable, those requirements are as follows:

- The aircraft shall be continuously in position from which a descent to landing can be made
- On the intended runway
- At a normal rate of descent
- Using normal maneuvers

- For Parts 121 and 135 operators, the descent rate shall allow touchdown to occur within the touchdown zone.
- The flight visibility may not be less than the visibility prescribed in the instrument approach procedure. Flight visibility is assessed using natural vision and means the average forward horizontal distance, from the cockpit of an aircraft in flight, at which prominent unlighted objects may be seen and identified by day and prominent lighted objects may be seen and identified by night.
- The required visual references shall be distinctly visible and identifiable. (See Table 1)

Under EASA regulations, a pilot may not continue an approach below DA/DH or MDA/MDH unless at least one of the visual references listed in Table 2 for the intended runway is distinctly visible and identifiable to the pilot.

TABLE 1: REQUIRED VISUAL REFERENCES, 14 CFR § 91.175 (C) AND (L)

Required Visual References Using Natural Vision (14 CFR § 91.175 (c))	Required Visual References Using an Enhanced Flight Vision System (14 CFR § 91.175 (l))
For operation below DA/DH or MDA/MDH – At least one of the following visual references for the intended runway must be distinctly visible and identifiable: Approach light system Threshold Threshold markings Threshold lights Runway end identifier lights Visual approach slope indicator Touchdown zone Touchdown zone markings Touchdown zone lights Runway Runway markings Runway lights	For operation below DA/DH or MDA/MDH – The following visual references for the intended runway must be distinctly visible and identifiable: Approach light system OR Visual references in <u>BOTH</u> paragraphs 91.175(l)(3)(ii)(A) and (B) -- (l)(3)(ii)(A) The runway threshold, identified by at least one of the following – -- beginning of the runway landing surface, -- threshold lights, or -- runway end identifier lights AND (l)(3)(ii)(B) The touchdown zone, identified by at least one of the following – -- runway touchdown zone landing surface, -- touchdown zone lights, -- touchdown zone markings, or -- runway lights.
Descent below 100 feet height above threshold elevation (THRE)– At least one of the following visual references for the intended runway must be distinctly visible and identifiable: Approach light system, as long as the red terminating bars or red side row bars are also distinctly visible and identifiable Threshold Threshold markings Threshold lights Runway end identifier lights	Descent below 100 feet height above threshold elevation (THRE)– The flight visibility must be sufficient for the following to be distinctly visible and identifiable to the pilot without reliance on the enhanced flight vision system to continue to a landing: The lights or markings of the threshold OR The lights or markings of the touchdown zone

Visual approach slope indicator Touchdown zone Touchdown zone markings Touchdown zone lights Runway Runway markings Runway lights	
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TABLE 2: REQUIRED VISUAL REFERENCES, EU-OPS SUB-PART E

Required Visual References Using Natural Vision EU-OPS Sub-Part E	Required Visual References Using an Enhanced Flight Vision System EU-OPS Sub-Part E
For operation below DA/DH or MDA/MDH – A pilot may not continue an approach below MDA/MDH unless at least one of the following visual references for the intended runway is distinctly visible and identifiable to the pilot: Elements of the approach light system; The threshold; The threshold markings; The threshold lights; The threshold identification lights; The visual glide slope indicator; The touchdown zone or touchdown zone markings; The touchdown zone lights; Runway edge lights; or Other visual references accepted by the Authority.	For operation below DA/DH or MDA/MDH – A pilot using an enhanced vision system certificated for the purpose of this paragraph may: (i) Continue an approach below DA/DH or MDA/MDH to 100 feet height above the threshold elevation of the runway provided that at least one of the following visual references is displayed and identifiable on the enhanced vision system: (A) Elements of the approach lighting; OR (B) The runway threshold, identified by at least one of the following: the beginning of the runway landing surface, the threshold lights, the threshold identification lights; and the touchdown zone, identified by at least one of the following: the runway touchdown zone landing surface, the touchdown zone lights, the touchdown zone markings or the runway lights.
Descent below 100 feet height above THRE– As above for descent below DA/DH or MDA/MDH	Descent below 100 feet height above THRE– A pilot may not continue an approach below 100 feet above runway threshold elevation for the intended runway, unless at least one of the visual references specified below is distinctly visible and identifiable to the pilot without reliance on the enhanced vision system: (A) The lights or markings of the threshold; or (B) The lights or markings of the touchdown zone.

- 1.3.3.1.3 Provided these requirements are met, the pilot may continue descending below DA/DH or MDA/MDH down to 100 feet above THRE. As the pilot approaches DA/DH or MDA/MDH, he or she looks for the approach lighting system, if there is one, as well as the runway threshold and touchdown zone lights, markings, surfaces, and features. These visual references not only contribute to assessment of flight visibility, but they help the pilot align the aircraft with the runway and provide position, lateral roll, rate of closure, and distance remaining information. This visual information serves as independent verification of the information provided by the aircraft displays and systems.

- 1.3.3.1.4 At 100 feet above the THRE, the pilot again makes a determination about whether the flight visibility is sufficient to continue the approach as well as whether the required visual references are distinctly visible and identifiable before descending below 100 feet. In the visual segment, which extends from DA/DH or MDA/MDH down to the runway, the primary reference for maneuvering the airplane is based on what the pilot sees visually. Supporting information is provided by aircraft instruments, displays, and the onboard navigation system.
- 1.3.3.2 Instrument approach operations with EFVS
- 1.3.3.2.1 Under FAA regulations, EFVS operations under 14 CFR §91.175 (l) and (m), §121.651, §125.381, and §135.225 are analogous to those conducted with natural vision. These regulations authorize EFVS to be used on other than Category II and III straight-in landing instrument approach procedures. Here again, the operator conducts the instrument approach procedure down to DA/DH or MDA/MDH in accordance with the published instrument approach procedure and that operator's approved procedures and callouts. Prior to reaching DH or MDA, the pilot's primary references for maneuvering the airplane are the aircraft instruments, displays and onboard navigation system.
- Under EASA regulations, EFVS (European "EVS") operations are conducted under EU-OPS Sub-Part E and are analogous to those conducted with natural vision. They are authorized to be used for ILS, MLS, PAR, GLS and APV approaches with a DH/DA no lower than 200 feet, or an approach flown using approved vertical flight path guidance to a MDH or DH no lower than 250 feet. Here again, the operator conducts the instrument approach procedure down to DH/DA or MDA/MDH in accordance with the published instrument approach procedure and that operator's approved procedures and callouts. Prior to reaching DH/DA or MDH/MDA, the pilot's primary references for maneuvering the airplane are the aircraft instruments, displays and onboard navigation system.
- For EFVS operations using EFVS approved for landing and roll-out: approaches are conducted using published straight-in precision instrument approach procedures or approaches with approved vertical path containing a DA/DH. Final approach course offsets greater than 3 degrees require further flight test evaluation. The maximum allowable final approach course offset is to be established by flight test. These tests shall include the factors related to the offset, such as the HUD/EFVS field of view, crosswinds, and the maximum drift angle possible for a conformal flight path vector.
- 1.3.3.2.2 For EFVS operations, the sensor imagery and required flight information and symbology shall be displayed on a HUD or an equivalent display so that the pilot flies both the instrument and visual segments head up, eliminating head down to head up transition and visual accommodation time. An equivalent display shall present the EFVS sensor imagery and aircraft flight symbology required by 14 CFR §91.175 (m) so that they are clearly visible to the pilot flying in his or her normal position and line of vision and looking forward along the flight path. In other words, an equivalent display shall be some type of head up presentation of the required information. The EFVS display shall also be conformal. That is, the sensor imagery, aircraft flight symbology and other cues that are referenced to the imagery and external scene shall be aligned with and scaled to the external view. EFVS operations require the pilot to accomplish several visual-based judgment and control tasks in quick succession. These include using the imagery, flight reference information, and eventually the outside view at the same time. The pilot shall be able to look for the outside visual references in the same location as they appear in the EFVS image and readily see them as soon as visibility conditions permit, without delays or distraction due to multiple head up and head down transitions. Scanning between head up and head down views can be distracting, increase pilot workload and potentially degrade path performance during a critical phase of flight. These effects are mitigated by displaying the EFVS imagery and flight information on the HUD.

1.3.3.2.3 At DA/DH or MDA/MDH, the pilot makes a decision whether to continue descending below DA/DH or MDA/MDH using an EFVS based on all of the requirements of the applicable regulations cited above. Those requirements are as follows:

Under US regulations:

- The aircraft must be continuously in position from which a descent to landing can be made:
- On the intended runway
- At a normal rate of descent
- Using normal maneuvers
- For Part 121 and 135 operators, the descent rate must allow touchdown to occur within the touchdown zone.
- The enhanced flight visibility may not be less than the visibility prescribed in the instrument approach procedure. Enhanced flight visibility is assessed using an EFVS (not natural vision) and means the average horizontal distance, from the cockpit of an aircraft in flight, at which prominent topographical objects may be clearly distinguished and identified by day or night by a pilot using an enhanced flight vision system.
- The required visual references must be distinctly visible and identifiable. (See Table 1) These visual reference requirements are more stringent than those required by 14 CFR § 91.175 (c) for natural vision because EFVS displays may not be able to display the color of the lights used to identify specific portions of the runway.

1.3.3.2.4 For EFVS only approved to 100 feet height above threshold elevation (THRE)

1.3.3.2.4.1 The portion of the visual segment in which EFVS may be used in lieu of natural vision extends from DA/DH or MDA/MDH down to 100 feet height above THRE (Figure 4). Provided the requirements identified above are met, the pilot may continue descending below DA/DH or MDA/MDH down to 100 feet height above THRE. As the pilot approaches DA/DH or MDA/MDH, he or she looks for the approach lighting system, if there is one, as well as the runway threshold and touchdown zone lights, markings, surfaces, and features using the EFVS. These visual references not only contribute to assessment of enhanced flight visibility, but they help the pilot align the aircraft with the runway and provide position, lateral roll, rate of closure, and distance remaining information just as they do when natural vision is used. The information provided by aircraft displays and systems serves as independent verification of the visual information provided by the EFVS.

1.3.3.2.4.2 For EFVS only approved to 100 feet height above THRE, the pilot can no longer rely entirely on EFVS or use enhanced flight visibility (under US regulations) to continue descent. At 100 feet above the THRE, the visual transition point, (Figure 4) the pilot makes a determination about whether the flight visibility (under US regulations) is sufficient to continue the approach and distinctly identify the required visual references using natural vision.

1.3.3.2.4.3 It should be noted that current regulations do not require that the EFVS be stowed or that the sensor image be removed from the HUD in order to meet this requirement. As long as the pilot can see the required visual references that would normally be seen through the HUD with natural vision, the regulatory requirement can be met. Lights and other features of the approach lighting system, runway threshold, or touchdown zone are often distinguishable from the sensor image as the aircraft gets closer to them. The pilot should, however, be able to easily and quickly declutter the EFVS or remove the sensor image at any time it is deemed necessary or appropriate.

1.3.3.2.4.4 For EFVS operations conducted to 100 feet above THRE, FAA regulations do not require that the sensor image and flight information from the EFVS be presented to the non-flying pilot, nor do they preclude it. EFVS equipage may vary. Some operators may choose to equip with a single EFVS display. However, note minimum standards contained in Appendix J, Transport Category Airplanes. Others may install an EFVS display and a separate repeater display located in or very near the primary field of view of the non-flying pilot. Still others may elect to equip with dual EFVS displays.

1.3.3.2.4.5 During approaches with no published vertical flight path or for flying a specific vertical flight path below DA/DH or MDA/MDH, the flight path angle reference cue may be used to position the aircraft on an appropriate glidepath to the touchdown zone. This is done by presetting the flight path angle reference cue to an angle consistent with the published approach procedure, the visual approach slope indicator, or the precision approach path indicator. The pilot would continue to fly at the MDA/MDH until the flight path angle reference cue is positioned over the desired touchdown point in the touchdown zone of the runway image as it appears on the EFVS. The pilot would adjust the rate of descent until the flight path vector is positioned over the touchdown zone and the flight path angle reference cue. Use of the flight path angle reference cue in this manner requires that it be displayed with the pitch scale and that the desired flight path angle be selectable by the pilot for the appropriate descent angle.

NOTE: *There are many approaches where the published approach descent angle is different from the published Visual Glide Slope Indicator (VGSI) angle. An operational procedure may be required to address non-coincident angles when they occur.*

Under EASA regulations, approaches utilizing EVS are not permitted without a published vertical flight path. Minimum standards are also contained in Appendix J, Transport Category Airplanes.

1.3.3.2.4.6 For EFVS only approved to 100 feet height above THRE, in the EFVS portion of the visual segment, which extends from DA/DH or MDA/MDH down to 100 ft above THRE, the primary reference for maneuvering the airplane is based on what the pilot sees visually through the EFVS. From 100 feet to the runway, the primary reference for maneuvering the airplane is based on what the pilot sees with natural vision. Supporting information is provided by the flight path vector, flight path angle reference cue, onboard navigation system, and other imagery and flight symbology displayed on the EFVS. The flight path vector provides information relevant to the vertical path.

1.3.3.2.4.7 Procedures should be developed for EFVS operations appropriate to the installed equipment and the operation to be conducted. In particular, procedures should support appropriate levels of crew coordination and pilot/crew decision making in the segments from final approach fix to DA/DH or MDA/MDH, in the EFVS segment from DA/DH or MDA/MDH down to 100 feet height above THRE, and the point at which a decision to rely on natural vision is made – whether that is at 100 feet height above threshold elevation or prior to reaching that point. Additionally, each EFVS has a specified limit to the field of regard which may affect its use during final approach or in crosswinds.

1.3.3.2.4.8 For EFVS only approved to 100 feet height above THRE, the required visual references must be seen with natural vision below 100 feet above THRE. (See Table 1)

Under European regulations, a pilot may not continue an approach below DA/DH or MDA/MDH unless at least one of the visual references listed in Table 2 for the intended runway is distinctly visible and identifiable to the pilot. EU-OPS specifies the visual references for descent below DA/DH/MDA/MDH as above and additional requirements are specified at 100 feet as listed in Table 2.

1.3.3.2.5 For EFVS approved for landing and rollout in visibility not less than 1000ft (or 300M if applicable) RVR

1.3.3.2.5.1 The portion of the visual segment in which EFVS may be used in lieu of natural vision extends from DA/DH down to landing, and rollout to a safe taxi speed (Figure 4). Provided the requirements identified above are met, the pilot may continue descending below DA/DH down to landing, and rollout to a safe taxi speed. As the pilot approaches DA/DH, he or she looks for the approach lighting system, if there is one, as well as the runway threshold and touchdown zone lights, markings, surfaces, and features using the EFVS. These visual references not only contribute to assessment of enhanced flight visibility, but they help the pilot align the aircraft with the runway and provide position, lateral roll, rate of closure, and distance remaining information just as they do when natural vision is used. The information provided by aircraft displays and systems serves as independent verification of the visual information provided by the EFVS.

1.3.3.2.5.2 The pilot can rely on EFVS to continue descent below DA/DH through landing and rollout provided:

- The enhanced flight visibility is not less than that required by the instrument approach procedure all the way to touchdown, and
- The visibility is not less than 1000ft (or 300M if applicable) RVR, and
- The required visual references are distinctly visible and identifiable from DA/DH to 100 ft and from 100 ft to touchdown.

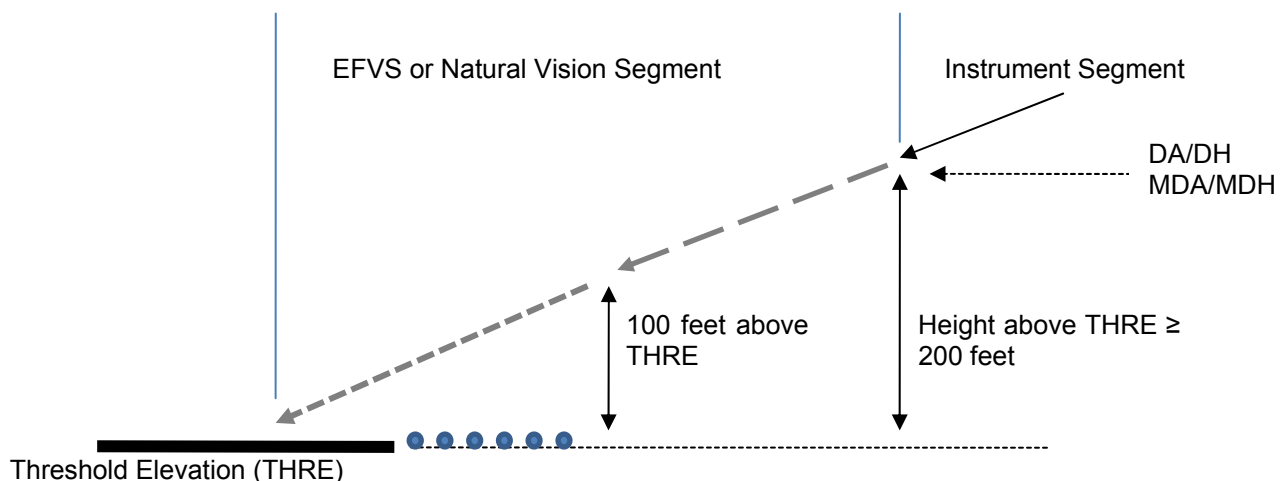


FIGURE 4: EQUIVALENT VISUAL OPERATIONS–EFVS APPROACH AND LANDING

1.3.3.2.5.3 For EFVS approved for landing and rollout in visibility no lower than 1000ft (or 300M if applicable) RVR, the primary reference for maneuvering the airplane is based on what the pilot sees visually through the EFVS. Supporting information is provided by the flight path vector, flight path angle reference cue, onboard navigation system, and other imagery and flight symbology displayed on the EFVS. The flight path vector provides information relevant to the vertical path.

EASA regulations require a separate repeater display located in or very near the primary field of view of the non-flying pilot. Operators may elect to equip with dual EVS displays.

1.3.3.2.5.4 Procedures should be developed for EFVS operations appropriate to the installed equipment and the operation to be conducted. In particular, procedures should support appropriate levels of crew coordination and pilot/crew decision making in the segments from final approach fix to DA/DH, in the EFVS segment from DA/DH down to landing and rollout to a safe taxi speed. Additionally, each EFVS has a specified limit to the field of regard which may affect its use during final approach or in crosswinds.

1.3.3.2.5.5 For EFVS approved for landing and rollout in visibility is not less than 1000ft (or 300M if applicable) RVR, the required visual references must be seen either with EFVS or natural vision. (See Table 1)

1.3.4 EFVS Intended Function

1.3.4.1 The intended function of an EFVS system as described in this MASPS is to improve visibility during low-visibility conditions. Specifically, the EFVS is used to visually acquire the references required to operate below the MDA/MDH or DA/DH as described in §91.175(l) and EU OPS Sub-Part E. The purpose of the EFVS sensor is to provide a visual advantage over the pilot's out-the-window view. In low visibility conditions, the "enhanced flight visibility" should exceed the "flight visibility" and the required visual references should become visible to the pilot at a longer distance in the EFVS than out-the-window.

1.3.4.2 The EFVS is not intended to change the technologies or procedures already used to safely fly the aircraft down to the MDA/MDH or DA/DH. The EFVS complements other instrument approach equipment by providing a means for the pilot to see (with the EFVS) the required visual references that might otherwise not be visible.

1.3.5 EFVS Assumptions

This document identifies generic system and sub-system performance, safety and redundancy requirements for the use of this technology. The operational rules provide the context for acceptable types of operations, and in some cases the top level performance and equipage of the aircraft or airport. The system and safety criteria also provide the necessary guidance for the required level of safety for each phase of flight and by type of operation.

1.4 SVS FOR LOWER THAN STANDARD MINIMA

1.4.1 SVS for Lower than Standard Minima Operations Overview

An SVS for Lower than Standard Minima is an SVS as defined in 1.2.1.2, displayed on a Primary Display (See Sections 1.2.1.4.1 and 2.1.1.1.1) which includes additional capability. SVS for Lower than Standard Minima can use CAT I ILS approaches to support safe operations to lower decision altitudes or reduced visibilities. Additional database elements beyond those required in not-for-credit SVS are required for operational credit implementations, specifically including the runway of intended landing.

The performance requirements for an SVS for Lower than Standard Minima system as outlined in this document anticipate a potential approval for operations in which lower than standard Category I ILS minima apply. For operations to a DH a radio altimeter is required. The minimum visibility will be established by flight test and simulation, and in accordance with applicable operational approvals.

SVS for Lower than Standard Minima systems use a combination of display imagery and flight guidance cues to support operations to lower than standard precision approach minima. The primary display systems used to present SVS imagery are Head-Up Display or Head-Down Display (PFD) as described in 1.2.1.4.1. and further outlined in AC25-11A, as amended. An egocentric representation of the external scene is required.

NOTE: *The performance and certification requirements for primary flight displays are not changed in SVS for Lower than Standard Minima applications, and those requirements are not addressed in this MASPS.*

1.4.2

SVS for Lower than Standard Minima Operational Application

The initial operational application for SVS for Lower than Standard Minima equipped aircraft is expected to be ILS approaches for which straight in minimums with a decision height (DH) have been published. SVS for Lower than Standard Minima systems are intended to enable operations under Special Authorization Category I (SA CAT I, FAA) and/or Lower than Standard CAT I visibility minimum (EASA). Maintaining flight technical error within defined limits, and improvement of visual search for the required visual references would be the rationale for lower than standard minima.

The SVS imagery provides information that conveys a sense of speed, altitude, attitude, distance and direction during the descent toward the runway. The runway of intended landing must be displayed. During the transition from the instrument to visual segment, the runway display also provides relative location of the runway to support visual search for the required visual references before final descent to landing.

The instrument portion of the instrument approach procedure is flown using conventional instrument procedures, including a flight director. During descent the pilot uses the SVS for Lower than Standard Minima system to assist with maintaining trajectory, and to monitor the descent toward a landing in the touchdown zone. At the authorized DH, at least one of the visual cues required by 91.175 (c)(3) or EU OPS Subpart E (Table 1) must be in view using natural vision to continue to landing, otherwise a missed approach is required. The SVS for Lower than Standard Minima imagery helps guide visual search for the required visual references. Figure 5 illustrates the approach segments.

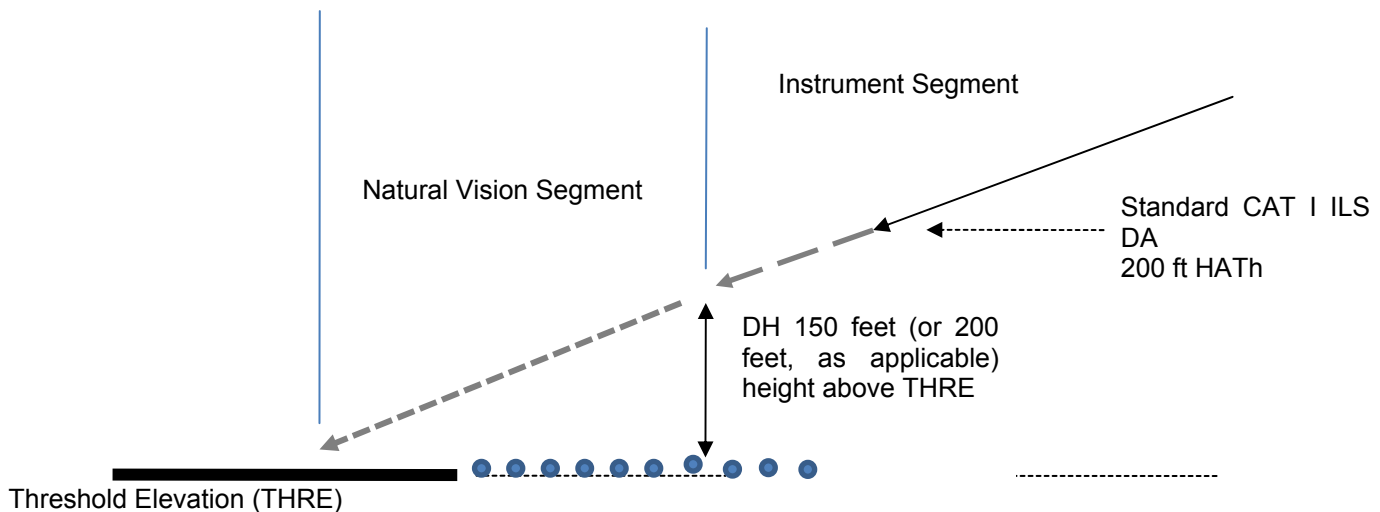


FIGURE 5: SVS FOR LOWER THAN STANDARD MINIMA APPROACH AND LANDING

The relationships between functions in a SVS for Lower than Standard Minima system are illustrated in Figure 6. This is one example of an architecture that may provide the required integrity performance. This example uses a combination of ground based ILS navigation signals for primary navigation reference, and a second precision positioning source (e.g. GPS with satellite based augmentation) to properly position the SVS imagery.

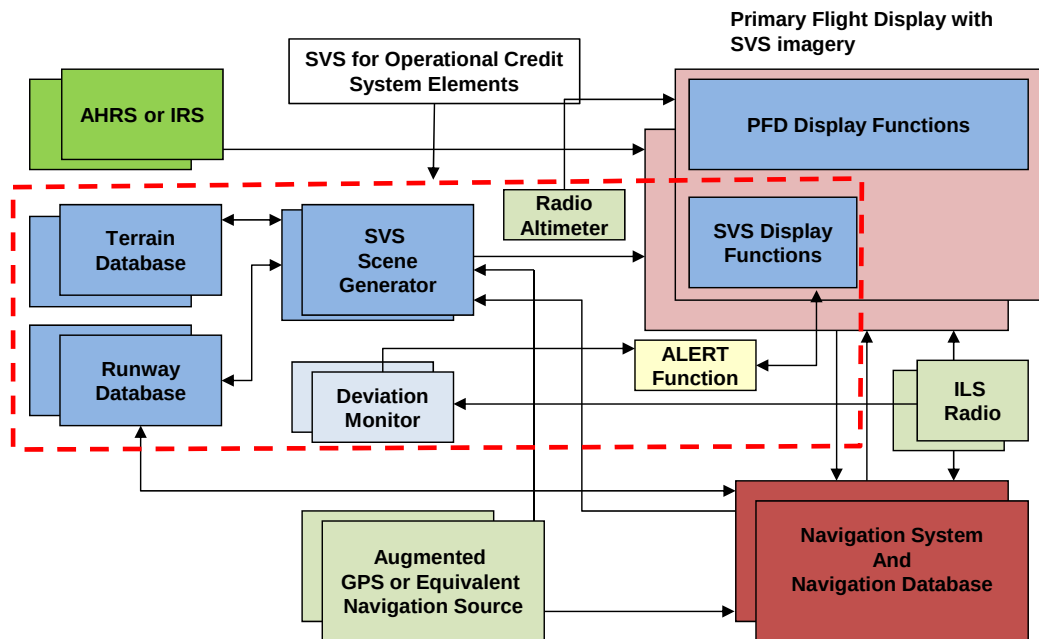


FIGURE 6: SVS FOR LOWER THAN STANDARD MINIMA SYSTEM BLOCK DIAGRAM (EXAMPLE)

1.4.3 SVS for Lower than Standard Minima Intended Function

1.4.3.1 The intended functions of an SVS for Lower than Standard Minima system as described in this MASPS are:

- (1) Provide PFD/HUD symbology and SV scene elements that, when used in conjunction, consistently permit vertical and lateral FTE to be maintained within defined limits. (See paragraph 3.3.2.2)
- (2) Direct the visual search for and acquisition of the required visual references.

1.4.4 SVS for Lower than Standard Minima Assumptions

This document identifies generic system and sub-system performance, safety and redundancy requirements for the use of an SVS for Lower than Standard Minima during the approach phase of flight. The system and safety criteria provide the necessary guidance for the required level of safety for the operation.

While the operations described herein provide the context for subsequent system safety analysis, the actual certification and operational approvals will be accomplished by the relevant certification and operational approval authorities, who may use the contents of this MASPS in whole or in part in granting such operational approval. Other guidance material may be developed from the performance criteria outlined in this MASPS to assist such authorities in the approval process.

The assumptions underlying the basic SVS for Lower than Standard Minima system design are outlined below.

1.4.4.1 Operational Environment

The SVS for Lower than Standard Minima design assumes that the operational environment meets certain minimum requirements as outlined in this section. The environment definition includes the navigation, ground infrastructure and meteorological conditions that will support safe operations to the authorized decision height and visibility. The combination of ground and airborne elements and pilot performance, operating together as a total system, provides the required accuracy and integrity as defined in Sections 2 and 3.

1.4.4.1.1 Navigation and Scene Positioning Systems

The initial implementation of an SVS for Lower than Standard Minima system uses a combination of navigation and scene positioning sources to provide the required system level integrity. An initial implementation will use an Instrument Landing System (ILS) precision approach as the source of navigation information to the published decision height, and a different position source for SVS image depiction.

The ILS used during SVS for Lower than Standard Minima operations should have no restrictions, in accordance with the requirements of FAA Order 8400.13 as amended (or equivalent EASA requirement).

NOTE: *While the initial implementation of an SVS for Lower than Standard Minima is expected to use ILS as the source of navigation, future solutions may be possible using other navigation and scene position sources which, in their end to end system architecture can demonstrate similar accuracy and integrity.*

1.4.4.1.2 Ground Infrastructure

This MASPS assumes that to support pilot visual search for the runway in the visual segment of the approach the runway is equipped as follows:

- (1) Approach light system: SSALR, MALSR, or ALSF-1/ALSF-2 (See Figure 8)
- (2) High intensity runway lights.
- (3) The touchdown zone sensor of an RVR reporting system.

1.4.4.1.3 Meteorological Conditions

The design intent of the SVS for Lower than Standard Minima system is to support operations to a decision altitude of 150 ft. (FAA) or 200 ft (EASA). Minimum visibility is expected to be not less than RVR 1400 (FAA) or 400m (EASA) as determined by simulator test, flight test, or a combination of these methods.

1.5 VERIFICATION PROCEDURES

1.5.1 The verification procedures specified in this document are intended as an acceptable means of demonstrating compliance with the performance requirements. Although test procedures are normally associated with performance verification, it is recognized that other methods (e.g., analysis, simulation, inspection) may be used, and may be more appropriate to the large-scale systems addressed in this MASPS. However, it is desirable that such other methods be validated by procedures involving actual measurements of the system.

1.5.2 Alternatives to the procedures specified herein may be used if it can be demonstrated that they provide at least equivalent information. Subsystem verification is useful as subsystems are added during system buildup and to ensure continued subsystem performance as it relates to overall system performance.

1.6 REFERENCE DOCUMENTS

References applicable to specific systems are given in their corresponding sections. Technical references applicable to specific systems are given in Appendix B. The System Safety Requirements Logic and examples are provided in Appendix C. EFVS Minimum System Performance Standard Rationale is explained in Appendix D. EVS/SVS/CVS Minimum System Performance Standard Rationale is explained in Appendix E. SVS for Lower than Standard Minima Minimum System Performance Standard Rationale is provided in Appendix F. A sample EFVS Flight Test Plan is provided in Appendix F for EFVS approved to 100feet above TDZE. A sample EFVS Flight Test Plan is provided in Appendix G for EFVS approved for landing and rollout, based on reported 1000ft RVR 300 meter visibility. A sample SVS for Lower than Standard Minima Flight Test Plan is provided in Appendix I.

CHAPTER 2

SYSTEM PERFORMANCE REQUIREMENTS

2.1 ENHANCED VISION SYSTEMS (EVS) / SYNTHETIC VISION SYSTEMS (SVS) / COMBINED VISION SYSTEMS (CVS)

2.1.1 EVS/SVS/CVS General Requirements

This portion of the MASPS provides the system performance of the EVS/SVS/CVS system by first describing the cockpit display that these types of images are rendered upon. Section 2.1.2 then provides the requirements for EVS/SVS/CVS images as shown on these cockpit display categories.

The following general requirements apply to all EVS/SVS/CVS implementations detailed in this section.

- a) The system shall have a means to automatically or manually control display brightness.
- b) The system shall not degrade presentation of flight and alerting information that is essential for controlling the aircraft in a particular flight phase, weather condition, traffic situation and aircraft configuration.
- c) A system modified to display EVS/SVS/CVS shall continue to meet requirements of original approval (if applicable).
- d) The system shall not adversely affect any other installed aircraft system.
- e) The system shall be shown to perform its intended function in each aircraft environment where system approval is desired. For example, if the system is intended to perform in (or after exposure to) known icing conditions, a means may be required to keep the EVS sensor window clear of ice accretion.

2.1.1.1 Display Implementation

Enhanced, Synthetic and or Combined Vision Systems (EVS/SVS/CVS) may be incorporated into differing display types installed in the cockpit. There are unique tactical and strategic requirements for each of these displays and the types of the display are categorized in the sections below. See FAA AC 25-11A for more information on electronic displays.

2.1.1.1.1 Primary Displays

Primary Displays are those cockpit displays used to provide information needed to guide and control the aircraft and provide the aircraft altitude, attitude and airspeed indications. See FAA AC 25-11A Appendix 1 for more information of what constitutes primary information.

2.1.1.1.1.1 Primary Flight Display (PFD)

EVS/SVS/CVS may be implemented on the primary flight display. The following requirements apply to EVS/SVS/CVS implemented on this display.

- a) The PFD shall remain subject to all applicable primary flight information rules and guidance for the category of aircraft.
- b) The image or loss thereof shall not adversely affect the PFD functionality.
- c) The displayed image should be aligned with airplane's inertial axis, physical axis or as appropriate for the intended function and may be variable and/or "phase of flight" dependent. The relationship between the image and the airplane's heading angle, pitch angle, roll angle, and track angle should be recognizable by the flight crew and not be misleading.
- d) The displayed image and symbology may have different scaling between the vertical and lateral axis. Scaling differences shall be evaluated to ensure the image is not misleading. All spatially referenced symbology within each axis shall be sufficiently scaled and aligned with the imagery so as not to present any misleading information to the pilot.

- e) Variable field of regard may be acceptable but it should be evaluated to ensure that the displayed image is not distracting or misleading and does not adversely affect crew workload.
- f) The system shall provide a clearly visible zero pitch reference line, distinct in visual appearance relative to any possible terrain, obstacle, or cultural feature display appearance.

2.1.1.1.1.2 Head-Up Display (HUD)

EVS/SVS/CVS may be implemented on a head-up or equivalent display. Due to the tactical nature of the HUD, the following requirements apply to EVS/SVS/CVS implemented on this display.

- a) The HUD shall remain subject to all applicable rules and guidance for the category of aircraft.
- b) The safety and performance of the pilot tasks associated with the use of the pilot compartment view shall not be degraded by the display of imagery on the HUD. Imagery on the HUD shall be conformal with the real world and appropriate for the system's intended function accounting for possible aircraft attitudes and wind effects. SAE design standards for HUD symbology, optical elements and video imagery are also prescribed with SAE Aerospace Standard (AS) 8055, SAE Aerospace Recommended Practice (ARP) 5288 and SAE ARP 5287. Specific design standards should be applied for resolution and line width, luminance and contrast ratio, chromaticity, and grayscale. Pilot tasks which shall not be degraded by the imagery include:
 - 1) Detection, accurate identification and maneuvering, as necessary, to avoid traffic, terrain, obstacles, and other hazards of flight.
 - 2) Accurate identification and utilization of visual references required for every task relevant to the phase of flight.

2.1.1.1.2 Secondary Displays

EVS/SVS/CVS may be implemented with ego-centric "inside aircraft" views or exocentric "outside aircraft" viewpoints on the secondary displays. The following requirements apply to EVS/SVS/CVS implemented on these types of displays.

- a) The display shall remain subject to all applicable rules and guidance for the category of aircraft.
- b) The orientation and perspective of the EVS/SVS/CVS view shall be clear to the pilot.
- c) For secondary displays, SVS depictions using the pilot's view looking forward and that include primary display information need to be approved accordingly. For example, if PFD information is displayed, it should meet PFD integrity levels
- d) EVS/SVS/CVS image, or loss thereof, shall not adversely affect other approved secondary display functionality (e.g., navigation display).

2.1.1.1.2.1 Electronic Flight Bag (EFB)

When EVS/SVS/CVS is installed in an EFB, this EFB shall be Class 3.

- a) The display shall remain subject to all applicable EFB guidance for such displays and their installation (FAA AC 120-76A or most current revision)
- b) For EFB's, SVS depictions using the pilot's view looking forward and that include primary display information need to be approved accordingly. For example, if PFD information is displayed, it should meet PFD integrity levels.
- c) EVS/SVS/CVS image, or loss thereof, shall not adversely affect other approved EFB functionality.

2.1.2 EVS/SVS/CSV System Requirements

These systems are installed such that they don't qualify for additional operational credit over and above that already certified. They are installed on a non-interference basis and shall meet the following two regulatory requirements; 1) that they don't create or contribute to an unsafe condition, and 2) that they perform their intended function.

2.1.2.1 EVS

Enhanced Vision Systems (EVS) require a real-time imaging sensor and display that provides demonstrated vision performance for its intended function which shall be clearly defined. The design and installation safety levels should be appropriate for the system's intended function.

The following requirements apply to EVS installations:

- a) The EVS depiction shall be crew de-selectable (if on the Primary Display, the pilot should be able to easily and quickly declutter the EVS or remove sensor image). For an EVS image displayed on a HUD, a control shall be provided which permits the pilot flying to deactivate and reactivate the display of the EVS image on demand without removing the pilot's hands from the primary flight controls (yoke or equivalent) or thrust control.
- b) The display status of EVS, either through crew de-selection or as a result of a failure, shall be clearly indicated or obvious to the crew.

NOTE: *Consideration should be given to recording the EVS display status in a flight data recorder or some form of nonvolatile memory.*

- c) The display and sensor field-of-regard (FOR) should be sufficient for the intended operational conditions.
- d) The sensor image may be presented on a display with or without primary flight data, such as attitude, heading, airspeed, radio/barometric altitude, lateral/vertical path deviations, flight path vector, and flight director commands.
- e) If primary display information is presented in the form of symbology overlaying the image presentation, then the primary display information shall be scaled and aligned with the image presentation.
- f) If primary flight and navigation information is displayed on an EVS display, it should meet the same integrity levels as the PFD information.
- g) Criteria for the design, analysis, testing and installation of the HUD, including field-of-view, head motion box, and alignment, shall follow applicable guidance of SAE ARP 5288.
- h) The EVS system installation and operations shall demonstrate that the criteria defined in 14 CFR §25.773, §23.773, §27.773, and §29.773, including validation that the display of EVS imagery does not conflict with the pilot compartment view, are met. The FAA may issue special conditions to achieve the intended level of safety in 14 CFR §25.773. The safety and performance of the pilot tasks associated with the use of the pilot compartment view shall not be degraded by the display of the EVS image. Pilot tasks which shall not be degraded by the EVS image include:
 - 1) Detection, accurate identification and maneuvering, as necessary, to avoid traffic, terrain, obstacles, and other hazards of flight.
 - 2) Accurate identification and utilization of visual references required for every task relevant to the phase of flight.
- i) If applicable, SAE design standards for HUD or EFVS symbology, optical elements and video imagery are also prescribed with SAE AS 8055, SAE ARP 5288 and SAE ARP 5287. Specific design standards should be applied for resolution and line width, luminance and contrast ratio, chromaticity, and grayscale.
- j) For HUD applications, the displayed field-of-regard (FOR) shall be conformal with the real world and appropriate for the system's intended function accounting for possible aircraft attitudes and wind effects.

- k) The EVS design, regardless of the display type, should also consider the following requirements for display characteristics:
 - 1) Display characteristics listed in AC 25-11A are applicable to all aircraft.
 - 2) Undesirable display characteristics shall be minimized (e.g., blooming, “burlap”, or running water).
 - 3) If EVS is implemented on a primary display, then the pilot's ability to see and use the required primary flight display information such as primary attitude, airspeed, altitude, or command bars shall not be hindered or compromised by the EVS video.

2.1.2.2

SVS

Synthetic Vision Systems (SVS) require a terrain and obstacle database, a precision *navigation* position, and a display. The design and installation safety levels should be appropriate for the system's intended function. The following guidance applies to SVS displays: FAA AC 20-167, FAA AC 25-11A, and FAA AC 23.1311-1B.

The following requirements apply to SVS installations:

- a) The synthetic vision scene depiction shall be crew de-selectable. For an SVS image displayed on a HUD, a control shall be provided which permits the pilot flying to deactivate and reactivate the display of the SVS image on demand without removing the pilot's hands from the primary flight controls (yoke or equivalent) and thrust control.
- b) The display status of synthetic vision scene depiction, either through crew de-selection or as a result of a failure, shall be clearly indicated or obvious to the crew.

NOTE: *Consideration should be given to recording the SVS display status in a flight data recorder or some form of nonvolatile memory.*

- c) The display may depict the scene from the pilot's view looking through the front window or from outside the aircraft. If implemented on a primary display, then the display shall depict the scene from the pilot's perspective looking through the front window.
- d) Synthetic vision scene compression may result from FOR selections or display size limitations. Regardless, prominent topographical features shall be easily identified and correlated with the actual external scene. Also, the crew should be able to perceive relative distances to prominent topographical features. For example, the pilot should be able to identify an immediate terrain threat versus a distant terrain conflict.
- e) Position accuracy, symbology, and topographical information should be consistent with each other.
- f) Any aircraft incorporating SVS from the pilot's perspective (ego-centric) shall also provide a TAWS or terrain warning system as defined in FAA AC 23-26 section 7.b. If terrain alerts and cautions are depicted on the SVS, they shall be consistent across all displays in the cockpit when terrain threats are identified.
- g) The terrain and obstacle database, along with any other database used to create the SVS image shall be compliant to DO-200A as applicable.
- h) A potential terrain or obstacle conflict shall be obvious to the crew. One mechanism for making such conflicts obvious on a primary display is an earth-based flight path vector.
- i) Topographical features shall not intersect published approach paths.
- j) The pilot's view shall not be depicted below the earth's surface.

- k) The scene range from the eye position to the terrain horizon shall be sufficient so as to not be misleading and shall be appropriate to the intended function. One example of a scenario that this requirement is trying to prevent is misleading information due to a SVS range limitation to the horizon that could lead to crew confusion at a critical phase of flight. At some airports the missed approach can take the aircraft on a course towards mountains, but the mountains may be 40 miles from the final approach fix. Pilots need to see that the mountains will be a factor in their missed approach long before they get to the runway. Thus, it is not acceptable for an approach to look like it is in the plains until short final when the mountains in the distance finally start appearing on the PFD.
- l) Water and sky depictions shall be clearly distinguishable.
- m) The field-of-regard should be appropriate for the system's intended function and account for possible aircraft attitudes and wind effects.
- n) Display characteristics shall comply with AC 23-26 and AC 25-11A, as applicable. For example, undesirable display characteristics shall be minimized (e.g., jitter, jerky motion, excessive delays).
- o) If SVS is implemented on a primary display, then the pilot's ability to see and use the required primary flight display information such as primary attitude, airspeed, altitude, or command bars shall not be hindered or compromised by the SVS.
- p) SVS based primary displays shall be clear and unambiguous when recovery from unusual attitudes is required. An accurate, easy, quick-glance interpretation of attitude should be possible for all unusual attitude situations and other "non-normal" maneuvers sufficient to permit the pilot to recognize the unusual attitude and initiate an appropriate recovery within one second. Information to perform effective manual recovery from unusual attitudes using chevrons, pointers, and/or permanent ground-sky horizon on all attitude indications is recommended. (See FAA AC 25-11A)
- q) Due to curvature of the earth, distant terrain may not appear above the artificial horizon. Threatening terrain, close enough to generate a TAWS or terrain warning alert, should appear above the artificial horizon if it is higher than the aircraft altitude.
- r) Dominant topographical features present in the SVS image should be identifiable in the outside view. The converse is also a requirement; dominant topographical features present in the outside view should be identifiable in the SVS image.

2.1.2.3 CVS

Combined Vision Systems (CVS) require a real-time imaging sensor and display that provides demonstrated vision performance for its intended function. They also require a terrain and obstacle database and a precision navigation position for the synthetic portion of the display. The design and installation safety levels should be appropriate for the system's intended function.

The following requirements apply to CVS installations:

- a) Combined Vision Systems shall meet the combined requirements of the EVS and SVS implementations.
- b) The EVS and SVS depictions shall be conformal with each other as required according to the intended function.
- c) The mode (EVS, SVS, or CVS) should be displayed to the crew.
- d) The blending of EVS and SVS images shall be such that there are no discrepancies significant enough to cause confusion to the flight crew. Image discrepancies between EVS and SVS that arise due to failure conditions shall be obvious to the crew.

2.2 EFVS

- 2.2.1** EFVS General Requirements. Enhanced Flight Vision Systems (EFVS) require a real-time imaging sensor providing: (1) demonstrated vision performance in low visibility conditions, so the required visual references become visible in the image before they are visible naturally out-the-window, with, (2) a level of safety suitable for the proposed operational procedure.
- 2.2.1.1** In the design of an EFVS, safety design goals are established for certification approval. The safety criteria for each phase of flight, including approach and landing systems are defined in terms of accuracy, continuity, availability and integrity. FAA and EASA design guidance provides that the overall safety requirement of the aircraft, in any mode of flight, is that any combination of failures that can cause an unsafe condition, including the probability of the crew to cope with the failures shall be fully assessed and categorized. The hazard level for any aircraft system, therefore, depends on the ability of the crew to cope with failures.
- 2.2.1.2** System failures which are not extremely improbable and produce effects with which the crew (or the aircraft itself) may not be able to safely cope, shall be mitigated. The aircraft systems shall be designed such that the entire fault probability is kept to an acceptable level, which is normally accomplished by redundancy and system monitoring.
- 2.2.1.3** The sensor image, combined with the required aircraft state and position reference symbology, is presented to the flight crew on the Head-Up Display (HUD) or other appropriate, equivalent display. For HUD operations, the pilot flying views the EFVS sensor and symbolic information that is properly aligned and registered to enable a one-to-one (conformal) overlay with the actual external scene. This document is not intended to be a HUD-approval document. The HUD is separately certified and shall remain subject to all applicable rules and guidance for the category of aircraft and operation. This MASPS pertains only to those items particular and unique to EFVS operations.
- 2.2.1.4** The HUD and displayed field-of-regard (FOR) should be sufficient for the EFVS information to be displayed conformally over the range of anticipated aircraft attitudes, aircraft configurations, and environmental (e.g., wind) conditions. The aircraft state and position reference data is presented in the form of symbology overlaying the image presentation. The flight instrument data on the HUD are derived from existing aircraft systems to include:
- a) Airspeed
 - b) Vertical speed
 - c) Aircraft attitude
 - d) Heading
 - e) Altitude
 - f) Command guidance as appropriate for the approach and landing to be flown
 - g) Path deviation indications
 - h) Flight path vector
 - i) Flight path angle reference cue.
- 2.2.1.5** For an EFVS intended for landing and rollout (i.e., from DA through roll-out at not less than 1000 ft. (or 300 M if applicable) RVR visibility, the following specific aircraft flight information, in addition to that noted above in 2.2.1.1.4, shall also be displayed:
- a) Radio altitude
 - b) Flare prompt, unless not adequate for the specific landing criteria required by paragraph 4.2. In this case, flare guidance is required. Note also minimum standards contained in Appendix J, Transport Category Airplanes.

- 2.2.1.6 The approach path situation information references and as appropriate, flight director guidance information should be based on the nav aids dictated by the straight-in instrument approach procedure in use.

For operations when EFVS is only approved for operations to 100 feet above the THRE, under FAA regulations, as defined in 14 CFR §91.175, upon reaching the DA/DH or MDA/MDH, the required visual references presented in Table 3 shall be distinctly visible and identifiable to the pilot using the enhanced flight vision system. Under EASA regulations, as defined in EU-OPS Sub-Part E, upon reaching the DA/DH or MDA/MDH, the required visual references presented in Table 4 shall be distinctly visible and identifiable to the pilot using the enhanced flight vision system.

2.2.2 EFVS System Performance - Standard Operation Conditions

- 2.2.2.1 In terms of sensor design requirements, the performance criteria can be quantified in terms of the range of the enhanced flight visibility, and the visual references of the runway environment that shall be seen by the sensor at operationally relevant distances.

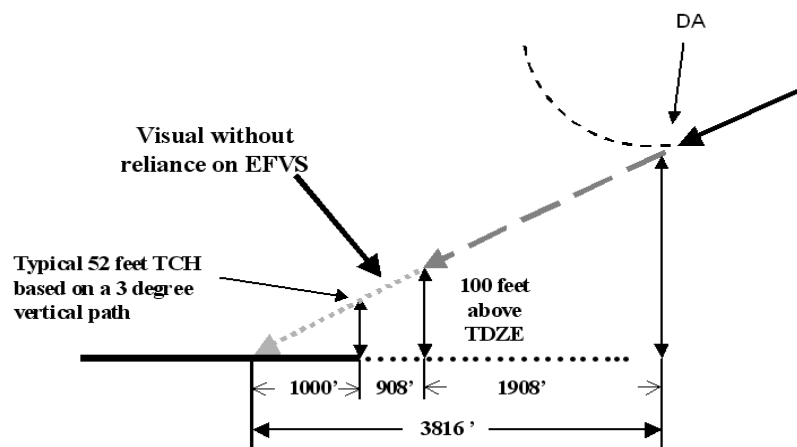


FIGURE 7: MINIMUM DETECTION RANGE

- 2.2.2.2 The minimum detection EFVS range (Figure 7 above) may be derived by using an assumed minimum distance of the aircraft at the nominal Category I (200 ft) decision altitude before which the EFVS shall image the runway threshold. On a 3 degree glideslope, the horizontal distance from the aircraft to the runway threshold is approximately 2816 feet (3816 feet from the precision touchdown zone markers). This range should be used as a minimum requirement. These values do not take into account pilot decision time or actual atmospheric conditions, or the use of non precision approaches which may require greater distances.
- 2.2.2.3 The EFVS operational requirement is further defined as meeting the detection and recognition criteria of the items defined by 14 CFR § 91.175(l). This regulation states the need for the pilot to see the required visual references at no lower than the DH/DA. The necessary visual references, which are performance and design criteria, are presented in Table 3.