



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

SAFETY, PERFORMANCE AND INTEROPERABILITY REQUIREMENTS DOCUMENT DEFINING TAKEOFF MINIMA BY USE OF ENHANCED FLIGHT VISION SYSTEMS

This document is the exclusive intellectual and commercial property of EUROCAE.

It is presently commercialised by EUROCAE.

This electronic copy is delivered to your company/organisation for internal use exclusively.

In no case it may be re-sold, or hired, lent or exchanged outside your company.

ED-257

October 2018

SAFETY, PERFORMANCE AND INTEROPERABILITY REQUIREMENTS DOCUMENT DEFINING TAKEOFF MINIMA BY USE OF ENHANCED FLIGHT VISION SYSTEMS

This document is the exclusive intellectual and commercial property of EUROCAE.

It is presently commercialised by EUROCAE.

This electronic copy is delivered to your company/organisation for internal use exclusively.

In no case it may be re-sold, or hired, lent or exchanged outside your company.

ED-257

October 2018

© EUROCAE, 2018

FOREWORD

1. This document was prepared jointly by EUROCAE Working Group 79 “Enhanced Vision Systems / Synthetic Vision Systems” and RTCA SC-213 “Enhanced Vision Systems / Synthetic Vision Systems” and was approved by the Council of EUROCAE on 05 October 2018.
2. EUROCAE is an international non-profit making organisation in Europe. Membership is open to manufacturers and users of equipment for aeronautics, trade associations, national civil aviation administrations, and, under certain conditions, non-European organisations. Its work programme is principally directed to the preparation of performance specifications and guidance documents for civil aviation equipment, for adoption and use at European and world-wide levels.
3. The findings of EUROCAE are resolved after discussion amongst Members of EUROCAE and in collaboration with RTCA Inc, Washington D.C., and/or the Society of Automotive Engineers (SAE), Warrendale PA, U.S.A., through their appropriate committees.
4. This document is technically identical to DO-374.
5. EUROCAE performance specifications and other documents are recommendations only. EUROCAE is not an official body of the European Governments. Its recommendations are valid as statements of official policy only when adopted by a particular government or conference of governments.
6. Copies of this document may be obtained from:

EUROCAE
9-23 rue Paul Lafargue
93200 Saint-Denis
France

Telephone: +33 1 49 46 19 65

Email: eurocae@eurocae.net

Website: www.eurocae.net

EXECUTIVE SUMMARY

This document provides the minimum operational, safety, and performance requirements (SPR) and interoperability requirements by which takeoff operations using an Enhanced Flight Vision System (EFVS) can be safely conducted in natural visibilities lower than currently authorized. These takeoff minima and associated SPRs are established for the use of EFVS, treated as subsystems, which together with other subsystems including navigational aids and airport lighting and markings, meet the operational goal/intended function and achieve the levels of reliability, availability, and integrity consistent with other systems and subsystems used for the similar intended function and phase of flight. In this document, recommendations for EFVS takeoff minima are defined with various associated aircraft equipage, operational and interoperability requirements, and airport infrastructure. The visibility minima are defined in terms of natural visibility since, in the event of a failure or failures, the PF uses a combination of the remaining functional elements, other aircraft subsystems, and available out-the-window natural vision cues (e.g., lights and/or markings of the runway) to mitigate the failure effects and conduct a safe, successful takeoff or rejected takeoff.

TABLE OF CONTENTS

FOREWORD	I
EXECUTIVE SUMMARY	II
CHAPTER 1 INTRODUCTION.....	1
1.1 PURPOSE OF THIS DOCUMENT	1
1.1.1 TAKEOFF MINIMA BY USE OF ENHANCED FLIGHT VISION SYSTEMS	1
1.1.2 ETOS INTENDED FUNCTION	3
1.1.3 USE OF DOCUMENT FOR APPROVALS	3
1.1.4 BACKGROUND – VISION SYSTEMS TECHNOLOGIES.....	4
1.1.5 EFVS TAKEOFF SYSTEM (ETOS) CONCEPT	5
1.1.6 RELATIONSHIP TO OTHER APPLICATIONS.....	7
1.2 SCOPE OF THE DOCUMENT	7
1.3 STRUCTURE OF THIS DOCUMENT	7
1.3.1 DOCUMENT ORGANIZATION.....	7
1.4 AIRCRAFT EQUIPMENT INFORMATION VULNERABILITIES	8
1.5 REFERENCES	9
1.5.1 ICAO	9
1.5.2 SOCIETY OF AUTOMOTIVE ENGINEERING (SAE) DOCUMENTS.....	9
1.5.3 FAA DOCUMENTS	9
1.5.4 EASA / TCCA	9
1.5.5 EUROCAE/RTCA DOCUMENTS.....	10
CHAPTER 2 APPROACH AND METHODOLOGY	11
2.1 DOCUMENT DEVELOPMENT PROCESS	11
2.2 METHODOLOGY	11
2.2.1 OPERATIONAL SERVICES AND ENVIRONMENT DEFINITION (OSD)	11
2.2.2 SAFETY AND PERFORMANCE REQUIREMENTS	11
2.2.3 INTEROPERABILITY REQUIREMENTS (INTEROP)	12
2.3 KEY TERMS.....	12
2.3.1 USE OF REQUIREMENTS AND RECOMMENDATIONS AND KEY WORDS	12
2.3.2 ASSUMPTIONS.....	12
2.3.3 MITIGATION MEANS.....	13
2.3.4 REQUIREMENTS	13
2.3.5 RECOMMENDATIONS.....	14
CHAPTER 3 SAFETY AND PERFORMANCE REQUIREMENTS (SPR).....	15
3.1 INTRODUCTION	15
3.1.1 OPA PROCESS	15
3.1.2 OSA PROCESS	15
3.1.2.1 MITIGATION MEANS.....	16
3.1.3 SPR PROCESS	16
3.2 ASSUMPTIONS.....	17
3.2.1 GENERAL ASSUMPTIONS.....	17
3.2.2 ENVIRONMENTAL ASSUMPTIONS	17

	3.2.3 OTHER ASSUMPTIONS	17
	3.3 OPERATIONAL REQUIREMENTS.....	17
	3.4 ETOS REQUIREMENTS.....	19
	3.4.1 FUNCTIONAL REQUIREMENTS.....	19
	3.4.1.1 AIRPORT / ANSP REQUIREMENTS	20
	3.4.2 PERFORMANCE REQUIREMENTS.....	20
	3.4.2.1 INTEGRITY AND SAFETY REQUIREMENTS.....	21
	3.5 DATA REQUIREMENTS	23
	3.6 RECOMMENDATIONS AND DESIGN CONSIDERATIONS	23
	3.7 TRAINING CONSIDERATIONS.....	23
CHAPTER 4	INTEROPERABILITY REQUIREMENTS.....	24
	4.1 PURPOSE OF INTEROPERABILITY REQUIREMENTS	24
	4.2 SCOPE OF INTEROPERABILITY REQUIREMENTS	24
	4.2.1 ETOS DOMAINS.....	24
	4.2.1.1 OWNERSHIP DOMAIN	24
	4.2.1.2 OTHER AIRCRAFT AND VEHICLES DOMAIN.....	24
	4.2.1.3 GROUND DOMAIN	24
	4.3 ETOS INTEROPERABILITY REQUIREMENTS	24
	4.3.1 INTEROP DATA	25
CHAPTER 5	MEMBERSHIP	26
APPENDIX A	OPERATIONAL SERVICES AND ENVIRONMENT DEFINITION.....	A-1
	A.1 INTRODUCTION	A-1
	A.2 BACKGROUND – AERODROME OPERATIONS.....	A-1
	A.3 BACKGROUND – TAKEOFF OPERATIONS	A-2
	A.4 ROLES AND RESPONSIBILITIES	A-4
	A.4.1 AIRPORT	A-4
	A.4.2 AIR TRAFFIC CONTROL – IF ACTIVE.....	A-4
	A.4.3 FLIGHT CREW	A-5
	A.5 INTENDED FUNCTION	A-5
	A.6 EFVS TAKEOFF - CONCEPT OF OPERATIONS.....	A-5
	A.6.1 IMPACT ON PHRASEOLOGY.....	A-8
	A.6.2 AIRSPACE CHARACTERISTICS	A-8
	A.6.3 PARTIAL AND MIXED EQUIPAGE CONSIDERATIONS	A-9
	A.6.3.1 AIR TRAFFIC CONTROL – IF ACTIVE	A-9
	A.6.3.2 COCKPIT	A-9
	A.6.3.3 AIR TRAFFIC CONTROL – TOWER NOT ACTIVE	A-9
APPENDIX B	OPERATIONAL PERFORMANCE ASSESSMENT	B-1
	B.1 INTRODUCTION	B-1
	B.1.1 PURPOSE.....	B-1
	B.1.2 GENERAL PERFORMANCE REQUIREMENTS	B-1
	B.1.3 COMPLIANCE TESTING.....	B-2
APPENDIX C	OPERATIONAL SAFETY ASSESSMENT (OSA)	C-1
	C.1 OBJECTIVES / SCOPE	C-1

C.2	SYSTEM SAFETY OVERVIEW	C-1
C.2.1.	EFVS ENVIRONMENT	C-1
C.3	OHA PROCESS	C-2
C.3.1	HAZARD ASSESSMENT	C-2
C.3.2	SYSTEM SAFETY LEVELS AND PROBABILITIES	C-3
C.3.3	DESIGN ASSURANCE LEVELS AND DEMONSTRATION	C-3
C.3.4	ENVIRONMENTAL QUALIFICATION	C-3
C.3.5	SAFETY DEMONSTRATION.....	C-3
C.3.5.1	MITIGATIONS	C-4
C.3.5.2	ADDITIONAL POSSIBLE MITIGATIONS BEYOND MINIMAL SET	C-6
C.3.5.3	MITIGATIONS NOT CONSIDERED TO BE ACCEPTABLE AT THIS TIME	C-6
C.4	MINIMUM SAFETY REQUIREMENTS	C-6
C.4.1	OVERALL OBJECTIVES	C-6
C.4.1.1	ASSUMPTIONS	C-7
C.5	ETOS-500 FHA: NO LOWER THAN 500 FT VISIBILITY, TYPE 1/E RUNWAY OR BETTER, AT LEAST 2 RVR REPORTING.....	C-8
C.6	ETOS-1000 FHA: NO LOWER THAN 1000 FT VISIBILITY.....	C-15

TABLE OF TABLES

TABLE 1-1: SUMMARY OF VISIBILITY MINIMA OPERATION.....	3
TABLE 3-1: OPERATIONAL REQUIREMENTS.....	17
TABLE 3-2: ETOS FUNCTIONAL REQUIREMENTS.....	19
TABLE 3-3: ETOS PERFORMANCE REQUIREMENTS.....	20
TABLE 3-4: ETOS SAFETY REQUIREMENTS.....	22
TABLE A-1: LOWEST ALLOWABLE VISIBILITY MINIMA PER OPSPEC C078/C079.....	A-3
TABLE C-1: HAZARD ASSESSMENT EFFECTS, PROBABILITIES AND DESIGN ASSURANCE LEVELS	C-2
TABLE D-1: ACRONYMS	D-1
TABLE E-1: GLOSSARY	E-1

TABLE OF FIGURES

FIGURE 1-1: EXAMPLE MINIMUM ETOS-1000 INFORMATION CONCEPT OVERVIEW	6
FIGURE 1-2: EXAMPLE MINIMUM ETOS-500 INFORMATION CONCEPT	6
FIGURE 2-1: SCHEMATIC OF REQUIREMENTS RELATIONSHIPS.....	14
FIGURE A-1: EXAMPLE ETOS-1000 CONCEPT	A-8
FIGURE A-2: EXAMPLE ETOS-500 CONCEPT	A-8

CHAPTER 1

INTRODUCTION

This document is the minimum operational, safety, and performance requirements (SPR) and interoperability requirements (INTEROP) for Enhanced Flight Vision System (EFVS) associated with recommended takeoff minima.

Takeoff minima are established for the use of vision systems technologies, treated as subsystems, which together with other subsystems including navigational aids and airport lighting and markings, are used to accomplish the operational goal, achieve levels of reliability, availability, and integrity appropriate to the intended function and phase of flight. These levels are consistent with other systems and subsystems used for the same intended function and phase of flight.

Safety, performance, and interoperability requirements are derived from examination of the operation and the associated performance and safety analyses. The operation is outlined in the Operational Services and Environment Definition (OSED) in Appendix A. The Operational Performance Assessment (OPA) for this operation is established in Appendix B. Finally, the Operational Safety Assessment (OSA) is presented in Appendix C which analyzes the operational safety by considering potential hazards to which the flight crew and/or aircraft might be exposed during the EFVS takeoff operation and derives requirements in order to control the likelihood of the hazards and their effects. The assessment criteria are derived in whole or in part from applicable, existing guidance material which identifies airworthiness approval guidance for airborne systems used during a takeoff in low visibility weather conditions.

All material in this document was developed jointly by EUROCAE Working Group 79 (WG-79) and RTCA Special Committee-213 (SC-213).

The requirements specified in this document are necessary to provide adequate assurance that the aircraft systems and other systems, when operating together, will perform their intended function – EFVS Takeoff – in an acceptably safe manner for the operations defined in the OSED. The system here includes the interaction and interoperability with ground and air navigation service provider elements.

1.1

PURPOSE OF THIS DOCUMENT

This document defines and allocates the set of minimum requirements for the end-to-end operational, safety, performance, and interoperability aspects for implementations of EFVS takeoff with recommended minima.

Allocation of these requirements is done by this SPR/INTEROP to the necessary domains of the aircraft with dependencies and assumptions, if necessary, to the airport operations, air navigation services providers (ANSP), and infrastructure level.

These requirements are intended to be used for approval processes including aircraft type design approval, aircraft operator operational approval, and (should they be necessary) Air Traffic Services (ATS) provider operational approval. Chapter 1.1.3 below provides more information on the use of this document for approvals.

In addition, this document provides guidance to determine the levels of design assurance and performance that are needed for each element (aircraft, operator, and, if applicable, ANSP—Air Navigation Service Provider and airport infra-structure level) to support the application.

1.1.1

Takeoff Minima by use of Enhanced Flight Vision Systems

An Enhanced Flight Vision System (EFVS) is an electronic means to provide a display of the forward external scene topography through the use of imaging sensors. The EFVS consists of a display element (a Head-Up Display (HUD) or an equivalent display), sensors that provide a real-time image of the forward external scene topography, conformal and non-conformal symbology, and associated electronics, controls, and indications.

An EFVS is the means by which to provide the pilot/flight crew with Enhanced Flight Visibility which 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.”

Within this context, approach and landing in instrument flight conditions can be conducted under 14 CFR §91.176(b), by use of an approved EFVS to 100 ft Height Above Touchdown Zone Elevation (HAT). Minimum Aviation System Performance Standards (MASPS) for EFVS equipage have been published as RTCA DO-315.

Further, MASPS for the use of EFVS during approach, landing, and roll-out down to 1000 ft Runway Visual Range (RVR) have been published as DO-315A (authorized under 14 CFR §91.176(a)) and the use of EFVS during approach, landing, and roll-out to a safe taxi speed down to 300 ft RVR have been published as RTCA DO-341. Important Advisory Circular (AC) materials for these operations are contained in AC 90-106A and AC 20-167A.

In this document, the visibility minima for an EFVS-enabled takeoff operation are defined. The baseline system equipage is a system that is certified and meets the RTCA DO-315A MASPS for approach and landing down to 1000 ft RVR.

Takeoff is a visual maneuver and the use of EFVS, in this phase of flight, with the visual advantage that it provides, creates an operational and safety benefit.

Takeoff begins at brake release on the runway to liftoff and climb to 35 ft. above ground level, and from brake release through deceleration to a stop for a rejected takeoff. The Pilot-Flying (PF) visually conducts the takeoff using the EFVS with the Pilot-Monitoring (PM), providing speed call-outs, systems monitoring, and other assistance as per Standard Operating Procedures.

An EFVS is the means by which the takeoff operation can be safely conducted in natural visibilities lower than authorized without the use of EFVS.

In this document, recommendations for EFVS takeoff minima are defined with various associated aircraft equipage, operational and interoperability requirements, and airport infrastructure. The visibility minima are defined in terms of natural visibility since, in the event of a failure or failures, the PF uses a combination of the remaining functional elements, other aircraft subsystems, and available out-the-window natural vision cues (e.g., lights and/or markings of the runway) to mitigate the failure effects and conduct a safe, successful takeoff or rejected takeoff. The two visibility minima conditions defined in this SPR are:

1. No lower than 1000 ft visibility and visible Runway Centerline Markings (RCLMs) or High Intensity Runway Lights (HIRLs)/Medium Intensity Runway edge Lights (MIRLs), if RCLMs obscured. RVR reporting is not required. An electronic means to define runway center or centerline may be used to augment this operation and is required in the absence of visible RCLMs or HIRLs/MIRLs.
2. No lower than 500 ft visibility on a Type 1/E runway or equivalent/better, with at least 2 RVR reports, High Intensity Runway edge Lights (HIRLs); and an electronic definition of the runway centerline or center by means of an XLS (Generic Landing System).

These two minima conditions and the associated required environmental conditions, runway equipage, and aircraft equipage are summarized in TABLE 1-1.

TABLE 1-1: SUMMARY OF VISIBILITY MINIMA OPERATION

	<i>Environ. Conditions</i>		<i>Runway Equipage</i>				<i>Aircraft Equipage</i>		
	Min. Reported Visibility	RCLM Visible	RW Type	RW CLL	RW Edge Lights	RVR Req'd	EFVS	Elec. Def. of RW CL	RCLM in EFVS
<i>ETOS-1000</i>	1000 ft (300 m)	Y	1	Not Req'd	N/A	N	Req'd	Not Req'd	N
		N			HIRL / MIRL				Y
<i>ETOS-500</i>	500 ft (150 m)	Y or N	1/E		HIRL	At least 2		Req'd	

Nomenclature: RW - Runway; Req'd – Required; N/A – not applicable

The terminology of an EFVS Takeoff System (ETOS) is used herein to indicate the aircraft systems requirements and the role of the EFVS imagery, symbology for the takeoff operation, and possibly other aircraft systems and subsystems, necessary for this operation.

The minimum system requirements for an ETOS are built from a baseline minimum capability as defined by EFVS and other associated aircraft systems that enable operations to landing as per DO-315A.

Additional functionality above and beyond this baseline equipage may be necessary for certain visibility and runway infrastructure conditions or for the takeoff operation itself. These items are defined and considered in their effect on takeoff visibility minima and required airport equipage (e.g., lights and/or markings of the runway).

Further, dependencies and assumptions, if necessary, are identified to the airport operations, air navigation services providers, and infrastructure level to enable these takeoff minima.

1.1.2

ETOS Intended Function

The intended function of the system – an EFVS Takeoff System (ETOS) - described herein is as follows:

An ETOS (an EFVS and associated aircraft systems) allows the pilot to safely track and maintain the runway centerline during a takeoff from brake release on the runway to liftoff and climb to 35 ft. AGL, and from brake release through deceleration to a stop for a rejected takeoff, in natural visibilities lower than authorized without the use of EFVS.

Takeoff minima are achieved through the use of vision systems technologies, treated as subsystems, which together with other subsystems including navigational aids and/or airport lighting and/or markings, are used to accomplish the operational goal, achieve levels of reliability, availability, and integrity appropriate to the intended function.

The OSED on which all analyses in this SPR/INTEROP is based is contained in Appendix A of this document.

This initial document is limited in scope to an ETOS. Subsequent amendments or other documents may be written and adopted using this same philosophy for other technologies.

1.1.3

Use of Document for Approvals

This document is intended to define the required elements and includes possible operational and mitigating equipage that support these recommended EFVS takeoff minima.

The corresponding safety, performance, and interoperability assessments are based on the detailed specification of the OSED. States or regions implementing an application different to that specified in the OSED must take into account those differences in the operations and/or environment in supporting analysis.

The assessments and specifications in this document are not intended to be a sole basis for operational and airworthiness approval. However, this material can be used as an important component for establishing minimum design and system performance standards for aircraft operator and aircraft certification approvals for EFVS takeoff minima.

1.1.4

Background – Vision Systems Technologies

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 (e.g., radar) or passive (e.g., Forward Looking InfraRed).

A Synthetic Vision System (SVS) as defined by 14 CFR Part 1 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.

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

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 US regulations, an EFVS used to conduct operations under 14 CFR §91.176, §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 §91.176, 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.

For European operators, EFVS operations are conducted under specific approvals (SPA) for Low Visibility Operations (LVO) - SPA.LVO - following Commission Regulation (European Union, EU) No. 965/2012 and shall have an EASA type design approval (CS.AWO.EFVS.A). For a foreign-registered aircraft conducting operations in European airspace, the EFVS shall comply with all of the EFVS requirements of the European operational regulations.

Under 14 CFR Part 91.176, the EFVS sensor imagery and aircraft flight symbology are presented on a head-up display, or an equivalent display. For EFVS takeoff, a HUD or equivalent display shall also be required.

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 SPR pertains only to those items particular and unique to EFVS takeoff operations.

The requirements contained in this document pertain to the use of an EFVS which involves a HUD or equivalent display as defined by 14 CFR Part 91.176. Wherever possible the requirements and mitigation for the ETOS define the minimum necessary information to enable or augment such a system. The SPR assumes the use of the HUD, however the applicant may propose an equivalent display, as per 14 CFR Part 91.176, to meet the system requirements and demonstrate that all safety and performance aspects are met. For simplicity, the term "equivalent display" will not always be used across this entire document.

1.1.5

EFVS Takeoff System (ETOS) Concept

The PF conducts a visual takeoff primarily using the ETOS and other supplemental information.

The ETOS-1000 concept enabling this visual takeoff is shown in [FIGURE 1-1](#). The EFVS, shown on the HUD, portrays the imaging sensor information (Item (1)). The extent of the imaging sensor information is, at a minimum, 15 deg vertical (V) x 20 deg horizontal (H) field-of-view as per DO-315A. The enhanced vision imagery is augmented with situational and conformal symbology that includes course or heading indication (Item (2)). Around the HUD and possibly permeating the HUD information and combiner glass, out-the-window natural vision information (Item (3)) may be seen and used depending upon on the lights and markings of the runway and surrounding topography and the prevailing natural visibility. This figure illustrates a baseline EFVS equipage assumption that is used to develop the SPR.

This baseline concept may be augmented as shown in [FIGURE 1-2](#) to include additional symbology which includes an expanded lateral path deviation where there is an electronic means to define the runway center or centerline (Item (4)), creating the ETOS-500 concept.

In addition, synthetic vision information may be added to form a combined vision system (Item (5)).

These elements convey situation information (i.e., information that directly informs the pilot about the status of the aircraft operation or specific flight parameters including flight path).

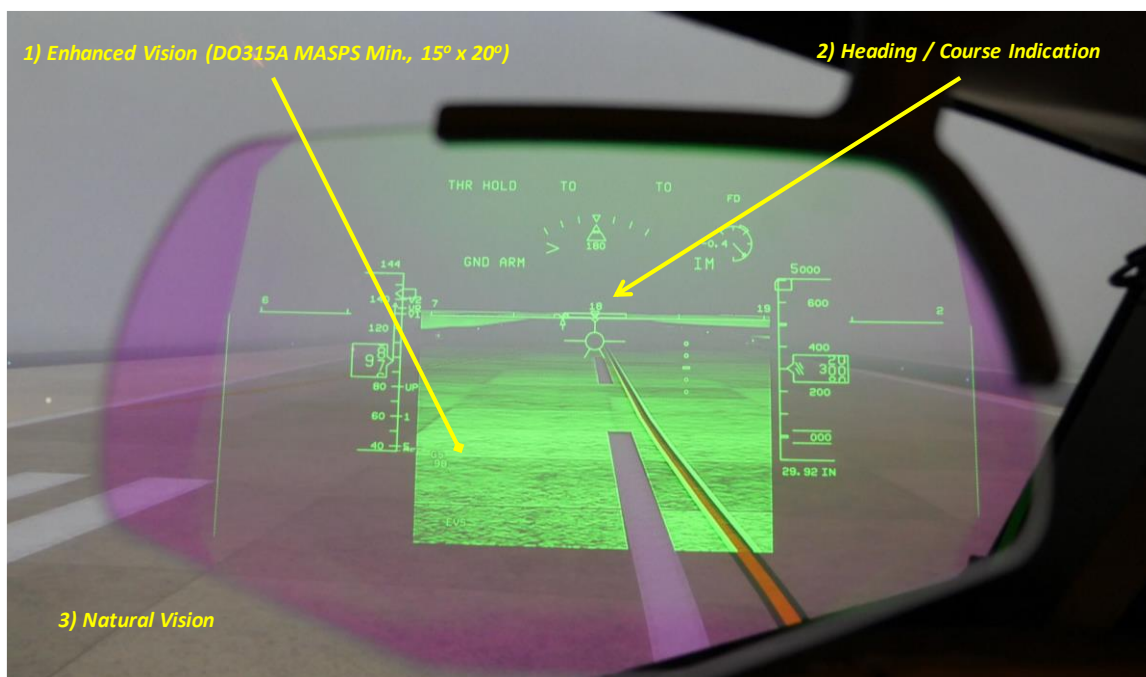


FIGURE 1-1: EXAMPLE MINIMUM ETOS-1000 INFORMATION CONCEPT OVERVIEW

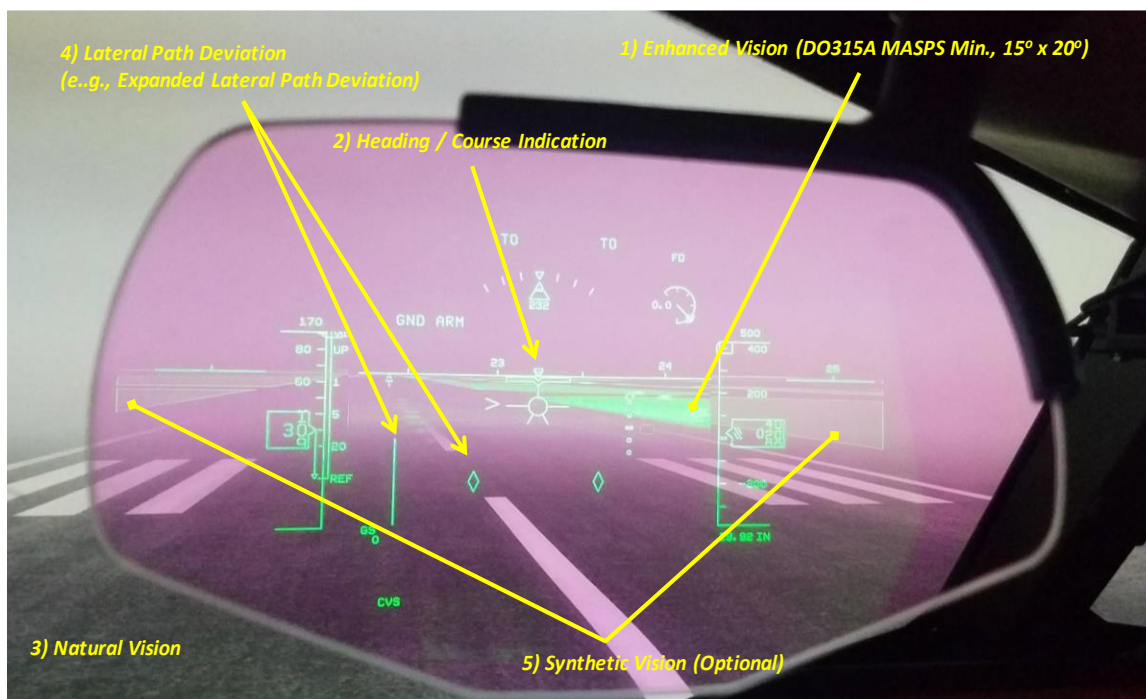


FIGURE 1-2: EXAMPLE MINIMUM ETOS-500 INFORMATION CONCEPT

1.1.6 Relationship to Other Applications

This technology and application are a natural consequence from and logical extension of existing vision systems technologies and applications.

SC-213 has developed DO-315 which describes Minimum Aviation System Performance Standards (MASPS) for Enhanced Vision Systems (EVS), Synthetic Vision Systems (SVS), and Combined Vision Systems (CVS) technologies. An approved combination of EVS and HUD is termed an Enhanced Flight Vision System (EFVS).

Further, MASPS have been established for systems used for approach to touchdown in visibility as low as 1000 ft RVR (or 300 m if applicable) by use of an approved EFVS (RTCA DO-315A). Under DO-359, MASPS have been established for systems that could be used on an instrument approach with lower decision altitude/height and/or possible lower visibility minima, by use of an approved SVS.

Lastly, MASPS were published in DO-341 for EFVS to enable straight-in instrument approaches with published vertical guidance to touchdown, landing, and roll-out to a safe taxi speed in visibility as low as 300 ft RVR (100 m) by use of an approved EFVS without need or reliance on natural vision. The operational concept follows a fail-operational design.

In the U.S., the approving regulation to use Enhanced Flight Vision system technology is established under Title 14 of the Code of Federal Regulations (CFR) §91.176 which states that an approved EFVS may be used in lieu of a pilot's natural vision. An approved EFVS effectively replaces the pilot's natural vision by providing the pilot with the required visual reference cues to fly, maneuver, land, and roll-out without the need for or reliance on natural vision. Airworthiness guidance also exists for Synthetic Vision and Combined Vision Systems under the latest version of Advisory Circular (AC) 20-167.

The operational scenarios used for design context 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.

1.2 SCOPE OF THE DOCUMENT

This document includes the definition of the services and the environmental conditions relevant to the implementation of EFVS takeoff minima, and the operational, safety, performance, and interoperability requirements for EFVS takeoff.

This document identifies associated safety and equipage implications for the use of this technology in both 14 Code of Federal Regulations (CFR) Part 23 and Part 25 aircraft. This document does not specifically address Part 27 and Part 29 helicopters, although the document in part may apply. The FAA's 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 FAA's 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.

1.3 STRUCTURE OF THIS DOCUMENT

1.3.1 Document Organization

Chapter 1 (the current chapter) provides an explanation of the scope and purpose of this document and introduces the ETOS application, and the SPR and INTEROP materials and processes.

Chapter 2 describes the approach and methodology aspects applied for the development of this application and the safety, performance and interoperability assessments.

Chapter 3 provides the consolidated Safety and Performance Requirements applicable to the ETOS application. It also includes the key assumptions.

Chapter 4 introduces the Interoperability Requirements applicable to the ETOS application.

Chapter 5 provides a list of participants who have contributed to the development of this document.

Appendix A is the Operational Services and Environment Definition (OSED) for ETOS. This describes the services, intended functions, and associated procedures of the application and the assumptions about the environment in which the application is specified to operate.

Appendix B is the Operational Performance Assessment (OPA). This determines minimum performance requirements for the ETOS application, associated processing.

Appendix C contains the Operational Safety Assessments (OSA) associated with various levels of ETOS minima. This Appendix explains in detail the methodologies used for these assessments, which are based on DO-264/ED78A. The Appendix also presents the detailed tables of results of the Safety Assessment itself.

Appendix D provides a list of acronyms and abbreviations used in this document and their applicable meaning/description.

Appendix E is a glossary of key terms used in this document and their definition.

1.4

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. This oversight is safety based and addresses failure modes of the system. These failure modes can be characterized by fault tree and aligned to failure modes documented in a Functional Hazard Assessment. This approach does not account for malicious intent as cybersecurity risks do. In addition, the State typically does not provide oversight on "non-trusted" 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 information may 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 performance requirements for aircraft information security in these MOPS, it is recommended that manufacturers look at a layered approach to mitigation aircraft information security risk 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 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 limited wiring connections to higher integrity systems or use of one-way digital busses. 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. These techniques need to address the end to end signal flows

for systems that are interconnected. Therefore, it is recommended that manufacturers reference their 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.

1.5 REFERENCES

This SPR/INTEROP document considers material from ICAO, EUROCONTROL, the FAA, EUROCAE, RTCA and other sources, as listed below.

1.5.1 ICAO

[1] "Air Traffic Services," ICAO, Annex 11 to the Convention on International Civil Aviation, Thirteenth edition, July 2001.

[2] "Aerodromes", ICAO, Annex 14 to the Convention on International Civil Aviation, Volume I, Fifth edition, 5 July 2009.

[3] "Aeronautical Information Services," ICAO, Annex 15 to the Convention on International Civil Aviation.

[4] "Air Traffic Management," ICAO, Procedures for Air Navigation Services, Document 4444, Fifteenth edition-2007.

[5] "Manual of Surface Movement Guidance and Control Systems (SMGCS)," ICAO Document 9476, 1st Edition, 1986.

[6] "Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual," ICAO Document 9830, 1st Edition, 2004.

1.5.2 Society of Automotive Engineering (SAE) Documents

SAE Aerospace Recommended Practice (ARP) 4761: *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment*, Dec 1996.

SAE ARP 4754A: *Guidelines for Development of Civil Aircraft and Systems*, Dec. 2010.

1.5.3 FAA Documents

AC 90-106A, [*Enhanced Flight Vision Systems*](#), Mar 2017.

AC 20-167A, *Airworthiness Approval of Enhanced Vision System, Synthetic Vision System, Combined Vision System, and Enhanced Flight Vision System Equipment*, Dec. 2016.

AC 120-29A, *Criteria for Approval of Category I and Category II Weather Minima for Approach*, Aug 2002.

Order JO 7110.65X - *Air Traffic Control*, Sept 2017.

Order 6750.24E, *Instrument Landing System and Ancillary Electronic Component Configuration and Performance Requirements*, Mar 2012.

AC 120-28D, *Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout Systems*, July 1999.

Flight Standards Information Management System, FAA 8900.1, *OpSpec C078/C079 – IFR Lower Than Standard Takeoff Minima, 14CFR Part 121 Aircraft Operations*.

1.5.4 EASA / TCCA

EASA CS-AWO Subpart 4, *Directional Guidance for Takeoff in Low Visibility*.

TCCA AC 700-035, *Special Authorization for Takeoff Operations below RVR 600 down to and including RVR 300*.

Commission Regulation (EU) No. 965/2012, "Technical Requirements and Administrative Procedures Related To Air Operations Pursuant to Regulation (EC) No. 216/2008 of the European Parliament and of the Council", 5 Oct 2012.

1.5.5 EUROCAE/RTCA Documents

RTCA	EUROCAE	Title
DO-160G	ED-14G	Environmental Conditions and Test Procedures for Airborne Equipment
DO-178() ¹	ED-12()	Software Considerations in Airborne Systems and Equipment Certification
DO-254	ED-80	Design Assurance Guidance for Airborne Electronic Hardware, Issued 19th April 2000.
DO-264	ED-78A	Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications, Dec 2000
DO-303	ED-126	Safety, Performance and Interoperability Requirements Document for the ADS-B Non-Radar-Airspace (NRA) Application
DO-315A		Minimum Aviation System Performance Standards (MASPS) for Enhanced Vision Systems, Synthetic Vision Systems, Combined Vision Systems and Enhanced Flight Vision Systems, Dec 2010.
DO-341		Minimum Aviation System Performance Standards (MASPS) For an Enhanced Flight Vision System to Enable All-Weather Approach, Landing, And Roll-Out to a Safe Taxi Speed
DO-359		Minimum Aviation System Performance Standard (MASPS) for Synthetic Vision Guidance Systems

¹ () indicates the latest revision of EUROCAE ED-12 / RTCA DO-178 "Software Considerations in Airborne Systems and Equipment Certification", or other revision that meets airworthiness requirements.

CHAPTER 2

APPROACH AND METHODOLOGY

2.1 DOCUMENT DEVELOPMENT PROCESS

This document was developed in accordance with the guidelines for the definition of operational, safety, performance, and interoperability requirements.

The approach used is top-down in nature with an initial focus on the operational perspective. The gradual increase of the involvement of systems expertise (and decrease of the relevance of operational aspects) occurs when the work advances to the SPR and INTEROP stages.

This work is iterative in nature as each phase of the process feeds back into the previous work, to mature and refine the work and ensure completeness and consistency. As an example, during initial Operational Safety Assessment (OSA), comments are fed back into the OSED identifying required additions or needs for clarification.

While the process moves from a more operational perspective to a system oriented one, it is critical that key operational and analytical people are involved throughout, to ensure overall consistency and coherence of the work and material.

2.2 METHODOLOGY

Requirements emerge for ETOS by developing an Operational Services and Environment Definition (OSED), deriving Safety and Performance Requirements (SPR), allocating those requirements to the relevant domains, and developing interoperability requirements (INTEROP) which specify the exchange of data between the domains. Each of these areas is described in the sections below.

2.2.1 Operational Services and Environment Definition (OSED)

The OSED (Appendix A) describes the services, intended functions, and associated procedure of the ETOS application, and the assumptions about the environment in which the application is specified to operate.

The OSED also defines the characteristics of the environmental conditions and procedures envisioned for this application. These environmental conditions play a role in determining the assumptions, requirements, and mitigations derived in the Operational Safety Assessment (OSA) and Operational Performance Assessment (OPA).

2.2.2 Safety and Performance Requirements

The OSED focuses on procedural aspects of the application, in which a flight crew uses the EFVS, out-the-window visual references, and flight deck technologies, including but not limited to synthetic vision systems and situation information, to help determine alignment and maintain that alignment with the correct runway center for departure through brake release to 35 ft above ground level or successfully complete a rejected takeoff. The OSED also contains descriptions of the natural vision conditions, the role of the Air Navigation Services Providers (ANSP), and use of airport and runway lighting and other airport infrastructure under which this operation is to be realized.

Two assessments were performed from this OSED to derive the requirements needed to assure proper and safe execution of the ETOS application:

- The OPA derives requirements by examining all operational requirements defined in the OSED. Compiling requirements from the OSED establishes the minimum requirements for the ETOS application under all conditions. The OPA is found in Appendix B. For this application, the performance requirements are invariant of the prevailing natural visibility (weather minima);
- The OSA derives safety requirements by considering potential hazards to which the flight crew and/or aircraft might be exposed during the ETOS application, and

derives requirements in order to control the likelihood of the hazards and their effects. In this application, multiple OSAs are defined in 0. These OSAs vary as a function of the prevailing natural visibility, the airport infrastructure (e.g., lighting), and installed vision system technologies performance. EFVS takeoff minima are achieved through the use of vision systems technologies, treated as subsystems, which together with other subsystems including navigational aids and airport lighting and markings, are used to accomplish the OPA and achieve levels of reliability, availability, and integrity appropriate to the intended function and phase of flight, as defined in the OSA.

NOTE: *For a more detailed description of the methodologies used for these assessments, please refer to Chapter 3.1 and the Appendices themselves.*

2.2.3 Interoperability Requirements (Interop)

The objective of the interoperability assessment is to identify the minimum requirements needed, to ensure that the elements of the aircraft equipped and approved for EFVS takeoff can operate effectively and efficiently within the airport and airspace environment. Recommendations are also proposed so that systems are designed in a robust fashion to accommodate growth and other EFVS capabilities.

2.3 KEY TERMS

The following sections define four key terms used throughout this document; these are: 1) assumptions; 2) mitigation means; 3) requirements; and, 4) recommendations.

Assumptions and mitigation means are important aspects of the operational definition of the ETOS application, and have profound impact on the associated requirements.

While the primary objective of this document is to present minimum requirements needed for the operations defined for the application, recommendations are also proposed—found primarily in the Interoperability Specification—which identify highly desirable options or performance above the absolute minimum specified.

2.3.1 Use of Requirements and Recommendations and Key Words

The SPR and INTEROP chapters contain "**shall**", "**should**", and "will" statements with the following meanings:

- "**Shall**" statements ensure safe, compatible and interoperable systems of sufficient performance for the ETOS application. The use of the word "**shall**" in bold type indicates a requirement for the application.
- The use of the word "**should**" in bold type indicates a recommendation that would typically improve the application but does not constitute a requirement.
- The use of the word "will" describes expected system behavior when the system complies with the reference requirements, and/or this chapter's requirements.

The INTEROP (Chapter 4) also contains recommendations (enumerated) that are included as guidance material to implementers of ETOS.

2.3.2 Assumptions

Assumptions form an important basis for all assessments and analyses contained in this document. All requirements must be considered within the context of the assumptions made, as well as the operations and environments defined.

For the implementation of ETOS in a given region, any deviation from the assumptions noted in this document could impact the corresponding requirements, and therefore must be accounted for in supporting analysis or introduction of other assumptions and/or mitigations.

Assumptions have been made at various stages of the development process of this document. These include procedural assumptions and assumptions on the environment (e.g., environmental conditions, existing infrastructure) within both the OSED and SPR work.

2.3.3 Mitigation means

Mitigation Means are procedures, alerts, or other aspects that are put in place to help reduce the frequency of exposure to hazards and/or to alleviate the consequences of hazards when encountered.

Some mitigations are fallback procedures, capabilities, or environmental conditions or infrastructure under which operations may be conducted. These are called External Mitigation Means (EMM).

Other mitigations are internal to the application and systems, and are therefore called Internal Mitigation Means (IMM).

Both External and Internal Mitigation Means constitute operational requirements if procedural. If technical, they correspond to safety requirements (see Chapter 2.3.4 below).

All requirements specified in this document are done so within the context of these mitigation means being present. The removal or changing of any of these will require proof that other mitigations are at least equivalent, or that corresponding requirements are more stringent so that the relevant hazards are still properly accounted for.

2.3.4 Requirements

Requirements on the ETOS application are expressed using the word "**shall**".

Operational Requirements are identified within the OSED (Appendix A). These include procedures that must be followed in the operations defined for the application to be properly executed. Within the OSED, these Operational Requirements are enumerated with the "OR#" tag.

Performance Requirements are principally identified within the OPA (Appendix B); some performance requirements are also identified in Appendix A and C. These are minimum requirements needed for the application to properly work under nominal and non-normal conditions. These Operational Performance Requirements are enumerated with the "PR#" tag.

Safety Requirements are identified within the OSA (Appendix C). They correspond to minimum quantitative or functional requirements that are defined on the ETOS to meet the Safety Objective assigned to each Operational Hazard. These requirements are enumerated with the "SR#" tag.

Chapter 3 contains all of the ETOS performance and safety requirements. The SPR retains the more demanding requirements when they are common to both the OPA and OSA. The consolidated SPR represents the minimum requirements needed for implementation of the ETOS application and are enumerated with the "SPR#" tag.

The last category of requirements is Interoperability Requirements. These are specified in Chapter 4 and are enumerated with the "IR#" tag. Interoperability requirements are requirements for the interchange of data between the operational participants. In the case of ETOS, these requirements also reflect operational or procedural approvals or capabilities that other agencies must be made to enable the use of ETOS for its intended function. Chapter 4 specifies these requirements.

The different types of requirements and where they are specified and what is used to derive them is shown in [FIGURE 2-1](#).

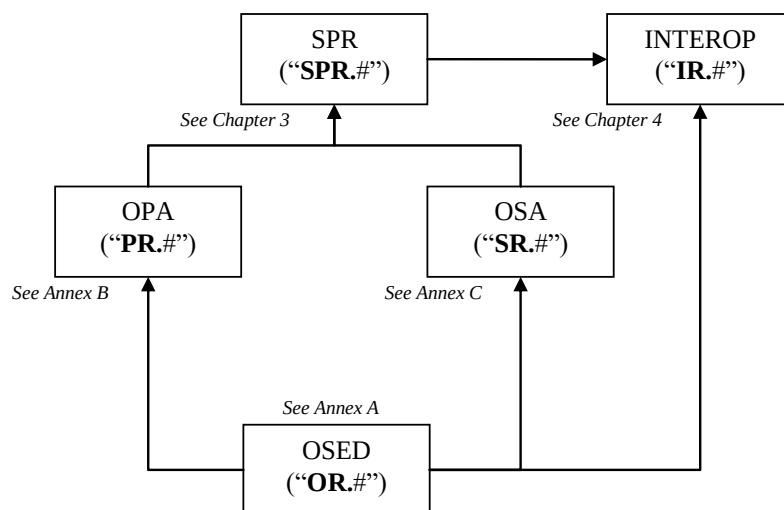


FIGURE 2-1: SCHEMATIC OF REQUIREMENTS RELATIONSHIPS

2.3.5

Recommendations

The primary objective of this document is to specify the minimum requirements needed for implementation of the ETOS application as defined in the OSED.

Recommendations are not minimum requirements for ETOS but are optional capabilities or desired performance levels above the minimum required. Many of these recommendations are made to ensure development of robust EFVS avionics systems capable of supporting multiple EFVS applications.

Recommendations are specified using the word “**should**” and within the Interop are given an “IRec#” tag.

CHAPTER 3

SAFETY AND PERFORMANCE REQUIREMENTS (SPR)

3.1 INTRODUCTION

The outcome of the Safety and Performance Requirements (SPR) assessment for the ETOS application is presented in the following where the ETOS intended function is:

An EFVS and associated aircraft systems which allows the pilot to safely track and maintain the runway centerline during a takeoff from brake re-lease on the runway to liftoff and climb to 35 ft. AGL, and from brake release through deceleration to a stop for a rejected takeoff, in natural visibilities lower than authorized without the use of EFVS.

The safety and performance requirements detailed here are the requirements that resulted from the Operational Performance Assessment (OPA, Appendix B) and the Operational Safety Assessment (OSA, Appendix C), based on the operational requirements created from the Concept of Operations (ConOps) or Operational Services and Environment Definition (OSED).

3.1.1 OPA Process

The OPA derives Performance Requirements (PR) by examining all Operational Requirements (OR) and assumptions defined in the OSED. Performance Requirements establish the minimum requirements for the ETOS application under nominal and non-normal conditions. The OPA is found in Appendix B.

The minimum requirements were established consistent with other systems and subsystems used for the same intended function and phase of flight.

Operational experts also provided important feedback, in operational terms, for what minimum performance is needed from the ETOS equipment to support their operational needs and to provide operational benefit.

3.1.2 OSA Process

Safety Requirements (SR) were derived in the OSA by considering potential Operational Hazards to which the flight crew and/or aircraft might be exposed during the ETOS application, in order to control the likelihood of the Operational Hazards being encountered and their Operational Effects experienced. The structure for an OSA is found in Appendix C including example Functional Hazard Analysis (FHA).

Two OSAs are presented. The OSAs define takeoff minima – as a function of the prevailing natural visibility – that are achievable through the use of vision systems technologies, treated as subsystems, which together with other subsystems including navigational aids and/or airport lighting and/or markings, are used to accomplish the operational goal, achieve levels of reliability, availability, and integrity appropriate to the intended function.

The two EFVS takeoff visibility minima conditions and associated OSAs are, in summary:

1. No lower than 500 ft visibility on a Type 1/E runway or equivalent/better, with at least 2 RVR reports, High Intensity Runway edge Lights (HIRLs); and an electronic definition of the runway centerline or center by means of an XLS.
2. No lower than 1000 ft visibility and visible Runway Centerline Markings (RCLMs) or HIRLs/MIRLs, if RCLMs obscured. RVR reporting is not required. An electronic means to define runway center or centerline may be used to augment this operation and is required in the absence of visible RCLMs or HIRLs/MIRLs.

These OSAs describe the interplay between Internal (i.e., installed aircraft equipage, EFVS technologies) and External (i.e., airport infrastructure such as lights and navigational aids) mitigation means that are used to meet the operational performance requirements (i.e., the OPA in Appendix B) and maintain the operational safety levels (i.e., the OSA) in the event of system and subsystem failures and faults not shown to be extremely improbable. Nonetheless, it is the applicant's responsibility to demonstrate a satisfactory safety (failure and performance) level appropriate to this operation and to the specific EFVS installation as an integrated part of the cockpit flight information system.

3.1.2.1

Mitigation Means

Mitigation means are procedures, alerts, or other aspects that are put in place to help reduce the frequency of exposure to Operation Hazards and/or to alleviate the consequences of Operational Hazards when encountered.

The mitigation means identified in this application are:

- Outside natural visual references
- ETOS-displayed runway heading/course
- ETOS-displayed navigational aid / path deviation (from XLS which provides an electronic means of defining the runway center or centerline)

Additional mitigation means beyond this minimum set were also identified and are recommended:

- Synthetic vision (head-up and/or head-down) showing a computer-generated view of the runway.

The transfer of control from PF to PM is not an acceptable mitigation except in the case of PF incapacitation.

3.1.3

SPR Process

The consolidated requirements expressed in this chapter are the final Safety and Performance Requirements and are enumerated with the "SPR#" tag. SPR requirements are allocated to the following:

- Requirements on controller procedures
- Requirements on the equipment
- Requirements on the flight crew procedures

NOTES:

1. *The SPR.# requirements in this Chapter represent the integration of requirements from the various Appendices of this document (OR.#s from the OSED in Appendix A, PR.#s from the OPA in Appendix B, and SR.#s from the OSA in Appendix C). OR.#s, PR.#s, and SR.#s should be interpreted to represent "OSED requirements", "OPA requirements", and "OSA requirements", respectively. While the OR.#, PR.#, and SR.# primarily specify operational, performance, and safety requirements, respectively, functional requirements are also brought forward from all three Appendices. The tags are used simply for traceability back to the Appendices. The final SPR.#s specified in this Chapter are organized by Operational Requirements, Functional Requirements and system-related (Aircraft Domain and Ground Domain) Performance Requirements. Each SPR.# is associated with at least one requirement from the OSED, OPA or OSA as noted in the tables.*