



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

MINIMUM AVIATION SYSTEM PERFORMANCE STANDARDS (MASPS) FOR AIRCRAFT STATE AWARENESS SYNTHETIC VISION SYSTEMS

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ED-249

January 2018

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FOREWORD

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IMPROVEMENT SUGGESTION FORM

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CHAPTER 1

PURPOSE AND SCOPE

1.1 INTRODUCTION

DO-315A addressed Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS), and Combined Vision Systems (CVS) technologies. This document identifies system and sub-system performance, safety and equipage requirements for the use of this technology under 14 CFR Part 25. These Minimum Aviation System Performance Standards (MASPS) may, in fact, also be applicable to non-Part 25 aircraft, but specific installation and operational deployment issues associated with these other vehicles have not been considered at this time. The performance standards for this SVS-only expanded functionality are updated from DO-315A. This document does not address EVS, CVS or Enhanced Flight Vision Systems (EFVS) or Synthetic Vision Guidance Systems (SVGS).

1.1.1 Purpose

This MASPS provides high level system requirements for an Aircraft State Awareness SVS (ASA SVS). This document expands the previously defined DO-315A intended function of an SVS beyond that of supplemental view of the external scene to include enhanced aircraft attitude and energy state awareness. This document defines a system that is intended to be presented full-time on the pilots' full color Primary Flight Displays (PFD).

Features of an ASA SVS may also be implemented on a Head-Up Display (HUD) or equivalent and standards for this are defined herein. If a HUD replaces the requirement for an HD PFD, this document may not contain all the appropriate requirements to perform the intended function and an additional assessment will need to be performed for compliance. Wherever the term HUD is used in this document, it is meant to be inclusive of a HUD equivalent type device such as a head worn display (HWD).

ASA SVS is intended to prevent the occurrence of spatial disorientation by supporting the pilots' continuous awareness of attitude, altitude, topography and energy state (speed, acceleration and altitude) related to the flight path and perceived motion of the aircraft. In addition to reducing the risk of controlled flight into terrain (CFIT) it is intended that an SVS meeting this MASPS will reduce the risk of loss-of-control inflight (LOC-I) accidents by preventing the attainment of any unusual (i.e., not normal) attitude and/or energy states that could result in a LOC-I.

NOTE: *The Commercial Aviation Safety Team (CAST) chartered the ASA Joint Safety Analysis Team in 2010 to investigate LOC-I accidents and incidents in which the flightcrew lost awareness of the airplane's attitude and/or energy state. 274 intervention strategies (IS) were identified as mitigations to the standard problems observed in the LOC-I accident analysis. The CAST ASA Joint Safety Intervention Team reviewed the IS and developed 11 new safety enhancements (SE) including training, operations and design implementations. This MASPS was created in support of the desire to provide an industry standard for SE-200: Virtual day visual meteorological condition (VMC) displays (such as synthetic vision or an equivalent system) with energy state symbology cues. While SE-200 was identified as the highest rated design intervention in terms of risk reduction percentage, it is recognized that there exist many other impactful design interventions for reducing LOC-I that are not covered in this MASPS, e.g., Bank Alerting with Recovery Guidance (SE-201), Bank Angle Protection (SE-202), and Low Speed Alerting (SE-192).*

1.1.2 Structure of the Document

Chapter 1 provides an explanation of the scope and purpose of this document and introduces the ASA SVS.

Chapter 2 describes the general requirements of the ASA SVS and its subsystem components.

Chapter 3 describes the detailed system performance requirements for the ASA SVS features and elements. The section also contains the minimum performance standards

for each subsystem/function that is a required element for the minimum system. These standards specify the required performance under standard operational conditions for design context. The section also includes the key assumptions made for the ASA SVS.

Chapter 4 describes the minimum system test procedures to verify system/application performance (e.g., end-to-end performance verification) and that the subsystem performance meets the minimum performance requirements in Chapter 3.

1.2 INTRODUCTION TO AIRCRAFT STATE AWARENESS SYNTHETIC VISION SYSTEM (ASA SVS)

1.2.1 Aircraft State Awareness Synthetic Vision System Overview

An SVS is an electronic means to display a computer-generated depiction 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. ASA SVS symbology includes flight path vector, speed error depiction, and flight path acceleration cue.

The ASA SVS provides the pilot with a virtual day- Visual Meteorological Conditions (VMC) display irrespective of the outside conditions. It is intended to support the pilots' early recognition of non-navigation related divergence from the intended path and thereby reduce the risk of LOC-I.

The ASA SVS is a combination of perspective view synthetic terrain depiction and overlaid primary flight display symbology. The ASA SVS flight instrument display provides a continuous, geo-spatially correct depiction of the external scene topography, including obstacles, augmented by the display of the runway of intended landing. The ASA SVS display is provided to both pilots and is implemented on a full color PFD designed to the guidance provided by AC 25-11B for aircraft certification under 14 CFR Part 25. ASA SVS includes additional symbology and display elements to enhance perception of aircraft motion and to enhance attitude and energy state awareness.

Additional flight instrument display symbology, including an earth referenced flight path vector (FPV), acceleration cue, speed error indicator and depiction of the runway of intended landing (DRIL), is required to provide the pilot a dynamic perception of place and motion cues as the aircraft moves toward the landing runway. Additional optical flow elements are required to improve attitude and terrain awareness at all attitudes, flight levels and topography conditions.

This document primarily describes the application of an ASA SVS based on an AC 25-11B compliant HD PFD. Minimum performance standards are also included for an optional HUD presentation (Section 2.2). Head Up Display with ASA SVS features may be installed as an optional addition to HD ASA SVS.

The intent of including the ASA component to the SVS display system is to prevent spatial disorientation and LOC-I by improving pilot awareness of attitude, energy state and topography awareness. To achieve this intent, additional ASA features on an SVS on the PFD are presented:

1. Full-time in flight;
2. In the primary fields of view;
3. To both pilots.

The ASA SVS features include:

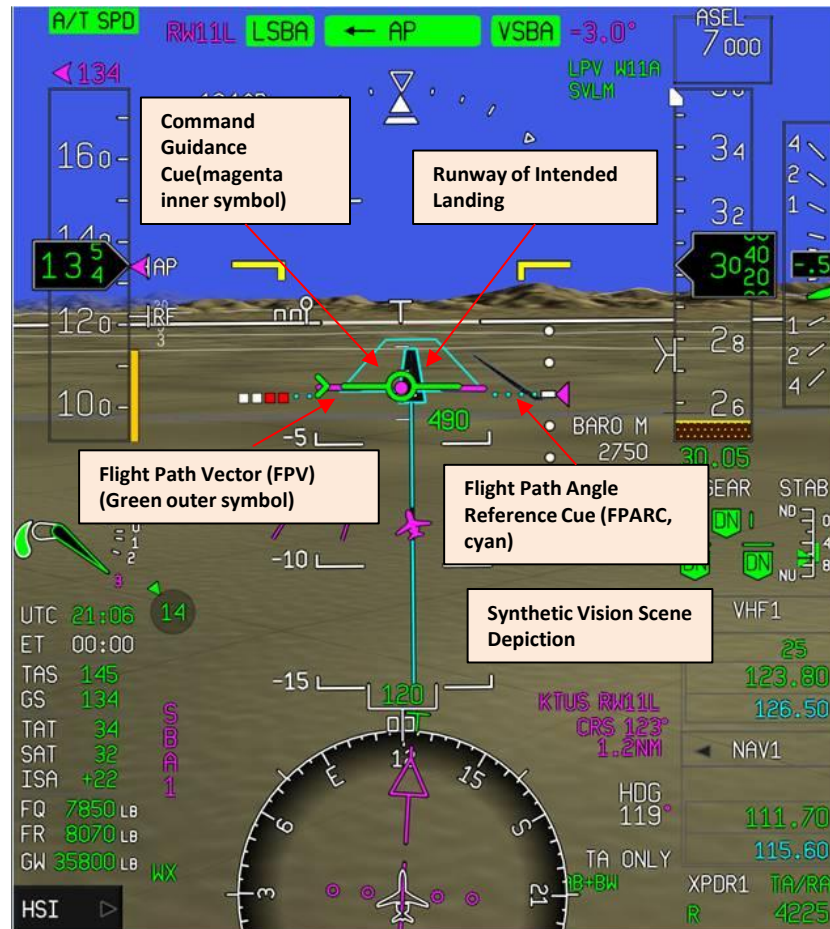
1. Energy state cues;
2. Full color depiction of 3D terrain;
3. Graphical elements to provide perception of aircraft motion.

NOTE: *Although not specified in this document, ASA SVS may also include a roll and pitch recovery display element.*

Full-time presentation of the ASA SVS on the PFD is intended to improve situation awareness, and is used as a preventative countermeasure to LOC-I, and also controlled flight into terrain (CFIT), type accidents. The ASA SVS has a two element enhancement to the PFD: external scene depiction and additional required primary flight symbology. By incorporating the elements into the PFD in the pilot's primary field of view, the pilot has continuous access to the three-dimensional (3D) topographic display that is merged intuitively with conformal attitude and energy awareness symbology. Presentation to

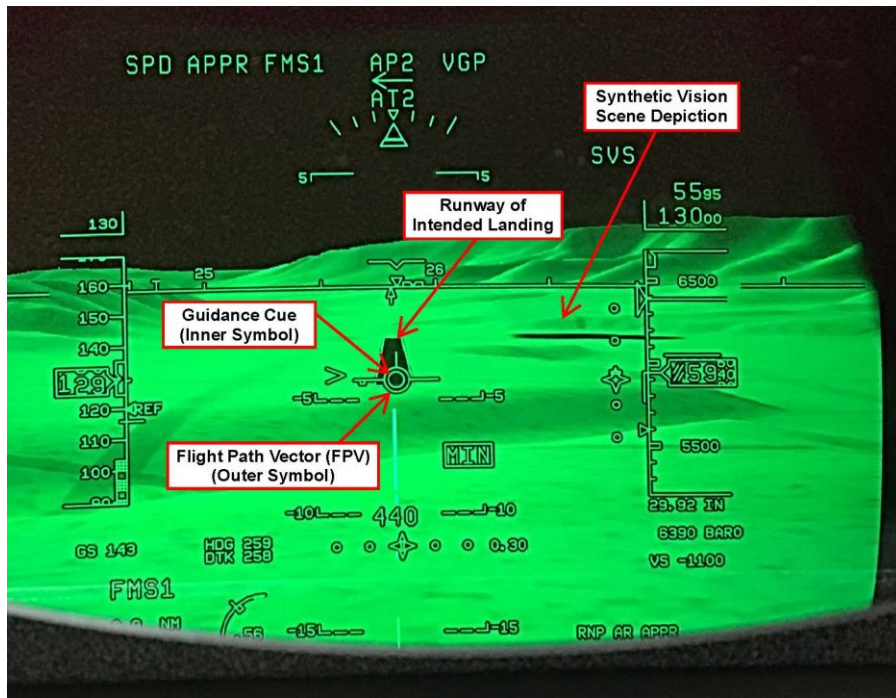
both pilots (i.e., pilot flying and pilot monitoring) supports Crew Resource Management (CRM) by providing a shared visual 3D model of aircraft state and external scene topography. Energy state cues are included in the ASA SVS PFD as an overlay to the full color SV (synthetic vision) scene. The energy state cues provide the pilots with enhanced awareness of current and predicted aircraft performance that enables the pilot to maintain a safe performance and to fly a more stabilized approach.

FIGURE 1-1 illustrates one implementation of some ASA SVS display features on a full color PFD. FIGURE 1-2 illustrates one implementation of some ASA SVS features implemented on a HUD.



Courtesy of Honeywell. Used with permission.

FIGURE 1-1: ASA SVS PFD ILLUSTRATION



Courtesy of Bombardier. Used with permission

FIGURE 1-2: HUD ILLUSTRATION WITH ASA SVS FEATURES

1.2.2

Aircraft State Awareness Synthetic Vision System Elements and Block Diagram

ASA SVS is an installed airborne system that is displayed full-time to both pilots on the full color HD PFD in the primary field of view and is comprised of the following components:

1. Synthetic vision flight display.
2. Terrain, runway and obstacle databases.
3. DRIL.
4. FPV.
5. Optical flow elements.
6. Speed error depiction.
7. Flight path acceleration cue.
8. Margin to stall depiction.

The relationship between functions of the ASA SVS is illustrated in notional block diagram [FIGURE 1-3](#).

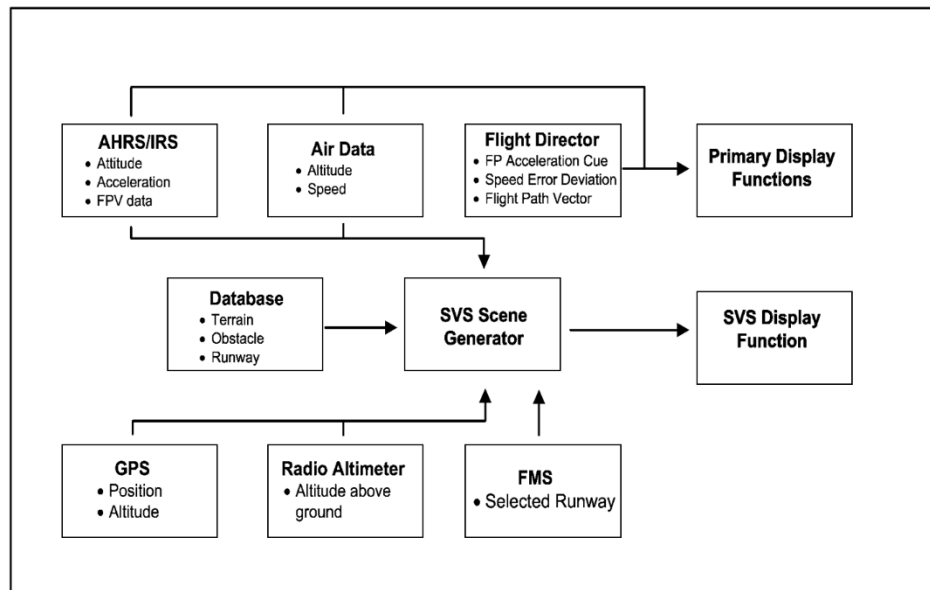


FIGURE 1-3: ASA SVS FUNCTIONAL ELEMENTS (NOTIONAL)

The above figure provides an example only of an architecture that provides the required intended function. This example uses a combination of on-board sensors like AHRS/IRS, air data sensor, GPS, radio altimeter; avionics systems such as FMS and Flight Director that all instrument flight equipped aircraft contain; and geo-spatially referenced databases to generate the SVS image, with the required ASA features, on the HD PFD. The standard inertial and air data provide the aircraft state data required to conform the displayed image with the aircraft's inertial and/or physical axes appropriate to the intended function. The radio altitude provides the accurate aircraft altitude above the ground to position the aircraft conformal to the runway at low altitudes in the terminal areas. The SV scene generator constructs the synthesized terrain topography combining with the obstacles and runways of intended landing using the geo-spatial onboard database information retrieved based on the GPS navigation position.

The energy state awareness cues of speed error tape, flight path vector and acceleration cue are presented with flight director guidance along with a combination of command, control, performance information and, air and inertial data from the sensors. The display element superimposes the energy state awareness cues along with the flight instrument symbology over the SV scene generator constructed topographical out-the-window image. The displayed elements present the features and characteristics required to improve attitude and terrain awareness at all attitudes, flight levels and topography conditions.

1.3

AIRCRAFT STATE AWARENESS SYNTHETIC VISION SYSTEM OPERATIONAL CONCEPT

The ASA SVS is incorporated into the PFD. The PFD is the primary means for presenting information to the pilot to support controlling, maneuvering and monitoring flight when manually flying the aircraft in all phases of flight. In addition, the PFD is used to monitor the aircraft flight path and energy state during automated flight control operations of the aircraft. The pilot's ability to see and use the required essential flight display information, e.g. primary attitude, airspeed, altitude, command bars, shall not be hindered or compromised by the SV scene. It shall continue to meet the same performance and information requirements as a conventional PFD.

Pilot disorientation can occur during all phases of flight, altitudes and topography. Great care should be exercised to ensure that SV optical flow features (i.e., display elements to enhance perception of aircraft motion) are present throughout all phase of flight to support early recognition of divergence from intended flight parameters including path.

1.4 AIRCRAFT STATE AWARENESS SYNTHETIC VISION SYSTEM INTENDED FUNCTIONS

The intended function of the ASA SVS is to provide a supplemental day VMC-like view of the external scene; that, along with additional required flight symbology, will improve awareness of terrain, obstacles, and relevant cultural features, and enhance pilot awareness of attitude and energy state. ASA SVS is intended as a preventative means to reduce the risk of LOC-I and CFIT; however, it does not replace TAWS.

ASA SVS provides enhanced attitude and energy awareness to both the pilot flying and pilot monitoring in all airborne phases of flight and in all flight environments including:

- All topography, including terrain rich environments, water and featureless terrain.
- From the surface to the maximum operating altitude.
- Various aircraft orientations including non-normal bank and pitch angles.

1.5 USE OF KEY WORDS

To ensure consistency of interpretation of performance requirements and test procedures contained in Section 2 of this MASPS, the following table of definitions is provided:

TABLE 1-1: TERMS FOR USE IN PERFORMANCE REQUIREMENTS AND TEST PROCEDURES

	Requirements	Good Industry Practice	Alternate Method
Word	<i>Shall</i>	<i>Should</i>	<i>May</i>
Meaning	Refers to a mandatory performance requirement or test procedure	Refers to a performance or test procedure recommendation that, although not mandatory, is considered good industry practice	With regard to performance requirements and test procedures, refers to an alternate approach for manufacturer consideration
Impact to Design	Could result in inability to meet intended function or interoperability with other equipment	Although not necessary to meet performance requirements, could result in a deficiency to the end user or installation problems if not followed	None. However, the alternate method should be followed in its entirety if the manufacturer chooses to use that method

In the text of performance requirements, the use of the words “must” and “will” is discouraged.

1.6 AIRCRAFT EQUIPMENT INFORMATION VULNERABILITIES

Aircraft equipment information vulnerabilities (such as cybersecurity risks) have been present for digital systems since the development of the personal computer (PC) in the late 70's and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment manufacturers to update installed avionics software, to update databases, or provide an alternate means of communicating with the flight crew or cabin (e.g., in-flight entertainment, weather, etc.).

In most countries, the State provides oversight of safety-of-flight systems (sometimes referred to as “authorized services”) which provide information to aircraft, such as ILS, VOR, GNSS, and DME, to name a few. However, the State typically does not provide

oversight on “non-trusted”¹ connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit input of externally-supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerability through equipment design, or become vulnerable as a result of being connected to a common interface. Therefore, it is important that manufacturers consider aircraft information security risk mitigation strategies in their equipment design, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

Apart from any specific aircraft-information-security-related performance requirements that are contained in this MASPS, it is recommended that manufacturers look at a layered approach to aircraft information security risk mitigation that includes both technical (e.g., software, signal filtering) and physical strategies. From a technical perspective, for example, this could include signal spoofing detection capabilities or more stringent, multi-factored authentication techniques such as passwords, PINs, and digital certificates. From a physical perspective, for example, such as in an in-flight entertainment system in the cabin, a manufacturer could consider connectors that require special tools to remove to prevent passenger tampering. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer is outsourcing software code development, is the contractor and its staff properly vetted?

Civil Aviation Authorities (CAAs) have a regulatory interest when an applicant’s design makes use of a non-trusted connectivity where the installation can potentially introduce aircraft information security vulnerability. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerability could propagate to existing downstream systems. Therefore, it is recommended that manufacturers reference their equipment aircraft information security review and mitigation strategies in the equipment’s installation manual so that the applicant can consider them in meeting the installation regulatory requirements.

1.7

ANTICIPATED FUTURE GROWTH

It is recognized that there may be expanded future use or intended function that impacts minimum performance requirements and design assurance level of the HD PFD ASA. Over design of the function on the front-end to accommodate future, yet-to-be-determined growth or technologies is a business decision best made by the manufacturer and was avoided in creation of this document.

¹ A “non-trusted” connectivity (sometimes referred to as third-party system) is any frequency or service where an Air Navigation Service Provider (ANSP) is not providing direct monitoring/protection.

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CHAPTER 2

AIRCRAFT STATE AWARENESS SYNTHETIC VISION SYSTEM GENERAL REQUIREMENTS

The requirements described below are general and, by their general nature, may not be quantitatively verifiable. Subjective evaluation and verification may be the norm.

Section 3 builds on the general requirements described below and provides the quantifiable and verifiable details and parameters where these are applicable.

2.1

ASA SVS GENERAL REQUIREMENTS

The SVS with ASA performance standards specified below are based on the premise that the ASA SVS system has two element enhancements to the PFD: external scene depiction and enhanced primary flight symbology.

For specific HUD general requirements that may be in addition to or in lieu of HD PFD requirements, see Section 2.2.

The following general requirements, and the specific requirements in Section 3, apply to an ASA SVS with the intended functionality described in Section 1.4 of this MASPS.

1. The display of the ASA SVS shall not negatively affect any basic PFD functionality nor degrade the presentation of any other flight or alerting information that is essential for controlling the aircraft in a particular flight phase, weather condition, traffic situation or aircraft configuration.
2. The ASA SVS display characteristics and dynamics shall be suitable and effective for manual control of the aircraft under all foreseeable normal and non-normal flight conditions, e.g., unusual attitudes, low speed conditions.
 - The system shall perform its intended function in all phases of flight and topography specifically including terrain rich environments, water and featureless terrain, from the surface to the maximum operating altitude and at various aircraft orientations including non-normal bank and pitch angles.
3. The system shall have a means to automatically or manually control display brightness.
4. A PFD modified to display an ASA SVS shall continue to meet all the requirements of its original approval (if applicable).
5. If not already approved, the PFD, with the ASA SVS features embedded, shall meet all the applicable primary flight information regulations and guidance for a 14 CFR Part 25 certified aircraft.
6. The installed ASA SVS shall not adversely affect any other installed aircraft system.
7. Scaling differences between the displayed image/symbology and the axes (vertical and lateral) shall not present misleading information. 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.

NOTE: *The displayed image may be aligned with aircraft's inertial axis or physical axis, both are acceptable for the intended function and may be phase of flight dependent. The relationship between the image and the aircraft's heading angle, pitch angle, roll angle, and track angle should be readily recognizable by the pilots. The displayed image and symbology can have different scaling between the vertical and lateral axes.*

8. If variable field of regard is installed, it shall present no distracting or misleading images or adversely affect pilot workload.
9. 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.

2.1.1

ASA SVS Scene Depiction Requirements

ASA SVS requires a terrain, runway and obstacle databases, a precision navigation position, and a display. The design and installation safety levels of the ASA SVS should be appropriate for the system's intended function. The following guidance applies to SVS displays: FAA AC 20-167A, FAA AC 25-11B.

The purpose of the SV scene depiction is to support spatial orientation by providing a representation of the external environment during day VMC, including the runway of intended landing, the surrounding topography and the relevant obstacles. Database elements shall be integrated into a unified representation of the outside view.

The following requirements apply to the ASA SVS scene depiction.

1. The SV scene depiction shall allow the pilots to easily recognize and use the primary flight display information such as primary attitude, airspeed, altitude, flight path, command bars, etc.
2. The ASA SVS primary display shall include a geospatially correct depiction of the external topography from the pilot flying's perspective and derived from aircraft attitude, altitude, position, and a coordinate-referenced database. Either a flight path (i.e., inertial referenced) or heading centered orientation may be demonstrated as an acceptable frame of reference for the SV scene depiction.
3. The scene shall include depiction of runways relevant to the operation. As a minimum the scene shall include a geospatially correct outline of the DRIL. The DRIL is used in concert with the flight path vector symbology cue to support energy, attitude and longitudinal alignment awareness.
4. The scene shall include optical flow elements, such as texturing, edges and grid lines, that provide a sense of motion over all topography during all phases of flight while exercising normal maneuvers (for example, approach or climb maneuvers at high bank with high thrust-to-weight ratios).
5. The SV scene depiction is intended to be depicted full time; however, in case of non-normal procedures, operations or emergency, a method to inhibit SVS shall be provided.
6. Display status of the SV scene depiction through pilot selection of inhibit function, or as a result of system removal from a failure or other reason, shall be clearly indicated or obvious to the pilots.
7. Prominent dominant topographical features present in the SV scene depiction shall be easily identified and correlated with the actual external scene. The converse is also a requirement; dominant topographical features present in the outside view should be identifiable in the SV scene depiction.
8. The SV scene shall enable the pilots to perceive relative distances to prominent topographical features. One method that has been demonstrated to be effective for distance estimation is the inclusion of indications of range on the SV scene display.
9. Position accuracy, symbology, and topographical information shall be consistent with each other.
10. All aircraft provide a TAWS or terrain warning system as defined in AC 20-167A Section H.2. If terrain alerts and cautions are depicted on the ASA SVS, they shall be consistent across all displays in the cockpit when terrain threats are identified.
11. The pilot's view shall not be depicted below the earth's surface.
12. The scene range from the eye position to the terrain horizon shall be sufficient so that the ASA SVS can fully perform the intended function described in Section 1.4.
13. Water and sky depictions shall be clearly distinguishable.
14. Display characteristics shall comply with AC 20-167A and AC 25-11B. All undesirable display characteristics shall be minimized (e.g., jitter, jerky motion, excessive delays, etc.).
15. ASA SVS primary displays shall be clear and unambiguous. A quick-glance interpretation of attitude should be possible for all unusual attitude situations and