European Union Aviation Safety Agency

Notice of Proposed Amendment 2019-06

Regular update of CS-ETSO

RMT.0457

EXECUTIVE SUMMARY

This Notice of Proposed Amendment (NPA) proposes to introduce new or updated standards for parts, taking into account the principles of efficiency and harmonisation.

In particular, this NPA proposes to:

— modify a number of ETSOs in order to harmonise them with the corresponding FAA TSOs;

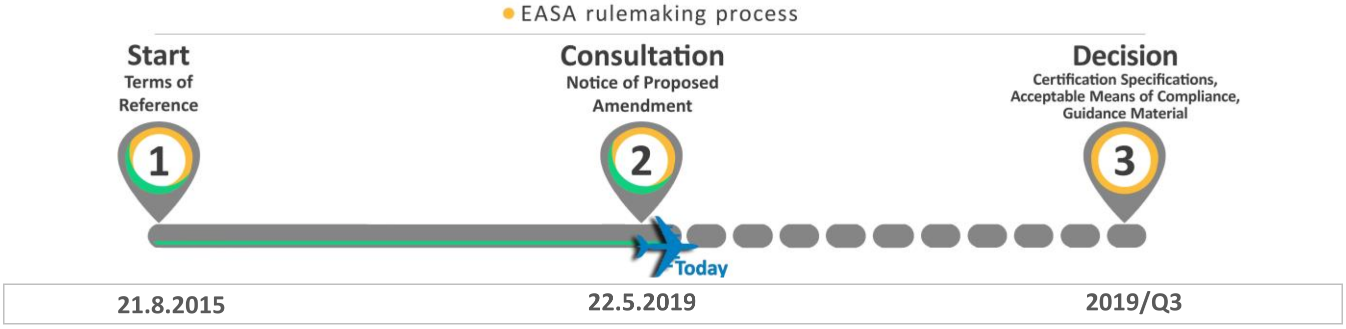
— introduce one new ETSO (Index 1) which is, where possible, technically similar to the corresponding FAA TSO; and

— introduce some new ETSOs (Index 2), which either do not exist in the FAA TSO series, or which contain significant technical differences from the corresponding FAA TSOs.

The proposed amendments are expected to extend the possibilities of ETSO authorisations for EU applicants and to align CS-ETSO with the state of the art and with European operational requirements.

These amendments will ensure a level playing field for European manufacturers, and will increase the cost-effectiveness of compliance demonstrations.

Action area:	Regular updates		
Affected rules:	CS-ETSO	**Rulemaking group:**	No
Affected stakeholders:	Manufacturers of parts	**Rulemaking Procedure:**	Standard
Driver:	Efficiency/proportionality; Level playing field		
Impact assessment:	None		



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1. About this NPA

1.1. How this NPA was developed

The European Union Aviation Safety Agency (EASA) developed this NPA in line with Regulation (EU) 2018/1139[1] ('Basic Regulation') and the Rulemaking Procedure[2]. This rulemaking activity is included in the latest European Plan for Aviation Safety (EPAS)[3] under rulemaking task (RMT).0457. The text of this NPA has been developed by EASA. It is hereby submitted to all interested parties[4] for consultation.

This NPA is structured as follows:

— Section 1 contains the procedural information related to this task.

— Section 2 (Explanatory Note) explains the core technical contents.

— Section 3 contains the proposed amendments to CS-ETSO.

1.2. How to comment on this NPA

Please submit your comments using the automated **Comment-Response Tool (CRT)** available at **http://hub.easa.europa.eu/crt/**[5].

The deadline for the submission of comments is **7 August 2019.**

1.3. The next steps

Following the closing of the public commenting period, EASA will review all the comments received. Based on the comments received, EASA will develop a decision that amends the Certification Specifications for European Technical Standard Orders (CS-ETSO). The comments received on this NPA and the EASA responses to them will be reflected in a comment-response document (CRD). The CRD will be appended to the decision.

[1] Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91 (OJ L 212, 22.8.2018, p. 1) (https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1535612134845&uri=CELEX:32018R1139).

[2] EASA is bound to follow a structured rulemaking process as required by Article 115(1) of Regulation (EU) 2018/1139. Such a process has been adopted by the EASA Management Board (MB) and is referred to as the 'Rulemaking Procedure'. See MB Decision No 18-2015 of 15 December 2015 replacing Decision 01/2012 concerning the procedure to be applied by EASA for the issuing of opinions, certification specifications and guidance material (http://www.easa.europa.eu/the-agency/management-board/decisions/easa-mb-decision-18-2015-rulemaking-procedure).

[3] https://www.easa.europa.eu/document-library/general-publications?publication_type%5B%5D=2467

[4] In accordance with Article 52 of the Basic Regulation, and Articles 5(3) and 6 of the Rulemaking Procedure.

[5] In case of technical problems, please contact the CRT webmaster (crt@easa.europa.eu).

2. In summary — why and what

2.1. Why we need to change the rules — issue/rationale

Worldwide aircraft experience, as well as scientific and technical progress, need to be reflected in existing or new ETSOs.

ETSOs are defined in Article 1(2)(g) of Regulation (EU) No 748/2012[6] as detailed airworthiness specifications issued by EASA to ensure compliance with the requirements of this Regulation as a minimum performance standard for specified articles (i.e. parts as defined by Article 3(4) and 'non-installed equipment' as defined in Article 3(29) of the Basic Regulation, see Article 1(2)(f) of Regulation (EU) No 748/2012).

2.2. What we want to achieve — objectives

The overall objectives of the EASA system are defined in Article 1 of the Basic Regulation. This proposal will contribute to the achievement of the overall objectives by addressing the issues outlined in Section 2.1.

The specific objective of this proposal is to update some existing ETSOs and to propose new ones, taking into account worldwide aircraft experience, as well as scientific and technical progress.

To achieve the above objectives, this NPA proposes to:

— modify a number of ETSOs in order to harmonise them with the corresponding FAA TSOs;

— introduce one new ETSO (Index 1) which is, where possible, technically similar to the corresponding FAA TSO[7]; and

— introduce some new ETSOs (Index 2), which do not yet exist in the FAA TSO series, or which contain significant technical differences from the corresponding FAA TSOs.

2.3. How we want to achieve it — overview of the proposals

The basis for the introduction and/or revision of each ETSO and the main differences from the current ETSOs are specified below. Table 1 and Table 2 at the end of this section summarise the proposed amendments.

The amendments introduced by this NPA are listed below.

[6] Commission Regulation (EU) No 748/2012 of 3 August 2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations (OJ L 224, 21.8.2012, p. 1).

[7] FAA TSOs are available at http://www.airweb.faa.gov.

CS-ETSO Subpart A

2.2 Software standards

It is proposed to improve the existing wording and its clarity by deleting the link between Subpart A and individual ETSOs.

2.3 Airborne electronic hardware (AEH)

It is proposed to delete the current provisions of this paragraph and instead, to introduce AMC 20-152[8], entitled 'Development Assurance for Airborne Electronic Hardware', as acceptable means of compliance for the development of airborne electronic hardware.

2.6 Open Problem Reports (OPRs)

This new paragraph is proposed to recognise AMC 20-189[9] 'Management of Open Problem Reports' as an acceptable process for the management of OPRs in ETSO authorisations for the system, software, and airborne electronic hardware (AEH) domains.

2.7 Embedded batteries

This new paragraph has been added to address ETSO articles that embed batteries whose energy is greater than or equal to 2 Wh.

CS-ETSO Subpart B

Index 1

ETSO-C10c: Pressure Altimeter System

This update of ETSO-C10b is based on FAA TSO-C10c, issued on 31 October 2016.

According to this revision proposal, newly designed pressure altimeter systems should meet the minimum performance standard (MPS) qualification and documentation requirements in SAE International's Aerospace Standard AS8009C, Pressure Altimeter Systems, dated 24 May 2016.

In line with the FAA TSO, some modifications to the referenced standards are introduced into the ETSO in Appendix 1.

ETSO-C13g: Life Preservers

This update of ETSO-C13f is based on FAA TSO-C13g, issued on 2 March 2017.

[8] Refer to NPA 2018-09 'Regular update of AMC-20: AMC 20-152 on Airborne Electronic Hardware and AMC 20-189 on Management of Open Problem Reports' (https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2018-09).

[9] Refer to NPA 2018-09 'Regular update of AMC-20: AMC 20-152 on Airborne Electronic Hardware and AMC 20-189 on Management of Open Problem Report' (https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2018-09).

According to this revision proposal, newly designed life preservers should meet the minimum performance standard (MPS) qualification and documentation requirements in SAE International's Aerospace Standard AS1354, Individual Inflatable Life Preserver, dated 24 February 2016.

In line with the FAA TSO, some modifications to the referenced standards are introduced into the ETSO in Appendices 1 and 2.

ETSO-C20a: Combustion Heaters and Accessories

This update of ETSO-C20 is based on FAA TSO-C20a, issued on 12 January 2017.

According to this revision proposal, newly designed combustion heaters should meet the minimum performance standard (MPS) qualification and documentation requirements in SAE International's Aerospace Standard AS8040B, Heater, Aircraft, Internal Combustion Heat Exchanger Type, dated 14 February 2013.

In line with the FAA TSO, some modifications to the referenced standards are introduced into the ETSO in Appendices 1 and 2.

ETSO-C27a: Twin Seaplane Floats

This update of ETSO-C27 is based on FAA TSO-C27a, issued on 31 July 2018.

According to this revision proposal, newly designed twin seaplane floats should meet the minimum performance standard (MPS) qualification and documentation requirements in Aerospace Industries of America, Inc., National Aerospace Standard (NAS) 807, Revision 2, Twin Seaplane Floats, dated 30 June 2017.

ETSO-C43d: Temperature Instruments

This update of ETSO-C43c is based on FAA TSO-C43d, issued on 20 March 2017.

According to this revision proposal, newly designed temperature instruments should meet the minimum performance standard (MPS) qualification and documentation requirements in SAE International's Aerospace Standard AS8005, Minimum Performance Standard for Temperature Instruments, Revision A, dated 1 September 1996.

In line with the FAA TSO, some modifications to the referenced standards are introduced into the ETSO in Appendix 1.

ETSO-C113b: Airborne Multipurpose Electronic Displays

This update of ETSO-C113a is based on FAA TSO-C113b, issued on 17 September 2018.

According to this revision proposal, newly designed airborne multipurpose electronic displays should meet the minimum performance standard (MPS) qualification and documentation requirements provided in SAE International's Aerospace Standard AS8034C, Minimum Performance Standards for Airborne Multipurpose Electronic Displays, dated 30 July 2018, as modified by paragraph 3.1.1.1 of this ETSO.

Additional requirements regarding colours are provided in Appendix 1 of this ETSO.

ETSO-C117b: Airborne Wind shear Warning and Escape Guidance Systems for Transport Aeroplanes

This update of ETSO-C117a is based on FAA TSO-C117b, issued on 27 March 2018.

According to this revision proposal, newly designed temperature instruments should meet the minimum performance standard (MPS) qualification and documentation requirements provided in Appendix 1 of this ETSO.

ETSO-C123d: Cockpit Voice Recorder Systems

This update amends the current minimum performance standard (MPS) in relationship with the guidance material that EASA is developing for compliance with point CAT.GEN.MPA.210 'Location of an aircraft in distress — Aeroplanes' of Annex IV (Part-CAT) to Commission Regulation (EU) No 965/2012; see Index 2 below.

ETSO-C124d: Flight Data Recorder Systems

This update amends the current minimum performance standards (MPS) in relationship with the guidance material that EASA is developing for compliance with point CAT.GEN.MPA.210 'Location of an aircraft in distress — Aeroplanes' of Annex IV (Part-CAT) to Commission Regulation (EU) No 965/2012; see Index 2 below.

ETSO-C126c: Emergency Locator Transmitter

This update of ETSO-C126b is based on FAA TSO-C126c, issued on 7 March 2019. It amends the current minimum performance standards (MPS) in relationship with the guidance material that EASA is developing for compliance with point CAT.GEN.MPA.210 'Location of an aircraft in distress — Aeroplanes' of Annex IV (Part-CAT) to Commission Regulation (EU) No 965/2012; see Index 2 below.

ETSO-C142b: Non-Rechargeable Lithium Cells and Batteries

This new ETSO is based on FAA TSO-C142b, issued on 26 March 2018.

According to this revision proposal, newly designed non-rechargeable lithium cells and batteries that are intended to provide power for aircraft equipment should meet the minimum performance standard (MPS) qualification and documentation requirements provided in RTCA DO-227A, Minimum Operational Performance Standard (MOPS) for Non-Rechargeable Lithium Batteries, issued on 21 September 2017, as amended by Appendix 1 of this ETSO.

ETSO-C145e A1: Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite Based Augmentation System

This update of ETSO-C145e is intended to provide applicants with the option to use an ETSO-2C204a SBAS circuit card assembly (CCA) functional sensor as part of their ETSO application, and to correct an unintended difference from Appendix 2 of published FAA TSO-145e. These changes are in line with FAA TSO-C145e.

No technical changes are proposed for the Minimum Operational Performance Standard (MOPS) in comparison with ETSO-C145e.

ETSO-C146e A1: Stand-Alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite Based Augmentation System

This update of ETSO-C146e is intended to provide applicants with the option to use an ETSO-2C205a class delta circuit card assembly (CCA) functional sensor as part of their ETSO application, and to correct an unintended difference from Appendix 2 of published FAA TSO-146e. These changes are in line with FAA TSO-C146e.

No technical changes are proposed for the Minimum Operational Performance Standard (MOPS) in comparison with ETSO-C146e.

ETSO-C151d: Terrain Awareness and Warning System (TAWS)

This new ETSO is based on FAA TSO-C151d, issued on 31 August 2017.

According to this revision proposal, newly designed TAWS equipment should meet RTCA DO-367, Minimum Operational Performance Standards (MOPS) for Terrain Awareness and Warning Systems (TAWS) Airborne Equipment, Section 2, dated 31 May 2017. Requirements for Class A, Class B, and Class C equipment are addressed in RTCA DO-367 Sections 2.2.1, 2.2.2 and 2.2.3, respectively.

ETSO-C159d: Next Generation Satellite Systems (NGSS) Equipment

This new ETSO is based on FAA TSO-C159d, issued on 31 July 2018.

According to this revision proposal, newly designed NGSS equipment should meet the minimum performance standard (MPS) qualification and documentation requirements provided in EUROCAE ED-243, Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (NGSS), dated April 2017.

The content of Appendix 1 has been moved to the main body of the ETSO.

Additionally, a clarification on security requirements has been added in paragraph 2.1

ETSO-C160a A1: VDL Mode 2 Communications equipment

This update of ETSO-C160a introduces the new EUROCAE ED-92C, Minimum Operational Performance Standard (MOPS) for an Airborne VDL Mode-2 System Operating in the Frequency Range 118-136.975 MHz, dated September 2018. The previous version of this standard will be maintained as a MOPS. Applicants for an ETSO authorisation of such an article will have the possibility to select the version of the MOPS to be complied with.

The existing revision letter of this ETSO is, however, kept in order to ensure synchronisation with the revision letter of the FAA TSO. An amendment number (A1) is added to highlight the update.

ETSO-C165b: Electronic Map Systems for Graphical Depiction of Aircraft Position

This update of ETSO-C165a is based on FAA TSO-C165b, issued on 28 November 2018.

According to this revision proposal, newly designed electronic map systems for graphical depiction of aircraft position should meet the minimum performance standard (MPS) qualification and documentation requirements provided in RTCA document DO-257B, Minimum Operational Performance Standards for the Depiction of Navigation Information on Electronic Maps, dated 22 March 2018.

The previous Appendix 1 of this ETSO has been deleted as part of the new amendment.

ETSO-C168: Aviation Visual Distress Signals

This new ETSO is based on FAA TSO-C168, issued on 25 March 2004.

According to this proposal, newly designed and manufactured aviation visual distress signals should meet the minimum performance standard (MPS) qualification and documentation requirements for the applicable equipment class defined by this ETSO.

ETSO-C176b: Cockpit Image Recorder Systems

This update amends the current minimum performance standard (MPS) in relationship with the guidance material that EASA is developing for compliance with point CAT.GEN.MPA.210 'Location of an aircraft in distress — Aeroplanes' of Annex IV (Part-CAT) to Commission Regulation (EU) No 965/2012; see Index 2 below.

C177b: Data Link Recorder Equipment

This update amends the current minimum performance standard (MPS) in relationship with the guidance material that EASA is developing for compliance with point CAT.GEN.MPA.210 'Location of an aircraft in distress — Aeroplanes' of Annex IV (Part-CAT) to Commission Regulation (EU) No 965/2012; see Index 2 below.

ETSO-C179b: Rechargeable Lithium Cells, Batteries and Battery Systems

This new ETSO is based on FAA TSO-C179b, issued on 23 March 2018.

According to this revision proposal, newly designed rechargeable lithium batteries and battery systems should meet the minimum performance standard (MPS) qualification and documentation requirements provided in the RTCA DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems, dated 19 December 2017.

ETSO-C196b: Airborne Supplemental Navigation Sensors for Global Positioning System Equipment Using Aircraft-Based Augmentation

This update of ETSO-C196a is intended to provide applicants with the option to use an ETSO-2C206 GPS circuit card assembly (CCA) as part of their ETSO application. This is in line with FAA TSO-C196b.

No technical changes are proposed for the MOPS in comparison with ETSO-C196a.

ETSO-C199 A1: Traffic Awareness Beacon System (TABS)

This update of ETSO-C199 is intended to correct some typos.

The existing revision letter is, however, kept to ensure synchronisation with the revision letter of the FAA TSO. This is possible since there are no changes in the technical content. An amendment number is added to highlight the update.

ETSO-C207a: Aeronautical Mobile Airport Communication System (AeroMACS)

This new ETSO is based on FAA TSO-C207a, issued on 18 August 2017.

According to this revision proposal, newly designed temperature instruments should meet the minimum performance standard (MPS) qualification and documentation requirements in RTCA Document DO-346, Minimum Operational Performance Standards (MOPS) for the Aeronautical Mobile Airport Communication System (AeroMACS), dated 20 February 2014, Section 2.

Table 1 — Summary of changes to Index 1 of CS-ETSO

Changes to Index 1 of CS-ETSO		
New ETSO reference	**ETSO title**	**Corresponding FAA TSO**
ETSO-C10c	Pressure Altimeter System	TSO-C10c (from 31.10.2016)
ETSO-C13g	Life Preservers	TSO-C13g (from 03.02.2017)
ETSO-C20a	Combustion Heaters and Accessories	TSO-C20a (from 12.01.2017)
ETSO-C27a	Twin Seaplanes Floats	TSO-C20a (from 31.07.2018)
ETSO-C43d	Temperature Instruments	TSO-C43d (from 20.03.2017)
ETSO-C113b	Airborne Multi-purpose Electronic Displays	TSO-C113b (from 17.09.2018)
ETSO-C117b	Airborne Wind shear Warning and Escape Guidance Systems for Transport Aeroplanes	TSO-C117b (from 27.03.2018)
ETSO-C123d	Cockpit Voice Recorder Systems	No corresponding FAA TSO revision
ETSO-C124d	Flight Data Recorder Systems	No corresponding FAA TSO revision
ETSO-C126c	Emergency Locator Transmitter	TSO-C126c (from 07.03.2019)
ETSO-C142b	Non-Rechargeable Lithium Cells and Batteries	TSO-C142b (from 26.03.2018)
ETSO-C145e A1	Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite-Based Augmentation System	TSO-C145e (from 05.05.2017)
ETSO-C146e A1	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite-Based Augmentation System	TSO-C146e (from 05.05.2017)
ETSO-C151d	Terrain Awareness and Warning System (TAWS)	TSO-C151d (from 31.08.2017)
ETSO-159d	Next Generation Satellite Systems (NGSS) Equipment	TSO-159d (from 31.07.2018)
ETSO-C160a A1	VDL Mode 2 Communications equipment	TSO-C160a (from 27.03.2012)
ETSO-C165b	Electronic Map Systems for Graphical Depiction of Aircraft Position	TSO-C165b (from 28.11.2018)

Changes to Index 1 of CS-ETSO		
New ETSO reference	**ETSO title**	**Corresponding FAA TSO**
ETSO-C168	Aviation Visual Distress Signals	TSO-C168 (from 25.03.2004)
ETSO-C176b	Aircraft Cockpit Image Recorder Systems	No corresponding FAA TSO revision
ETSO-C177b	Data Link Recorder Equipment	No corresponding FAA TSO revision
ETSO-C179b	Rechargeable Lithium Cells, Batteries and Battery Systems	TSO-C179b (from 23.03.2018)
ETSO-C196b	Airborne Supplemental Navigation Sensors for Global Positioning System Equipment Using Aircraft-Based Augmentation	TSO-C196b (from 20.12.2013)
ETSO-C199 A1	Traffic Awareness Beacon System	TSO-C199 (from 10.10.2014)
ETSO-C207a	Aeronautical Mobile Airport Communication System (AeroMACS)	TSO-C207a (from 18.08.2017)

Index 2

ETSO-2C19c A1: Portable Water-Solution Type Hand Fire Extinguishers

This update of ETSO-2C19c is intended to correct some typos in paragraph 3.1.1. During the previous update of this ETSO, the old MOPS reference was not removed, and only the new MOPS reference was added.

The existing revision letter is, however, kept to ensure synchronisation with the revision letter of the FAA TSO, and an amendment number is added to highlight the change.

ETSO-2C197a: Information Collection and Monitoring Systems

Refer to new standards in relationship with EASA RMT.0400 (OPS.090) 'Amendment of requirements for flight recorders and underwater locating devices'; see dedicated explanation below.

ETSO-2C204a: Circuit Card Assembly (CCA) Functional Sensors using Satellite-Based Augmentation System (SBAS) for Navigation and Non-Navigation Position/Velocity/Time (PVT) Output

This new ETSO is based on FAA TSO-C204a, issued on 5 September 2017.

This ETSO provides the requirements for circuit card assembly functional sensors that use satellite-based augmentation for navigation and non-navigation position/velocity/time output which are designed and manufactured on or after the date of this ETSO.

To be identified with the applicable ETSO marking, these ETSO articles should meet the requirements provided in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2, as modified by Appendices 2 and 4 of the ETSO-C145e standard. Compared with the corresponding FAA TSO, this new ETSO contains additional requirements that are related to partial environmental testing, and the delivery of test procedures for the end user, allowing the possibility of installation in equipment other than C145e equipment. For this reason, this new ETSO has been included in Index 2.

ETSO-2C205a: Circuit Card Assembly (CCA) Functional Class Delta Equipment Using the Satellite-Based Augmentation System (SBAS) For Navigation Applications

This new ETSO is based on FAA TSO-C205a, issued on 5 September 2017.

This ETSO provides the requirements for circuit card assembly functional class delta equipment that uses the satellite-based augmentation system for navigation applications which are designed and manufactured on or after the date of this ETSO.

To be identified with the applicable ETSO marking, these ETSO articles should meet the requirements provided in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2, as modified by Appendices 2 and 4 of the ETSO-C146e standard. Compared with the corresponding FAA TSO, this new ETSO contains additional requirements that are related to partial environmental testing, and the delivery of test procedures for the end user, allowing the possibility of installation in equipment other than ETSO-C146e equipment. For this reason, this new ETSO has been included in Index 2.

ETSO-2C206: Circuit Card Assembly Functional Sensors using Aircraft-Based Augmentation for Navigation and Non-Navigation Position/Velocity/Time (PVT) Output

This new ETSO is based on FAA TSO-C206, issued on 20 December 2013.

This ETSO provides the requirements for circuit card assembly functional sensors that use aircraft-based augmentation for navigation and non-navigation position/velocity/time output which are designed and manufactured on or after the date of this ETSO.

To be identified with the applicable ETSO marking, these ETSO articles should meet the requirements provided in RTCA document DO-316, Minimum Operational Performance Standards (MOPS) for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, dated 14 April 2009, Section 2.

Compared with the corresponding FAA TSO, this new ETSO contains additional requirements that are related to partial environmental testing, and the delivery of test procedures for the end user, allowing the possibility of installation in equipment other than ETSO-C196b equipment. For this reason, this new ETSO has been included in Index 2.

ETSO-2C515 A1: Aircraft Halocarbon Clean Agent Hand-Held Fire Extinguisher

This update of ETSO-2C515 is intended to correct some typos in paragraph 3.1.1. Appendix 2 was not mentioned in paragraph 3.1.1.

The existing revision letter is, however, kept, since the technical content of this ETSO has not been amended.

ETSO-2C516: Airborne Systems For Video/Audio Surveillance Of Cabin And Cargo Areas

This new ETSO provides the requirements that airborne systems for video/audio surveillance of cabin and cargo areas designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

According to this proposal, newly designed airborne systems for video/audio surveillance of cabin and cargo areas must meet the standards provided in Appendix 1 of this ETSO.

Currently, there is no FAA TSO that corresponds to the proposed ETSO-2C516.

ETSO-2C517: Automatic Deployable Flight Recorder (ADFR) Systems

Refer to the new standards in relationship with EASA RMT.0400 (OPS.090) 'Amendment of requirements for flight recorders and underwater locating devices'; see dedicated explanation below.

ETSO-2C518: Runway Overrun Awareness And Alerting Systems

This new ETSO provides the requirements that runway overrun awareness and alerting systems that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

According to this proposal, newly designed runway overrun awareness and alerting systems must meet the standards provided in EUROCAE ED-250, Minimum Operational Performance Standard for a Runway Overrun Awareness and Alerting System, dated December 2017.

Currently, there is no FAA TSO that corresponds to the proposed ETSO-2C518.

ETSO-2C519: Emergency Breathing Systems (EBSs)

This new ETSO provides the requirements that an emergency breathing system for operations to or from helidecks located in hostile sea areas, which is designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

According to this proposal, newly designed EBSs must meet the standards provided in the AeroSpace and Defence Industries Association of Europe — Standardization (ASD-STAN) document EN 4856:2018.

Currently, there is no FAA TSO that corresponds to the proposed ETSO-2C519.

New standards regarding requirements for flight recorders and underwater locating devices in Part-CAT

In 2015, a new air operation requirement was introduced in Part-CAT (CAT.GEN.MPA.210 'Location of an aircraft in distress — Aeroplanes'), which requires some categories of large aeroplanes manufactured after January 2021 to be equipped with 'robust and automatic means to accurately determine, following an accident where the aeroplane is severely damaged, the location of the point of end of flight'. The most mature technologies to meet this requirement are automatic deployable flight recorders (ADFRs), which per ED-112A must each be fitted with an emergency locator transmitter (ELT), and the type of ELT that is automatically triggered in flight upon the detection of a catastrophic situation (also called a 'distress-tracking ELT').

The above changes are introduced under RMT.0400 (OPS.090) 'Amendment of requirements for flight recorders and underwater locating devices, which also considers the new 'high rate tracking' (HRT) technology complemented with a 121.5 MHz homing device to address the CAT.GEN.MPA.210 requirement. HRT technology is not yet mature enough to be the subject of a specific ETSO.

To support the implementation of this CAT.GEN.MPA.210 requirement, the following amendments of existing ETSOs and a new ETSO-2C517 are proposed:

ETSO-C123d: Cockpit Voice Recorder Equipment

According to this revision proposal, newly designed cockpit voice recorder (CVR) equipment should meet the standards provided in EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, as amended by the new Appendix 1.

In particular, Appendix 1 extends the duration of the deep-sea pressure and seawater immersion tests to 90 days in accordance with ETSO-C121b 'Underwater Locating Device (Acoustic) (Self-powered)'.

This update clarifies that the procedures to retrieve recorded information from a recorder (damaged or undamaged) must be documented, and that any special tools/recovery techniques that are necessary for that purpose shall be made available to the accident investigation authorities on request.

For deployable recorders, the reference to ED-112A, Section 3, has been replaced by a reference to the newly proposed ETSO-2C517.

Currently, the FAA TSO that corresponds to ETSO-C123d is at Revision b.

ETSO-C124d: Flight Data Recorder Equipment

According to this revision proposal, newly designed flight data recorder (FDR) equipment should meet the standards provided in EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, as amended by the new Appendix 1.

In particular, Appendix 1 extends the duration of the deep-sea pressure and seawater immersion tests to 90 days in accordance with ETSO-C121b 'Underwater Locating Device (Acoustic) (Self-powered)'.

This update clarifies that the procedures to retrieve recorded information from a recorder (damaged or undamaged) must be documented, and that any special tools/recovery techniques that are necessary for that purpose shall be made available to the accident investigation authorities on request.

For deployable recorders, the reference to ED-112A, Section 3, has been replaced by a reference to the newly proposed ETSO-2C517.

Currently, the FAA TSO that corresponds to ETSO-C123d is at Revision b.

ETSO-C176b: Cockpit Image Recorder Systems

According to this revision proposal, newly designed cockpit image recorder (CIR) systems should meet the standards provided in EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, as amended by the new Appendix 1.

In particular, Appendix 1 extends the duration of the deep-sea pressure and seawater immersion tests to 90 days in accordance with ETSO-C121b 'Underwater Locating Device (Acoustic) (Self-powered)'.

This update clarifies that the procedures to retrieve recorded information from a recorder (damaged or undamaged) must be documented, and that any special tools/recovery techniques that are necessary for that purpose shall be made available to the accident investigation authorities on request.

For deployable recorders, the reference to ED-112A Section 3 has been replaced by a reference to the newly proposed ETSO-2C517.

Currently, the FAA TSO that corresponds to ETSO-C176b is at Revision a.

ETSO-C177b: Data Link Recorder Equipment

According to this revision proposal, newly designed data link recorder (DLR) equipment should meet the standards provided in EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, as amended by the new Appendix 1.

In particular, Appendix 1 extends the duration of the deep-sea pressure and seawater immersion tests to 90 days in accordance with ETSO-C121b 'Underwater Locating Device (Acoustic) (Self-powered)'.

This update clarifies that the procedures to retrieve recorded information from a recorder (damaged or undamaged) must be documented, and that any special tools/recovery techniques that are necessary for that purpose shall be made available to the accident investigation authorities on request.

For deployable recorders, the reference to ED-112A Section 3 has been replaced by a reference to the newly proposed ETSO-2C517.

Currently, the FAA TSO that corresponds to ETSO-C177b is at Revision a.

ETSO-2C517: Automatic Deployable Flight Recorder (ADFR) Systems

According to this new ETSO, newly designed automatic deployable flight recorder (ADFR) systems should meet the standards provided in EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, as amended by Appendix 1.

Currently, there is no FAA TSO that corresponds to the proposed ETSO-2C517.

ETSO-C126c: Emergency Locator Transmitter

According to this revision proposal, newly designed emergency locator transmitters (ELTs) should meet the minimum performance standard (MPS) qualification and documentation standards provided in EUROCAE ED-62B, Minimum Operational Performance Standard for Aircraft Emergency Locator Transmitters 406 MHz, dated December 2018. ELTs that are of the distress tracking type (ELT(DT)) shall also meet the additional minimum performance specification for internal/integral GNSS receivers described in Appendix 1 to this ETSO.

Currently, the FAA TSO that corresponds to ETSO-C126c is at Revision b.

ETSO-2C197a: Information Collection and Monitoring Systems

According to this revision proposal, applicants for newly designed information collection and monitoring systems that record cockpit audio, aircraft data, airborne images, or data link communications should provide all the documents specified in EUROCAE ED-155, Section 2-1, 2-1.3.4.

Table 2 — Summary of changes to Index 2 of CS-ETSO

Changes to Index 2 of CS-ETSO	
New ETSO reference	**ETSO title**
ETSO-2C19c A1	Portable Water-Solution Type Hand Fire Extinguishers
ESO-2C197a	Information Collection and Monitoring Systems
ETSO-2C204a	Circuit Card Assembly Functional Sensors using Satellite-Based Augmentation System (SBAS) for Navigation and Non-Navigation Position/Velocity/Time Output
ETSO-2C205a	Circuit Card Assembly Functional Class Delta Equipment Using The Satellite-Based Augmentation System For Navigation Applications
ETSO-2C206	Circuit Card Assembly Functional Sensors using Aircraft-Based Augmentation for Navigation and Non-Navigation Position/Velocity/Time Output
ETSO-2C515 A1	Aircraft Halocarbon Clean Agent Hand-Held Fire Extinguishers
ETSO-2C516	Airborne Systems for Video/Audio Surveillance of Cabin and Cargo Areas
ETSO-2C517	Automatic Deployable Flight Recorder (ADFR) Systems
ETSO-2C518	Runway overrun awareness and alerting system
ETSO-2C519	Emergency Breathing System (EBS)

2.4. What are the expected benefits and drawbacks of the proposals

Technology and its related requirements are continuously changing, and thus new industry standards have been developed, or existing industry standards (to which existing ETSOs refer) have been updated and improved. As a result of this, new ETSOs could be developed and existing ETSOs need to be revised. This will contribute to ensuring that parts to be used on aircraft correspond to the latest (and safest) standards and technological solutions.

This practice is also expected to bring economic benefits to the industry, and no specific drawbacks have been identified.

3. Proposed amendments

The text of the amendment is arranged to show deleted text, new or amended text as shown below:

— deleted text is marked with ~~struck through~~;

— new or amended text is highlighted in blue;

— an ellipsis '[…]' indicates that the rest of the text is unchanged.

3.1. Draft certification specifications (CSs)

CS-ETSO is amended as follows:

SUBPART A — GENERAL

1. APPLICABILITY

1.1 Requirements for the issue of European ~~T~~technical ~~S~~standard ~~O~~order (ETSO) authorisations are found in Part-21, Section A, Subpart O.

1.2 Marking requirements for the issue of European ~~T~~technical ~~S~~standard ~~O~~order (ETSO) authorisations are found in Part-21, Section A, Subpart Q.

2. STANDARDS TO MEET TECHNICAL CONDITIONS

2.1 Environmental standards

Unless otherwise stated in paragraph 3.1.2 of the specific ETSO, the applicable environmental standards are contained in EUROCAE/RTCA document ED-14D, Change 3/DO-160D 'Environmental Conditions and Test Procedures for Airborne Equipment', Change 3, dated December 2002, ED-14E/DO-160E dated March 2005, ED-14F/DO-160F dated March 2008, ED-14G/DO-160G dated December 2010, or ED-14G Change 1/DO-160G Change 1 dated January 2015.

Compliance shall be demonstrated entirely with one of the above versions of the applicable environmental standards.

2.2 Software ~~standards~~

~~When~~ If the ETSO article includes ~~airborne~~ software, ~~unless otherwise stated in paragraph 3.1.3 of the specific ETSO, one~~ the software shall be developed with development assurance. Acceptable means of compliance for the development assurance of the airborne software is outlined in the latest revision of AMC 20-115, entitled Airborne Software ~~Considerations~~ Development Assurance ~~in Airborne Systems and Equipment Certification~~using EUROCAE ED-12 and RTCA DO-178.

The software level, also known as the 'item development assurance level (IDAL)', may be determined by using the guidance proposed in Section 2.4 of this document, below. The applicant must declare the software level(s) to which the software has been developed and verified.

2.3 Airborne electronic hardware (AEH)

If the ETSO article includes airborne electronic hardware, the airborne electronic hardware shall be developed with development assurance. The acceptable means of compliance for the development of airborne electronic hardware is outlined in the latest revision of AMC 20-152[10], entitled 'Development Assurance for Airborne Electronic Hardware'.

The airborne electronic hardware design assurance level, also known as the 'item development assurance level (IDAL)', may be determined by using the guidance proposed in Section 2.4 of this document, below. The applicant must declare the airborne electronic hardware design assurance level(s) to which it has been developed and verified.

~~If the article contains a complex application specific integrated circuit (ASIC) or a complex programmable logic device such as a programmable array logic components (PAL), a field-programmable gate array components (FPGA), a general array logic components (GAL), or an erasable programmable logic device (EPLD), all of which are known as 'complex electronic hardware' to accomplish the function, develop the component according to EUROCAE/RTCA document ED-80/DO-254 'Design Assurance Guidance for Airborne Electronic Hardware', dated April 2000.~~

~~Supplemental guidance material for all airborne electronic hardware (including boards, simple electronic hardware, use of COTS devices) included in the ETSO article may be found in 'EASA CM-SWCEH-001 Development Assurance of Airborne Electronic Hardware' Issue 01, revision 01, dated March 2012.~~

~~The design assurance level, also known as the 'item development assurance level (IDAL) for airborne electronic hardware (AEH)', may be determined by using the guidance proposed in Section 2.4. The applicant must declare the design assurance level(s) to which the AEH has been developed and verified.~~

2.4 Failure condition classification and development assurance

During the development of an ETSO article, consideration should be given to failure conditions, and the ETSO article should then be developed in accordance with the possible effects of those failure conditions at the system and aircraft levels (see AMC CS xx.1309 for further guidance; for CS-23 aircraft, further guidance can be found in FAA AC 23.1309-1E).

The ETSO article shall be developed according to at least the development assurance level that is appropriate to the failure condition classifications that are expected for the intended installation.

~~Where~~ If the effects at the system or aircraft level are not known, due to the non-availability of aircraft or system design data, the applicant should develop an assumption for the failure classification. The assumed failure classification should be at least as high as the ~~assumed failure classifications may be used~~, ~~but at a~~ minimum hazard classification ~~to the~~ level required in the ETSO.

The ~~C~~classification of failure conditions at the level of the ETSO article may change as a result of particular aircraft installation architectures and characteristics.

[10] Refer to NPA 2018-09 'Regular update of AMC-20: AMC 20-152 on Airborne Electronic Hardware and AMC 20-189 on Management of Open Problem Reports' (https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2018-09).

EUROCAE/SAE document ED-79A/ARP 4754A, 'Guidelines for Development of Civil Aircraft and Systems', dated December 2010, may be used to assign the development assurance levels of the ETSO article, software and AEH. The document may also be used ~~as well~~ as guidance to ensure that a proper development, validation and verification process is followed for ~~of~~ the ETSO article and its functional requirements.

2.5 ETSO article using an ETSO-2C153-authorised IMA platform or module

~~When~~ If the ETSO article implements one (or several) ETSO-2C153-authorised integrated modular avionics (IMA) platforms/modules and ~~for which~~ the applicant seeks compliance credit from this (these) ETSOA authorisation(s) to demonstrate compliance with one or several functional ETSO standard(s), the applicant shall apply for authorisation to the ETSO-C214 standard, together with the intended functional ETSO standard(s).

Note: ~~a~~A functional ETSO standard is any ETSO standard of CS-ETSO that describes ~~describing~~ an 'aircraft' function, i.e. it is typical of ~~typically~~ the majority of ~~all~~ ETSO standards, except ETSO-2C153 and ETSO-C214.

2.6 Open Problem Reports (OPRs)

Problem reports that are related to ETSO articles that contain software or airborne electronic hardware shall be identified and managed. Acceptable means of compliance for the management of OPRs are outlined in the latest revision of AMC 20-189[11] 'Management of Open Problem Reports'.

2.7 Embedded batteries

If an ETSO article embeds a battery whose energy is greater than or equal to 2 Wh, the article and the battery shall also be approved against the applicable battery ETSO.

For rechargeable lithium batteries whose energy is less than 2 Wh, the battery shall be certified to UL 1642, UL 2054 or IEC 62133, unless it is shown to meet the requirements of RTCA DO-311A Energy Category 2.

For non-rechargeable lithium batteries whose energy is less than 2 Wh, the battery shall be certified to UL 1642 and shall comply with the UN transport regulation.

If there is no ETSO that is applicable to a particular battery that a manufacturer intends to use in an ETSO article, the manufacturer should contact EASA.

3. ADDITIONAL INFORMATION

3.1 In some ETSOs, reference is made to an associated FAA standard. In these cases, the corresponding FAA technical standard order (TSO) can be consulted on http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgTSO.nsf/Frameset?OpenPage.

3.2 Standards documents referred to in this CS-ETSO may be purchased or obtained from the following organisations:

— ASD-STAN documents:

[11] Refer to NPA 2018-09 'Regular update of AMC-20: AMC 20-152 on Airborne Electronic Hardware and AMC 20-189 on Management of Open Problem Reports' (https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2018-09).

AeroSpace and Defence Industries Association of Europe – Standardization
Rue Montoyer 10 - 1000 Brussels
(E-mail: sales@asd-stan.org, website: www.asd-stan.org)

— ASTM documents ~~may be purchased from~~:
American Society for Testing and Materials, ASTM International,
100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania 19428-2959, USA
(Website: www.astm.org)

— EUROCAE documents ~~may be purchased from~~:
European Organisation for Civil Aviation Equipment
9-23 rue Paul Lafargue, ''Le Triangle'' building, 93200 Saint-Denis, France
Telephone: +33 1 49 46 19 65
(E-mail: eurocae@eurocae.net, website: www.eurocae.net)

— EUROCONTROL Surveillance Document Library:
https://www.eurocontrol.int/articles/surveillance-library

— FAA standards ~~may be purchased from~~:
Superintendent of Documents, Government Printing Office
732N Capitol Street NW, Washington DC 20401, USA
(Website: www.gpoaccess.gov)

— FCC Documents:
http://www.fcc.gov

— Global System, Inc., documents ~~may be purchased from~~:
Global Systems, Inc., 2144 Michelson Drive, Irvine, California 92715, USA
Telephone: (714) 851-0119

— MIL specifications ~~may be obtained from~~:
DODSSP, Standardization Documents Order Desk
Building 4D, 700 Robbins Avenue, PHILADELPHIA, PA 19111-5094, USA
or from the ASSIST Customer Service Desk, telephone (215) 697-6396
(Website: http://quicksearch.dla.mil/)

— NAS specifications ~~may be obtained from~~:
Aerospace Industries Association (AIA)
1327 Jones Drive, Ann Arbor, MI 48105, USA
(Website: www.techstreet.com)

— RTCA documents ~~may be purchased from~~:
Radio Technical Commission for Aeronautics, Inc.
1828 L Street NW, Suite 805, Washington DC 20036, USA
(Website: www.rtca.org)

— SAE documents ~~may be purchased from~~:
Society of Automotive Engineers, Inc.
400 Commonwealth Drive, WARRENDALE, PA 15096-001, USA
(Website: www.sae.org)

SUBPART B —– LIST OF ETSOs (INDEX 1 AND INDEX 2)

Index 1

EASA ETSO ref.	Title	Last amended by
ETSO-C1e	Cargo Compartment Fire Detection Instruments	CS-ETSO/13
ETSO-C2d	Airspeed Instruments	CS-ETSO/Initial Issue
ETSO-C3e	Turn and Slip Instruments	CS-ETSO/11
ETSO-C4c	Bank and Pitch Instruments	CS-ETSO/Initial Issue
ETSO-C5f	Direction Instrument, Non-Magnetic (Gyroscopically Stabilized)	CS-ETSO/11
ETSO-C6e	Direction Instrument, Magnetic (Gyroscopically Stabilized)	CS-ETSO/6
ETSO-C7d	Direction Instrument, Magnetic Non-Stabilized Type (Magnetic Compass)	CS-ETSO/Initial Issue
ETSO-C8e	Vertical Velocity Instrument (Rate-of-Climb)	CS-ETSO/6
ETSO-C10~~b~~c	~~Aircraft Altimeter,~~ Pressure Altimeter System ~~Actuated, Sensitive Type~~	CS-ETSO/~~Initial Issue~~15
ETSO-C13~~f~~g	Life preservers	CS-ETSO/~~1~~15
ETSO-C14b	Aircraft Fabric, Intermediate Grade; External Covering Material	CS-ETSO/Initial Issue
ETSO-C15d	Aircraft Fabric, Grade A; External Covering Material	CS-ETSO/Initial Issue
ETSO-C16b	Electrically Heated Pitot and Pitot-Static Tubes	CS-ETSO/13
ETSO-C20a	Combustion Heaters	CS-ETSO/~~Initial Issue~~15
ETSO-C21b	Aircraft Turnbuckle Assemblies and/or Turnbuckle Safetying Devices	CS-ETSO/Initial Issue
ETSO-C22g	Safety Belts	CS-ETSO/Initial Issue
ETSO-C23f	Personal Parachute Assemblies and Components	CS-ETSO/13
ETSO-C25a	Aircraft Seats and Berths (Type I Transport 6g Forward Load)	CS-ETSO/Initial Issue
ETSO-C26d	Aircraft Wheels and Wheel-Brake Assemblies (CS-23, 27 and 29 aircraft)	CS-ETSO/12
ETSO-C27a	Twin Seaplane Floats	CS-ETSO/~~Initial Issue~~15
ETSO-C28	Aircraft Skis	CS-ETSO/Initial Issue

EASA ETSO ref.	Title	Last amended by
ETSO-C30d	Aircraft Position Lights	CS-ETSO/13
ETSO-C39c	Aircraft Seats and Berths Certified by Static Testing only	CS-ETSO/6
ETSO-C42	Propeller Feathering Hose Assemblies	CS-ETSO/Initial Issue
ETSO-C43~~c~~d	Temperature Instruments	CS-ETSO/~~Initial Issue~~15
ETS0-C44c A1	Fuel Flowmeters	CS-ETSO/8
ETS0-C45b A1	Manifold Pressure Instruments	CS-ETSO/8
ETSO-C46a	Maximum Allowable Airspeed Indicator System	CS-ETSO/Initial Issue
ETS0-C47a A1	Pressure Instruments — Fuel, Oil, and Hydraulic (Reciprocating Engine-Powered Aircraft)	CS-ETSO/8
ETSO-C49b	Electric Tachometer: Magnetic Drag (Indicator and Generator)	CS-ETSO/Initial Issue
ETSO-C53a	Fuel and Engine Oil System Hose Assemblies	CS-ETSO/Initial Issue
ETSO-C54	Stall Warning Instruments	CS-ETSO/Initial Issue
ETSO-C55a	Fuel and Oil Quantity Instruments	CS-ETSO/7
ETS0-C56b A1	Engine-Driven Direct Current Generators/Starter Generators	CS-ETSO/8
ETSO-C59b	Airborne Selective Calling Equipment	CS-ETSO/13
ETSO-C62e	Aircraft Tyres	CS-ETSO/7
ETSO-C63e	Airborne Weather Radar Equipment	CS-ETSO/13
ETSO-C64b	Oxygen Mask Assembly, Continuous Flow, Passenger	CS-ETSO/12
ETSO-C69c	Emergency Evacuation Slides, Ramps and Slide/Rafts Combinations	CS-ETSO/Initial Issue
ETSO-C70b	Life Rafts	CS-ETSO/11
ETSO-C71	Airborne Static ('DC to DC') Electrical Power Converter (for Air Carrier Aircraft)	CS-ETSO/Initial Issue
ETSO-C72c	Individual Flotation Devices	CS-ETSO/Initial Issue
ETSO-C73	Static Electrical Power Inverter	CS-ETSO/Initial Issue
ETSO-C76b	Fuel Drain Valves	CS-ETSO/11
ETSO-C78a	Crewmember Demand Oxygen Mask	CS-ETSO/13
ETSO-C79	Fire Detectors (Radiation Sensing Types)	CS-ETSO/Initial Issue
ETSO-C80	Flexible Fuel and Oil Cell Material	CS-ETSO/Initial Issue

EASA ETSO ref.	Title	Last amended by
ETSO-C85b	Survivor Locator Lights	CS-ETSO/12
ETSO-C87a	Airborne Low-Range Radio Altimeter	CS-ETSO/8
ETSO-C88b	Automatic Pressure Altitude Reporting Code Generating Equipment	CS-ETSO/11
ETSO-C89a	Crew Member Oxygen Regulators, Demand	CS-ETSO/11
ETSO-C90d A1	Cargo Pallets, Nets and Containers	CS-ETSO/11
ETSO-C92c	Ground Proximity Warning, Glide Slope Deviation Alerting Equipment	CS-ETSO/Initial Issue
ETSO-C95a	Mach Meters	CS-ETSO/7
ETSO-C96b	Anticollision Light Systems	CS-ETSO/13
ETSO-C99a	Flight Deck (Sedentary) Crew Member Protective Breathing Equipment	CS-ETSO/11
ETSO-C100c	Aviation Child Safety Device (ACDS)	CS-ETSO/11
ETSO-C101	Overspeed Warning Instruments	CS-ETSO/Initial Issue
ETSO-C102	Airborne Radar Approach and Beacon Systems for Helicopters	CS-ETSO/Initial Issue
ETSO-C103	Continuous Flow Oxygen Mask Assembly (for Non-Transport Category Aircraft)	CS-ETSO/Initial Issue
ETSO-C105	Optional Display Equipment for Weather and Ground Mapping Radar Indicators	CS-ETSO/Initial Issue
ETSO-C106 A1	Air Data Computer	CS-ETSO/8
ETSO-C109	Airborne Navigation Data Storage System	CS-ETSO/Initial Issue
ETSO-C110a	Airborne Passive Thunderstorm Detection Systems	CS-ETSO/Initial Issue
ETSO-C112e	Secondary Surveillance Radar Mode S Transponder	CS-ETSO/11
ETSO-C113~~a~~b	Airborne Multi-purpose Electronic Displays	CS-ETSO/~~11~~15
ETSO-C114 A1	Torso Restraint Systems	CS-ETSO/8
ETSO-C115d	Required Navigation Performance (RNP) Equipment using Multi-Sensor Inputs	CS-ETSO/13
ETSO-C116a	Crew Member Portable Protective Breathing Equipment	CS-ETSO/11
ETSO-C117~~a~~b	Airborne Wind Shear Warning and Escape Guidance Systems (Reactive Type) for Transport Aeroplanes	CS-ETSO/~~Initial Issue~~15
ETSO-C118a	Traffic Alert and Collision Avoidance System I (TCAS I)	CS-ETSO/13

EASA ETSO ref.	**Title**	**Last amended by**
ETSO-C119d	Airborne Collision Avoidance System II (ACAS II) Version 7.1 with Hybrid Surveillance	CS-ETSO/11
ETSO-C121b	Underwater Locating Device	CS-ETSO/8
ETSO-C123~~c~~d	Cockpit Voice Recorder Systems	CS-ETSO/~~13~~15
ETSO-C124~~c~~d	Flight Data Recorder Systems	CS-ETSO/~~13~~15
ETSO-C126~~b~~c	~~406 and 121.5 MHz~~ Emergency Locator Transmitter	CS-ETSO/~~11~~15
ETSO-C127b	Rotorcraft, Transport Aeroplane, and Small Aeroplane Seating Systems	CS-ETSO/11
ETSO-C132a	Geosynchronous Orbit Aeronautical Mobile Satellite Services Aircraft Earth Station Equipment	CS-ETSO/12
ETSO-C135a	Large Aeroplane Wheels, and Wheels and Brake Assemblies	CS-ETSO/6
ETSO-C139a	Aircraft Audio Systems and Equipment	CS-ETSO/11
ETSO-C141	Aircraft Fluorescent Lighting Ballast/Fixture Equipment	CS-ETSO/Initial Issue
ETSO-C142~~a~~b	Non-Rechargeable Lithium Cells and Batteries	CS-ETSO/~~3~~15
ETSO-C144a	Passive Airborne Global Navigation Satellite System (GNSS) Antenna	CS-ETSO/6
ETSO-C145e A1	Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite-Based Augmentation System	CS-ETSO/~~13~~15
ETSO-C146e A1	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite-Based Augmentation System	CS-ETSO/~~13~~15
ETSO-C147a	Traffic Advisory System (TAS) Airborne Equipment	CS-ETSO/12
ETSO-C151~~c~~d	Terrain Awareness and Warning System (TAWS)	CS-ETSO/~~11~~15
ETSO-C154c	Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment	CS-ETSO/7
ETSO-C155b	Recorder Independent Power Supply	CS-ETSO/13
ETSO-C157b	Flight Information Services-Broadcast (FIS-B) Equipment	CS-ETSO/12
ETSO-C158	Aeronautical Mobile High Frequency Data Link (HFDL) Equipment	CS-ETSO/7
ETSO-C159~~c~~d	Next Generation Satellite Systems (NGSS) Equipment	CS-ETSO/~~13~~15
ETSO-C160a A1	VDL Mode 2 Communications Equipment	CS-ETSO/~~8~~15
ETS0-C161a	Ground-Based Augmentation System Positioning and Navigation Equipment	CS-ETSO/7

EASA ETSO ref.	Title	Last amended by
ETSO-C162a	Ground-Based Augmentation System Very High Frequency Data Broadcast Equipment	CS-ETSO/7
ETSO-C165~~a~~b	Electronic Map Systems for Graphical Depiction of Aircraft Position	CS-ETSO/~~9~~15
ETS0-C166b A3	Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Service-Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)	CS-ETSO/13
ETSO-C168	Aviation Visual Distress Signals	CS-ETSO/15
ETSO-C170	High-Frequency (HF) Radio Communication Transceiver Equipment Operating Within the Radio Frequency 1.5 to 30 Megahertz	CS-ETSO/7
ETSO-C172a	Cargo Restraint Strap Assemblies	CS-ETSO/12
ETSO-C173a	Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid Batteries	CS-ETSO/11
ETS0-C174 A1	Battery-Based Emergency Power Unit (BEPU)	CS-ETSO/8
ETSO-C175	Galley Cart, Containers and Associated Components	CS-ETSO/3
ETSO-C176~~a~~b	Aircraft Cockpit Image Recorder Systems	CS-ETSO/~~13~~15
ETSO-C177~~a~~b	Data Link Recorder Equipment	CS-ETSO/~~12~~15
ETSO-C178	Single Phase 115 VAC, 400 Hz Arc Fault Circuit Breakers	CS-ETSO/8
ETSO-C179~~a~~b	~~Permanently Installed~~ Rechargeable Lithium Cells, Batteries, and Battery Systems	CS-ETSO/~~7~~15
ETSO-C184	Galley Equipment	CS-ETSO/7
ETSO-C190	Active Airborne Global Navigation Satellite System (GNSS) Antenna	CS-ETSO/6
ETSO-C194	Helicopter Terrain Awareness and Warning System (HTAWS)	CS-ETSO/7
ETSO-C195b	Avionics Supporting Automatic Dependent Surveillance-Broadcast (ADS-B) Aircraft Surveillance	CS-ETSO/12
ETSO-C196~~a~~b	Airborne Supplemental Navigation Sensors for Global Positioning System Equipment Using Aircraft-Based Augmentation	CS-ETSO/~~7~~15
ETSO-C198	Automatic Flight Guidance and Control System (AFGCS) Equipment	CS-ETSO/8
ETSO-C199 A1	Traffic Awareness Beacon System (TABS)	CS-ETSO/~~13~~15
ETSO-C200a	Low-Frequency Underwater Locating Device (ULD)	CS-ETSO/12
ETSO-C201	Attitude and Heading Reference Systems (AHRS)	CS-ETSO/11
ETSO-C202	Cargo Stopper Devices	CS-ETSO/11

EASA ETSO ref.	**Title**	**Last amended by**
ETSO-C203 A1	Fire containment covers (FCC)	CS-ETSO/13
ETSO-C207a	Aeronautical Mobile Airport Communication System (AeroMACS)	CS-ETSO/~~12~~15
ETSO-C209	Electronic Flight Instrument System (EFIS) Display	CS-ETSO/13
ETSO-C210	Airborne Head-Up Display	CS-ETSO/13
ETSO-C214	Functional ETSO equipment using an ETSO-2C153-authorised IMA platform or module	CS-ETSO/14

Index 2

EASA ETSO ref.	Title	Last amended by
ETSO-2C11e	Power Plant Fire Detection Instruments (Thermal and Flame Contact Types)	CS-ETSO/Initial Issue
ETSO-2C19c A1	Portable Water-Solution Type Hand Fire Extinguishers	CS-ETSO/~~12~~15
ETSO-2C34f	ILS Glide Slope Receiving Equipment Operating within the Radio Frequency Range of 328.6–335.4 Megahertz (MHz)	CS-ETSO/Initial Issue
ETSO-2C35d	Radar Marker Receiving Equipment	CS-ETSO/Initial Issue
ETSO-2C36f	Airborne ILS Localizer Receiving Equipment Operating within the Radio Frequency Range 108–112 Megahertz	CS-ETSO/Initial Issue
ETSO-2C40c	VOR Receiving Equipment Operating within the Radio Frequency Range of 108–117.95 Megahertz	CS-ETSO/Initial Issue
ETSO-2C41d	Airborne Automatic Direction Finding (ADF) Equipment	CS-ETSO/Initial Issue
ETSO-2C48a	Carbon Monoxide Detector Instruments	CS-ETSO/6
ETSO-2C66b	Distance Measuring Equipment (DME) Operating within the Radio Frequency Range 960–1215 Megahertz	CS-ETSO/Initial Issue
ETSO-2C75	Hydraulic Hose Assembly	CS-ETSO/Initial Issue
ETSO-2C93b	Airborne Interim Standard Microwave Landing System Converter Equipment	CS-ETSO/Initial Issue
ETSO-2C104a	Microwave Landing System (MLS) Airborne Receiving Equipment	CS-ETSO/Initial Issue
ETSO-2C122	Devices That Prevent Blocked Channels Used in Two-Way Radio Communications Due to Simultaneous Transmissions	CS-ETSO/Initial Issue
ETSO-2C128	Devices That Prevent Blocked Channels Used in Two-Way Radio Communications Due to Unintentional Transmissions	CS-ETSO/Initial Issue
ETSO-2C153	Integrated Modular Avionics (IMA) Platform and Modules	CS-ETSO/10
ETSO-2C169a	VHF Radio Communications Transceiver Equipment Operating within the Radio Frequency Range 117.975 to 137 Megahertz	CS-ETSO/6
ETSO-2C197a	Information Collection and Monitoring Systems	CS-ETSO/~~7~~15
ETSO-2C204a	Circuit Card Assembly (CCA) Functional Sensors using Satellite-Based Augmentation System (SBAS) for Navigation and Non-Navigation Position/Velocity/Time (PVT) Output	CS-ETSO/15
ETSO-2C205a	Circuit Card Assembly Functional Class Delta Equipment Using The Satellite-Based Augmentation System For Navigation Applications	CS-ETSO/15
ETSO-2C206	Circuit Card Assembly Functional Sensors using Aircraft-Based Augmentation for Navigation and Non-Navigation Position/Velocity/Time Output	CS-ETSO/15
ETSO-2C500a	Combined ILS/MLS Airborne Receiving Equipment	CS-ETSO/Initial Issue
ETSO-2C501	Mode S Aircraft Data Link Processor	CS-ETSO/Initial Issue

EASA ETSO ref.	**Title**	**Last amended by**
ETSO-2C502	Helicopter Crew and Passenger Integrated Immersion Suits	CS-ETSO/1
ETSO-2C503	Helicopter Crew and Passenger Immersion Suits for Operations to or from Helidecks Located in a Hostile Sea Area	CS-ETSO/1
ETSO-2C504	Helicopter Constant-Wear Life Jackets for Operations to or from Helidecks Located in a Hostile Sea Area	CS-ETSO/1
ETSO-2C505	Helicopter Life Rafts for Operations to or from Helidecks Located in a Hostile Sea Area	CS-ETSO/1
ETSO-2C509	Light Aviation Secondary Surveillance Transponders (LAST)	CS-ETSO/2
ETSO-2C512	Portable Gaseous Oxygen Supply (PGOS)	CS-ETSO/3
ETSO-2C513	Tow Release	CS-ETSO/3
ETSO-2C514a	Airborne Systems for Non-Required Telecommunication Services (in Non-Aeronautical Frequency Bands) (ASNRT)	CS-ETSO/13
ETSO-2C515 A1	Aircraft Halocarbon Clean Agent Hand-Held Fire Extinguishers	CS-ETSO/~~11~~15
ETSO-2C516	Airborne Systems for Video/Audio Surveillance of Cabin and Cargo Areas	CS-ETSO/15
ETSO-2C517	Automatic Deployable Flight Recorder (ADFR) Systems	CS-ETSO/15
ETSO-2C518	Runway Overrun Awareness And Alerting System	CS-ETSO/15
ETSO-2C519	Emergency Breathing System (EBS)	CS-ETSO/15

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: PRESSURE ALTIMETER SYSTEM ~~AIRCRAFT ALTIMETER, PRESSURE ACTUATED, SENSITIVE TYPE.~~

1 — Applicability

This ETSO ~~gives~~ provides the requirements which pressure altimeter systems ~~altimeters pressure actuated~~ that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~provided in the SAE International's Aerospace Standard ~~(AS) document:~~ AS8009C, Pressure Altimeter Systems, dated 24 May 2016, as modified by Appendix 1 to this ETSO. ~~AS 392C, „Altimeter, Pressure Actuated Sensitive Type', revision date February, 1959 with the following exceptions, and as amended and supplemented by this ETSO: Exceptions~~

~~(i) The following specifically numbered paragraphs in AS 392C do not concern minimum performance and therefore are not essential to compliance with this paragraph: 3.1, 3.1.1, 3.1.2, 3.2, 3.2(a)(b)(c)(d)(e)(f).~~

~~(ii) In lieu of Section 7. in AS 392C, it is a requirement that the altimeters covered by this section be capable of successfully passing the test in paragraphs 7.1 through 7.5 and an External Case Pressure Test which is as follows:~~

~~External Case Pressure Test The static pressure source of the instrument shall be sealed when an ambient temperature of 25°C and an ambient pressure of 29.92 inches (absolute) of mercury have been achieved. The ambient pressure shall then be increased at a rate of 20 inches of mercury in two seconds to 50 inches (absolute) of mercury and held at that pressure for three minutes. There shall be no adverse effect on the instrument or its accuracy.~~

~~(iii) The „Reference Section' under Table II of AS 392C is not applicable.~~

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3.1.2 — Computer Software Environmental Standard

None.

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

None The declaration of design and performance (DDP) and the installation manual shall state the maximum calibrated altitude.

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

4 — Marking

4.1 — General

Marking is detailed in See CS-ETSO, Subpart A, paragraph 1.2. In addition, the maximum altitude for which altimeter is qualified to operate shall be legibly and permanently marked.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

MINIMUM PERFORMANCE STANDARD (MPS) FOR PRESSURE ALTIMETER SYSTEMS

This Appendix defines modifications and additions to the MPS for pressure altimeter equipment specified in SAE AS8009C, Pressure Altimeter Systems, dated 24 May 2016.

SAE AS8009C Section(s)	Change
3.4	**Add a note following the paragraph to read:** **Note:** Markings for the altitude range may be omitted from the dial of instruments that use a tape-type display.
3.10	**Delete current Section 3.10 and Table 9. Replace with the following:** **3.10 Temperature Corrections** Altimeters covered by this standard shall not incorporate automatic temperature corrections.
3.11	**Add new third paragraph to read:** Instruments that use a tape-type display or present altitude with a digital readout are permitted to use tic marks every 100 feet with a more prominent mark every 500 feet in agreement with SAE ARP4102/7, Appendix A, Symbols 39 and 40.
3.12	**Change the third sentence to read:** The word ALTITUDE or ALT may be marked on the dial in capital letters and may be in the same finish as the numerals.
3.12	**Add a note following the paragraph to read:** **Note:** Markings for the altitude range may be omitted for instruments that use a tape-type display.
5.	**Add new paragraph:** Some of these tests may be performed only once provided that it is demonstrated that this test will demonstrate performance for each article.
5.11	**Add a requirement for performance testing of Electronic Display Altimeters:** Electronic displays shall demonstrate their compliance with the SAE AS8034B requirements specified in Table 10 using the test procedures specified in SAE AS8034B, Section 6, as applicable.
6.29	**Add a requirement for environmental testing of Electronic Display Altimeters:** Electronic displays shall demonstrate the compliance of their equipment with the requirements of SAE AS8034B specified in Table 10 using the environmental performance requirements specified in SAE AS8034B, Section 5.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: LIFE PRESERVERS

1 — Applicability

This ETSO ~~gives~~ provides the requirements which life preservers that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical ~~c~~Conditions

3.1 — Basic

The standards of this ETSO apply to items of equipment that are intended to function as life preservers.

3.1.1 — Minimum ~~p~~Performance ~~s~~Standard

The applicable ~~S~~standards are those ~~set forth~~ provided in ~~the appendix 1 to this ETSO.~~ SAE International's Aerospace Standard AS1354, Individual Inflatable Life Preserver, dated February 2016, as modified by Appendix 1.

3.1.1.1 — Functional Qualification

Demonstrate the required functional performance under the test conditions specified in AS1354, Individual Inflatable Life Preserver, dated February 2016, as modified by Appendix 1 and Appendix 2.

3.1.2 — Environmental Standard

~~None~~

Demonstrate the required performance under the test conditions specified in AS1354, Individual Inflatable Life Preserver, dated February 2016, as modified by Appendix 1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

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3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

~~None~~

3.2.1 — Failure Condition Classification

Not applicable.

4 — Marking

4.1 — General

~~Marking is detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

~~As given in~~See Appendix 1.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

~~Federal Test Method Standards No 191A may be obtained (or purchased) from the General Service Administration, Business Service Center, Region 3, 7th and D Streets, S.W., Washington DC 20407.~~

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APPENDIX 1 MINIMUM PERFORMANCE STANDARD FOR LIFE PRESERVERS

1. Purpose. This standard provides the minimum performance standards for life preservers.

2. Scope. This standard covers inflatable (Type I) and non-inflatable (Type II) life preservers. Both Type I and Type II life preservers are divided into the following four categories: 'Adult,' 'Adult-Child,' 'Child,' and 'Infant-Small Child.'

3. Materials. The materials used must be of a quality which experience and/or tests have demonstrated to be suitable for use in life preservers.

   3.1 Non-metallic Materials.

   3.1.1 The finished device must be clean and free from any defects that might affect its function.

   3.1.2 Coated fabrics and other items, such as webbing, subject to deterioration must have been manufactured not more than 18 months prior to the date of delivery of the finished product or requalified per paragraph 5.1 Material Tests of this standard.

   3.1.3 The materials must not support fungal growth.

   3.1.4 Coated fabrics, including seams, subject to deterioration used in the manufacture of the devices must retain at least 90 percent of their original physical properties after these fabrics have been subjected to accelerated ageing test specified in paragraph 5.1 Material Tests of this standard.

   3.1.4.1 Strength. Coated fabrics used for these applications must conform to the following minimum strengths after ageing:

   Tensile Strength (Grab Test)
   Warp 37 N/mm (210 pounds/inch)
   Fill 32 N/mm (180 pounds/inch)

   Tear Strength
   1.8 x 1.8 N/mm (10 x 10 pounds/inch) (Tongue Test) or
   1.8 x 1.4 N/mm (10 x 8 pounds/inch) (Trapezoid Test)

   3.1.4.2 Adhesion. In addition to the requirements of 3.1.4.1, coated fabrics must meet the following minimum strength after ageing:
   Coat Adhesion
   1.8 N/mm width at 21 ± 3°C at a separation rate of 50 to 65 mm/minute (10 pounds/inch width at 70 ± 5 degrees F at a separation rate of 2.0 to 2.5 inches/minute).

   3.1.4.3 Permeability. For coated fabrics used in the manufacture of inflation chambers, the maximum permeability to helium may not exceed 5 liters/square meter in 24 hours at 25°C (77 degrees F) or its equivalent using hydrogen. The permeameter must be calibrated for the gas used. In lieu of this permeability test, an alternate test may be used provided the alternate test has been approved as an equivalent to this permeability test by the Agency

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3.1.5 Seam Strength and Adhesives. Cemented or heat sealable seams used in the manufacture of the device must meet the following minimum strength requirements.

3.1.5.1 Cemented Seams. Seams using adhesive on coated fabrics must be sealed with tape having a minimum width of 30 mm (1 3/16 inches). Devices manufactured with cemented seams must meet the following minimum strength requirements:

Seam Shear Strength (Grab Test)
30.6 N/mm width at 24°C (175 pounds/inch width at 75 degrees F)
7.0 N/mm width at 60°C (40 pounds/inch width at 140 degrees F)

Peel Strength (Peel Test)
1.8 N/mm width at 21°C (10 pounds/inch width at 70 degrees F)

3.1.5.2 Heat Sealed Seams. The application of tape over heat sealed seams is optional. Devices manufactured with heat sealed seams used in the manufacture of the device must meet the following minimum strength requirements:

Seam Strength (Grab Test)
7.9 N/mm width at 21°C (45 pounds/inch width at 70 degrees F)
5.3 N/mm width at 60°C (30 pounds/inch width at 140 degrees F)

3.1.6 Seam Tape. If tape is used, the fabric used for the seam tape must have a minimum breaking strength (Grab Test) of not less than 8.8 N/mm (50 pounds/inch) width in both the warp and fill directions. When applied to the seam area, the adhesion strength characteristics must meet the seam strength requirements in paragraph 3.1.5.

3.1.7 Materials Other Than Coated Fabrics.

3.1.7.1 Webbing. Webbing used to attach the life preserver to the wearer must have a minimum tensile strength of 1023 N (230 pounds).

3.1.7.2 Thread. Thread used in the life preserver must be Size E nylon or equivalent with a minimum tensile strength of 38 N (8.5 pounds).

3.1.8 Flammability. The device (including packaging) must be constructed of materials which are in compliance with CS-25.853(a) [Appendix F, Part I (a)(1)(iv)].

3.1.9 Molded Nonmetallic Fittings. Molded nonmetallic fittings must retain their physical characteristics when subjected to temperatures of –51 to +71°C (-60 to +160 degrees F).

3.2 Metallic Parts. All metallic parts must be made of corrosion resistant material or must be suitably protected against corrosion.

4. Detail Requirements.

4.1 Design and Construction.

4.1.1 Reversibility. The life preserver must perform its intended function when reversed, unless the design of the preserver precludes the probability of improper donning.

4.1.2 Compartmentation, Type I Life Preserver. An inflatable life preserver may have one or more separate gas tight flotation chambers. Each separate flotation chamber must meet the inflation requirements of paragraph 4.1.4.

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4.1.3 Protection Against Abrasion and Chafing, Type I Life Preserver. The flotation chambers must be protected in such a manner that metallic or nonmetallic parts do not cause chafing or abrasion of the material in either the packed or inflated condition.

4.1.4 Inflation, Type I Life Preserver.

4.1.4.1 Oral Inflation. A means must be provided by which the wearer, excluding child and infant small child wearers who would require adult assistance, without previous instruction, may inflate each flotation chamber by blowing into a mouthpiece. The mouthpiece for oral inflation must be readily available to the wearer without interfering with the wearer's face or body. For infant small child and child life preservers, the oral inflation means must be readily available to assisting persons.

4.1.4.2 Oral Inflation Valve. The opening pressure of the oral inflation valve, with no back pressure applied to the valve, may not exceed 3 kN/m^2 (0.44 pounds per square inch gage (psig)). The oral inflation valve may not leak when back pressure throughout the range from 0 – 69 kN/m^2 (0 psig through 10 psig) is applied. The joint between the oral inflation valve and the flotation chamber may not fail when a 445 N (100-pound) tensile load is applied for at least 3 seconds outwardly from and perpendicular to the surface of the flotation chamber at the point of valve attachment. To support the flotation chamber fabric during load application, an adapter having an inside diameter at least 19 mm (3/4 inch) larger than the outside diameter of the valve at the point of attachment must be used.

4.1.4.3 Manual Mechanical Inflation. A means must be provided by which the wearer, or person assisting a child or infant small child wearer who would require adult assistance, without previous instruction, may inflate each flotation chamber of the life preserver by manual operation.

4.1.4.3.1 Gas Reservoir. A reservoir containing a suitable compressed gas must be provided to inflate each flotation chamber of the life preserver. If carbon dioxide (CO_2) cylinders are used, the standards of MIL-C-601G Amendment 1 dated August 31, 1972 or the equivalent are acceptable not withstanding any size or weight limitations.

4.1.4.3.2 Pull Cord Assembly. The mechanical inflation means must have a pull cord assembly for each gas reservoir. The pull cords must be identical in length, clearly visible, and extend between 38 to 76 mm (1 1/2 to 3 inches) below the edge of the life preserver. The end of each pull cord assembly must be attached to a red pull knob or tab having rounded edges.

4.1.5 Deflation, Type I Life Preserver. A means by which the wearer or the person assisting a child or infant small child wearer who would require adult assistance, may quickly deflate each flotation chamber must be provided. Use of the deflation means may not preclude subsequent re-inflation of the flotation chamber by either oral or mechanical inflation means. Inadvertent deflation of the flotation chamber must be precluded. In particular, inadvertent deflation from movement of a child or infant small child and deliberate deflation by a child or small child must be precluded.

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4.1.6 Functional Temperature Range. The life preserver must be capable of satisfactory inflation after exposure for a minimum period of five minutes to the temperature range from –40 to +60°C (-40 to +140 degrees F).

4.1.7 Overpressure Protection. Type I Life Preserver. A flotation chamber, when orally inflated to a operating pressure not less than 7 kN/m² (l psig), must not burst upon subsequent discharge of the mechanical inflation system.

4.1.8 Buoyancy. The life preserver must provide a buoyant force not less than that shown in Table I, Minimum Buoyant Force. The buoyant force of the life preserver is equal to the weight of the volume of fresh water displaced by the life preserver when totally submerged. Buoyancy must be demonstrated using the standard gas reservoirs described in 4.1.4.3.1 without further oral inflation, starting from a vacuumed flat unit.

TABLE I, MINIMUM BUOYANT FORCE

Category of preserver	Weight of wearer (kg / pounds)	Minimum buoyant force in fresh water at 21 ± 3°C (70 ± 5 degrees F) (N / pounds)
Adult	Above 41kg (90 pounds)	156N (35 pounds)
Adult - Child Combination	16kg (35 pounds) and above	156N (35 pounds)
Child	16kg (35 pounds) to 41kg (90 pounds)	111N (25 pounds)
Infant - Small Child	Under 16kg (35 pounds)	89N (20 pounds)

4.1.9 Flotation Attitude.

4.1.9.1 Adult, Adult-Child, and Child Life Preservers. The life preserver must, within 5 seconds, right the wearer, who is in the water in a face-down attitude. The life preserver must provide lateral and rear support to the wearer's head such that the mouth and nose of a completely relaxed wearer is held clear of the water line with the trunk of the body inclined backward from the vertical position at an angle of 30 degrees minimum.

4.l.9.2 Infant-Small Child Life Preservers. The life preserver must prevent contact of the wearer's upper torso (i.e., from the waist up) with the water. There must be a means to confine the wearer in the proper position for utilization of the life preserver and prevent the wearer from releasing the confining means. With the wearer in the most adverse condition of weight and position attainable when the confining means are properly used, there must be no tendency of the life preserver to capsize or become unstable, take on water, or allow contact of the upper torso with water. Means must be provided to prevent the entrapment of rain or choppy water.

4.1.10 Tether Infant-Small Child Category Life Preserver. A tether not less than 2.83 m (72 inches) in length, must be attached to the infant-small child life preserver. The attach point must be located such that the flotation attitude specified in paragraph 4.1.9.2 is maintained when the line is under sufficient tension to remove the slack as when held by an adult in the water. With the life preserver on the infant-small child, there must be provisions for stowing or securing the tether in a manner that it remains readily accessible and will not dangle loosely so as to pose a hazard during an emergency evacuation.

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4.1.11 Life Preserver Retention and Donning Characteristics. The means of retaining the life preserver on the wearer, excluding infant-small child wearers, must require that the wearer secure no more than one attachment and make no more than one adjustment for fit. It must be demonstrated, in accordance with the donning tests specified in paragraph 5.9, that at least 75% of the total number of test subjects and at least 60% of the test subjects in each age group specified in paragraph 5.9 can don the life preserver within 25 seconds unassisted, starting with the life preserver in its storage package. Percentage calculations may not be increased when rounded off. It must be demonstrated that an adult unassisted can install an appropriate life preserver on another adult or a child within 30 seconds. It also must be demonstrated, in accordance with the donning tests specified in paragraph 5.9, that 60% of the adult test subjects can install an infant-small child dummy in an infant-small child life preserver within 90 seconds.

4.1.12 Comfort, Fit, and Adaptability. The design of the life preserver must be such that:

4.1.12.1 After donning, inadvertent release by the wearer is not likely.

4.1.12.2 Adjustment may be made by the wearer, or the person assisting a child or infant-small child wearer, while in the water.

4.1.12.3 Unobstructed view by the wearer, excluding infant-small child wearers, is allowed in both the forward and sideward directions. An observation window must be provided for viewing of an infant-small child wearer by the assisting person if the life preserver is enclosed.

4.1.12.4 Blood circulation of the wearer is not restricted.

4.1.12.5 The wearer's breathing is not restricted.

4.1.13 Survivor Locator Light. The life preserver must be equipped with a survivor locator light which meets the requirements of ETSO-C85a. The light must be automatically activated. This can be accomplished upon contact with water, upon inflation or by any other means not requiring additional user action.

4.1.14 Life Preserver Package. A package must be provided for the life preserver for storage of the life preserver on board the aircraft. The means of opening the package must be simple and obvious, and must be accomplished in one operation without the use of any tool or excessive physical force.

4.1.15 Color. The color of the life preserver must be an approved international orange-yellow or similar high visibility color. The color of the flight crew life preservers may be an approved red-orange or similar high visibility contrasting color.

4.2 Marking. The following information and instructions must be shown:

4.2.1 Pictorial Presentation. The proper donning procedure and other operational instructions on the use of the life preserver must be simple, obvious, and presented primarily pictorially with minimum use of words.

4.2.1.1 Orientation of Instructions. Instructions pertaining to operations which would normally be accomplished after the life preserver has been donned must be oriented so that the wearer, or the person assisting a child or an infant-small child wearer, may read them while in the water.

4.2.1.2 Readability in Emergency Lighting Conditions. Size, position, and contrast of instructions must be such that the pictorial descriptions and written instructions are easily distinguishable and readable in low level illumination.

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The markings and instructions must be readable by a person having 20/20 vision at a minimum viewing distance of 610 mm (24 inches) with illumination no greater than 0.54 lx (0.05 foot-candle). For written instructions, an acceptable means of complying with this requirement is by use of bold lettering approximately 5.6 mm (0.22 inch) high with a stroke width of 1.2 mm (0.047 inch).

4.2.3 Date of manufacture of fabric (month and year).

4.2.4 Size category: 'Adult,' 'Adult-Child,' 'Child,' or 'Infant-Small Child,' as appropriate and weight limitation of each category.

4.2.5 The life preserver package must clearly indicate that it contains a life preserver, the size category and the weight limitation of the life preserver. The package also must be marked with the life preserver ETSO and part number or the information must be visible through the package.

5. Tests.

5.1 Material Tests. The material properties specified in paragraph 3 of this standard must be conducted in accordance with the following test methods or other approved equivalent methods:

Accelerated AgeMethod	5850	Per Note (9)(1)
Tensile Strength (Grab Test)	Method 5100	Per Note (9)(7)
Tear Strength (Trapezoid Test)	Method 5136	Per Note (9)(5)
Tear Strength (Tongue Test)	Method 5134	Per Note (9)
		(Alternate to Trapezoid Test see 3.1.4.1)
Ply Adhesion	Method 5960	Per Note (9)(3)
Coat Adhesion	Method 5970	Per Note (9)(8)
Permeability	Method 5460	Per Note (5)(6)
Seam Shear Strength		Per Note (9)(2)
Seam Peel Strength	Method 5960	Per Note (9)(3)
Flammability		CS-25, Appendix F,Part I(b)(5), Horizontal Burn Rate Per Note (4)

NOTES:

(1) Samples of coated fabric and seams for the accelerated ageing tests must be exposed to a temperature of 70 ± 3°C (158 ± 5 degrees F) for not less than 168 hours. After exposure, the samples must be allowed to cool to 21 ± 1°C (70 ± 2 degrees F) for neither less than 16 hours nor more than 96 hours before determining their physical properties in accordance with paragraph 3.1 of this standard.

(2) Samples must consist of two strips of material 50mm (2 inches) maximum width by 127 mm (5 inches) maximum length. Strips must be bonded or heat sealed together along the width with an overlap of 19 mm (3/4 inch) maximum. Heat sealed seams must have a 3.2 ± 0.8 mm (1/8 ± 1/32) inch width minimum heat seal bead with the heat seal 6.3 mm (1/4 inch) from each end. The free ends must be placed in the testing machine described in FTMS 191A, Method 5100 and separated at a rate of 305 ± 13 mm/minute (12 ± 0.5 inches/minute). The average value of two samples must be reported. Samples may be multilayered to ensure against premature material failure. Samples may be gripped across the full 50 mm (two inches) of width.

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(3) Separation rate must be 50 to 65 mm/minute (2.0 to 2.5 inches/minute). Sample shall be 25 mm (one inch).

(4) The material must meet the flammability requirements of CS-25.853(a) [Appendix F, Part I (a) (l) (iv)]

(5) Federal Test Method Standard No. 191 in effect December 31, 1968.

(6) ASTM Method D1434-82, Procedure V, approved July 30, 1982, is an acceptable alternate method.

(7) Use of pneumatic grips, for holding test samples, is an acceptable alternate to the mechanical grips described in Method 5100.

(8) The sample shall be prepared using the adhesive and construction methods used to manufacture the life preserver. Separation rate must be 50 to 65 mm/minute (2.0 to 2.5 inches/minute).

(9) Federal Test Method Standard No. 191A dated July 20, 1978.

5.2 Leakage Test, Type I Life Preserver. The life preserver may not lose more than 3.5 kN/m^2 (1/2 psig) per flotation chamber after each flotation chamber has been inflated to not less than 13.8 kN/m^2 (2 psig) and hung in a rack for at least 12 hours.

5.3 Overpressure Test, Type I Life Preserver. Each flotation chamber of the life preserver must withstand an inflation pressure of not less than 69 kN/m2 (10 psig) for at least 5 minutes.

5.4 Submersion Test. The life preserver must be submerged in fresh water at 22 ± 3°C (72 ± 5 degrees F) so that no part of it is less than 610 mm (24 inches) below the surface. The buoyancy of the preserver must not be less than the value specified in paragraph 4.1.8 of this standard. Submersion must continue for at least 8 hours, except that the test may be discontinued in less than 8 hours if buoyancy measurements taken at four successive 30-minute intervals show that the buoyancy of the preserver has stabilized at a value at least equal to the value specified in paragraph 4.1.8 of this standard.

5.5 Salt Spray Test.

5.5.1 Salt Spray Test Procedure. All metal parts must be placed in an atomized salt solution spray for a period of not less than 100 hours. The solution must be atomized in the chamber at a rate of 10 litres per cubic metre of chamber volume (3 quarts per 10 cubic feet of chamber volume) per each 24-hour period. The temperature in the chamber must be maintained at 35 ± 1°C (95 ± 2 degrees F) throughout the test.

5.5.2 Salt Spray Solution. The salt used must be sodium chloride or equivalent containing not more than 0.2 percent of impurities on the dry weight basis. The spray solution must be prepared by dissolving 20 ± 2 parts by weight of salt in 80 ± 2 parts by weight of water containing not more than 200 parts per million of solids. The spray solution must be kept from exceeding this level of solids throughout the test. The spray solution must be maintained at a specific gravity of from 1.126 to 1.157 and a pH between 6.5 and 7.2 when measured at 35 ± 1°C (95 ± 2 degrees F).

5.6 Inflator Test, Type I Life Preserver.

5.6.1 Operating Force. The force necessary to operate the mechanical inflation means may not exceed 67 N (15 pounds) when applied through the pull cord.

5.6.2 Pull Cord Strength. The pull cord may not fail or separate from the mechanical inflation means when a minimum tension load of 267 N (60 pounds) is applied to the cord for at

~~least 3 seconds. If the pull cord is designed to separate from the mechanical inflation means when operated, the pull cord shall be capable of withstanding a minimum tension load of 133 N (30 pounds) for 3 seconds without failure.~~

~~5.6.3 Proof Pressure. The mechanical inflation means must withstand a hydrostatic pressure of not less than 10.3 MN/m2 (1,500 psig) without deformation or leakage. The mechanical inflation means may not leak when subjected to 13.8 kN/m2 (2 psig) air pressure and may not lose more than 3.4 kN/m2 (0.5 psig) when subjected to 276 kN/m2 (40 psig) air pressure. Each test pressure must be applied for not less than 30 seconds.~~

~~5.6.4 Mechanical Inflation Valve. The mechanical inflation valve must allow a minimum flow of 4 liters of air per minute at 276 kN/m2 (40 psig) inlet pressure. The valve may not leak when subjected to a vacuum of 3 kN/m2 (12 inches of water) applied so as to reduce the seating spring pressure and with atmospheric pressure on the opposite side. The joint between the valve and the flotation chamber may not fail when a 1112 N (250-pound) load is applied, for at least 3 seconds, outwardly from and perpendicular to the surface of the flotation chamber at the point of valve attachment. To secure the joint during application of the load, an adapter having an inside diameter at least 19 mm (3/4 inch) larger than the outside diameter of the valve at the point of attachment must be used.~~

~~5.7 Jump Test.~~

~~5.7.1 Adult, Adult-Child or Child. An inflated adult, adult-child, or child Type I or Type II life preserver, excluding infant-small child life preservers, must remain attached and not cause injury to the wearer when the wearer jumps into the water at any attitude from a height above the water of at least 1.5 m (5 feet). There must not be any damage to the preserver following the jump. Minor skin chafing is not considered an injury in this respect.~~

~~5.7.2 Infant-Small Child. An infant-small child life preserver must remain inflated and undamaged and the infant-small child dummy, specified in paragraph 5.9.1, must remain properly secured when an adult holding the dummy, with the preserver installed on the dummy, jumps into the water from a height above the water of at least 1.5 m (5 feet). The adult must be wearing an inflated life preserver for the test.~~

~~5.8 Fire Protection Test. Materials used in the life preserver and the storage package for the life preserver must be tested by the horizontal burn rate test prescribed in paragraph 5.1 of this standard.~~

~~5.9 Donning Test.~~

~~5.9.1 Test Subjects. There must be a minimum of 25 test subjects. There must be a minimum of five test subjects in each of the following age groups: 20-29 years; 30-39 years; 40-49 years; 50-59 years; and 60-69 years. Not more than 60% of the test subjects in any age group may be of the same sex. The number of test subjects in any age group may not exceed 30% of the total number of test subjects. Infant-small child donning tests must be performed by a minimum of 5 adult test subjects of both sexes between the ages of 20-40. Tests must be performed using an articulating infant-small child dummy, as described below. Adult test subjects must have no prior experience in donning tests of life preservers.~~

~~5.9.2 Infant-Small Child Test Dummy. The dummy to be used in the donning tests must have the basic physical characteristics for a composite 50th percentile unisex child of 24 months with a height of 864 mm (34 inches) and weighing 12.3 kg (27.2 pounds). The~~

~~dummy shall have articulating joints and, if used for water testing, must not absorb water. The anthropometric values for the dummy are presented in Table II. These data are considered valid for the stated chronological age plus or minus three months and are representative of U.S. children, as reported by the University of Michigan from 1975-1985.~~

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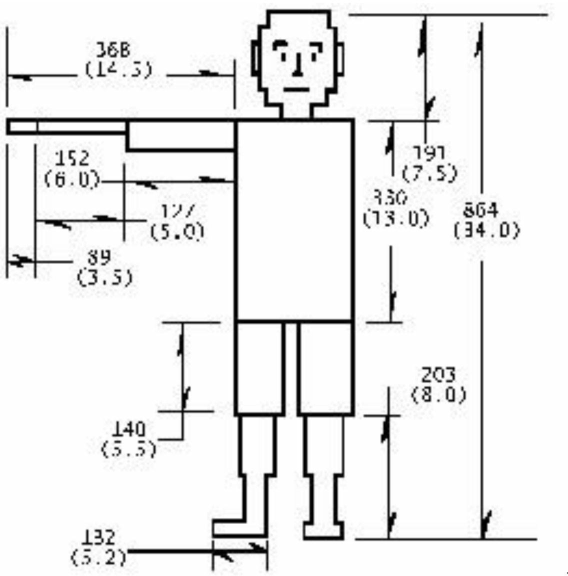
TABLE II, ANTHROPOMETRIC CHARACTERISTICS OF TWO YEAR OLD CHILD

Body Segment	Length (mm (in))	Weight (gm)	Volume (%)
Top of Head (ref.) -			
Top of Shoulder/			
Upper Arm Pivot -	191 (7.5)*	1, 591.6	12.9
Elbow Pivot -	152 (6.0)	876.0 (2)	7.1
Wrist Pivot -	127 (5.0)	530.5 (2)	4.3
Finger Tip -	89 (3.5)	123.5 (2)	1.0
Top of Shoulder/			
Upper Arm Pivot -			
Crotch/ Thigh Pivot	330 (13.0)*	5, 564.4	45.1
Knee Pivot -	140 (5.5)*	579.9 (2)	4.7
Bottom of Foot	203 (8.0)*	481.1 (2)	3.9
Total	*864 (34.0) Height	12,338.0 (27.2 lb)	100.0

Shoulder Breadth	234 (9.2)
Chest Breadth	168 (6.6)
Chest Depth	117 (4.6)
Waist Breadth	150 (5.9)
Waist Depth, seated	150 (5.9)
Hip Breadth	185 (7.3)
Foot	132 (5.2)
Circumferences	
Head	488 (19.2)
Neck	234 (9.2)
Chest	488 (19.2)
Waist	460 (18.1)
Hip	470 (18.5)
Mid-Thigh	251 (9.9)
Calf	196 (7.7)
Ankle	135 (5.3)
Upper Arm	150 (5.9)
Forearm	147 (5.8)
Wrist	130 (5.1)



5.9.3 Test Arrangement. Subjects must be seated in actual or simulated air carrier coach class seating with a seat row in front of the subjects creating a seat row pitch not exceeding 31 inches. Each subject must have the seat belt fastened. Subjects may be tested singularly or in groups seated side by side. Infant-small child life preserver donning tests must be performed with adults in adjacent seats who must not assist or hamper the adult performing the donning test. Subjects must receive no donning information other than a typical preflight briefing and donning demonstration on the use of life preservers.

5.9.4 Test Procedure. The donning test must be begun with the life preserver contained in the storage package required by paragraph 4.1.14, and the package held in the test subject's hand. Separate timing must be kept for each test subject. Timing starts on signal when the test subject has both hands on the packaged life preserver and stops when the life preserver is properly donned, secured, and adjusted for fit. During the test,

~~the test subject may release the seat belt and rise from the seat but may not move to any extent from the area immediately in front of the seat.~~

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Appendix 1

Functional and Environmental Qualification Requirements

Appendix 1 modifies the text in SAE International's Aerospace Standard AS1354, Individual Inflatable Life Preserver, dated February 2016. Compliance with the modified text is required in order to comply with the requirements of this ETSO.

When reading AS1354	**Do the following:**
Section 1	Disregard
Section 2	Apply all the subsections unless they are disregarded or modified below:
	Page 4, replace subsection 2.1 with the following text: 2.1 Applicable Documents The following publications form a part of this document to the extent specified herein. The applicable issue of cited publications shall be the issue that was in effect on the date of the publication of this document, unless otherwise specified. In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes the applicable laws and regulations unless a specific exemption has been obtained.
	Page 6, subsection 2.3 applies as written, except the replacement of the definition of the following terms as follows : APPROVED: The status of equipment that meets EASA standards. CHILLED HANDS TEST METHOD: A technique to simulate the reduced dexterity of chilled, wet hands that may occur during an emergency in a cold and wet environment. A naïve test subject simultaneously submerges left and right forearms and hands in 50 °F (10 °C) water for 2 minutes and immediately upon removal attempts to open/operate the designated packaging/equipment. The test subject *shall* be healthy and wear a loose-fitting, sleeveless upper garment that will not inhibit blood flow to the arms and hands. (Alternate: GLOVED HANDS TEST METHOD) SEAT PITCH: The distance from any point on one seat to exactly the same point on the seat in front or behind it. TEST SUBJECTS: Individuals who participate in life preserver tests (e.g. donning, retention, flotation). All such individuals shall be naïve, i.e. they shall have had no experience in using a life preserver or the specific equipment to be tested, and they shall not have viewed or talked with other persons performing the same or similar activities. Note that individuals who have experience in using marine or boating life preservers are considered to be acceptable test subjects.
Section 3	Apply all the subsections unless they are disregarded or modified below:

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	Page 7, Section 3, replace the introductory text with the following: 3. DESIGN AND PERFORMANCE REQUIREMENTS Tests and measurements performed to demonstrate compliance with this standard shall be conducted with equipment that is calibrated according to the original equipment manufacturer (OEM) specifications, using standards and references that are traceable to a recognised national authority (e.g. the National Institute of Standards and Technology (NIST)). The description of the test results shall include the accuracy and precision of the measurement(s), e.g. measured in 5-pound increments with an accuracy of ± 0.10 pounds. All tests that require timing shall use time-encoded video. In addition, tests that require human subjects or a child test dummy shall use time-encoded video. Demonstration life preservers are not addressed by this ETSO. They are not intended to be functional and should be marked accordingly.
	Page 10, replace subsection 3.9 with the following text: 3.9 Donning Donning tests shall be performed to show compliance with the design requirements and the comprehensibility of markings. The procedure for donning the life preserver shall be simple and obvious such that it can be rapidly donned by an untrained person without any assistance. This shall be demonstrated in accordance with the test criteria and procedures in subsection 5.3. For the adult and adult-child category, it shall be demonstrated that at least 75 % of the total number of test subjects, and at least 60 % of the test subjects in each age group specified in subsection 5.3.1, can don the life preserver within 25 seconds, unassisted, starting with the packaged life preserver on the test participant's lap. It must also be demonstrated that an unassisted adult can install an appropriate life preserver on another adult or child within 30 seconds. For the child and infant-small child category, it shall be demonstrated that at least 60 % of five adult test subjects of both sexes between the ages of 20 and 40, unassisted, can install a child life preserver on a child who weighs between 35 and 90 pounds (15.88 and 40.82 kg) and an infant-small child life preserver on a child dummy within 90 seconds, unassisted, starting with the *packaged* life preserver. The donning-time test does not apply to constant wear life preservers that are intended to be fully donned by the wearer while on board the aircraft. The donning-time test does apply to constant wear life preservers that are intended to be partially donned by the wearer while on board the aircraft and require an additional donning procedure prior to inflating the life preserver or entering the water. For these partially donned life preserver designs, the test shall begin with the life preserver in the partially donned condition.
	Page 10, replace subsection 3.10 with the following text: 3.10 Retention

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	The means of retaining the life preserver on the wearer for an adult, adult-child, and child life preserver shall require the wearer to secure no more than one attachment and make only one adjustment for fit. This requirement does not apply to constant wear life preservers. The retention means shall not make use of knots. The means of retaining the life preserver shall not require any action to secure it other than fastening and fit adjustment (e.g. removal of rubber bands, unfastening of attachment points). Partially donned life preservers shall not require the wearer to secure more than one attachment or make more than one adjustment for fit after the life preserver is partially donned. The means of retaining the life preserver shall be shown to be operable within 5 seconds with chilled or gloved hands (e.g. fastening/unfastening buckles, snapping/unsnapping, etc.). This will be demonstrated in accordance with the Chilled Hands or Gloved Hands Test Methods in subsection 5.4.2. This requirement does not apply to constant wear life preservers that are intended to be fully donned by the wearer while on board the aircraft. The adult, adult-child, and child category life preserver shall remain inflated, secured, and not cause injury to a wearer when it is tested in accordance with 5.4. There shall be no damage to the life preserver as a result of the jump. Chafing of the wearer's skin shall not be considered to be an injury. The infant-small child category life preserver shall remain inflated and undamaged, and the infant-small child dummy, specified in 5.3.2, shall remain properly secured in the donned life preserver, while being held by an adult *and tested in accordance with 5.4.3.*
	Page 11, replace subsection 3.11.2 with the following text: 3.11.2 Infant-Small Child The life preserver *shall* provide insulation for the wearer's head and upper torso (i.e. from the waist up) with a minimum R-value of 0.25 (equivalent to approximately 2 mm of wetsuit fabric). There shall be a means, other than knots, to restrict the position of the life preserver relative to the wearer, so as to provide proper function and prevent the wearer from releasing the means of restriction. Means shall be provided to prevent the introduction and/or entrapment of water. This shall be demonstrated in accordance with the Flotation Attitude Test procedure in 5.5.2.
	Page 11, replace subsection 3.13 with the following text: 3.13 Tether, Infant-Small Child Category A tether of PIA-C-5040, Type 3 cord or equivalent, at least 72 inches (182.88 mm) long, shall be attached to the infant-small child life preserver. The attachment shall be located such that the flotation attitude specified in 3.11.2 is maintained when the line is held taut in the water. The attachment shall be shown to withstand a 70-pound (31.75 kg) pull for at least 3 seconds without a failure of the line or the attachment. A positive-buoyancy attachment means shall be provided at the free end of the tether. The attachment means shall be shown to be operable with cold, wet hands, using either the Chilled Hands or Gloved Hands Test Method. *This must be demonstrated in*

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	accordance with subsection 5.9. There shall be a provision for stowing or securing the tether during use so that it remains readily accessible and does not dangle loosely.
	Page 11, replace subsection 3.14 with the following text: 3.14 Survivor Locator Light The life preserver shall be equipped with a survivor locator light that meets the requirements of ETSO-C85b or TSO-C85b, Survivor Locator Lights. The light shall automatically activate upon initial immersion in the water or by other means that do not require additional action by the wearer once the life preserver is fully donned. The light shall be located so to enhance visibility from a surface vessel or from an aircraft.
	Page 12, replace subsection 3.17.2 with the following text: 3.17.2 Package Opening Opening of the package shall be demonstrated in accordance with the Package Opening test procedures in 5.7.
	Page 12, replace subsection 3.18.1 with the following text: 3.18.1 Instructions The proper donning procedure and other operational instructions shall be simple, obvious, and *shall* be presented pictorially with a minimum use of words. Instructions that pertain to operations normally accomplished after the life preserver has been donned shall be oriented so that the wearer, or the person assisting a child or an infant-small child wearer, can see them while in the water. Instructions shall be sized, positioned and contrasted with the background to make them easily readable and comprehensible at a viewing distance of 24 inches (60.96 cm) with illumination no greater than 0.05 ft-c (0.54 lux) by a person who has 20/20 vision. Written instructions shall use bold lettering at least 0.22 inches (5.6 mm) high with a stroke width of at least 0.047 inches (1.2 mm). Comprehensibility shall be demonstrated in accordance with the Comprehensibility test procedure in subsection 5.8.
Section 4	Apply all the subsections unless they are disregarded or modified below:
	Page 13, replace subsection 4.2.1 with the following text: 4.2.1 Permeability The materials used in the construction of the air holding cell shall have a maximum permeability to helium of 5 L/m2 in 24 hours at 77 °F (25 °C) when tested in accordance with 5.6.3.
Section 5	Apply all the subsections unless they are disregarded or modified below:
	Page 15, replace subsection 5.1.2 with the following text: 5.1.2 Overpressure

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	The life preserver shall meet the minimum buoyancy requirements defined in 3.4 when it is subjected to overpressure. Inflate each flotation chamber via the oral inflation tube to 1 psig (6.89 kPa), then manually actuate the discharge of the gas reservoir for each chamber. Submerge the life preserver in fresh water at a temperature of 70 °F ± 5 °F (21.1 °C ± 2.8 °C), so that no part of it is less than 24 inches (60.96 cm) below the surface of the water. Measure the buoyancy to show compliance with the applicable requirement in Table 1. Keep the life preserver submerged for at least 8 hours, after which time it shall be shown to meet or exceed the requirement in Table 1. Alternatively, the test may be discontinued in less than 8 hours if buoyancy measurements taken at 4 successive 30-minute intervals show that the buoyant force of the life preserver has stabilised at or above the value specified in Table 1.
	Pages 15-16, replace subsection 5.3.1 with the following text: 5.3.1 Test Subjects At least 25 test subjects shall be employed in tests of an adult or adult-child preserver. At least 5 of those test subjects shall be from each of the following age groups: 20 to 29 years; 30 to 39 years; 40 to 49 years; 50 to 59 years; and 60 to 69 years. No more than 60 % of the test subjects in any age group may be of the same sex. The number of test subjects in any age group may not exceed 30 % of the total number of test subjects. Child-donning tests shall be performed by a minimum of 5 adult test subjects of both sexes between the ages of 20 and 40. Tests shall be performed using a child that weighs between 35 and 90 pounds (15.88 and 40.91 kg). Infant-small child donning tests shall be performed by a minimum of 5 adult test subjects of both sexes between the ages of 20 and 40. Tests shall be performed using an articulating infant-small child dummy per subsection 5.3.2. Adult test subjects shall have no experience with inflatable life preservers or donning tests. Test subjects shall not be familiar with the manufacture, production, or maintenance of inflatable life preservers. Test subjects shall receive no donning instructions other than the general introduction briefing and preflight video briefing on the use of the life preserver per Appendix D — Donning Test Briefings. Instructions for the child and infant-small child category life preserver shall be the typical briefing given by a flight attendant to a parent/guardian that accompanies a child or infant on a flight. Test subjects may be informed (during the pre-test introduction briefing) that this is a timed test, and that their task is to don the life preserver within the applicable timeframe specified in subsection 3.9. *Furthermore, the installation, operating and maintenance instructions shall also reflect the requirements of this section. The operating instructions must report the detailed content of the simulated preflight briefing and any special instructions for the unique aspects of operating the design of the life preserver that should be considered for its operational use and continued performance.*
	Page 16, replace subsection 5.3.3 with the following text:

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5.3.3 Arrangement

Subjects in tests of an adult, adult-child, or child life preserver shall be seated in previously approved air carrier coach class seating, with a seat row in front of the test subjects, creating a seat pitch not exceeding 31 inches (78.74 cm). Subjects shall be seated one per row. All subjects shall have their seat belts fastened.

Infant-small child life preserver donning tests shall be performed with the adult test subject holding the infant on his/her lap, seated between two other adult subjects who shall not assist or hamper the test subject who performs the donning test. The adult test subject shall be wearing his/her own life preserver.

Page 16, replace subsection 5.3.4 with the following text:

5.3.4 Procedure

The donning test shall start on signal with the packaged life preserver held on the test subject’s lap, or for a constant wear life preserver, the test shall start in the partially donned configuration. The timing of the test shall end when the life preserver is properly donned, secured, and adjusted for fit (the means of adjustment shall be adjusted for a snug fit on the test subject). Donning tests shall be captured on video; the timing for each individual subject shall be recorded separately.

Page 16, add two new subsections to 5.4 as follows:

5.4.2 Retention Mechanism Test

Demonstrate the operability of the life preserver retention mechanism using either the Chilled Hands or Gloved Hands Test Method (see 2.3 Definitions). At least 4 out of 5 test subjects shall secure the life preserver retention mechanism (e.g. fasten and then unfasten it) within 5 seconds. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the retention mechanism task within the allowed time.

5.4.3 Infant-Small Child Life Preserver

The infant-small child category life preserver shall remain inflated and undamaged, and the infant-small child dummy, specified in 5.3.2, shall remain properly secured in the donned life preserver, while being held by an adult who jumps into the water from a height of 5 feet (1.52 m) above the water. The adult shall wear an inflated life preserver for this test.

Page 17, replace subsection 5.6.2 with the following text:

5.6.2 Flammability

The life preserver and package shall be constructed of material that meets the requirements of the latest amendment of CS-25, Appendix F, Part I. The definition and use of parts that are considered to be small parts (e.g. oral inflation tubes, clips, etc.) that

	would not contribute significantly to the propagation of a fire must be coordinated in advance with EASA.
	Page 17, replace subsection 5.6.3 with the following text: 5.6.3 Permeability The permeability shall be tested in accordance with the permeability test procedure in FTMS 191, Method 5460; or alternatively, ASTM D1434-82, Procedure V may be used. The permeameter shall be calibrated for the gas that is used.
	Page 18, replace subsection 5.7.1 with the following text: 5.7.1 Pull Force The pull force necessary to operate the opening mechanism *shall* be mechanically demonstrated not to exceed 9 pounds (40 N), or the opening of the mechanism shall be demonstrated in less than 7 seconds by at least 8 of 10 females over the age of 60, without any preview of the instructions. The timing *shall* start when the test participant has both hands on the package and is ready to open it, and shall end when the package is fully opened (e.g. the pull tab/strip is completely removed). A nick or cut shall not be introduced in the edge of the material at the tear line unless it is normally a part of the package design. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the opening of the package within the allowed time.
	Page 18, replace subsection 5.7.2 with the following text: 5.7.2 Operation of the Opening Mechanism Operation of the opening mechanism *shall* be demonstrated within 10 seconds by 8 of 10 females with reduced dexterity simulated by the Chilled Hands or Gloved Hands Test Method, and without a preview of the instructions. The timing *shall* start when the test participant has both hands on the package and is ready to open it, and end when the life preserver is fully removed from the package. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the opening of the package within the allowed time.
	Page 18, replace subsection 5.8 with the following text: 5.8 Comprehensibility Comprehensibility shall be demonstrated by 5 out of 6 test subjects, tested independently, using an open-ended answer format (see *examples in* ANSI Z535 or ISO 9186:2001) and/or a successful empirical demonstration of the equipment or feature.
	Page 18, add new subsection 5.9 as follows: 5.9 Tether Attachment Test

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	Demonstrate that the means of attachment, on the tether of the infant-small child life preserver, is operable using either the Chilled Hands or Gloved Hands Test Method (see 2.3 Definitions). At least 4 out of 5 test subjects shall secure the means of attachment of the life preserver. In cases for which additional participants are required, 75 % of the total number of test participants for each demonstration must complete the attachment task. This test may be performed on dry land. NOTE: The attachment should be demonstrated in the manner in which it is designed to be used; it should be attached to something as designed.
Appendix A	No change
Appendix B	No change
Appendix C	Page 24, replace Appendix C with Appendix 2 Tests Involving Subjects. See Appendix 2 on final page.
	Page 25, add a new Appendix D as follows: Appendix D — Donning Test Briefings You must use the following scripts for the donning-test briefing. For the assisted donning tests, substitute the appropriate donning time requirement as specified in subsection 3.9. The scripts may be modified as applicable for constant wear life preservers that are designed to be partially donned during flight. General introduction briefing script: You are participating in a passenger safety study to determine how long it takes to put on an aircraft life preserver. You are seated in a seat that is similar to those found on passenger aeroplanes; please fasten your seatbelt [pause until all seatbelts are fastened]. The test will simulate an actual airline emergency; your goal is to put on the life preserver as quickly as possible within 25 seconds or less. Video cameras will record your actions. To start the test, your instructor will say: ‘3, 2, 1, go!’ This is your signal to open the package and put on the life preserver. Following this introduction, a video of a simulated passenger information briefing will be presented. After the video, you will be handed your life preserver package. [Optional: Before the video, please review the safety information card for additional instructions on putting on the life preserver.] Preflight video briefing script: This test will simulate an actual airline emergency; your goal is to put on the life preserver as quickly as possible within 25 seconds or less. To start the test, your instructor will say: ‘3, 2, 1, go!’ This is your signal to open the package and put on the life preserver. To put on your life preserver:

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	— Pull the tab and tear open the package. — Remove the life preserver from the package. — Pull the life preserver over your head. — Grab the waist strap and wrap it around your waist. — Insert the clip into the buckle and pull the end of the waist strap to tighten the belt. — Raise your arms when you have finished.

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APPENDIX 2

TESTS INVOLVING SUBJECTS*

**NOTE: Tests that require human subjects or a child test dummy shall use time-encoded video.*

Test name	Paragraph	Number of subjects
Donning Test	**5.3**	
• Adult or Adult-Child	5.3.1	— 25 *adults* minimum — Age groups: 20-29, 30-39, 40-49, 50-59, 60-69 yrs (see 5.3.1 for more details)
• Child	5.3.1	— 5 adults: ages: 20-40 years, male and female — 5 children: each child: 35-90 lbs (15.88-40.91 kg)
• Infant-Small Child	5.3.1 5.3.2	— 5 adults: ages: 20-40 years, male and female — 1 anthropometric, infant-small child test dummy or child
Retention Test	**5.4**	
• Adult, Adult-Child, and Child	5.4.1	— 3 *adults* minimum, including at least one 5th percentile female and one 95th percentile male (measured by weight and head circumference)
• *Chilled Hands or Gloved Hands Test Method*	5.4.2	*— 5 adults minimum (see 2.3)*
• *Infant-Small Child*	5.4.3	*— 1 adult holding child test dummy or child (see 5.3.2)*
Flotation Attitude Test	**5.5**	
• Adult, Adult-Child, or Child	5.5.1	— 3 minimum, including at least one 5th percentile female and one 95th percentile male (measured by weight and head circumference)
Packaging Opening	**5.7**	
• Pull Force (2 methods)	5.7.1	— Mechanical: not to exceed 9 lbs (40 N) OR — 10 minimum, female, older than 60 yrs
• Operation of the Opening Mechanism	5.7.2	—10 minimum, female with reduced dexterity simulated by chilled or gloved hands (see 2.3)
Comprehensibility	**5.8**	— 6 adults
Tether Attachment	**5.9**	*— 5 adults minimum*

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: COMBUSTION HEATERS AND ACCESSORIES

1 — Applicability

This ETSO gives provides the requirements which combustion heaters and accessories that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The Aapplicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical cConditions

3.1 — Basic

3.1.1 — Minimum pPerformance sStandard

The applicable Sstandards are those set forthprovided in the Society of Automotive Engineers, Inc ., (SAE) Aerospace Standard AS 143B „HEATERS, AIRPLANE, INTERNAL COMBUSTION HEAT EXCHANGER TYPE', issued January 11, 1943, revised January 1949 SAE International's Aerospace Standard AS8040B, Heater, Aircraft, Internal Combustion Heat Exchanger Type, dated February 2013, as amended by Appendices 1 and 2 of this ETSO.

3.1.1.1 — Functionality

This standard in this ETSO applies to equipment that is intended to provide heated air for civil aircraft.

Note: For combustion heaters and accessories, the maintenance and inspection items contained in the instructions for continued airworthiness play an important role in preventing failures that result in combustion by-products entering the cabin/flight deck.

3.1.2 — Environmental Standard

Demonstrate the required performance under the test procedures in SAE AS8040B, Heater, Aircraft, Internal Combustion Heat Exchanger Type, dated February 2013, as amended by Appendix 1 of this ETSO, using standard environmental conditions and test procedures that are appropriate for airborne equipment.

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~~As indicated in AS 143B.~~

3.1.3 — ~~Computer~~ Software

See CS-ETSO, Subpart A, paragraph 2.2.

~~None~~

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

~~None~~

3.2.1 — Failure Condition Classification

(1) A failure of the function defined in paragraph 3.1.1.1 of this ETSO is a *major* failure condition.

(2) A loss of the function defined in paragraph 3.1.1.1 of this ETSO is a *minor* failure condition.

(3) Design the system to at least fulfil these failure conditions above.

4 — Marking

4.1 — General

~~Markings is detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

~~None~~

If the article includes software and/or airborne electronic hardware, then the part numbering scheme for the article must identify the configuration of both the software and the airborne electronic hardware. The part numbering scheme can use separate, unique part numbers for the software, the hardware, and the airborne electronic hardware.

If the combustion heater includes a deviation from this ETSO, the marking must include a means to indicate that a deviation was granted.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

MPS FOR COMBUSTION HEATER BASED ON SAE AS8040B

This Appendix prescribes the MPS for Combustion Heaters. The applicable standard is SAE International's Aerospace Standard AS8040B, Heater, Aircraft, Internal Combustion Heat Exchanger Type, dated February 2013. EASA has modified it as follows:

Section: 3. Accessories

3.2.a. Includes the fuel/air ratio controller, fuel lines and preheater.

3.2.b. Rewritten to read 'Ignition System: The ignition system uses an aircraft-supplied energy source to enable the proper functioning of the igniter. Examples of accessory devices that may be utilised in a heater ignition system include but are not limited to:'

3.2.b.2. Replaces the term 'spark plug' with 'igniter'.

3.2.b.3. Removes the statement 'Heaters with output ratings of 11,700 W (40,000 Btu/hour) or less may use an electrically heated resistance wire as an ignition source.'

3.2.c. Includes the requirement 'Any component whose failure could lead to an unsafe condition, such as ducting, that is in a fire zone, must be fireproof.'

3.2.c. Includes ducting/tubing, the combustion air blower, combustion air flow sensor, ventilation air flow sensor, and air flow/pressure regulator.

3.2.d.1. Revised to read 'Cabin temperature controls'.

3.2.e. Includes a device to sense differential pressure across the combustion chamber, a device to sense combustion, a device that senses excessive combustion by products in the ventilation air, a device to shut off fuel flow when required, and a device to alert the crew that a safety system has engaged.

3.3.2. Includes the phrase 'having the capacity to withstand at least as well as .015-inch-thick stainless steel, the heat produced when there is a severe fire of extended duration.'

3.5. Includes service ceiling.

3.6. Includes the statement 'It is best practice to set inspection, maintenance and/or replacement intervals based on individual component performance during design qualification testing (such as endurance testing).'

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Section: 4. Detail Requirements

4.3.1. Replaces 'gasoline or aviation grade kerosene, or both' with 'fuel'.

4.3.4. Adds 'fittings and controls' after 'All fuel lines'.

4.3.5. Replaces 'no lead or low lead type gasoline and kerosene' with the word 'applicable'. Adds 'Low starting temperature limits for other types of fuels need to be addressed on a case-by-case basis.' to the end of this paragraph.

4.5. Replaces '649 °C (1 200 °F)' with 'material capabilities in this section of the heater'. Adds the sentence 'Best practice is to ensure that the temperature at the point of discharge does not exceed 649 °C (1 200 °F). Consideration should also be given to the impact of heat impingement on the region of the aircraft that surrounds the combustion heater.' to the end of the paragraph.

4.6.3. Adds to the end of the paragraph the following: 'or heated solid surface, though it is not considered to be a best practice to use resistance wires as ignition sources for power levels above 11 700 W.'

4.6.8. Adds the statement 'Other types of fuels need to be addressed on a case-by-case basis.' to the end of the paragraph.

4.6.9. Adds the statement 'Other types of fuels need to be addressed on a case-by-case basis.' to the end of the paragraph.

4.7.d. Replaced with this paragraph: 'These safety controls shall be independent of the controls that are normally used to control the operation of the heater. The shut-off of ignition and fuel shall occur at a point that is remote from the heater itself. The combustion heater shall have a means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means. The requirement to shut off ignition and fuel at a point that is remote from the heater until restarted by the crew, may require a safety interlock relay and an additional fuel shut-off device to be supplied in addition to the valve that is usually supplied with the heater as an accessory. The relay and valve are the responsibility of the installer. See 5.2.10.6 for the tests to be conducted on safety controls.'

4.9. Adds at end of first paragraph: 'Use electrical load analysis to show that the heater is safe to operate in the worst-case situation.'

4.12. Adds a new paragraph:

Radio Interference

4.12.1 If the manufacturer elects to demonstrate compliance with the standard radio interference requirements, it is considered to be a best practice to test the combustion heat exchanger per EUROCAE ED-14/RTCA DO-160F Chapter 21, or a later EASA accepted revision, and report the result in the aircraft flight manual supplement.

4.12.2 If the manufacturer elects not to demonstrate compliance with the radio interference requirements, the manufacturer shall include the following statement in the aircraft flight manual supplement for the combustion heat exchanger:

'This combustion heat exchanger assembly does not include protection against radio and/or avionics interference, and has not been tested against it.'

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Section: 5 Required Testing

The initial paragraph includes the statement 'Test plans and reports shall be generated and retained for the life of the design.'

5.2.2.2. Revised to include 'A suitable instrument with a resolution no higher than 5 ppm, calibrated against a known standard, will be used to determine CO concentration.'

5.2.2.3. Adds the statement 'A pressure decay test may alternatively be used, provided that the decay rate can be determined to be equivalent to the requirements listed above.' at the end of the paragraph.

5.2.3. Replaces:

> 'The service ceiling determined by this test shall meet the requirement specified by the purchaser.'

with:

> 'It is typical for the service ceiling of a combustion heater to be at least 6 100 m (20 000 ft), and in order to ensure that there is an adequate margin with this test being performed on only one heater, a safety margin of 5 % shall be applied. Therefore, in order to set a service ceiling of 6 100 m (20 000 ft), the peak of the ignition characteristics curve shall be no lower than 6 405 m (21 000 ft).'

5.2.4. The text is replaced by the following:

'Install the test unit into the test set up used in 5.2.2.1 and cold soak the combustion heater assembly to - 54 °C (- 65 °F) for gasoline type heaters, and - 29 °C (- 20 °F) for kerosene type heaters (for other fuel types, the applicable temperature will be determined on a case-by-case basis). The valve leakage in the closed position with either the rated fuel pressure or the minimum practical fuel pressure shall not exceed 0.068 fluid ounces (2 mL) of fuel in 10 minutes. Supply combustion air and ventilating air to the heater at sea-level pressure and a temperature of - 54 °C (- 65 °F). The temperature of the fuel supplied to the heater shall be - 54 °C (- 65 °F) for gasoline-type heaters and - 29 °C (- 20 °F) for kerosene-type heaters. The combustion and ventilating air pressure levels and the mass flow rates shall be the same as in 5.2.2.1. Glow plug ignited heaters shall ignite within 200 seconds. Spark ignited heaters shall ignite within 15 seconds when burning gasoline-type fuels, and within 60 seconds when burning kerosene-type fuels. Measure and record the parameters specified in 5.2.2.1.'

5.2.10.6.2.1. This includes the following statement after the first sentence in the second paragraph: 'Leakage through the fuel valve shall then be measured, and shall not exceed 0.068 fluid ounces (2 mL) in 10 minutes.'

Section: 6 Desirable Features

6.1.2 This includes the statement 'Other types of fuels need to be addressed on a case-by-case basis.'

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APPENDIX 2

INSTRUCTIONS FOR CONTINUED AIRWORTHINESS
OF THE AIRCRAFT COMBUSTION HEATER AND ACCESSORIES

1.0 The following information contained in this Appendix must be included in the manual to ensure that the combustion heater and its accessories continue to comply with the ETSO once it is installed in a product.

1.1 Scheduling information for each part of the combustion heater, stating the inspection criteria and service limits. Necessary cross-references to the Airworthiness Limitations section must also be included.

1.2 Troubleshooting information that describes the probable malfunctions, and how to recognise and resolve those malfunctions.

1.3 Information that describes the order and method for removing and replacing parts, the order and method for disassembly and assembly, with any necessary precautions to be taken.

1.4 Cleaning and inspection instructions that cover the material and apparatus to be used and the methods and precautions to be taken. Methods of inspection must also be included.

1.5 Details of repair methods for worn or otherwise substandard parts and components, along with the information necessary to determine when a replacement is necessary.

1.6 Instructions for testing, including the use of the test equipment and instrumentation.

1.7 A list of the tools and equipment that are necessary for maintenance, and guidance for their use.

1.8 Instructions on how to ensure that the combustion heater assembly is fit to return to service after maintenance and prior to installation (for example, procedures for a pressure decay test).

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European Technical Standard Order (ETSO)

Subject: TWIN SEAPLANE FLOATS

1 — Applicability

This ETSO ~~gives~~ provides the requirements which twin seaplane floats that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical ~~c~~Conditions

3.1 — Basic

3.1.1 — Minimum ~~p~~Performance ~~s~~Standard

~~Standards set forth in the National Aircraft Standards Specification NAS 807, dated June 1, 1951 as amended and supplemented by this ETSO:~~

~~(i) Section 4.3.3.4 Unsymmetrical Landing. Two-Float Landing with Drift.~~
~~Third sentence :~~
~~„The side load shall be tanb/4 times the step landing load of 4.3.3.1.“~~

~~(ii) Section 4.3.3. Limit Load Factors for General Structure Design. Definition of symbols following subpart (b) :~~
~~„V_{SO} = airplane design stalling speed at design landing weight with zero thrust and landing flaps or other high lift devices in position for landing.~~
~~W = one half the airplane design landing weight.“~~

The applicable standards are those provided in Aerospace Industries of America, Inc., National Aerospace Standard (NAS) 807, Revision 2, Twin Seaplane Floats, dated 30 June 2017.

3.1.2 — Environmental Standard

~~None~~

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — ~~Computer~~ Software

~~None~~

See CS-ETSO, Subpart A, paragraph 2.2.

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3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

~~None~~

3.2.1 — Functionality

The standards of this ETSO apply to twin seaplane floats that are suitable for use on aeroplanes.

3.2.2 — Failure Condition Classification

A failure condition classification is not required.

3.2.3 — Functional Qualification

The materials and workmanship must conform to the requirements specified in Section 3 of NAS 807, Revision 2. The functional performance must be demonstrated under the test conditions specified in Section 4 of NAS 807, Revision 2. The applicant must define the design parameters to which the article is qualified (e.g. maximum aeroplane weight, Vso, etc.).

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: TEMPERATURE INSTRUMENTS

1 — Applicability

This ETSO gives provides the requirements which temperature instruments that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The Aapplicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical cConditions

3.1 — Basic

3.1.1 — Minimum pPerformance sStandard

The applicable Sstandards are those set forthprovided in the Society of Automotive Engineers, Inc. (SAE) International's Aerospace Standard (AS) 8005, 'Minimum Performance Standard for Temperature Instruments', reaffirmed October, 1984 Revision A, September 1996, as modified by Appendix 1 amended and supplemented by this ETSO:

Exceptions:

(i) In the friction error test of SAE AS 8005AAS8005A, paragraph 4.8, the vibration (to minimize minimise friction) provisions of paragraph 4.3 do not apply.

(ii) For clarification, the vibration test of SAE AS 8005AS8005A, paragraph 5.8, shall be conducted in accordance with the test procedure of EUROCAE/RTCA document ED-14G/DO-160DG, paragraph 8.5.1 or the latest revision of EUROCAE/RTCA document ED-14/DO-160.

3.1.2 — Environmental sStandard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 —Computer Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

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3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of referenced documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

MODIFICATIONS TO SAE AS8005A

— Change Section 4.1 of SAE AS8005A to read:

‘Unless otherwise specified herein, all the tests required shall be made at the atmospheric conditions specified in Section 3.5 of ED-14/DO-160.’

— Remove Section 4.3 of SAE AS8005A, as vibration as a means to reduce friction is no longer acceptable.

— In Section 5 of SAE AS8005A, remove the sentence ‘The order of tests shall be in accordance with paragraph 3.2, page 5,DO-138.’

— In Section 5 of SAE AS8005A, the text ‘RTCA Document Number DO-138 entitled “Environmental Conditions and Test Proc. for Airborne Electronic/Electrical Equipment and Instruments”, dated 27 June 1968’ shall be replaced with ‘EUROCAE/RTCA document ED-14G/DO-160G or the latest revision of EUROCAE/RTCA document ED-14/DO-160’

— In Section 5 of SAE AS8005A, any reference to ‘DO-138’ shall be replaced by a reference to ‘ED-14G/DO-160G or the latest revision of ED-14/DO-160’.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AIRBORNE MULTIPURPOSE ELECTRONIC DISPLAYS

1 — Applicability

This ETSO provides the requirements which airborne multipurpose electronic displays that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are those ~~set forth~~ provided in ~~the~~ SAE AS8034~~B~~C, Minimum Performance Standards for Airborne Multipurpose Electronic Displays, dated ~~6/1/2011~~ 30 July 2018, as modified by paragraph 3.1.1.1 of this ETSO. Additional requirements on colour can be found in Appendix 1 ~~to~~of this document.

To be eligible to this ETSO standard, the equipment shall at least contain a display unit that provides ~~providing~~ the visualisation function.

It should be noted that this ETSO standard does not provide minimum performance standards for head-up displays or headworn displays. ETSO-C210 provides requirements for head-up displays.

3.1.1.1 — Modifications to AS8034C Section 5

SAE AS8034C, Section 5, second bullet, page 22, is modified as follows:

'During the specified testing, ~~(5.5, 5.20)~~ it is up to the applicant to prove that the touchscreen functions as intended during the test and that no false positive touches are received. ~~Touch screen compliance may be demonstrated by testing during DO-160G, outside of the DO-160G testing, analysis or some combination thereof.~~'

SAE AS8034C, Section 5.1, is amended as follows:

— Modify the text of Section 5.1 to replace 'The following performance requirements (5.1.1

through 5.1.6)' with 'The following performance requirements (5.1.1 through 5.1.7)'.

— An additional section is added:

'5.1.7 Touchscreen

The display system shall meet the touchscreen display characteristics of the following paragraphs:

a. 4.7.1 Latency

b. 4.7.3 Touchscreen Selection Accuracy'

For SAE AS8034C, Section 5.4.4.3, Overpressure Test, the last sentence is amended as follows:

'When the equipment is subjected to the overpressure test, the requirements of 5.1 (excluding 5.1.7) shall be met.'

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — ~~Computer~~ Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware ~~Qualification~~

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

None.

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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~~**Appendix 1 — Colour**~~
APPENDIX 1

COLOUR

SAE AS8034B, Section 4.3.4, ~~requires~~ lays down colour-coding requirements. This Appendix provides additional guidance on colour.
1. Display features, precipitation, and turbulence areas should be colour-coded as depicted in Table A1 and Table A2 respectively, unless otherwise specified by the ETSO application being displayed.

Table A1

Display Feature	**Colour**
Warnings	Red
Flight envelope and system limits, non-normal sources	Red/Amber/Yellow/White as appropriate ~~Note 1~~
Cautions~~, non-normal sources~~	Amber/Yellow
Scales and associated figures	White Note ~~2~~
Earth	Tan/Brown
Sky	Cyan/Blue
Engaged Modes/normal conditions/safe operation	Green

~~**Note 1:** Use of Amber/Yellow as appropriate is also acceptable.~~

Note ~~2~~: Use of the colour green for tape elements (for example, airspeed and altitude) has also been found to be acceptable if the colour green does not adversely affect flight crew alerting.

Table A2

Precipitation and Turbulence	**Colour**
Precipitation up to 4 ~~millimeters~~ millimetres per hour (mm/hour)	Green
Precipitation 4–12 mm/hour	Amber/Yellow
Precipitation 12–50 mm/hour	Red
Precipitation Above 50 mm/hour	Magenta
Turbulence	White or Magenta

2. Background colour (~~gray~~ grey or other shade) may be used to enhance the display presentation.

3. Colours should track brightness so that chrominance and relative chrominance separation are maintained as much as possible during day-night operations.

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European Technical Standard Order (ETSO)

Subject: AIRBORNE ~~WINDSHEAR~~ WIND SHEAR WARNING AND ESCAPE GUIDANCE SYSTEMS (REACTIVE TYPE) FOR TRANSPORT AEROPLANES

1 — Applicability

This ETSO ~~gives~~ provides the requirements that airborne ~~windshear~~ wind shear warning and escape guidance systems (reactive type) for transport aeroplanes ~~which~~ that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking. It is not applicable to systems that look ahead to sense ~~windshear~~ wind shear conditions before the phenomenon is encountered, nor to systems that use atmospheric and/or other data to predict the likelihood of a ~~windshear~~ wind shear alert.

Appendix 1 of this ETSO describes the MPS for the airborne wind shear warning and escape guidance systems for transport category aeroplanes.

Appendix 2 of this ETSO describes the wind field models used to evaluate the performance of the wind shear warning and escape guidance system.

Appendix 3 of this ETSO describes the conversion of the velocity equations in Appendix 2 to rectangular coordinates.

Appendix 4 of this ETSO contains data that defines the Dryden turbulence model and the discrete gust model used in conducting the wind shear alert tests.

Appendix 5 of this ETSO describes shear intensity.

Appendix 6 of this ETSO provides a sample computer listing for a simplified aircraft simulation model for evaluating the effectiveness of various guidance schemes.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — General

3.1.1 — Minimum Performance Standard

The applicable standards are provided in the attached Appendix 1.

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a. Purpose and Scope.

(1) Introduction. This ETSO prescribes the minimum performance standards for airborne wind shear warning and escape guidance systems for transport category aeroplanes. This document defines performance, functions, and features for systems providing wind shear warning and escape guidance commands based upon sensing the aeroplane's encounter of such phenomena. Airborne wind shear warning and escape guidance systems that are to be identified with ETSO identification and that are manufactured on or after the date of this ETSO must meet the minimum performance standard specified herein.

(2) Scope. This ETSO applies only to wind shear warning systems which identify wind shear phenomenon by sensing the encounter of conditions exceeding the threshold values contained in this ETSO. In addition to wind shear warning criteria, this ETSO provides criteria applicable to systems that provide optional wind shear caution alert capability. Windshear escape guidance is provided to assist the pilot in obtaining the desired flight path during such an encounter.

(3) Applicable Documents. The following documents shall form a part of this ETSO to the extent specified herein. Should conflicting requirements exist, the contents of this ETSO shall be followed.

(i) EUROCAE/RTCA Document ED-14D/DO-160D, „Environmental Conditions and Test Procedures for Airborne Equipment' change 3, dated December 2002 respectively subsequent revisions, see CS-ETSO Subpart A § 2.

(ii) EUROCAE/RTCA Document ED-12B/DO-178B, „Software Considerations in Airborne Systems and Equipment Certification,' dated December 1992 respectively subsequent revisions, see CS-ETSO Subpart A § 2.

(iii) Society of Automotive Engineers, Inc. (SAE) Aerospace Recommended Practice (ARP) 4102/11, „Airborne Windshear Systems," dated July 1988.

(4) Definitions of Terms.

(i) Airborne Windshear Warning System. A device or system which uses various sensor inputs to identify the presence of windshear once the phenomena is encountered and provides the pilot with timely warning. The system may include both windshear warning and windshear caution alerts. A warning device of this type does not provide escape guidance information to the pilot to satisfy the criteria for warning and flight guidance systems.

(ii) Airborne Windshear Warning and Escape Guidance System. A device or system which uses various sensor inputs to identify the presence of windshear once the phenomenon is encountered and provides the pilot with timely warning and adequate flight guidance to improve the probability of recovery from the windshear encounter. This system may include both windshear warning and windshear caution alerts.

(iii) Airborne Windshear Auto Recovery System. A device or system which integrates or couples autopilot and/or autothrottle systems of the aircraft with an airborne windshear flight guidance system.

(iv) Airborne Windshear Escape Guidance System. A system which provides the crew with flight guidance information to improve the recovery probability once encountering a windshear phenomenon.

(v) Failure. The inability of a system, subsystem, unit, or part to perform within previously specified limits.

(vi) False Warning or Caution. A warning or caution which occurs when the design windshear warning or caution threshold of the system is not exceeded.

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~~(vii) Nuisance Warning or Caution. A warning or caution which occurs when a phenomenon is encountered, such as turbulence, which does not, in fact, endanger the aircraft because of the duration of subsequent change of the windshear magnitude.~~

~~(viii) Recovery Procedure. A vertical flight path control technique used to maximize recovery potential from an inadvertent encounter with windshear.~~

~~(ix) Severe Windshear. A windshear of such intensity and duration which would exceed the performance capability of a particular aircraft type, and likely cause inadvertent loss of control or ground contact if the pilot did not have information available from an airborne windshear warning and escape guidance system which meets the criteria of this ETSO.~~

~~(x) Windshear Caution Alert. An alert triggered by increasing performance conditions which is set at a windshear level requiring immediate crew awareness and likely subsequent corrective action.~~

~~(xi) Windshear Warning Alert. An alert triggered by decreasing performance conditions which is set at a windshear level requiring immediate corrective action by the pilot.~~

~~b. General Standards. The following general requirements shall be met by all windshear warning and escape guidance systems:~~

~~(1) Airworthiness. Design and manufacture of the airborne equipment must provide for installation so as not to impair the airworthiness of the aircraft. Material shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft systems. Workmanship shall be consistent with high quality aircraft electromechanical and electronic component manufacturing practices.~~

~~(2) General Performance. The equipment must perform its intended function, as defined by the manufacturer.~~

~~(3) Fire Resistance. Except for small parts (such as knobs, fasteners, seals, grommets, and small electrical parts) that would not significantly contribute to the propagation of fire, all materials used must be self-extinguishing. One means for showing compliance with this requirement is contained in CS 25.853 and Appendix F.~~

~~(4) Operation of Controls. Controls intended for use during flight shall be designed to minimize errors, and when operated in all possible combinations and sequences, shall not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.~~

~~(5) Accessibility of Controls. Controls that are not normally adjusted in flight shall not be readily accessible to the operator.~~

~~(6) Interfaces. The interfaces with other aircraft equipment must be designed such that normal or abnormal windshear warning and escape guidance equipment operation shall not adversely affect the operation of other equipment.~~

~~(7) Compatibility of Components. If a system component is individually acceptable but requires calibration adjustments or matching to other components in the aircraft for proper operation, it shall be identified in a manner that will ensure performance to the requirements specified in this ETSO.~~

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(8) Interchangeability. System components which are identified with the same manufactured part number shall be completely interchangeable.

(9) Control/Display Capability. A suitable interface shall be provided to allow data input, data output, and control of equipment operation. The control/display shall be operable by one person with the use of only one hand.

(10) Control/Display Readability. The equipment shall be designed so that all displays and controls shall be readable under all cockpit ambient light conditions ranging from total darkness to reflected sunlight and arranged to facilitate equipment usage. Limitations on equipment installations to ensure display readability should be included in the installation instructions.

(11) Effects of Test. The design of the equipment shall be such that the application of the specified test procedures shall not produce a condition detrimental to the performance of the equipment except as specifically allowed.

(12) Equipment Computational Response Time. The equipment shall employ suitable update rates for computation and display of detection and guidance information.

(13) Supplemental Heating or Cooling. If supplemental heating or cooling is required by system components to ensures that the requirements of this ETSO are met, they shall be specified by the equipment manufacturer in the installation instructions.

(14) Self-Test Capability. The equipment shall employ a self-test capability to verify proper system operation.

(i) Any manually initiated self-test mode of operation shall automatically return the system to the normal operating mode upon completion of a successful test.

(ii) Any automatically activated self-test feature must annunciate this mode of operation to the pilot if this feature activates annunciation lights, aural messages, or displaces the guidance commands in any way.

(iii) Conduct of the system self-test feature must not adversely affect the performance of operation of other aircraft systems.

(iv) Failure of the system to successfully pass the self-test shall be annunciated.

(15) Independence of Warning and Escape Guidance Functions. Irrespective of whether the warning and escape guidance functions are in a combined system or are separate systems, they should be sufficiently independent such that a failure of either system does not necessarily preclude or inhibit the presentation of information from the other. A warning system failure shall not result in ambiguous or erroneous guidance system mode annunciation.

(16) System Reliability.

(i) The probability of a false warning being generated within the windshear warning system or the windshear warning and escape guidance system shall be 1×10^{-4} or less per flight hour.

(ii) The probability of an unannunciated failure of the windshear warning system or the windshear warning and escape guidance system shall be 1×10^{-5} or less per flight hour (reserved).

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c. Equipment Functional Requirements - Standard Conditions. The equipment shall meet the following functional requirements.

(1) Mode Annunciation. The windshear escape guidance display mode of operation shall be annunciated to the pilot upon escape guidance activation during a windshear encounter and upon reversion to a different flight guidance mode.

(2) Malfunction/Failure Indications. The equipment shall indicate:
(i) Inadequate or absence of primary power.
(ii) Equipment failures.
(iii) Inadequate or invalid warning or guidance displays or output signals.
(iv) Inadequate or invalid sensor signals or sources.

These malfunction/failure indications shall occur independently of any operator action. The lack of adequate warning displays, escape guidance information, or sensor signals or sources shall be annunciated when compliance with the requirements of this ETSO cannot be assured.

(3) Windshear Caution Alert. If the equipment includes a windshear caution alert:
(i) It shall provide an annunciation of increasing performance shear (updraft, increasing headwind, or decreasing tailwind) in accordance with the shear intensity curve shown in figure 1.
(ii) This caution alert shall display or provide an appropriate output for display of an amber caution annunciation dedicated for this purpose. An aural alert may be provided as an option. The caution display (or output) should remain until the threshold windshear condition no longer exists (not less than a minimum of 3 seconds) or a windshear warning alert occurs.
(iii) Gust conditions shall not cause a nuisance caution alert. Turbulence shall not cause more than one nuisance caution alert per 250 hours (or 3,000 flight cycles based on 1 hour/flight cycle) of system operation.

(4) Windshear Warning Alert.
(i) A windshear warning alert shall provide an annunciation of decreasing performance shear (downdraft, decreasing headwind, or increasing tailwind) with a magnitude equal or greater than that shown in the shear intensity curve shown in figure 1.
(ii) This warning alert shall display or provide an appropriate output for display of a red warning annunciation labeled „windshear“ dedicated for this purpose. The visual alert should remain at least until the threshold windshear condition no longer exists or a minimum of 3 seconds, whichever is greater. An aural alert shall be provided that annunciates „windshear“ for three aural cycles. The aural alert need not be repeated for subsequent windshear warning alerts within the same mode of operation.
(iii) Gust conditions shall not cause a nuisance warning alert. Turbulence shall not cause more than one nuisance warning alert per 250 hours (or 3,000 flight cycles based on 1 hour/flight) of system operation.

(5) Operating Altitude Range. The system shall be designed to function from at least 50 feet above ground level (AGL) to at least 1000 feet AGL.

(6) Windshear Escape Guidance. Flight guidance algorithms shall incorporate the following design considerations:
(i) At the point of system warning threshold, the available energy of the aeroplane must be properly managed through a representative number of windfield conditions.

~~These conditions must take into account significant shear components in both the horizontal and vertical axes, individually and in combination.~~

~~(ii) The flight path guidance commands must be suitable to the dynamic response of aircraft of the type on which the system is intended for installation.~~

~~(iii) If the magnitude of the shear components are such as to overcome the performance capability of the aeroplane, guidance commands must be such that ground impact will occur in the absence of ability to produce additional lift, absence of excessive kinetic energy, and without putting the aircraft into a stalled condition.~~

~~(iv) Flight guidance command information shall be provided for presentation on the primary flight display/attitude direction indicator (PFD/ADI) and any available Head Up Display (HUD).~~

~~(v) Flight guidance displays which command flight path and pitch attitude should be limited to an angle-of-attack equivalent to onset of stall warning or maximum pitch command of 27º, whichever is less.~~

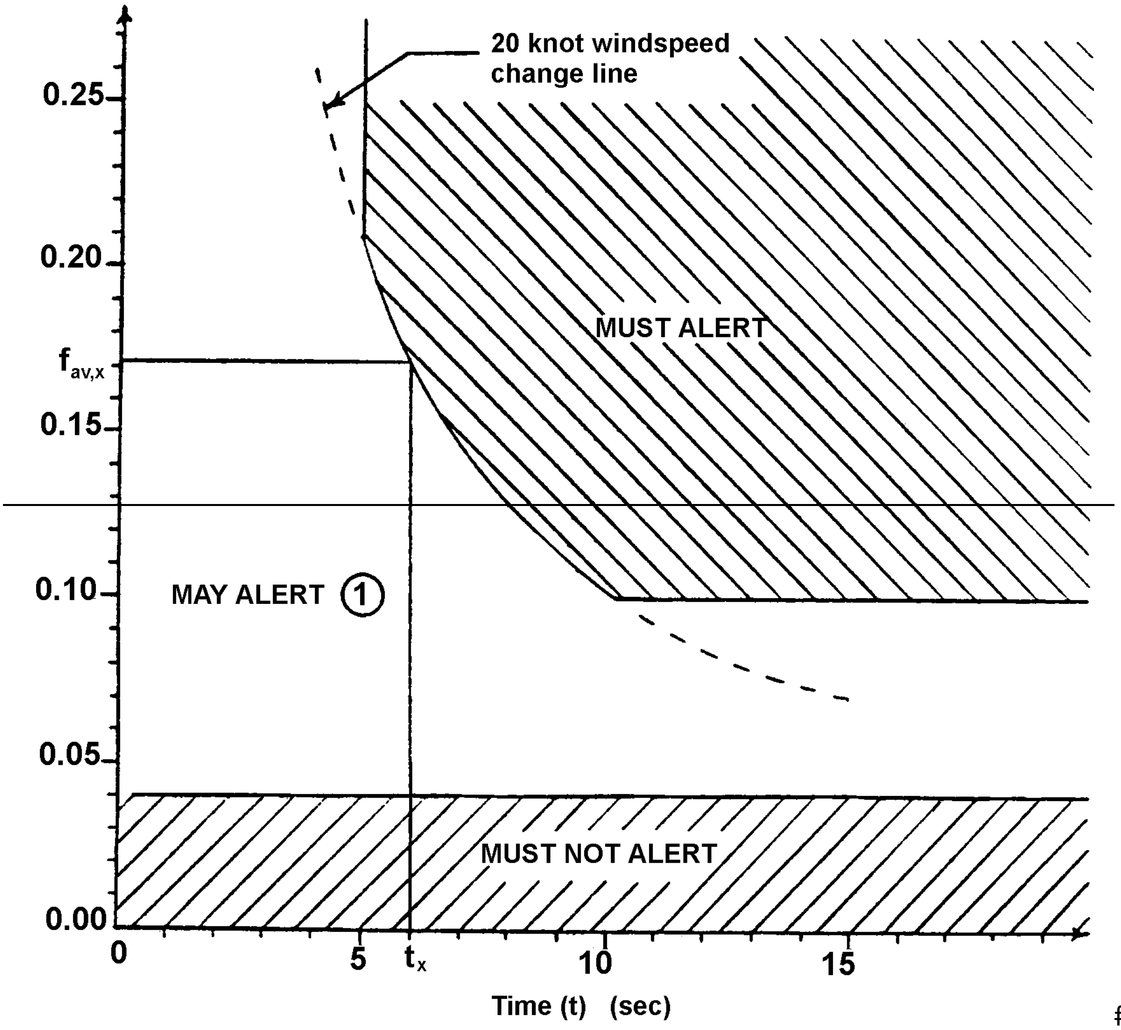
~~(vi) Flight guidance commands and any auto recovery mode (if included) may be automatically activated concurrent with or after the windshear warning alert occurs or may be manually selected. If manual selection is utilized, it shall only be via the takeoff-go around (TOGA) switch or equivalent means (i.e., a function of throttle position, other engine parameters, etc.).~~

~~(vii) Manual deselection of windshear flight guidance and any auto recovery mode (if included) shall be possible by means other than the TOGA switches.~~

~~(viii) Systems incorporating automatic reversion of flight guidance commands from windshear escape guidance to another flight guidance mode should provide a smooth transition between modes. Flight guidance commands shall not be removed from the flight guidance display until either manually deselected or until the aircraft, following exit of the warning conditions, has maintained a positive rate of climb and speed above 1.3~~ ~~V_{s1}~~ ~~for at least 30 seconds.~~

~~FIGURE 1~~

SHEAR INTENSITY CURVE



$f_{av,x}$ = average shear intensity to cause a warning at time t_x (resulting in a 20 knot windspeed change, bounded as shown; applies to horizontal, vertical, and combination shear intensities)

$$= \frac{\int_0^{t_x} f(t)dt}{t_x}$$ whereby f(t) = instantaneous shear intensity at time t

① A nuisance warning test utilizing the Dryden turbulence model and discrete gust model are conducted independently from alert threshold tests to verify the acceptability of potential nuisance warnings due to turbulence or gusts.

d. Equipment Performance – Environmental Conditions. The environmental tests and performance requirements described in this subparagraph are intended to provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual operations. Some of the environmental tests contained in this subparagraph need not be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase „When Required.' If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these „When Required' tests shall be performed.

~~Unless otherwise specified, the test procedures applicable to a determination of equipment performance under environmental test conditions are set forth in EUROCAE/RTCA Document ED-14D/DO-160D, „Environmental Conditions and Test Procedures for Airborne Equipment." Performance tests which must be made after subjection to test environments may be conducted after exposure to several environmental conditions.~~

~~(1) Temperature and Altitude Tests (ED-14D/DO-160D, Section 4.0). EUROCAE/RTCA Document ED-14D/DO-160D contains several temperature and altitude test procedures which are specified according to the category for which the equipment will be used. These categories are included in paragraph 4.2 of ED-14D/DO-160D. The following subparagraphs contain the applicable test conditions specified in Section 4.0 of ED-14D/DO-160D.~~

~~(i) Low Operating Temperature Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.1, and the following requirements of this standard shall be met:~~

~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(ii) High Short-Time Operating Temperature Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.2, and the following requirements of this standard shall be met:~~

~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(iii) High Operating Temperature Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.3, and the following requirements of this standard shall be met:~~

~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(iv) In-Flight Loss of Cooling Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.5.4, and the following requirements of this standard shall be met:~~

~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~

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~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(v) Altitude Test. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.6.1, and the following requirements of this standard shall be met:~~
~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(vi) Decompression Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.6.2, and the following requirements of this standard shall be met:~~
~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(vii) Overpressure Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 4.6.3, and the following requirements of this standard shall be met:~~
~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(2) Temperature Variation Test (ED-14D/DO-160D, Section 5.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 5.0, and the following requirements of this standard shall be met:~~
~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

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~~(3) Humidity Test (ED-14D/DO-160D, Section 6.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 6.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(4) Shock tests (ED-14D/DO-160D, Section 7.0).~~

~~(i) Operational Shocks. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 7.2, and the following requirements of this standard shall be met:~~

~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(ii) Crash Safety Shocks. The application of the crash safety shock tests may result in damage to the equipment under test. Therefore, this test may be conducted after the other tests have been competed. In this case, paragraph 3.1.1 (b)(11), „Effects of Test,“ of this standard does not apply. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 7.3, and shall meet the requirements specified therein.~~

~~(5) Vibration Test (ED-14D/DO-160D, Section 8.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 8.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(6) Explosion Proofness Test (ED-14D/DO-160D, Section 9.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D , Section 9.0. During these tests, the equipment shall not cause detonation of the explosive mixture within the test chamber.~~

~~(7) Waterproofness Tests (ED-14D/DO-160D , Section 10.0).~~

~~(i) Drip Proof Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 10.3.1, and the following requirements of this standard shall be met:~~

~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(ii) Spray Proof Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 10.3.2, and the following requirements of this standard shall be met:~~
~~NOTE: This test shall be conducted with the spray directed perpendicular to the most vulnerable area(s) as determined by the equipment manufacturer.~~
~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(iii) Continuous Stream Proof Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 10.3.3, and the following requirements of this standard shall be met:~~
~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(8) Fluids Susceptibility Tests (ED-14D/DO-160D, Section 11.0).~~
~~(i) Spray Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 11.4.1, and the following requirements of this standard shall be met:~~

~~At the end of the 24-hour exposure period, the equipment shall operate at a level of performance that indicates that no significant failures of components or circuitry have occurred. Following the two-hour operational period at ambient temperature, after the 160-hour exposure period at elevated temperature, the following requirements of this standard shall be met:~~
~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~
~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

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~~(ii) Immersion Test (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraph 11.4.2, and the following requirements of this standard shall be met:~~

~~At the end of the 24-hour immersion period specified in ED-14D/DO-160D, paragraph 11.4.2, the equipment shall operate at a level of performance that indicates that no significant failures of components or circuitry have occurred. Following the two-hour operational period at ambient temperature, after the 160-hour exposure period at elevated temperature, the following requirements of this standard shall be met:~~

~~(a) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(9) Sand and Dust Test (ED-14D/DO-160D, Section 12.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 12.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(10) Fungus Resistance Test (ED-14D/DO-160D, Section 13.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 13.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(11) Salt Spray Test (ED-14D/DO-160D, Section 14.0) (When Required). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 14.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~

(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(iii) Section 3.1.1(c)(3) - Windshear Caution Alert
(iv) Section 3.1.1(c)(4) - Windshear Warning Alert
(v) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(12) Magnetic Effect Test (ED-14D/DO-160D, Section 15.0). The equipment shall be subject to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 15.0, and the equipment shall meet the requirements of the appropriate instrument or equipment class specified therein.

(13) Power Input Tests (ED-14D/DO-160D, Section 16.0).

(i) Normal Operating Conditions. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraphs 16.5.1 and 16.5.2, as appropriate, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(ii) Abnormal Operating Conditions. The application of the low voltage conditions (DC) (Category B equipment) test may result in damage to the equipment under test. Therefore, this test may be conducted after the other tests have been completed. Section 3.1.1(b)(11), „Effects of Test," does not apply. The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, paragraphs 16.5.3 and 16.5.4, as appropriate, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications
(c) Section 3.1.1(c)(3) - Windshear Caution Alert
(d) Section 3.1.1(c)(4) - Windshear Warning Alert
(e) Section 3.1.1(c)(6) - Windshear Escape Guidance

Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.

(14) Voltage Spike Conducted Test (ED-14D/DO-160D, Section 17.0).
The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 17.0, and the following requirements of this standard shall be met:

(a) Section 3.1.1(c)(1) - Mode Annunciation
(b) Section 3.1.1(c)(2) - Malfunction/Failure Indications

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~~(c) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(d) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(e) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(15) Audio Frequency Conducted Susceptibility Test (ED-14D/DO-160D, Section 18.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 18.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(16) Induced Signal Susceptibility Test (ED-14D/DO-160D, Section 19.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 19.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(17) Radio Frequency Susceptibility Test (Radiated and Conducted) (ED-14D/DO-160D, Section 20.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 20.0, and the following requirements of this standard shall be met:~~

~~(i) Section 3.1.1(c)(1) - Mode Annunciation~~
~~(ii) Section 3.1.1(c)(2) - Malfunction/Failure Indications~~
~~(iii) Section 3.1.1(c)(3) - Windshear Caution Alert~~
~~(iv) Section 3.1.1(c)(4) - Windshear Warning Alert~~
~~(v) Section 3.1.1(c)(6) - Windshear Escape Guidance~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~(18) Emission of Radio Frequency Energy Test (ED-14D/DO-160D, Section 21.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 21.0, and the requirements specified therein shall be met.~~

~~(19) Lightning Induced Transient Susceptibility (ED-14D/DO-160D, Section 22.0). The equipment shall be subjected to the test conditions as specified in EUROCAE/RTCA Document ED-14D/DO-160D, Section 22.0, and the requirements specified therein shall be met:~~

~~Additionally, all system controls, displays, inputs, and outputs shall perform their intended functions.~~

~~e. Equipment Test Procedures.~~

~~(1) Definitions of Terms and conditions of Tests. The following definitions of terms and conditions of tests are applicable to the equipment tests specified herein:~~

~~(i) Power Input Voltage. Unless otherwise specified, all tests shall be conducted with the power input voltage adjusted to design voltage ±2 percent. The input voltage shall be measured at the input terminals of the equipment under test.~~

~~(ii) Power Input Frequency.~~

~~(a) In the case of equipment designed for operation from an AC power source of essentially constant frequency (e.g., 400 Hz), the input frequency shall be adjusted to design frequency ±2 percent.~~

~~(b) In the case of equipment designed for operation from an AC power source of variable frequency (e.g., 300 to 1000 Hz), unless otherwise specified, test shall be conducted with the input frequency adjusted to within 5 percent of a selected frequency and within the range for which the equipment is designed.~~

~~(iii) Windfield Models. Unless otherwise specified, the windfield models used for tests shall be those specified in appendix 1 of this ETSO.~~

~~(iv) Adjustment of Equipment. The circuits of the equipment under test shall be aligned and adjusted in accordance with the manufacturer's recommended practices prior to the application of the specified tests.~~

~~(v) Test Instrument Precautions. Due precautions shall be taken during the conduct of the tests to prevent the introduction of errors resulting from the connection of voltmeters, oscilloscopes, and other test instruments across the input and output impedances of the equipment under test.~~

~~(vi) Ambient Conditions. Unless otherwise specified, all tests shall be conducted under conditions of ambient room temperature, pressure, and humidity. However, the room temperature shall be not lower than 10° C.~~

~~(vii) Warm-up Period. Unless otherwise specified, all tests shall be conducted after the manufacturer's specified warm-up period.~~

~~(viii) Connected Loads. Unless otherwise specified, all tests shall be performed with the equipment connected to loads which have the impedance values for which it is designed.~~

~~(2) Test Procedures. The equipment shall be tested in all modes of operation that allow different combinations of sensor inputs to show that it meets both functional and accuracy criteria.~~

~~Dynamic testing provides quantitative data regarding windshear warning and escape guidance equipment performance using a simplified simulation of flight conditions. This testing, when properly performed and documented, may serve to minimize the flight test requirements.~~

~~It shall be the responsibility of the equipment manufacturer to determine that the sensor inputs, when presented to the windshear warning and escape guidance equipment, will produce performance commensurate with the requirements of this standard. Additional sensor inputs may be optionally provided to enhance equipment capability and/or performance.~~

~~The equipment required to perform these tests shall be defined by the equipment manufacturer as a function of the specific sensor configuration of his equipment. Since these tests may be accomplished more that one way, alternative test equipment setups may be used where equivalent test function can be accomplished. Combinations of tests may be used wherever appropriate.~~

~~The test equipment signal sources shall provide the appropriate signal format for input to the specific system under test without contributing to the error values being measured. Tests need only be done once unless otherwise indicated.~~

~~The scenarios established for testing windshear warning and escape guidance systems represent realistic operating environments to properly evaluate such systems. The windfield models contained in appendix 1 of this ETSO should be used to evaluate the performance of the windshear warning and escape guidance system. The manufacturer may propose different windfield models provided it is shown that they represent conditions at least as severe as those contained in this ETSO.~~

~~(3) Test Setup. Simulator tests shall be used to demonstrate the performance capability of the windshear warning and escape guidance equipment. A suitable equipment interface shall be provided for recording relevant parameters necessary to evaluate the particular system under test. The aircraft simulator shall be capable of appropriate dynamic modeling of a representative aircraft and of the windfield and turbulence conditions contained in appendices 1 and 2 of this ETSO or other windfield/turbulence models found acceptable by the Administrator.~~

~~(4) Functional Performance (paragraphs (c)(1) through (c)(6)). Each of the functional capabilities identified in paragraphs (c)(1) through (c)(6) shall be demonstrated with the windshear warning and escape guidance equipment powered. These capabilities shall be evaluated either by inspection or in conjunction with the tests described in paragraphs (e)(5) through (e)(11).~~

~~(5) Mode Annunciation (paragraph (c)(1)). With the equipment operating, verify the windshear escape guidance display mode of operation is annunciated to the pilot upon escape guidance activation and upon reversion to a different flight guidance mode.~~

~~(6) Malfunction/Failure Indications (paragraph (c)(2)). Configure the equipment for simulation tests as defined in paragraph (e)(3).~~

~~(i) With the system active (within the operating altitude range) and inactive (outside the operating altitude range), remove one at a time each required electrical power input to the equipment. There shall be a failure indication by the equipment of each simulated failure condition.~~

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(ii) With the system active (within the operating altitude range) and inactive (outside the operating altitude range), cause each sensor or other signal input to become inadequate or invalid. There shall be a failure indication by the equipment of each simulated failure condition.

(7) Windshear Caution Alert (paragraph (c)(3)). For equipment incorporating a windshear caution alert function, accomplish the following tests:

(i) Configure the equipment for simulation test as defined in paragraph (e)(3). Subject the equipment to acceleration waveform values meeting the following conditions (reference figure 2). The system shall generate an appropriate caution alert (or no alert) within the time intervals specified when subjected to the following average shear intensity ($f_{av,x}$) values:

$f_{av,x}$ (1)	Time of Exposure (t) (sec)	Result
0.02	20	no alert
0.04	20	no alert
0.105	10	alert within 10 sec
1.049/t	t	alert within t sec (2)
0.21	5	alert within 5 sec
=0.270	5	alert within 5 sec

Notes: (1) The average shear intensity which must result in a caution alert after a time t_x or less meets the definition of $f_{av,x}$ in figure 1. The maximum instantaneous shear intensity of the test waveform is restricted to 0.075 or 100 percent of $f_{av,x}$ above the average shear value $f_{av,x}$, whichever is less. The minimum instantaneous shear intensity of the test waveform is zero. Test waveform rise and fall rates shall be limited to a maximum of 0.1 per second. The shear intensity before time 0 is zero for a sufficiently long time to allow the system to settle to stable conditions.

(2) t = 6, 7, 8, 9

The test conditions specified above shall be repeated 5 times. A different waveform for $f_{av,x}$ will be utilized for each of the 5 runs. An appropriate alert (or no alert) must be generated for each test condition.

Verify the system displays or provides an appropriate output for display of an amber caution annunciation dedicated for this purpose. Verify the visual caution display (or output) remains at least until the threshold windshear condition no longer exists or a minimum of 3 seconds (whichever is greater), or until a windshear warning occurs.

(ii) Subject the equipment to windspeeds defined by the Dryden turbulence model contained in appendix 2. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in appendix 2 for a minimum total test duration of 250 hours (or 3,000 flight cycles based on 1 hour/flight cycle). No more than one nuisance caution shall be generated during this test.

(iii) Subject the equipment to windspeeds defined by the discrete gust rejection model contained in appendix 2. No alert shall be generated as a result of this test.

(8) Windshear Warning Alert (paragraph (c)(4)).

~~(i) Configure the equipment for simulation tests as defined in paragraph (e)(3). Subject the equipment to acceleration waveform values meeting the following conditions (reference figure 2). The system shall generate an appropriate warning alert (or no alert) within the time intervals specified when subjected to the following average shear intensity ($f_{av,x}$) values:~~

~~$f_{av,x}$ (1)~~	~~Time of Exposure (t) (sec)~~	~~Result~~
~~0.02~~	~~20~~	~~no alert~~
~~0.04~~	~~20~~	~~no alert~~
~~0.105~~	~~10~~	~~alert within 10 sec~~
~~1.049/t~~	~~t~~	~~alert within t sec (2)~~
~~0.21~~	~~5~~	~~alert within 5 sec~~
~~=0.270~~	~~5~~	~~alert within 5 sec~~

~~Notes: (1) The average shear intensity which must result in a warning alert after a time t_x or less meets the definition of $f_{av,x}$ in figure 1. The maximum instantaneous shear intensity of the test waveform is restricted to 0.075 or 100 percent of $f_{av,x}$ above the average shear value $f_{av,x}$, whichever is less. The minimum instantaneous shear intensity of the test waveform is zero. Test waveform rise and fall rates shall be limited to a maximum of 0.1 per second. The shear intensity before time 0 is zero for a sufficiently long time to allow the system to settle to stable conditions.~~

~~(2) t = 6, 7, 8, 9~~

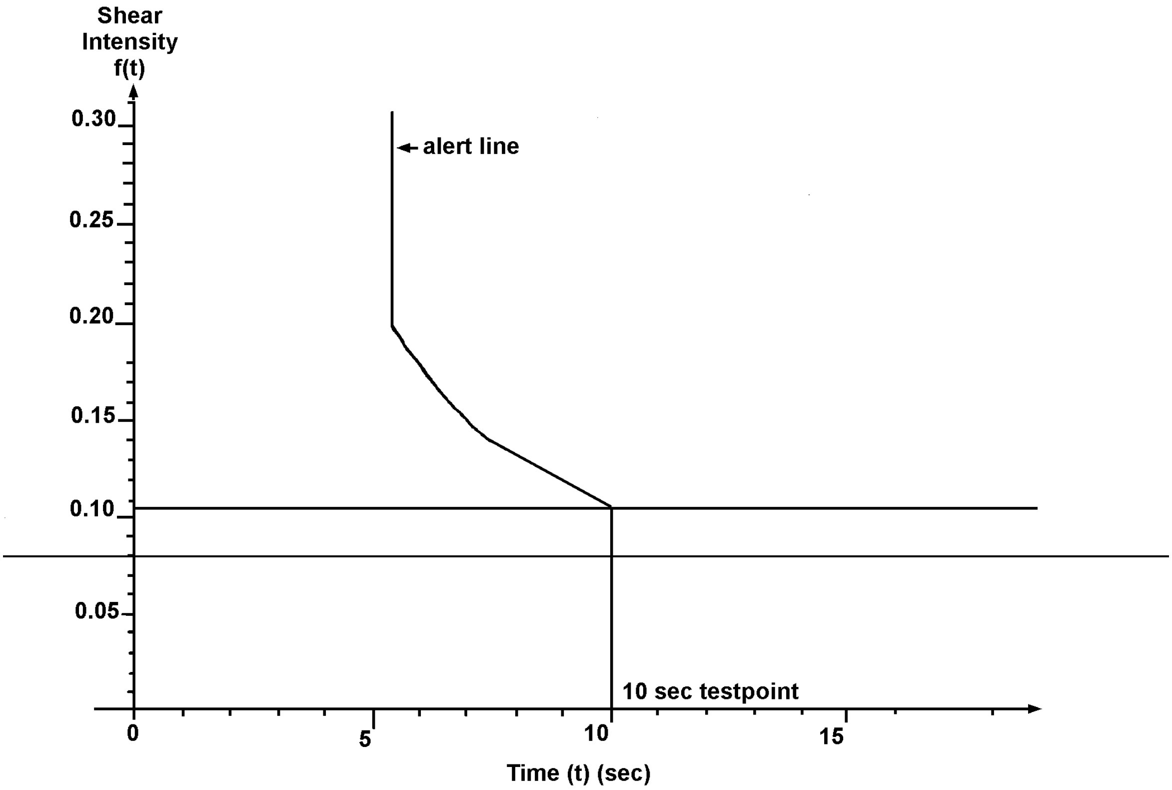
~~The test conditions specified above shall be repeated 5 times. A different waveform for $f_{av,x}$ will be utilized for each of the 5 runs. An appropriate alert (or no alert) must be generated for each test condition.~~

~~Verify the system displays or provides an appropriate output for display of a red warning annunciation labeled „windshear“ dedicated for this purpose. Verify the visual warning display (or output) remains until the threshold windshear condition no longer exists or a minimum of 3 seconds, whichever is greater. Verify an aural alert is provided that annunciates „windshear“ for three aural cycles.~~

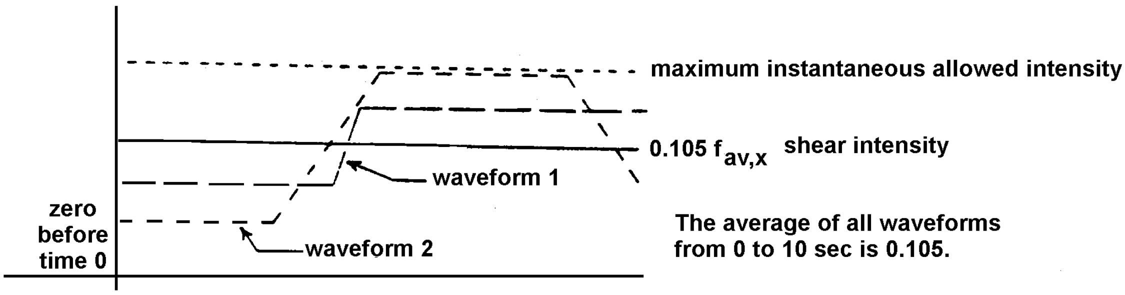
~~(ii) Subject the equipment to windspeeds defined by the Dryden turbulence model contained in appendix 2. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in appendix 2 for a minimum total test duration of 250 hours (or 3,000 flight cycles based on 1 hour/flight cycle). No more than one nuisance warning shall be generated during this test~~

~~FIGURE 2~~

~~WINDSHEAR ALERT TEST~~



Sample waveforms for 10 sec test point



~~(iii) Subject the equipment to windspeeds defined by the discrete gust rejection model contained in appendix 2. No alert shall be generated as a result of this test.~~

~~(9) Operating Altitude Range (paragraph (c)(5)). Configure the equipment for simulation tests as defined in paragraph (e)(3). Simulate a takeoff to an altitude of at least 1500 feet AGL. Verify the windshear warning and escape guidance system is operational from at least 50 feet AGL to at least 1000 feet AGL. Simulate an approach to landing from 1500 feet AGL to touchdown. Verify the windshear warning and escape guidance system is operational from at least 1000 feet AGL to at least 50 feet AGL.~~

~~(10) Windshear Escape Guidance (paragraph (c)(6)). Configure the equipment for simulation tests as defined in paragraph (e)(3). Subject the equipment to each of the windfield conditions contained in appendix 1 for each operating mode (takeoff, approach, landing, etc.) available. Each test condition shall be repeated 5 times. Recovery actions for the fixed pitch method comparison shall be initiated immediately upon entering the shear condition.~~

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(i) Verify the flight path guidance commands manage the available energy of the aircraft to achieve the desired trajectory through the shear encounter. These tests shall be performed with vertical only, horizontal only, and combination vertical and horizontal shear conditions.

(a) For the takeoff case, verify the flight guidance commands produce a trajectory that provides a resultant flight path at least as good (when considered over the entire spectrum of test cases) as that obtained by establishing a 15° pitch attitude (at an approximate rate of 1.5° per second) until onset of stall warning and then reducing pitch attitude to remain at the onset of stall warning until exiting the shear condition. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path provided by the fixed pitch method that results from use of the guidance commands provided by the system must be adequately substantiated.

(b) For the approach/landing case, verify the flight guidance commands produce a trajectory that provides a resultant flight path at least as good (when considered over the entire spectrum of test cases) as that obtained by establishing maximum available thrust and a 15° pitch attitude (at an approximate rate of 1.5° per second) until onset of stall warning and then reducing pitch attitude to remain at the onset of stall warning until exiting the shear condition. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path provided by the fixed pitch method that results from use of the guidance commands provided by the system must be adequately substantiated.

(c) For shear conditions exceeding the available performance capability of the aircraft, verify the flight guidance commands result in ground impact in the absence of ability to produce additional lift, absence of excessive kinetic energy, and without putting the aircraft into a stalled condition.

(ii) Verify the flight guidance command outputs are capable of display on associated flight displays. Interface specifications shall be verified and determined to be appropriate for the systems identified in the equipment installation instructions.

(iii) Verify that pitch attitude commands do not result in an angle-of-attack exceeding the onset of stall warning or a maximum pitch command of 27°, whichever is less.

(iv) For systems incorporating manual activation of recovery flight guidance commands, verify the system is activated only by the TOGA switches (or equivalent means). For systems providing automatic activation of recovery guidance, verify the system is activated concurrent with the windshear warning alert.

(v) Verify that windshear recovery guidance commands and any automatic recovery mode can be deselected by a means other than the TOGA switches.

(vi) For systems incorporating automatic reversion of flight guidance commands from windshear escape guidance to another flight guidance mode, verify that the transition between flight guidance modes provides smooth guidance information.

(vii) Verify flight guidance commands are not removed from the flight guidance display until either manually deselected or until the aircraft, following exit of the warning conditions, has maintained a positive rate of climb and speed above 1.3 V_{s1} for at least 30 seconds.

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3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — ~~Computer~~ Software

See CS-ETSO, Subpart A, paragraph 2.2.

~~In addition, the software for windshear warning and escape guidance functions must be verified and validated to at least Level C. An installation safety analysis for a particular aircraft installation should be accomplished to determine if software must be verified and validated to the more stringent Level B requirements.~~

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in 3.1.1 above that results in an unannunciated malfunction or a missed wind shear detection is a major failure condition.

A loss of the function defined in 3.1.1 above is a minor failure condition.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

EASA PERFORMANCE STANDARD FOR AIRBORNE WIND SHEAR WARNING AND ESCAPE GUIDANCE SYSTEMS FOR TRANSPORT AEROPLANES

1. PURPOSE.

This Appendix establishes the minimum performance standards (MPS) for airborne wind shear warning and escape guidance systems for transport category aeroplanes.

2. SCOPE.

The scope of this Appendix is to provide MPS for airborne wind shear warning and escape guidance systems for transport category aeroplanes. All the paragraph references cited herein are in reference to this Appendix only.

This performance standard applies only to wind shear warning systems which identify wind shear phenomena by sensing an encounter with conditions that exceed the threshold values contained in this performance standard. In addition to wind shear warning criteria, this performance standard provides criteria that are applicable to systems that provide optional wind shear caution alert capability. Wind shear escape guidance is provided to assist the pilot in obtaining the desired flight path during such an encounter.

3. DEFINITION OF TERMS.

a. Airborne wind shear warning system.
   A device or system which uses various sensor inputs to identify the presence of wind shear once the phenomenon is encountered, and provides the pilot with a timely warning. The system may include both wind shear warning and wind shear caution alerts. A warning device of this type does not provide escape guidance information to the pilot to satisfy the criteria for warning and flight guidance systems.
b. Airborne wind shear warning and escape guidance system.
   A device or system which uses various sensor inputs to identify the presence of wind shear once the phenomenon is encountered, and provides the pilot with a timely warning and adequate flight guidance to improve the probability of recovery from the wind shear encounter. This system may include both wind shear warning and wind shear caution alerts.
c. Airborne wind shear autorecovery system.
   A device or system which integrates or couples autopilot and/or autothrottle systems of the aeroplanes with an airborne wind shear flight guidance system.
d. Airborne wind shear escape guidance system.
   A system which provides the crew with flight guidance information to improve the probability of recovery once a wind shear phenomenon is encountered.
e. Failure.
   The inability of a system, subsystem, unit, or part to perform within the previously specified limits.
f. False warning or caution.
   A warning or caution which occurs when the wind shear warning or caution threshold of the system is not exceeded.
g. Nuisance warning or caution.
   A warning or caution which occurs when a phenomenon is encountered, such as turbulence, which does not, in fact, endanger the aircraft because of the duration of the subsequent change in the magnitude of the wind shear.
h. Recovery procedure.

A vertical flight path control technique that is used to maximise the potential for a recovery from an inadvertent encounter with wind shear.

i. Severe wind shear.
A wind shear of sufficient intensity and duration that it exceeds the performance capability of a particular aircraft type. This would be likely to cause an inadvertent loss of control or ground contact if the pilot did not have information available from an airborne wind shear warning and escape guidance system which meets the criteria of this ETSO.

j. Wind shear caution alert.
An alert that is triggered by increasing performance conditions, which is set at a wind shear level that requires immediate crew awareness and probably subsequent corrective action by the pilot.

k. Wind shear warning alert.
An alert that is triggered by decreasing performance conditions, which is set at a wind shear level that requires immediate corrective action by the pilot.

4. GENERAL REQUIREMENTS.

In addition to the performance requirements provided in the main text of this MPS and in the appendices of ETSO-C117b, the following general requirements and equipment characteristics are defined below:

a. General standards.
The following general requirements shall be met by all wind shear warning and escape guidance systems:

(1) Airworthiness.
The design and manufacture of the airborne equipment shall provide for installation so as not to impair the airworthiness of the aircraft. The material shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft systems. The workmanship shall be consistent with high-quality aircraft electromechanical and electronic component manufacturing practices.

(2) General performance.
The equipment shall perform its intended function, as defined by the manufacturer.

(3) Fire resistance.
Except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not significantly contribute to the propagation of fire, all the materials that are used shall be self-extinguishing. One means to show compliance with this requirement is contained in Part 25, Appendix F.

(4) Operation of controls.
Controls that are intended for use during flight shall be designed to minimise errors, and when operated in all possible combinations and sequences shall not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.

(5) Accessibility of controls.
Controls that are not normally adjusted in flight shall not be readily accessible to the operator.

(6) Interfaces.
The interfaces with other aircraft equipment shall be designed such that the normal or abnormal operation of wind shear warning and escape guidance equipment does not adversely affect the operation of other equipment.

(7) Compatibility of components.

If a system component is individually acceptable but requires calibration adjustments or matching to other components in the aircraft for its proper operation, it shall be identified in a manner that will ensure its performance to the requirements specified in this ETSO.

(8) Interchangeability.

System components which are identified with the same manufactured part number shall be completely interchangeable.

(9) Control/display capability.

A suitable interface shall be provided to allow data input, data output, and control of the operation of the equipment. The control/display shall be operable by one person with the use of only one hand.

(10) Control/display readability.

The equipment shall be designed so that all the displays and controls are readable under all cockpit ambient light conditions, ranging from total darkness to reflected sunlight, and are arranged to facilitate the use of the equipment. If limitations are necessary on equipment installations to ensure that the displays are readable, they shall be included in the installation instructions.

(11) Effects of test.

The design of the equipment shall be such that the application of the specified test procedures does not produce a condition that is detrimental to the performance of the equipment, except as specifically allowed.

(12) Equipment computational response time.

The equipment shall employ suitable update rates for the computation and display of detection and guidance information.

(13) Supplemental heating or cooling.

If supplemental heating or cooling is required by system components to ensure that the requirements of this ETSO are met, they shall be specified by the equipment manufacturer in the installation instructions.

(14) Self-test capability.

The equipment shall employ a self-test capability to verify the proper operation of the system.

(i) Any manually initiated self-test mode of operation shall automatically return the system to the normal operating mode upon completion of a successful test.

(ii) Any automatically activated self-test feature shall annunciate this mode of operation to the pilot if this feature activates annunciation lights, aural messages, or displaces the guidance commands in any way.

(iii) Use of the system self-test feature shall not adversely affect the performance of operation of other aircraft systems.

(iv) A failure of the system to successfully pass the self-test shall be annunciated.

(15) Independence of warning and escape guidance functions.

Irrespective of whether the warning and escape guidance functions are in a combined system or are separate systems, they should be sufficiently independent such that a failure of either system does not necessarily preclude or inhibit the presentation of information from the other. A warning system failure shall not result in any ambiguous or erroneous guidance system mode annunciations.

(16) System reliability.

(i) The probability of a false warning being generated within the wind shear warning system or the wind shear warning and escape guidance system shall be 1E-4 or less per flight hour.

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(ii) The probability of an unannunciated failure of the wind shear warning system or the wind shear warning and escape guidance system shall be 1E-5 or less per flight hour (reserved).

b. Equipment functional requirements — standard conditions.

The equipment shall meet the following functional requirements.

(1) Mode annunciation.

The wind shear escape guidance display mode of operation shall be annunciated to the pilot upon escape guidance activation during a wind shear encounter, and upon reversion to a different flight guidance mode.

(2) Malfunction/failure indications.

The equipment shall indicate:

(i) any inadequacy or absence of primary power;

(ii) equipment failures;

(iii) inadequate or invalid warning or guidance displays or output signals;

(iv) inadequate or invalid sensor signals or sources.

These malfunction/failure indications shall occur independently of any operator actions. The lack of adequate warning displays, escape guidance information, or sensor signals or sources shall be annunciated when compliance with the requirements of this ETSO cannot be assured.

(3) Wind shear caution alert.

If the equipment includes a wind shear caution:

(i) it shall provide an annunciation of increasing performance shear (updraft, increasing headwind, or decreasing tailwind) in accordance with the shear intensity curve shown in Figure 1;

(ii) this caution alert shall display or provide an appropriate output for display of an amber caution annunciation dedicated for this purpose. An aural alert may be provided as an option. The caution display (or output) should remain until the threshold wind shear condition no longer exists (not less than 3 seconds) or a wind shear warning alert occurs;

(iii) gust conditions shall not cause a nuisance caution alert. Turbulence shall not cause more than one nuisance caution alert per 250 hours (or 3 000 flight cycles based on 1 hour/flight cycle) of system operation.

(4) Wind shear warning alert.

(i) A wind shear warning alert shall provide an annunciation of decreasing performance shear (downdraft, decreasing headwind, or increasing tailwind) with a magnitude that is equal or greater than that shown in the shear intensity curve shown in Figure 1.

(ii) This warning alert shall display or provide an appropriate output for display of a red warning annunciation labelled 'wind shear' dedicated for this purpose. The visual alert should remain at least until the threshold wind shear condition no longer exists, or for a minimum of 3 seconds, whichever is greater. An aural alert shall be provided that annunciates 'wind shear' for 3 aural cycles. The aural alert need not be repeated for subsequent wind shear warning alerts within the same mode of operation.

(iii) Gust conditions shall not cause a nuisance warning alert. Turbulence shall not cause more than 1 nuisance warning alert per 250 hours (or 3 000 flight cycles based on 1 hour/flight) of system operation.

(5) Wind shear alert with increased approach sensitivity and reduced take-off sensitivity modes.

(i) Increased approach sensitivity mode. If your system separates approach and take-off scenarios, you may reduce the shear intensity level in the approach mode to increase the probability of providing timely wind shear alerts. You may lower the floor of the shear intensity curve 'must alert' curve in Figure 1 from 0.105 to 0.090. If you lower the floor, you may also modify the turbulence rejection tests in paragraph 4(d)(7)(ii) such that an alert in this region is not a failure of the turbulence rejection test.

(ii) Reduced take-off sensitivity mode. If your system separates approach and take-off scenarios, you may desensitise the take-off mode to reduce the probability of unwanted alerts. You may raise the floor of the shear intensity 'must alert' curve in Figure 1 from 0.105 to 0.120.

(iii) Additional reduced take-off sensitivity mode. Some high-performance jet aircraft receive unwanted wind shear alerts after take-off when climbing at high rates through atmospheric wind gradients. If these unwanted alerts risk desensitising pilots to wind shear alerting, you may tailor the floor of the shear intensity 'must alert' curve in Figure 1 to reduce these unwanted alerts under the following conditions:

(a) The airborne wind shear warning and escape guidance system can determine that the aircraft is in the take-off versus approach phase.

(b) The aircraft is climbing at a high rate of climb, the aircraft continues to climb at a high rate, and the rate of climb is known to create unwanted wind shear alerts.

(c) The aircraft power setting is at or near a level that is representative of the maximum for the segment of the take-off, for example maximum take-off thrust.

(d) The Figure 1 shear intensity 'must alert' curve shall be complied with after take-off.

(6) Alerting prioritisation.

If alerting is prioritised in the presentation for wind shear warning and escape guidance system (reactive wind shear), forward-looking wind shear system, terrain awareness and warning system, ground proximity warning system, traffic collision avoidance system, or when a simultaneous aural annunciation could occur, sequencing shall be implemented that ensures that reactive wind shear warning alerts are presented or annunciated first. Reactive wind shear alerts that are cautions have a lower priority than all terrain awareness and warning or ground proximity warning system alerts.

(7) The reactive wind shear systems caution alert should be disabled if a forward-looking wind shear system is in operation. It is acceptable to issue reactive wind shear caution alerts if the forward-looking wind shear system is inoperative.

(8) Operating altitude range.

The system shall be designed to function from at least 50 feet above ground level (AGL) to at least 1 000 feet AGL.

(9) Wind shear escape guidance.

Flight guidance algorithms shall incorporate the following design considerations:

(i) At the point of the system warning threshold, the available energy of the aeroplane shall be properly managed through a representative number of wind field conditions. These conditions shall take into account significant shear components in both the horizontal and vertical axes, individually and in combination.

(ii) The flight path guidance commands shall be suitable for the dynamic response of aeroplane of the type on which the system is intended for installation. The applicant shall demonstrate that the flight guidance commands during a dynamic wind shear encounter can be followed without resulting in pilot-induced oscillations.

(iii) If the magnitude of the shear components is such as to overcome the performance capability of the aeroplane, guidance commands shall be such that a ground impact will occur in the absence of the ability to produce additional lift, an absence of excessive kinetic energy, and without putting the aircraft into a stalled condition.

(iv) Flight guidance command information shall be provided for presentation on the primary flight display/attitude direction indicator (PFD/ADI) and any available head-up display (HUD).

(v) Flight guidance displays which command the flight path and pitch attitude should be limited to an angle of attack that is equivalent to the onset of a stall warning or a maximum pitch command of 27°, whichever is less.

(vi) Flight guidance commands and any autorecovery mode (if included) may be automatically activated concurrently with or after the wind shear warning alert occurs, or may be manually selected. If manual selection is utilised, it shall only be via the take-off/go-around (TOGA) switch or equivalent means (i.e. a function of the throttle position, other engine parameters, etc.).

(vii) Manual deselection of wind shear flight guidance and any autorecovery mode (if included) shall be possible by means other than the TOGA switches.

(viii) Systems that incorporate the automatic reversion of flight guidance commands from wind shear escape guidance to another flight guidance mode should provide a smooth transition between the modes. Flight guidance commands shall not be removed from the flight guidance display until either they are manually deselected or until the aircraft, following the end of the warning conditions, has maintained a positive rate of climb and speed above 1.3 Vs1 for at least 30 seconds.

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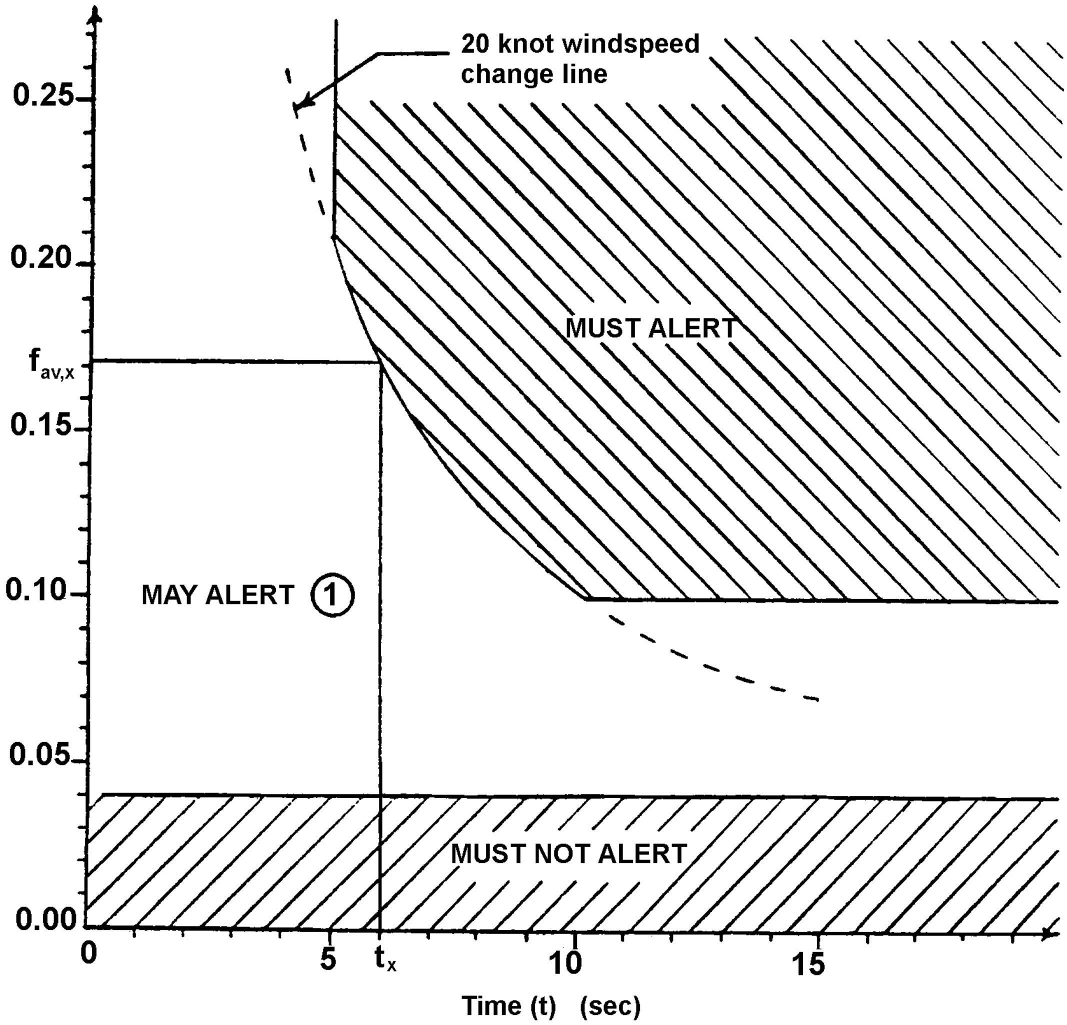
FIGURE 1 — SHEAR INTENSITY CURVE



$f_{av,x}$ = average shear intensity to cause a warning at time t_x (resulting in a 20-knot wind speed change, bounded as shown; applies to horizontal, vertical, and combination shear intensities),

$$= \frac{\int_0^{t_x} f(t)dt}{t_x},$$

whereby f(t) = instantaneous shear intensity at time t.

① A nuisance warning test that utilises the Dryden turbulence model and discrete gust model is conducted independently from the alert threshold tests to verify the acceptability of potential nuisance warnings due to turbulence or gusts.

c. Equipment performance — environmental conditions.

(1) The environmental tests and performance requirements described in this subsection are intended to provide a laboratory means to determine the overall performance characteristics of the equipment under conditions that are representative of those that may be encountered in actual operations. Table 1 defines the environmental tests that

are required for the equipment. It shows the section numbers in ED-14G that describe the individual environmental tests. Some of the environmental tests contained in this subsection do not need to be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase 'When required' in Table 1. If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these 'When required' tests shall be performed.

(2) Environmental requirements. The following subset of performance requirements shall be met under environmental conditions. Additionally, all the system controls, displays, inputs and outputs shall perform their intended functions when subjected to the ED-14G environmental conditions.

(i) Section 4.b(1) — Mode Annunciation

(ii) Section 4.b(2) — Malfunction/Failure Indications

(iii) Section 4.b(3) — Wind Shear Caution Alert, except paragraph 4.b(3)(iii)

(iv) Section 4.b(4) — Wind Shear Warning Alert, except paragraph 4.b(4)(iii)

(v) Section 4.b(5) — Wind Shear Alert with Increased Approach Sensitivity and Reduced Take-off Sensitivity Modes

(vi) Section 4.b(9) — Wind Shear Escape Guidance

(3) The applicant shall conduct environmental qualification tests for the following shear intensity ($f_{av,x}$) and exposure time (sec) in Figure 1: 0.1050, 10; 0.1748, 6; and 0.2100, 5; and ensure that the system generates and displays alerts when required. A single representative wind shear waveform may be used for all environmental tests if the system design is such that different waveforms will not affect the performance under environmental conditions. Gust and turbulence rejection tests are not required under environmental conditions.

Table 1 — Required EUROCAE ED-14G Testing By Category

Environmental Test	**ED-14G Section**	**Required Test**
Temperature and Altitude	4	
Ground Survival Low Temperature and Short-Time Operating Low Temperature		√
Low Operating Temperature		√
Ground Survival High Temperature and Short-Time Operating High Temperature		√
High Operating Temperature		√
In-Flight Loss of Cooling		When required
Altitude		√
Decompression		When required
Overpressure		When required
Temperature Variation	5	√
Humidity	6	√
Operational Shocks and Crash Safety	7	
Operational Shocks		√

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Crash Safety		√
Vibration	8	√
Explosion proofness	9	When required
Waterproofness	10	
Condensing Water Proof		When required
Drip Proof		When required
Spray Proof		When required
Continuous Stream Proof		When required
Fluids susceptibility	11	
Spray		When required
Immersion		When required
Sand and dust	12	When required
Fungus resistance	13	When required
Salt spray	14	When required
Magnetic effect	15	√
Power input	16	
Normal Operating Conditions (AC/DC)		√
Abnormal Operating Conditions (AC/DC)		√
Load Equipment Influence on Aircraft Electrical Power System (AC/DC)		When required
Voltage spike	17	
Category A Requirements (If applicable)		√
Category B Requirements (If applicable)		√
Audio frequency conducted susceptibility	18	√
Induced signal susceptibility	19	√
RF susceptibility	20	√
Emission of RF energy	21	√
Lightning-induced transient susceptibility	22	√
Lightning Direct Effects	23	When required

d. Equipment test procedures.

(1) Definitions of terms and conditions of tests. The following definitions of terms and conditions of tests are applicable to the equipment tests specified herein:

(i) Power input voltage. Unless otherwise specified, all the tests shall be conducted with the power input voltage adjusted to design voltage ± 2 per cent. The input voltage shall be measured at the input terminals of the equipment under test.

(ii) Power input frequency.

(a) In the case of equipment that is designed for operation from an AC power source of essentially constant frequency (e.g. 400 Hz), the input frequency shall be adjusted to design frequency ± 2 per cent.

(b) In the case of equipment designed for operation from an AC power source of variable frequency (e.g. 300 to 1 000 Hz), unless otherwise specified, the test shall be conducted with the input frequency adjusted to within 5 % of a selected frequency and within the range for which the equipment is designed.

(iii) Wind field models. Unless otherwise specified, the wind field models used for the tests shall be those specified in Appendix 2 of ETSO-C117b.

(iv) Adjustment of equipment. The circuits of the equipment under test shall be aligned and adjusted in accordance with the manufacturer's recommended practices prior to the application of the specified tests.

(v) Test instrument precautions. Due precautions shall be taken during the execution of the tests to prevent the introduction of errors that result from the connection of voltmeters, oscilloscopes, and other test instruments across the input and output impedances of the equipment under test.

(vi) Ambient conditions. Unless otherwise specified, all the tests shall be made within the following ambient conditions:

— Temperature: + 15 to + 35 °C (+ 59 to + 95 °F).
— Relative humidity: Not greater than 85 %.
— Ambient pressure: 84–107 kPa (equivalent to + 5 000 to – 1 500 ft) (+ 1 525 to – 460 m).

(vii) Warm-up period. Unless otherwise specified, all the tests shall be conducted after the manufacturer's specified warm-up period.

(viii) Connected loads. Unless otherwise specified, all the tests shall be performed with the equipment connected to loads which have the impedance values for which it is designed.

(2) Test procedures. The equipment shall be tested in all the modes of operation that allow different combinations of sensor inputs to show that it meets both the functional and accuracy criteria.

Dynamic testing provides quantitative data regarding the performance of wind shear warning and escape guidance equipment using a simplified simulation of flight conditions. This testing, when properly performed and documented, may serve to minimise the flight test requirements.

It shall be the responsibility of the equipment manufacturer to determine that the sensor inputs, when presented to the wind shear warning and escape guidance equipment, will produce performance that is commensurate with the requirements of this standard. Additional sensor inputs may be optionally provided to enhance the capability and/or performance of the equipment.

The equipment required to perform these tests shall be defined by the equipment manufacturer as a function of the specific sensor configuration of the equipment. Since these tests may be accomplished in more than one way, alternative test equipment set-ups may be used where equivalent test functions can be accomplished. Combinations of tests may be used wherever appropriate.

The signal sources of the test equipment shall provide the appropriate signal formats for input to the specific system under test without contributing to the error values that are being measured. Tests need only be performed once, unless it is otherwise indicated.

The scenarios that are established for testing wind shear warning and escape guidance systems represent realistic operating environments to properly evaluate such systems.

The wind field models contained in Appendix 2 of ETSO C117b should be used to evaluate the performance of the wind shear warning and escape guidance systems. The manufacturer may propose different wind field models provided that it is shown that they represent conditions that are at least as severe as those contained in this ETSO.

Note: The test waveform parameters provided in the ETSO are sufficiently broad to cover the wind field parameters that were observed in the known accident cases. However, the manufacturer is encouraged to verify that the detection systems will actually detect these wind shears by subjecting them to the wind field conditions specified for use in evaluating guidance commands.

(3) Test set-up. Simulator tests shall be used to demonstrate the performance capability of the wind shear warning and escape guidance equipment. A suitable equipment interface shall be provided for recording the relevant parameters that are necessary to evaluate the particular system under test. The aircraft simulator shall be capable of appropriate dynamic modelling of a representative aircraft and of the wind field and turbulence conditions contained in Appendices 2 and 3 of this ETSO, or other wind field/turbulence models that are found to be acceptable by the administrator.

Note: This section requires testing in a single representative aircraft simulator. Approval of the installation will require system testing in an aircraft simulator that is representative of the aircraft. Thus, we recommend you to accomplish the Section 4(d)(3) simulator testing in as many representative simulators as are necessary to cover all the intended installations.

(4) Functional performance (paragraphs 4(b)(1) through 4(b)(5), 4(b)(8) and 4(b)(9)). Each of the functional capabilities identified in paragraphs 4(b)(1) through 4(b)(5), 4(b)(7) and 4(b)(8) shall be demonstrated with the wind shear warning and escape guidance equipment powered. These capabilities shall be evaluated either by inspection or in conjunction with the tests described in paragraphs 4(d)(5) through 4(d)(10).

(5) Mode annunciation (paragraph 4(b)(1)). With the equipment operating, verify that the wind shear escape guidance display mode of operation is annunciated to the pilot upon activation of the escape guidance and upon reversion to a different flight guidance mode.

(6) Malfunction/failure indications (paragraph 4(b)(2)). Configure the equipment for simulation tests as defined in paragraph 4(d)(3).

(i) With the system active (within the operating altitude range) and inactive (outside the operating altitude range), remove one at a time each required electrical power input to the equipment. There shall be a failure indication by the equipment of each simulated failure condition.

(ii) With the system active (within the operating altitude range) and inactive (outside the operating altitude range), cause each sensor or other signal input to become inadequate or invalid. There shall be a failure indication by the equipment of each simulated failure condition.

(7) Wind shear caution alert (paragraphs 4(b)(3) and 4(b)(5)(i)). For equipment that incorporates a wind shear caution alert function, accomplish the following tests:

(i) Configure the equipment for a simulation test as defined in paragraph 4(d)(3). Subject the equipment to acceleration waveform values that meet the following conditions (reference Figure 2). The system shall generate an appropriate caution alert (or no alert) within the time intervals specified when subjected to the following average shear intensity ($f_{av,x}$) values:

$f_{av,x}$ (1)	Time of Exposure (t)	Alert within (sec) (3)
0.0200	20	no alert
0.0400	20	no alert
0.1050	10	10
0.1166	9	9
0.1311	8	8
0.1499	7	7
0.1748	6	6.2
0.2100	5	5.7
0.2700 (2)	5	5

Notes:

(1) The average shear intensity which shall result in a caution alert after a time t_x or less meets the definition of $f_{av,x}$ in Figure 1. The maximum instantaneous shear intensity of the test waveform is restricted to 0.075 or 100 % of $f_{av,x}$ above the average shear value $f_{av,x}$, whichever is less. The minimum instantaneous shear intensity of the test waveform is zero. The test waveform rise and fall rates shall be limited to a maximum of 0.1 per second. The shear intensity before time 0 is zero for a sufficiently long time to allow the system to settle to stable conditions.

(2) In order to achieve the test condition with the shear intensity $f_{av,x}$ equal to or greater than 0.270, it is necessary to have an initial rise of sufficient rate to achieve a shear intensity f value that will allow subsequent rise and fall rates that are limited to 0.1 per second to achieve the required $f_{av,x}$ value.

(3) Account for latency due to the alert calculation and alert annunciation display functionality when measuring the alert time.

The test conditions specified above shall be repeated 5 times for each axis (horizontal and vertical). A total of 90 runs are required for verification of the detection (9 conditions × 5 for each axis) for both performance increasing and performance decreasing wind shears. A different waveform for $f_{av,x}$ will be utilised for each of the 5 runs. An appropriate alert (or no alert) shall be generated for each test condition.

Verify that the system displays or provides an appropriate output for display of an amber caution annunciation that is dedicated for this purpose. Verify that the visual caution display (or output) remains at least until the threshold wind shear condition no longer exists, or a minimum of 3 seconds (whichever is greater), or until a wind shear warning occurs.

(ii) Subject the equipment to wind speeds that are defined by the Dryden turbulence model contained in Appendix 4 of ETSO C117b. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in Appendix 4 of ETSO C117b for a minimum total test duration of 250 hours (or 3 000 flight cycles based on 1 hour/flight cycle).

No more than 1 nuisance caution shall be generated during this test.

An alternative test equipment set-up may be used to accomplish the equivalent test function for the turbulence testing. A combination of analysis, simulation and testing may be used to demonstrate the performance of the equipment.

(iii) Subject the equipment to the wind speeds that are defined by the discrete gust rejection model contained in Appendix 4 of ETSO C-117b. No alert shall be generated as a result of this test.

(8) Wind shear warning alert (paragraphs 4(b)(4) and 4(b)(5)(ii)).

(i) Configure the equipment for simulation tests as defined in paragraph (d)(3). Subject the equipment to acceleration waveform values that meet the following conditions (reference Figure 2). The system shall generate an appropriate warning alert (or no alert) within the time intervals that are specified when it is subjected to the following average shear intensity ($f_{av,x}$) values:

$f_{av,x}$ (1)	Time of Exposure (t)	Alert within (sec) (3)
0.0200	20	no alert
0.0400	20	no alert
0.1050	10	10
0.1166	9	9
0.1311	8	8
0.1499	7	7
0.1748	6	6.6
0.2100	5	6.2
0.2700 (2)	5	5.7

Notes:

(1) The average shear intensity which shall result in a warning alert after a time t_x or less meets the definition of $f_{av,x}$ in Figure 1. The maximum instantaneous shear intensity of the test waveform is restricted to 0.075 or 100 % of $f_{av,x}$ above the average shear value $f_{av,x}$, whichever is less. The minimum instantaneous shear intensity of the test waveform is zero. The test waveform rise and fall rates shall be limited to a maximum of 0.1 per second. The shear intensity before time 0 is zero for a sufficiently long time to allow the system to settle to stable conditions.

(2) In order to achieve the test condition with the shear intensity $f_{av,x}$ equal to or greater than 0.270, it is necessary to have an initial rise of a sufficient rate to achieve a shear intensity f value that will allow the subsequent rise and fall rates that are limited to 0.1 per second to achieve the required $f_{av,x}$ value.

(3) Account for any latency due to the alert calculation and alert annunciation display functionality when measuring the alert time.

The test conditions specified above shall be repeated 5 times for each axis (horizontal and vertical). A total of 90 runs are required for verification of the detection (9 conditions × 5 for each axis) for both increasing and decreasing wind shears. A different waveform for $f_{av,x}$ will be utilised for each of the 5 runs. An appropriate alert (or no alert) shall be generated for each test condition.

Verify that the system displays or provides an appropriate output for display of a red warning annunciation labelled 'wind shear' that is dedicated for this purpose. Verify that the visual warning display (or output) remains until the threshold wind shear condition no longer exists, or a minimum of 3 seconds, whichever is greater. Verify that an aural alert is provided that annunciates 'wind shear' for 3 aural cycles.

(ii) Subject the equipment to the wind speeds that are defined by the Dryden

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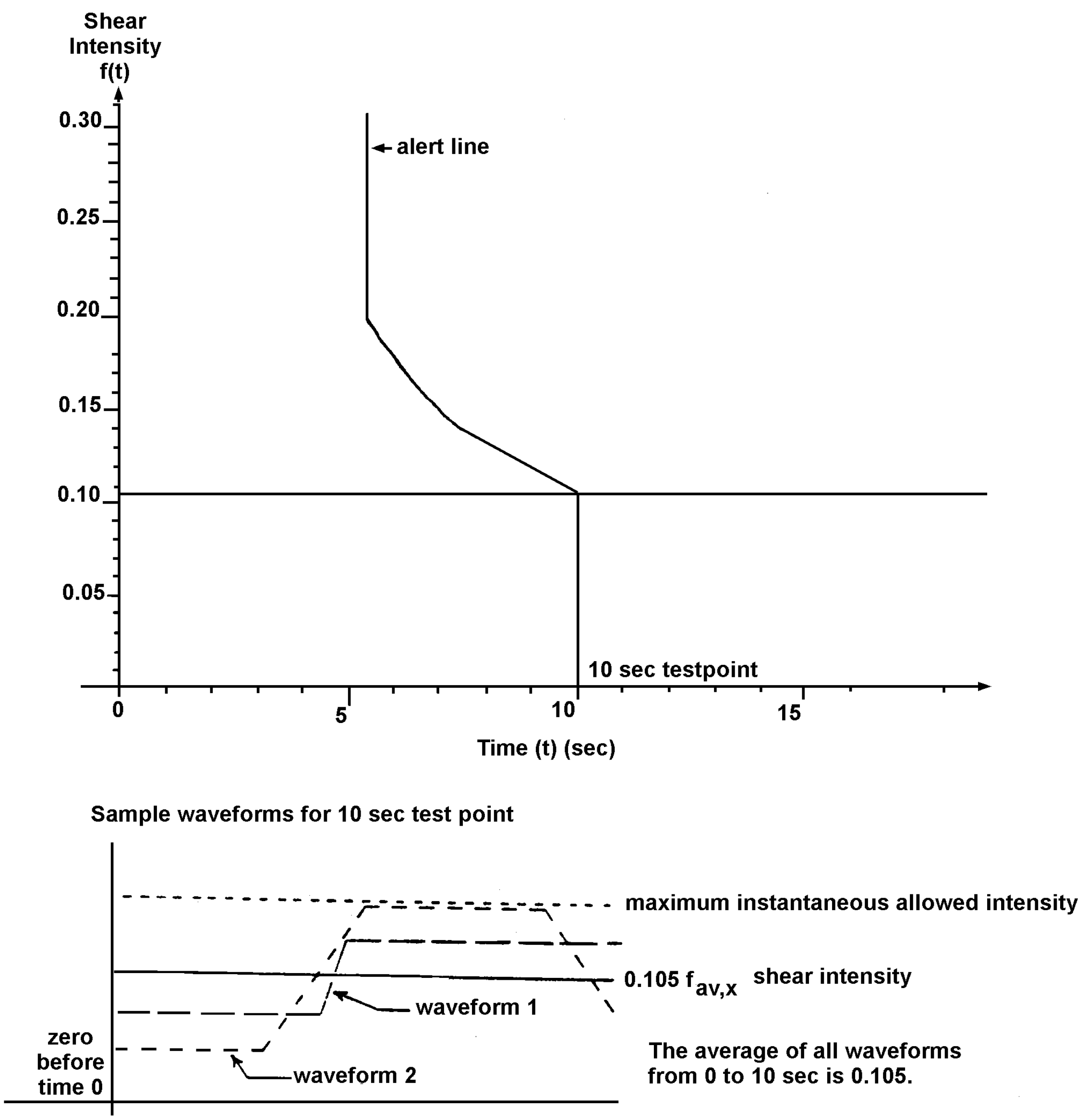
turbulence model contained in Appendix 4 of ETSO C117b. The system shall be exposed to these conditions for a minimum of 50 hours (or 600 flight cycles) at each altitude specified in Appendix 4 of ETSO C117b for a minimum total test duration of 250 hours (or 3 000 flight cycles based on 1 hour/flight cycle). No more than 1 nuisance warning shall be generated during this test.

An alternative test equipment set-up may be used to accomplish the equivalent test function for the turbulence testing. A combination of analysis, simulation, and testing may be used to demonstrate the performance of the equipment specified in this paragraph 4(d)(8)(ii).

(iii) Subject the equipment to the wind speeds that are defined by the discrete gust rejection model contained in Appendix 4 of ETSO C117b. No alerts shall be generated as a result of this test.

FIGURE 2 — WIND SHEAR ALERT TEST



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(9) Operating altitude range (paragraph 4.b(8)). Configure the equipment for the simulation tests as defined in paragraph (d)(3). Simulate a take-off to an altitude of at least 1 500 feet AGL. Verify the wind shear warning and escape guidance system is operational from at least 50 feet AGL to at least 1 000 feet AGL. Simulate an approach to landing from 1 500 feet AGL to touchdown. Verify the wind shear warning and escape guidance system is operational from at least 1 000 feet AGL to at least 50 feet AGL.

(10) Wind shear escape guidance (paragraph 4.b(9)). Configure the equipment for simulation tests as defined in paragraph (d)(3). Subject the equipment to each of the wind field conditions contained in Appendix 2 of ETSO C117b for each operating mode (take-off, approach, landing, etc.) that is available. Each test condition shall be repeated 5 times. Recovery actions for the fixed pitch method comparison shall be initiated immediately upon entering the shear condition.

Notes:

(1) Evaluate wind shear escape guidance commands using a simulation that incorporates the necessary dynamic modelling of the representative aircraft (more than 1 representative aircraft model may be necessary) in which installation of the equipment is intended. Dynamic modelling of the representative aircraft should include consideration of all the relevant effects, including but not limited to pitch and roll rates, control authority, delays between control inputs and aircraft responses, display system leads and lags, etc.

(2) The simulator should provide for a pilot in the loop evaluation of guidance flyability during simulated wind shear encounters. The guidance command gains should be consistent with those incorporated in the flight guidance system. While 'fine-tuning' of the guidance commands to obtain the optimum performance for a specific aeroplane may be accomplished, the use of unique tailoring for a specific aeroplane may not be necessary. Evaluation through means of a suitable engineering simulation may be acceptable to demonstrate the suitability of the guidance commands for a representative aeroplane. However, the equipment manufacturer should demonstrate that the flight guidance commands during a dynamic wind shear encounter can be followed without resulting in pilot-induced oscillations.

(i) Verify that the flight path guidance commands manage the available energy of the aircraft to achieve the desired trajectory through the shear encounter. These tests shall be performed with vertical only, horizontal only, and a combination of vertical and horizontal shear conditions. You may reduce the number of times you repeat each of these tests conditions to less than 5. To reduce the number of repetitions to less than 5, you shall have gathered sufficient data to demonstrate that the flight path guidance commands meet these requirements. You should also include aircraft weight and centre of gravity variations if applicable.

a. For the take-off case, verify that the flight guidance commands produce a trajectory that provides a resultant flight path that is at least as good (when considered over the entire spectrum of test cases) as that obtained by establishing a 15° pitch attitude (at an approximate rate of 1.5° per second) until the onset of a stall warning, and then reducing the pitch attitude to remain at the onset of a stall warning until the shear condition is exited. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path that is provided by the fixed pitch method that results from the use of the guidance commands provided by the system shall be adequately substantiated.

b. For the approach/landing case, verify that the flight guidance commands produce a trajectory that provides a resultant flight path that is at least as good (when considered over the entire spectrum of test cases) as that obtained by establishing the maximum available thrust and a 15° pitch attitude (at an approximate rate of 1.5° per second) until the onset of stall warning, and then reducing the pitch attitude to remain at the onset of stall warning until the shear condition is exited. Evidence of a significant decrement (considered over the entire spectrum of test cases) below the flight path that is provided by the fixed pitch method that results from the use of the guidance commands that are provided by the system shall be adequately substantiated.

c. For shear conditions that exceed the available performance capability of the aircraft, verify that the flight guidance commands result in a ground impact in the absence of the ability to produce additional lift, an absence of excessive kinetic energy, and without putting the aircraft into a stalled condition.

Note: There is no requirement to perform the tests described in paragraphs 4(d)(10)(ii) through (vii) with horizontal only, vertical only, and a combination of vertical and horizontal shear conditions. You may perform the tests described in paragraphs 4(d)(10)(ii) through (vii) with only the combination vertical and horizontal shear conditions.

(ii) Verify that the flight guidance command outputs are capable of display on the associated flight displays. The interface specifications shall be verified and determined to be appropriate for the systems that are identified in the equipment installation instructions.

(iii) Verify that the pitch attitude commands do not result in an angle of attack that exceeds the onset of a stall warning or a maximum pitch command of 27°, whichever is less.

(iv) For systems that incorporate manual activation of recovery flight guidance commands, verify that the system is activated only by the TOGA switches (or equivalent means). For systems that provide automatic activation of recovery guidance, verify that the system is activated concurrently with the wind shear warning alert.

(v) Verify that the wind shear recovery guidance commands and any automatic recovery mode can be deselected by a means other than the TOGA switches.

(vi) For systems that incorporate automatic reversion of flight guidance commands from wind shear escape guidance to another flight guidance mode, verify that the transition between the flight guidance modes provides smooth guidance information.

(vii) Verify that flight guidance commands are not removed from the flight guidance display until either they are manually deselected or until the aircraft, following the exit of the warning conditions, has maintained a positive rate of climb and speed above 1.3 Vs1 for at least 30 seconds.

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APPENDIX 2

This ~~appendix~~ Appendix contains data that defines the ~~windfield~~ wind field models to be used in conducting the tests specified in paragraph ~~(e)(10~~4(d)(19)~~)~~ of this ETSO. This material was developed by the National Aeronautics and Space Administration (NASA), reference NASA Technical Memorandum 100632 [ref. 1].

The downburst model parameters below provide the variables to be used to obtain the representative test conditions: (1) and (2)

Radius of Downdraft (ft)	Maximum Outflow (ft/s)	Altitude of Max. Outflow (ft)	Distance From Starting Point (3) (ft)
920	37	98	20 000 (– 9 000)
1 180	47.6	98	15 000 (– 14 000)
2 070	58.4	131	25 000 (– 4 000)
4 430	68.9	164	30 000 (1 000)
9 010	72.2	262	30 000 (1 000)
3 450	88.2	197	25 000 (– 4 000)
3 180	53.1	262	30 000 (1 000)
1 640	46	164	25 000 (– 4 000)
5 250	81.3	197	30 000 (1 000)
1 250	67.6	100	25 000 (– 4 000)

(1) From analytic microburst model documented in NASA TM-100632. These parameters are based on data from Proctor's Terminal Area Simulation System (TASS) model.

(2) For the take-off case, the downburst ~~center~~ centre is positioned at the point the aircraft lifts off the runway for all test cases.

(3) For the approach/landing case, the downburst ~~center~~ centre is positioned as stated. The test is begun with the aircraft at an initial altitude of 1 500 feet on a 3° glideslope (touchdown point approximately 29 000 feet away). The ~~D~~distance from starting point indicates where the ~~center~~ centre of the downburst shaft is located relative to the starting point. The number in ~~parenthesis~~parentheses next to it indicates the relative distance of the microburst ~~center~~ centre from the touchdown point (not the end of the runway). A negative number indicates that the microburst ~~center~~ centre is located before the touchdown point, positive indicates it is past the touchdown point.

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SUMMARY

A simple downburst model has been developed for use in batch and real-time piloted simulation studies of guidance strategies for terminal area transport aircraft operations in wind shear conditions. The model represents an axisymmetric stagnation point flow, based on velocity profiles from the Terminal Area Simulation System (TASS) model developed by Proctor [ref. 6-9], and it satisfies the mass continuity equation in cylindrical coordinates. Altitude dependence, including boundary layer effects near the ground, closely matches real-world measurements, as do the increase, peak, and decay of outflow and downflow with increasing distance from the downburst center centre. Equations for horizontal and vertical winds were derived, and found to be infinitely differentiable, with no singular points existent in the flow field. In addition, a simple relationship exists among the ratio of maximum horizontal to vertical velocities, the down draft downdraft radius, depth of outflow, and altitude of maximum outflow. In use, a microburst can be modelled by specifying four characteristic parameters. Velocity components in the x, y and z directions, and the corresponding nine partial derivatives are obtained easily from the velocity equations.

INTRODUCTION

Terminal area operation of transport aircraft in a wind shear environment has been recognised recognized as a serious problem. Studies of aircraft trajectories through downbursts show that specific guidance strategies are needed for aircraft to survive inadvertent downburst encounters. In order for guidance strategies to perform in simulations as in actual encounters, a realistic set of conditions must be present during development of the strategies. Thus, aeroplane and wind models that closely simulate real-world conditions are essential in obtaining useful information from the studies.

Wind models for use on personal computers, or for simulators with limited memory space availability, have been difficult to obtain because variability of downburst characteristics makes analytical models unrealistic, and large memory requirements make use of numerical models impossible on any except very large capacity computers.

Bray [ref. 12] developed a method for analytic modelling of wind shear conditions in flight simulators, and applied his method in modelling a multiple downburst scenario from Joint Airport Weather Studies (JAWS) data. However, the altitude dependence of his model is not consistent with observed data, and, although flexibility in sizing the downbursts is built into the model, it does not maintain the physical relationships which are seen in real-world data among the sizing parameters. In particular, boundary layer effects should cause radial velocity to decay vertically to zero at the ground, as does the vertical velocity.

In a study conducted at NASA Langley Research Center, three different guidance strategies for a Boeing 737-100 aeroplane encountering a microburst on take-off were developed [ref. 23-4]. These strategies were first developed using a personal computer, and then implemented in a pilot-in-the-loop simulation using a very simple wind model in both efforts. The wind velocities used are depicted in Figure 1. [fig. 1]. This model consisted of a constant outflow outside of the downburst radius and a constant slope headwind to tailwind shear across the diameter of the downburst. It was recognized that a more realistic wind model could significantly alter the outcome of the trajectory. For the subsequent part of this study, which involves altering the aeroplane model to simulate approach to landing and escape maneuvers and additional takeoff cases, a more realistic wind model was preferred. The simple analytical model outlined in this report was developed for this purpose.

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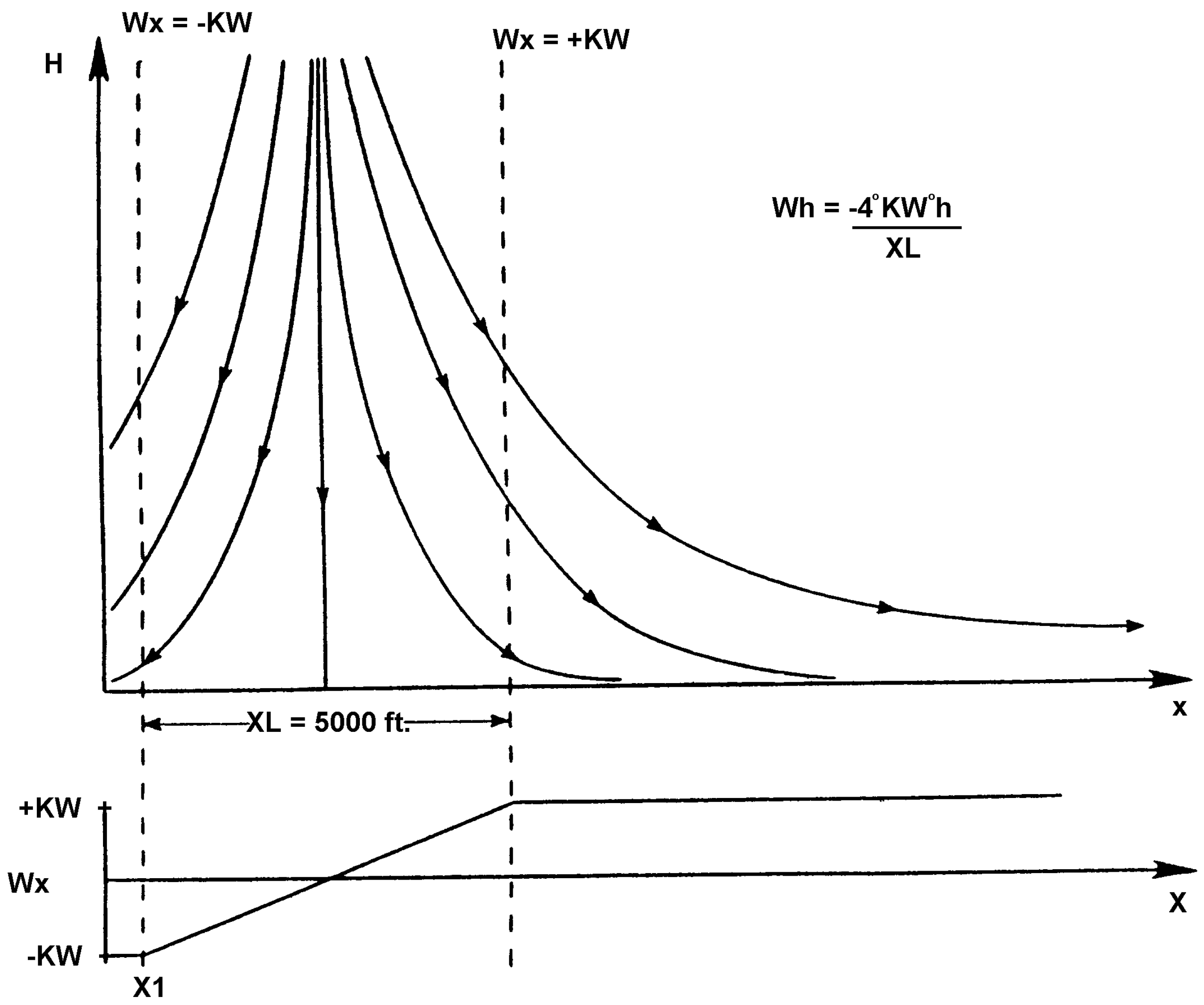

Figure 1 — Wind Model Used In Guidance Studies

It was recognised that a more realistic wind model could significantly alter the outcome of the trajectory. For the subsequent part of this study, which involves altering the aeroplane model to simulate approach to landing and escape manoeuvres and additional take-off cases, a more realistic wind model was preferred. The simple analytical model outlined in this report was developed for this purpose.

SYMBOLS

JAWS	Joint Airport Weather Studies
NIMROD	Northern Illinois Meteorological Research on Downbursts
R	radius of downburst shaft (ft)
r	radial coordinate (distance from downburst ~~center~~ centre) (ft)

TASS	Terminal Area Simulation System
u	velocity in r-direction (or x-direction) (knots)
v	velocity in y-direction (knots)
w	velocity in z-direction (knots)
w_{max}	magnitude of maximum vertical velocity (knots)
u_{max}	magnitude of maximum horizontal velocity (knots)
x	horizontal (runway) distance, aeroplane to downburst ~~center~~ centre (ft)
y	horizontal (side) distance, aeroplane to downburst ~~center~~ centre (ft)
z	aeroplane altitude above ground level (ft)
z_h	depth of outflow (ft)
z_m	height of maximum U-velocity (ft)
z_{m2}	height of half-maximum U-velocity (ft)
z*	characteristic height, out of boundary layer (ft)
ϵ	characteristic height, in boundary layer (ft)
λ	scaling factor (s^{-1})

DEVELOPMENT OF VELOCITY EQUATIONS

Beginning with the full set of Euler and mass continuity equations, some simplifying assumptions about the ~~down burst~~downburst flow conditions were made. Effects of viscosity were parameterised explicitly, and the flow was assumed to be invariant with time. The downburst is axisymmetric in cylindrical coordinates, and characterised by a stagnation point at the ground along the axis of the downflow column. The flow is incompressible, with no external forces or moments acting on it.

The resulting mass conservation equation is

$$\nabla \cdot \mathrm{v} = 0. \quad (1)$$

Written out in full, equation 2 is

$$\frac{\partial u}{\partial r} + \frac{\partial w}{\partial z} + \frac{u}{r} = 0 \cdot \quad (2)$$

This equation is satisfied by solutions of the form

$$w = g(r^2)q(z)$$

(3a)

$$u = \frac{f(r^2)}{r}p(z)$$

(3b)

provided that

$$f'(r^2) = \frac{\lambda}{2}g(r^2) \quad (4a)$$

$$q'(z) = -\lambda p(z). \quad (4b)$$

Note that $f'(r^2) = \frac{\partial f(r^2)}{\partial r^2}$. To solve this system of equations, solutions were assumed for two of the functions and the other two were obtained from equations 4a and 4b.

It was desired that the velocity profiles of this analytic model exhibit the altitude and radial dependence shown in the large-scale numerical weather model TASS (Terminal Area Simulation System) model [ref. 3,46-9]. The TASS model is based on data from the Joint Airport Weather Studies (JAWS) [ref. 510], and provides a three-dimensional velocity field, frozen in time, for given locations of an aeroplane within the shear [ref. 611-12].

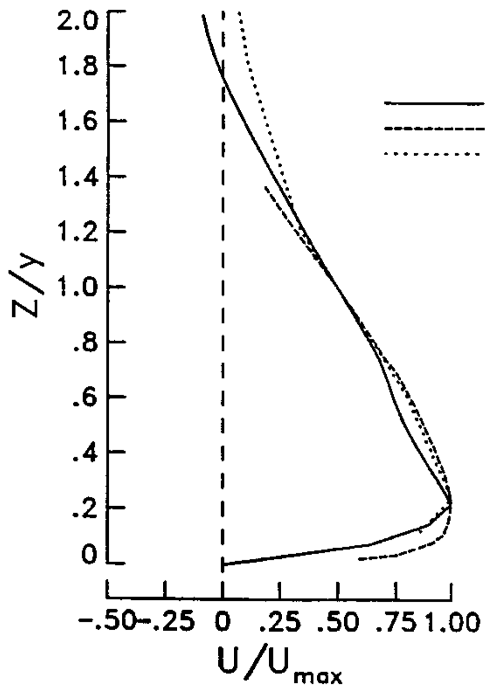

Figure 2 — Vertical Profile of Microburst Outflow (Non-dimensional)

Figure 2 shows dimensionless vertical profiles of horizontal velocity, u, for TASS data, laboratory data obtained by impingement of a jet on a flat plate, and data from NIMROD (Northern Illinois Meteorological Research on Downbursts) [ref. 713-21]. Specific points of interest are the maximum horizontal velocity (located 100-200 metersmetres above the ground), below which is a decay region due to boundary layer effects, zero velocity at the stagnation point on the ground, and an exponential decay with altitude above the maximum velocity altitude. Vertical velocity profiles from TASS data are shown in figure Figure 3, also exhibiting a decay to zero at the stagnation point.

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VERTICAL PROFILES OF VERTICAL VELOCITY FOR 30 JUN 82 CASE:
SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT

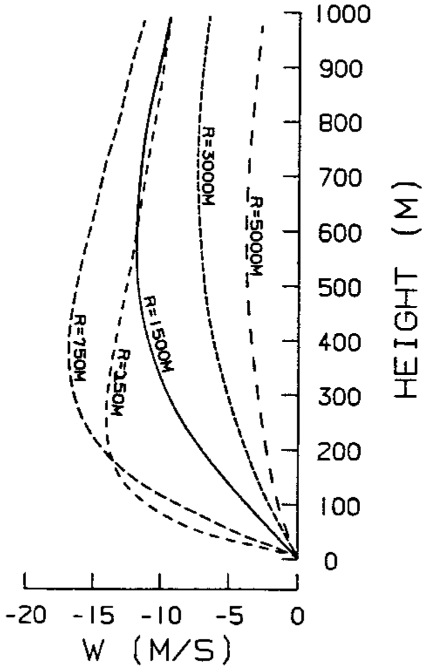

Figure 3 — Vertical Profile of Microburst Downflow

The radially varying characteristics desired for the horizontal wind were two peaks of equal magnitude and opposite direction located at a given radius, with a smooth, nearly linear transition between the two. Beyond the peaks, the velocity should show an exponential decay to zero. The vertical velocity was required to have a peak along the axis of symmetry (r = 0), and decay exponentially at increasing radius.

A pair of shaping functions that gave velocity profiles matching TASS data as required are given below.

$$g(r^2) = e^{-(r/R)^2}$$

$$p(z) = e^{-z/z*} - e^{-z/\varepsilon}$$

The remaining solutions were found by integrating equations 4a and 4b, yielding:

$$f(r^2) = \frac{\lambda R^2}{2}\left[1 - e^{-(r/R)^2}\right]$$

$$q(z) = -\lambda\left\{\varepsilon\left(e^{-z/\varepsilon} - 1\right) - z*\left(e^{-z/z*} - 1\right)\right\}.$$

Figures 4 and 5 show plots of these shaping functions.

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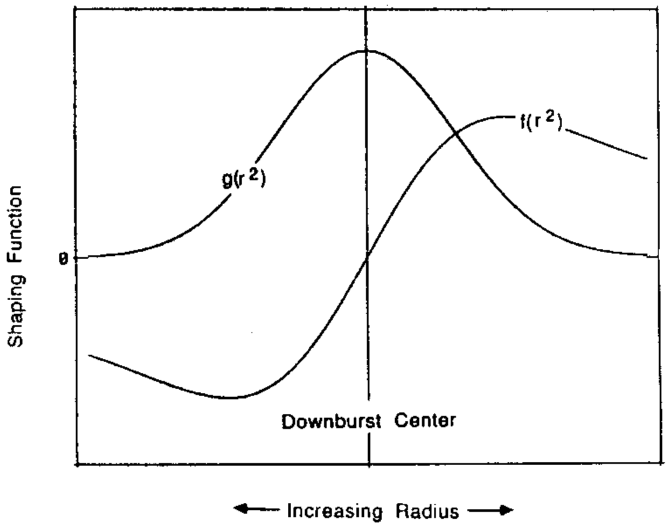

Figure 4 — Characteristic Variation of Horizontal Shaping Functions

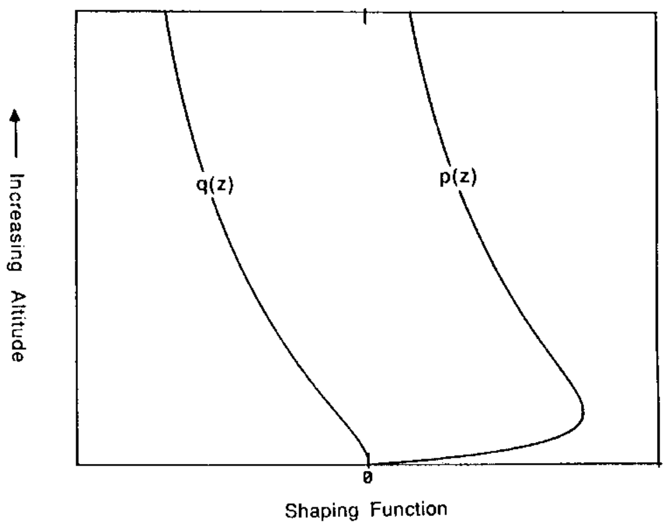

Figure 5 — Characteristic Variation of Vertical Shaping Functions

Combining the functions as in equation 3, the horizontal and vertical velocities are expressed as

$$u = \frac{\lambda R^2}{2r}\left[1 - e^{-(r/R)^2}\right]\left(e^{-z/z*} - e^{-z/\varepsilon}\right) \qquad (5)$$

$$w = -\lambda e^{-(r/R)^2}\left[\varepsilon\left(e^{-z/\varepsilon} - 1\right) - z*\left(e^{-z/z*} - 1\right)\right]. \qquad (6)$$

By taking derivatives of equations 5 and 6 with respect to r and z, respectively, and substituting in equation 2, it can be shown that the velocity distributions satisfy continuity.

The parameters z* and ε were defined as characteristic scale lengths associated with ‘out of boundary layer’ and ’in boundary layer’ behaviour, respectively. Analysis of TASS data indicated that $z^* = z_{m2}$, the altitude at which the magnitude of the horizontal velocity is half the maximum value.

It was also noted that the ratio

$$\frac{z_m}{z^*} = 0.22$$

To determine the location of the maximum horizontal velocity, the partial derivatives of u with respect to r and z where set equal to zero. The resulting equation for the ~~r –~~ r-derivative is

$$2\left(\frac{r}{R}\right)^2 = e^{-(r/R)^2} - 1.$$

The resulting equation for the z-derivative is

$$\frac{z_m}{z^*} = \frac{1}{(z^*/\varepsilon) - 1} \ln(z^*/\varepsilon).$$

Recalling that $z_m/z^* = 0.22$, the values 1.1212 and 12.5 were obtained from iteration for the ratios r/R and z*/ε, respectively.

Using these values, the maximum horizontal velocity can be expressed as $u_{max} = 0.2357\,\lambda\,R$. The maximum vertical wind is located at r = 0 and $z = z_h$, by definition, and is given by $w_{max} = \lambda z^*\left(e^{-(z_h/z^*)} - 0.92\right)$.

A ratio of maximum outflow and downflow velocities can be formed

$$\frac{u_m}{w_m} = \frac{0.2357R}{z^*\left(e^{-(z_h/z^*)} - 0.92\right).}$$

The Scaling factor, λ, was determined by using either of equations 5 or 6 for horizontal or vertical velocity, and setting it equal to the maximum velocity, u_{max} or w_{max}, respectively. Solving for λ resulting in:

$$\lambda = \frac{w_m}{z^*\left(e^{-(z_h/z^*)} - 0.92\right)} = \frac{u_m}{0.2357R.}$$

The velocity equations were easily converted to rectangular coordinates, as shown in Appendix 3. Partial derivatives with respect to x, y, and z were obtained by differentiating the velocity equations, and are also listed in the Appendix.

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DISCUSSION AND RESULTS

Vertical and horizontal velocity profiles for u and w are shown in ~~figures~~ Figures 6 and 7.

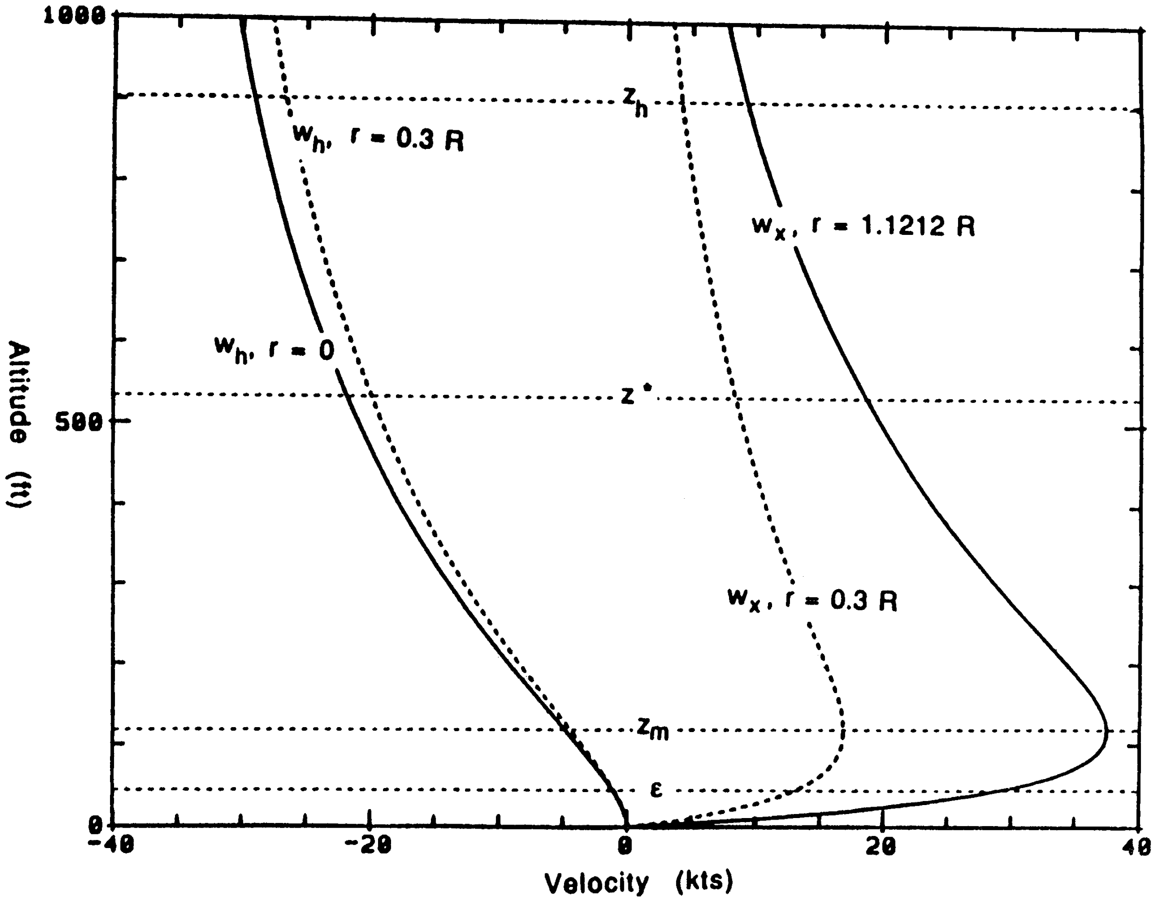

Figure 6 — Vertical Velocity Profiles for the Analytical Model

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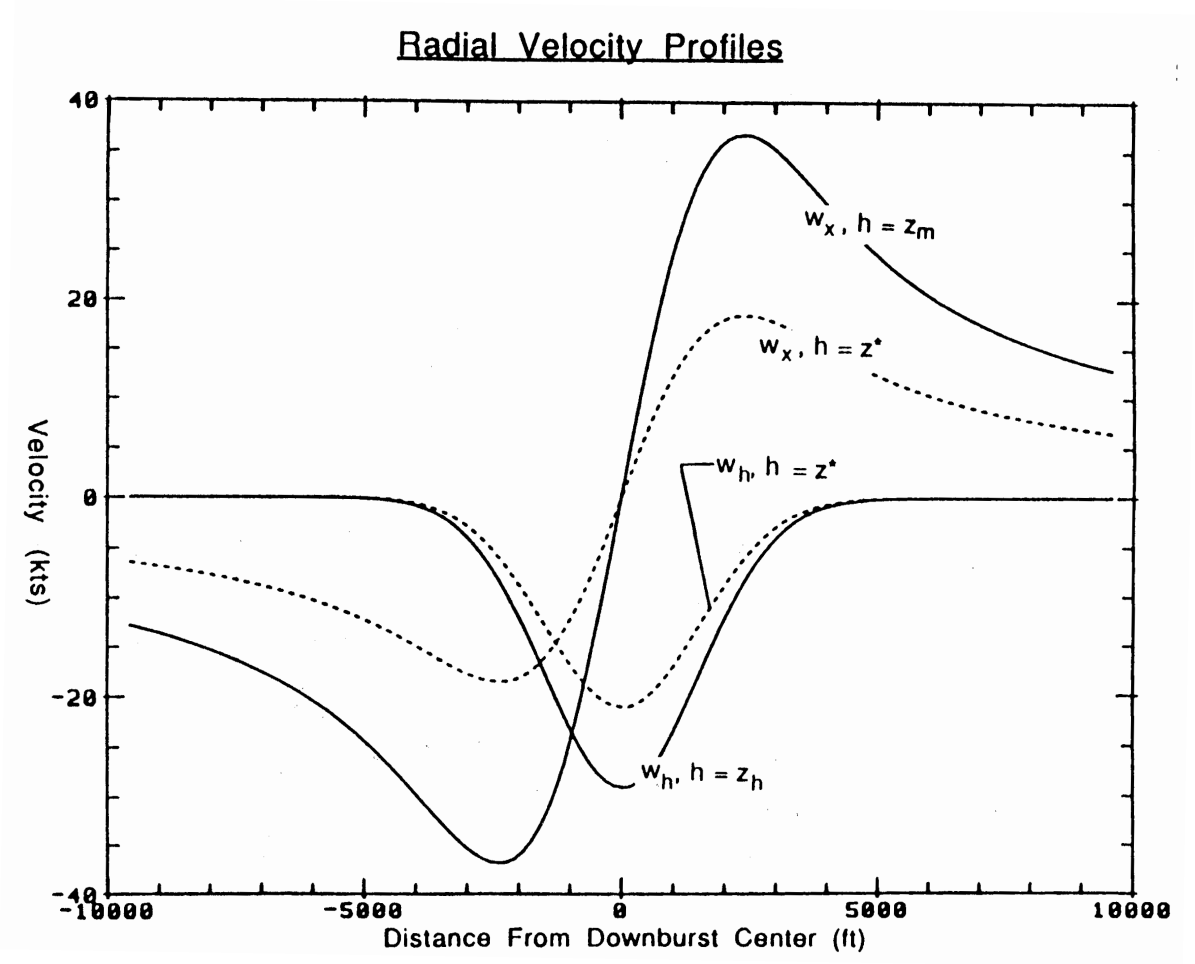

Figure 7 — Radial Velocity Profiles for the Analytical Model

Four profiles are shown for each component. The horizontal wind profiles in Figure 6 were taken at the radios of peak outflow (r = 1.1212 R) and at about one-fourth that radius (r = 0.3 R), where the maximum outflow is approximately half the value at the peak outflow radius. The vertical wind profiles were taken at the radius of peak downflow (r = 0) and at r = 0.3 R. Horizontal wind and vertical wind profiles in Figure 7 were taken at altitudes of h = z_m (maximum outflow), h = z* (half-maximum outflow), and h = z_h (depth of outflow).

This analytical model is compared with TASS, laboratory, and NIMROD data in Figure 8. The figure shows that, when non-dimensionalised by the altitude of half-maximum outflow (z*) and by the maximum outflow (u = u_{max}), the analytical model agrees closely with the other data.

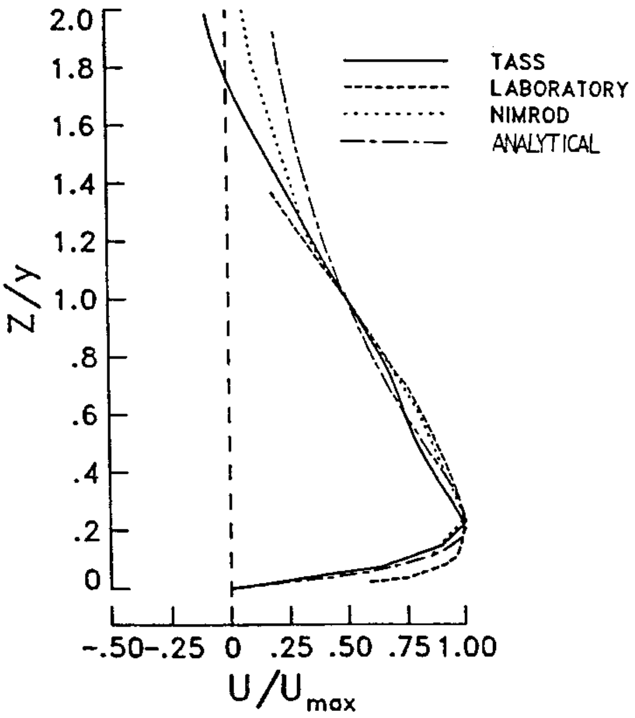

Figure 8 — Comparison of Wind Model Vertical Profiles

Different shears can be modelled by specifying four parameters, and the location of downburst centre relative to the aeroplane flying through it. The four parameters are: 1) a characteristic horizontal dimension; 2) maximum wind velocity; 3) altitude of maximum outflow; and 4) depth of outflow. The characteristic horizontal dimension specified is the radius of the downdraft column, noting that this is about 89~~per cent~~ of the radius of peak outflow. The maximum wind velocity can be either horizontal or vertical.

CONCLUDING REMARKS

The analytic ~~micorburst~~ microburst model developed for use in real-time and batch simulation studies was shown to agree well with real-world measurements for the cases studied. The functions chosen for the model showed boundary-layer effects near the ground, as well as the peak and decay of outflow at increasing altitudes, and increasing downflow with altitude. The exponential increase and decay of downflow and outflow (in the radial direction) are also characterised by the model. Equations for horizontal and vertical winds are simple and continuously differentiable, and partial derivatives in rectangular or cylindrical coordinates can be easily obtained by direct differentiation of the velocity equations. The governing equation for this system is the mass conservation law, and the analytic velocity functions developed here satisfied this condition. The model is sustained by a strong physical basis and yields high fidelity results, within the limitations of maintaining simplicity in the model, and variability of the microburst phenomenon. Parameterisation of some of the characteristic dimensions allows flexibility in selecting the size and intensity of the microburst.

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APPENDIX 3

This Appendix describes the conversion of the velocity equations in Appendix 2 to rectangular coordinates.

Define intermediate variables to simplify written equations:

$e_r = e^{-(r/R)^2}$ $\qquad$ $e_d = e_z - e_e$

$e_e = e^{-(h/\varepsilon)}$ $\qquad$ $e_c = z^*(1 - e_z) - \varepsilon(1 - e_e)$

$e_z = e^{-(h/z^*)}$

Horizontal and Vertical Velocities

$$W_X = \frac{\lambda R^2}{2r^2}(1 - e_r)e_d x_{ad}$$

$$W_y = \frac{\lambda R^2}{2r^2}(1 - e_r)e_d y_{ad}$$

$$W_h = -\lambda e_r e_c$$

Partial Derivatives

$$\frac{\partial w_x}{\partial x} = \frac{\lambda R^2 e_d}{2r^2}\left[e_r\left(\frac{2x_{ad}{}^2}{R^2} + \frac{2x_{ad}{}^2}{r^2} - 1\right) - \frac{2x_{ad}{}^2}{r^2} + 1\right]$$

$$\frac{\partial w_x}{\partial y} = \frac{\lambda R^2 x_{ad} y_{ad} e_d}{r^2}\left[e_r\left(\frac{1}{R^2} + \frac{1}{r^2}\right) - \frac{1}{r^2}\right]$$

$$\frac{\partial w_x}{\partial h} = \frac{\lambda R^2 x_{ad}}{2r^2}(1 - e_r)\left[\frac{e_e}{\varepsilon} - \frac{e_z}{z^*}\right]$$

$$\frac{\partial w_y}{\partial x} = \frac{\lambda R^2 x_{ad} y_{ad} e_d}{r^2}\left[e_r\left(\frac{1}{R^2} + \frac{1}{r^2}\right) - \frac{1}{r^2}\right]$$

$$\frac{\partial w_y}{\partial y} = \frac{\lambda R^2 e_d}{2r^2}\left[e_r\left(\frac{2y_{ad}{}^2}{R^2} + \frac{2y_{ad}{}^2}{r^2} - 1\right) - \frac{2y_{ad}{}^2}{r^2} + 1\right]$$

$$\frac{\partial w_y}{\partial h} = \frac{\lambda R^2 y_{ad}}{2r^2}(1 - e_r)\left[\frac{e_e}{\varepsilon} - \frac{e_z}{z^*}\right]$$

$$\frac{\partial w_h}{\partial x} = \frac{2\lambda x_{ad} e_r e_c}{R^2}$$

$$\frac{\partial w_h}{\partial y} = \frac{2\lambda y_{ad} e_r e_c}{R^2}$$

$$\frac{\partial w_h}{\partial h} = -\lambda e_r e_d$$

Other Relationships

From TASS $\frac{z_m}{z*} = 0.22$ $\frac{z*}{\varepsilon} = 12.5$

Maximums $w_{x\,max} = 0.2357\lambda R$

$w_{y\,max} = w_{x\,max}$

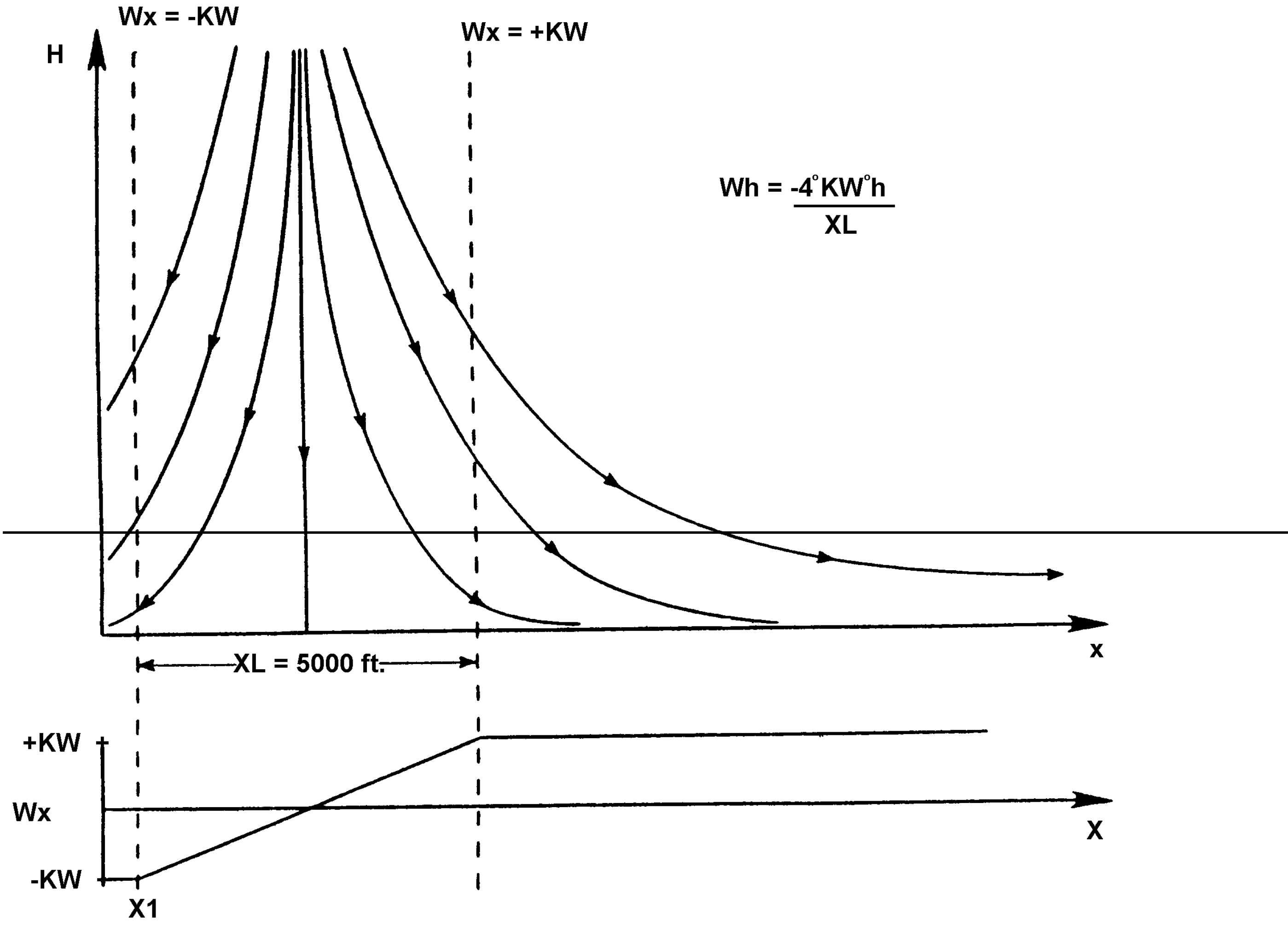
$w_{h\,max} = \lambda z^*(e^{-(z_h/z^*)} - 0.92)$.

(λ is determined from the above relationships)

$$\frac{w_{x_{max}}}{w_{h_{max}}} = \frac{0.2357R}{z*\left(e^{-z_h/z*} - 0.92\right)}$$

Variable List

z^* = altitude where w_x is half the value of $w_{x\,max}$ (ft)
ε = characteristic height of boundary layer effects (ft)
z_h = depth of outflow (ft)
z_m = altitude of maximum outflow (ft)
λ = scaling parameter (s^{-1})
r = radial distance from aeroplane to downburst (ft)
h = altitude of aeroplane (ft)
R = radius of downdraft (ft)
x_{ad}, y_{ad} = x, y coordinates, aeroplane to microburst (ft)
$w_{x\,max}$, $w_{y\,max}$, $w_{h\,max}$ maximum winds, x, y, and h directions



~~Figure 1 Wind Model Used In Guidance Studies~~

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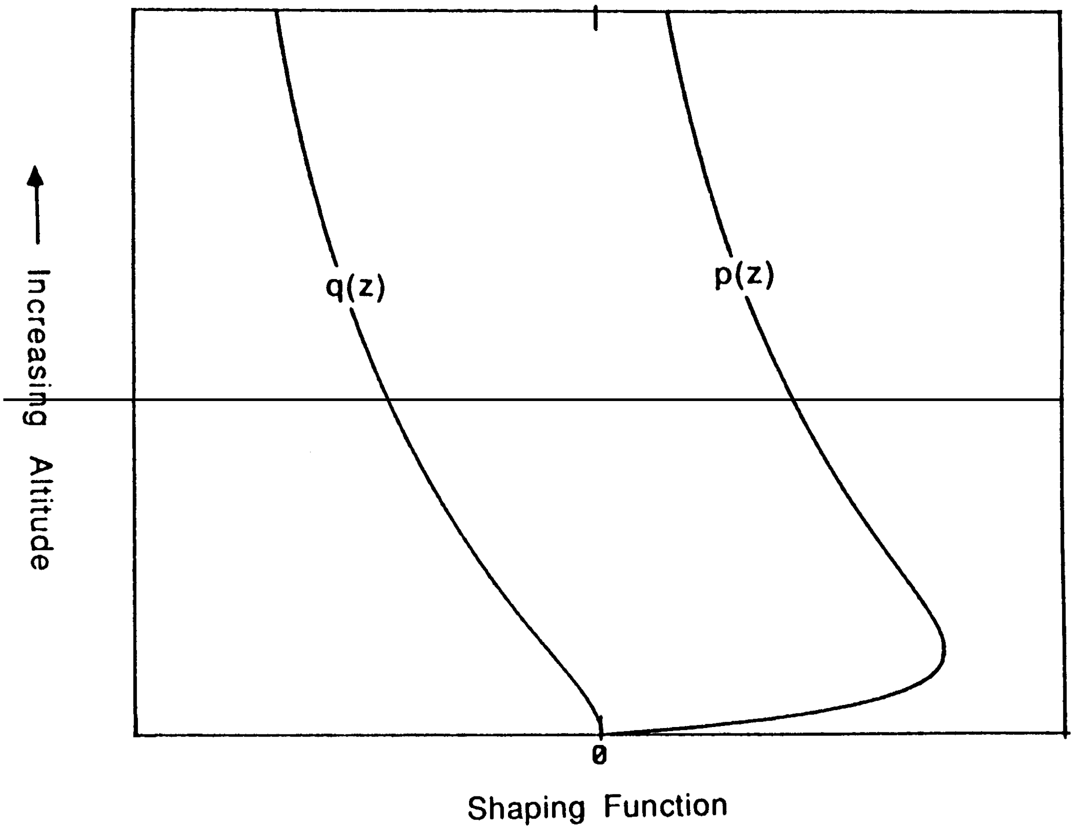

Figure 5 Characteristic Variation of Vertical Shaping Functions

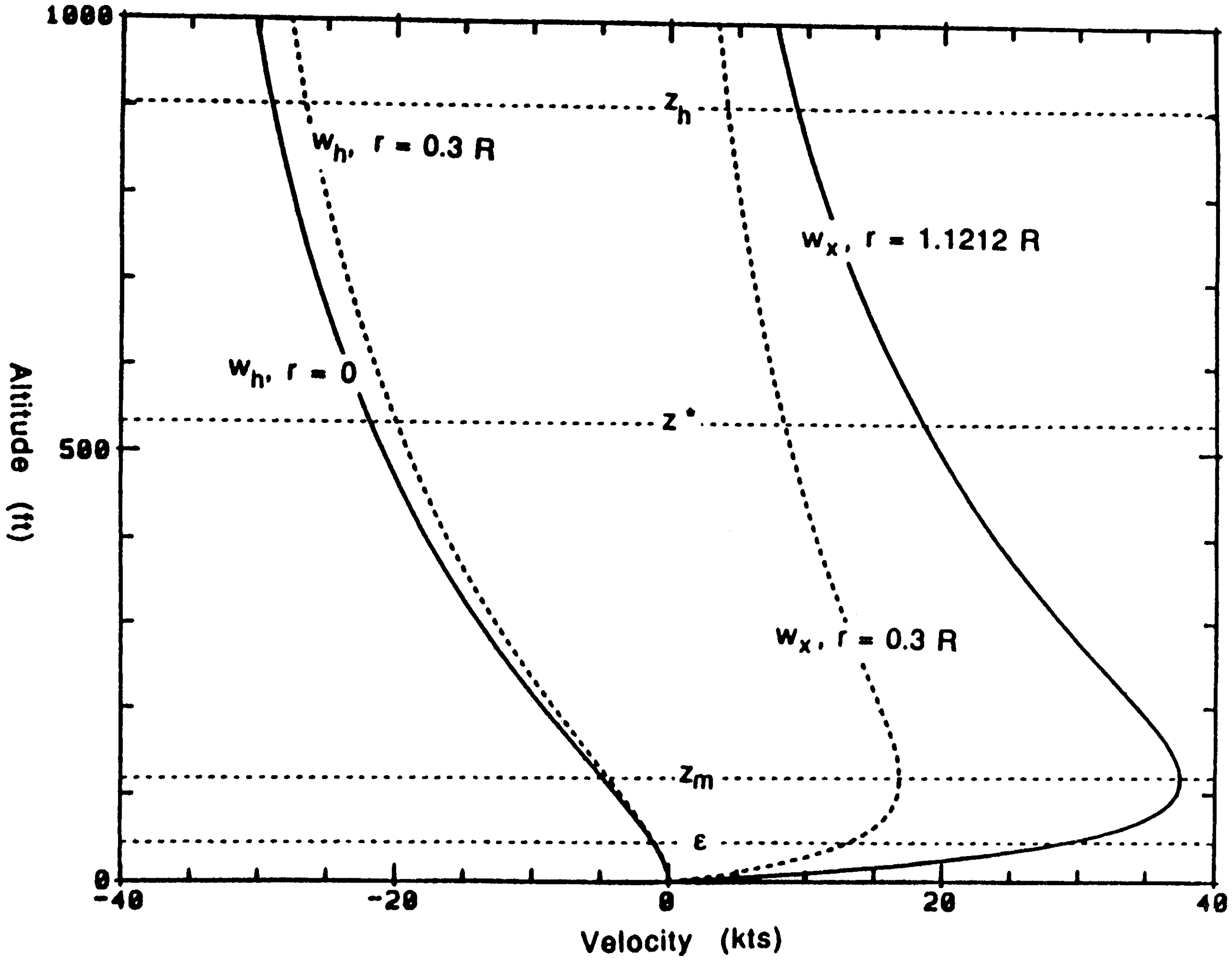

Figure 6 — Vertical Velocity Profiles For Analytical Model

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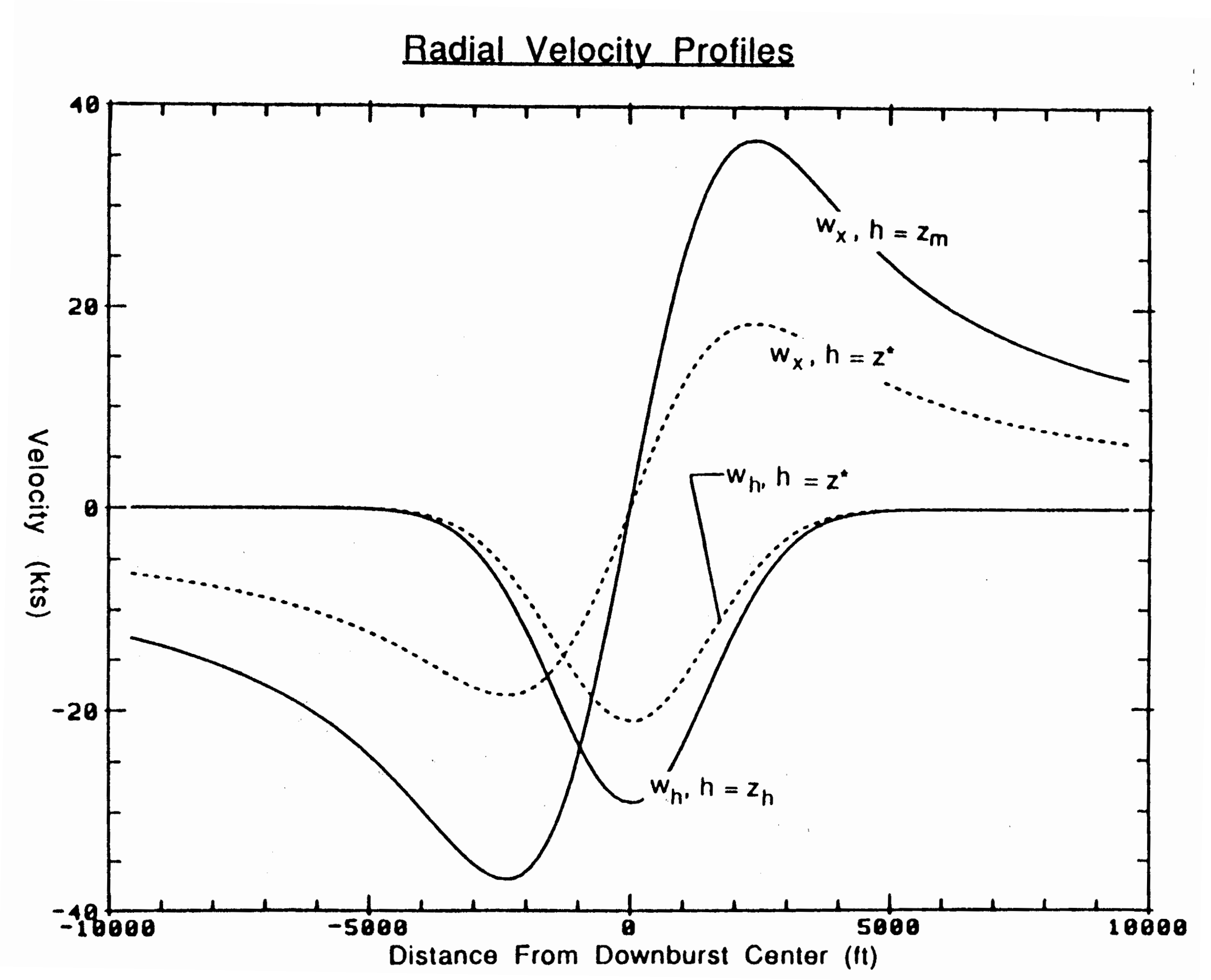

~~Figure 7 Radial Velocity Profiles For Analytical Model~~

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APPENDIX 4

This ~~appendix~~ Appendix contains data that defines the Dryden turbulence model and discrete gust model to be used in ~~conduction~~ conducting the tests specified in paragraphs (e)(7)(ii), (e)(7)(iii), (e)(8)(ii), and (e)(8)(iii) of this ETSO.

Dryden Turbulence Model

Fu(S) = SIGMAu * SQRT (TAUu/PI) * 1/(1 + TAUu*S)

~~Fu(S) = SIGMAu * SQRT (TAUu/PI) * 1/(1+TAUu*S)~~

$$Fv(S) = SIGMAv * SQRT\left(\frac{TAUv}{PI2}\right) * \frac{(1 + SQRT3*TAUv*S)}{(1 + TAUv*S)*(1 + TAUv*S)}$$

$$Fw(S) = SIGMAw * SQRT\left(\frac{TAUw}{PI2}\right)\frac{(1 + SQRT3*TAUw*S)}{(1 + TAUw*S)*(1 + TAUw*S)}$$

~~Fv(S) = SIGMAv * SQRT (TAUv/PI2) * (1 + SQRT3*TAUv*S)~~
~~(1 + TAUv*S)*(1 + TAUv*S)~~

~~Fw(S) = SIGMAw * SQRT (TAUw/PI2) * (1 + SQRT3*TAUw*S)~~
~~(1 + TAUw*S)*(1 + TAUw*S)~~

where:

SIGMAu, SIGMAv, SIGMAw are the RMS intensities;
TAUu = Lu/VA;
TAUv = Lv/VA;
TAUw = Lw/VA;
Lu, Lv, Lw are the turbulence scale lengths;
VA is the aircraft's true airspeed (ft/se~~c~~);
PI = 3.1415926535;
PI2 = 6.2831853070 (2 times PI);
SQRT3 = 1.732050808 (square root of 3); and
S is the Laplace transform variable.

The following table lists SIGMAu, SIGMAv, SIGMAw, Lu, Lv, and Lw versus altitude. Extrapolation will not be used, and simulator altitudes outside the bounds of the turbulence list will use the data at the boundary.

Altitude	RMS Intensities (ft/se~~c~~)			Scale Lengths (fe~~e~~t)		
(fe~~e~~t)	Long	Lat	Vert	Long	Lat	Vert
100	5.6	5.6	3.5	260	260	100
300	5.15	5.15	3.85	540	540	300
700	5.0	5.0	4.3	950	950	700
900	5.0	5.0	4.45	1 123	1 123	900
1 500	4.85	4.85	4.7	1 579	1 579	1 500

The applicant shall demonstrate that the variance of their turbulence implementation is adequate.

Discrete Gust Rejection

Discrete gusts (in the horizontal axis) with ranges of amplitude and frequency (A and OMEGA) of the form
$[A(1 - \cos(OMEGAt))]$ shall be used. The following table lists the values of A and OMEGA to be used (this simulates an approximate 15-knot gust condition):

A	OMEGA (rad/s~~ec~~)	Approx. Gust Duration (s~~ec~~)
7.5	2.10	3
7.5	1.26	5
7.5	0.78	8
7.5	0.63	10
7.5	0.52	12
7.5	0.42	15
7.5	0.31	20

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APPENDIX ~~3~~5

SHEAR INTENSITY

$$f(t) = \frac{\dot{w}_x}{g} - \frac{w_h}{V}$$

where

$\dot{w}_x$ = Horizontal component of the wind rate of change expressed in g units (1.91 kt~~s~~/s~~ec~~ = 0.1 g) (positive for increasing headwind).

W_h = Vertical component of the wind vector w (ft/sec) (positive for downdraft).

V = True airspeed (ft/s~~ec~~).

g = Gravitational acceleration (ft/s~~ec~~^{2}).

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APPENDIX 46

The following computer listing (written in QuickBasic) provides a simplified aircraft simulation model for evaluating the effectiveness of various guidance schemes. This simulation runs on a personal computer, and the results obtained using it have been found to be comparable to those obtained on a full six-degrees-of-freedom simulator. This model was developed by J. Rene Barrios of the Honeywell Company.

The Wind Shear Simulation Model (WSSM) is a point mass three-degrees-of-freedom mathematical model which simulates the motion of an aircraft in a vertical plane. The equations of motion, which are described in the wind axes, include the wind components of velocity and acceleration so that the aircraft dynamics during a wind shear encounter are accurately modelled. This model has been used by several investigators to study the behaviour of an aircraft during wind shear encounters.

Note: The Wind Shear Simulation Model provided at the end of this Appendix is an example written in Microsoft QuickBasic. Other programming languages such as Microsoft FORTRAN, C, of assembly language are also acceptable.

The Equations of Motion

The motion of a constant mass point in the vertical plane may be described by four equations of state and a control variable. For an aircraft, it is convenient to use an orthogonal reference frame which is attached to the frame of the aircraft, and its x-direction points in the direction of motion. Such a reference frame is the relative wind reference frame.

The following equations model the states of the aircraft in the wind axes: ~~(Copies of that listing may be may be purchased from the Superintendent of Documents, Government Printing Office, Washington, DC 20402-9325, USA.)~~

Vdt = g[(T.csalf) − D)/W − sngam] − Wxdt.csgam − Wzdt.sngam (1)

Gdt = {g[(T.snalf + L)/W − csgam] + Wxdt.sngam − Wzdt.csgam}/V (2)

Hdt = V.sngam + Wz (3)

Xdt = V.csgam + Wx (4)

Where:

Vdt	Rate of change of true airspeed in knots/second
G	Gravitational constant in knots/second
T	Total engine thrust in lb
csalf	cos (alpha)
alpha	Angle of attack in radians
D	Total drag in lb.
W	Gross weight in lb
sngam	sin (gamma)
gamma	Flight path angle in radians
Wxdt	Inertial wind shear x-component in knots/second
Gdt	Rate of change of gamma in rad/second
snalf	sin (alpha)

L	Total lift in lb
V	True airspeed in knots
Hdt	Altitude rate in knots
Wz	Inertial wind z-component in knots
Xdt	Ground speed in knots

In the above equations, the positive directions are upwards and forwards. This implies that tailwinds and updrafts are positive, while headwinds and downdrafts are negative. All the states can be determined from a given alpha; therefore, alpha is the control variable.

Since the model is that of a point mass, it is necessary to introduce the concept of alpha command and actual alpha to account for the effect of the horizontal tail/elevator. This is done by introducing a lag between the alpha_command and the actual alpha. Therefore, any command that is given to the elevator or stabiliser can be interpreted as an alpha_command, which will cause a change in angle of attack.

From equations 1, 2, 3 and 4, it can be seen that any change in alpha will produce a change in the longitudinal and normal accelerations, which in turn will change the states of the aircraft.

The Path Control Function

The different segments of the trajectory flown by the WSSM are described by a series of alpha_commands, which are generated by the procedure explained below.

1. The aircraft is trimmed for the initial conditions specified by the user. The initial conditions are usually specified as the altitude, gross weight, flaps, speed, flight path angle, and wind characteristics. The trimming operation consists in finding the angle of attack that satisfies the equations of state and will result in an unaccelerated motion.
2. After the initial trim, alpha_command must be specified for each segment of the trajectory, which usually consists of a climb or descent segment at constant speed of constant path angle, and guidance through wind disturbances. The wind disturbance is provided by wind models that can be selected at initialisation time.
3. In order to specify an alpha command, the user must supply a subroutine where a quadratic function is defined in such a way that when minimised with respect to alpha, and constrained by the equations of state, the minimising alpha will produce the desired path in an optimal manner. For example, if we want to fly initially at a constant path angle, say 8 degrees, then the quadratic function may be defined by the expression:

   $$\mathrm{cst} = \left(\mathrm{gamma} + \mathrm{Gdt} * \mathrm{dt} - \frac{8}{57.3}\right)^2 \qquad (5)$$

   Where:

cst	Function to be minimised w/r/t alpha
dt	Time increment used in simulation in sec.
Gdt*dt	A predictive term which anticipates the change in gamma

   Other expressions follow:

   $$\mathrm{cst} = (\mathrm{V} + \mathrm{Vdt} * \mathrm{dt} - \mathrm{V\_cmd})^2 \qquad \text{Constant speed}$$
   $$\mathrm{cst} = (\mathrm{alpha} + \mathrm{gamma} + \mathrm{Gdt} * \mathrm{dt} - \mathrm{pitch\_cmd})^2 \qquad \text{Constant Pitch}$$

   The minimisation of the function cst is performed by a subroutine at each time frame and is totally transparent to the user, who has to supply only the objective function cst.

4. Each expression defining a different value of the objective function cst is called a 'LAW'. The user selects the guidance law to be used during the wind shear encounter at menu a time. This method allows the user to compare different guidance laws under the exact same conditions.

The Wind Models

The WSSM has two types of wind models: the Dallas-Ft Worth accident wind field, simulated by a quad_vortex model, and the constant shear model, which is user defined via the initial conditions menu.

Plotting Capabilities

The WSSM can plot up to 3 runs with 10 parameters per run. The length of each run should be kept under 60 seconds. This feature allows the user to compare different trajectories by overlaying the results.

The Program

The WSSM is written in Microsoft QuickBasic, which is a highly structured language with a very friendly full page editor. QuickBasic is very convenient for development, since it allows the user to stop execution, change the program and continue executing. It also interfaces with Microsoft FORTRAN, C, or assembly language.
The procedure suggested for this application is that the WSSM be compiled without subroutines DETECT and GUIDE. DETECT and GUIDE can be separately compiled and put in a library called WNDSHR.QLB. These external subroutines may be written in Microsoft FORTRAN, C, or assembly language.

Listing of Program

```
'************ AIRCRAFT FLIGHT PROFILE SIMULATION **********
'
'
DECLARE SUB PLOT ( )
DECLARE SUB TAKEOFF ( )
DECLARE SUB EULER ( )
DECLARE SUB MCRBRST ( )
DECLARE SUB WINDS ( )
DECLARE SUB OPT ( )
DECLARE SUB MIN (DM, M2, C1, C2, C3, M)
DECLARE SUB BEGIN ( )
DECLARE SUB VSHAKER ( )
DECLARE SUB COST ( )
DECLARE SUB LIMIT ( )
DECLARE SUB RATES ( )
DECLARE SUB THRUST ( )
DECLARE SUB ATMOS ( )
DECLARE SUB PRINTS ( )
DECLARE SUB DRAGS ( )
COMMON SHARED FLPS%, GEAR%, GEAR$, CL, CD, LIFT, DRAG, ALPHA
COMMON SHARED SEC, ALT, DST, HDOT, ALF, GAM, GAMREF, GREF, G
COMMON SHARED WSALERT%, WXO, WL, WX, WXDT, WZ, WZDT, DFW
COMMON SHARED WV, LC%, GM, GREFF, NOSAVE, GMO
COMMON SHARED DELTA, ISA, T0, SPDSND, VT, VC, MACH, A0, TAT, TAMF
COMMON SHARED THRST, EPR, TFCT, APPFLG%
COMMON SHARED SNGM, CSGM, CSAL, SNAL, VDOT, WG, GDOT, XDOT
COMMON SHARED AWX, AWZ, AU, AZ, VG, GRND, KF1, GMIN, KF2
COMMON SHARED ACMD, OLDALF, DT, HP, LP, ALFLIM
COMMON SHARED LAW%, GMR, ASS, CST, VTO, GCMD
COMMON SHARED OUTFILE$, DM, ALT1, PL$, TTT, WXDTO, TDX, TSH, WZO, TDZ, TSV
COMMON SHARED GM1, VTP, THETA
COMMON SHARED ALFRTE, PLMFLG%
'********************************************
' MAIN PROGRAM *
'********************************************
START: '< ----------------<< RE-RUNS START HERE
CLOSE : CLEAR
COLOR 15, 1: CLS : VIEW PRINT
LOCATE 8, 23: PRINT "WINDSHEAR SIMULATION"
LOCATE 10, 23: PRINT "FOR "
LOCATE 12, 23: PRINT "BOEING 737/200 "
LOCATE 23, 23: PRINT "TYPE " + CHR$(&H22) + "I" + CHR$(&H22) + " FOR INFORMATION"
DO WHILE a$ = ""
a$ = INKEY$
LOOP
IF a$ = "I" OR a$ = "i" THEN
a$ = "": CLS
'---------------------- INFORMATION PAGE-----------------------------------------
```

```
LOCATE 2, 2: PRINT "BOEING 737/200 INFORMATON"
LOCATE 3, 2: PRINT "JT8D-17 ENGINES"
LOCATE 5, 2: PRINT "------------------------------------------------------------------------"
LOCATE 7, 2: PRINT "ALLOWABLE WEIGHT RANGES..................: 75,000 TO 120,000 POUNDS"
LOCATE 9, 2: PRINT "ALLOWABLE TAKEOFF FLAP SETTINGS.........: 1, 2, 5, 15, 20, 25 DEGREES"
LOCATE 11, 2: PRINT "ALLOWABLE LANDING FLAP SETTINGS.........: 30, 40 DEGREES"
LOCATE 13, 2: PRINT "TAKEOFF EPR AT SEA LEVEL, STD. DAY...: 2.1 "
LOCATE 15, 2: PRINT "REFERENCE WING AREA.......................: 980 SQUARE FEET"
LOCATE 17, 2: PRINT "REFERENCE TAKEOFF SPEED..................: V2 + 10"
LOCATE 19, 2: PRINT "REFERENCE LANDING SPEED..................: 1.3 Vs"
LOCATE 23, 2: PRINT "Press Any Key to Continue..."
DO: LOOP WHILE INKEY$ = ""
END IF
ANS$ = "2"
CLS
WHILE (ANS$ = "2")
LOCATE 10, 30: PRINT "Fly ..... 1"
LOCATE 12, 30: PRINT "Plot ..... 2"
LOCATE 14, 30: PRINT "Exit ..... 3"
LOCATE 18, 30: INPUT "Selection ....."; ANS$
IF ANS$ = "2" THEN
CALL PLOT
COLOR 15, 1
CLS
END IF
WEND
IF ANS$ = "3" THEN END
CALL BEGIN 'GET DATA/INITIALIZE VARIABLES
CALL THRUST 'INITALIZE THRUST
CALL TAKEOFF 'INITALIZE TAKEOFF
CALL COST 'SUBROUTINE COST
CALL PRINTS 'SUBROUTINE PRINT
FOR ICL% = 1 TO TTT ' TTT IS THE RUN TIME IN SECONDS
CALL THRUST ' SUBROUTINE EPR/THRUST
CALL WINDS ' SUBROUTINE WINDS
' CALL DETECT ' SUBROUTINE WINDSHEAR DETECTION
' SUPPLIED BY USER
' MUST RESIDE IN LIBRARY WNDSHR.QLB
CALL OPT ' SUBROUTINE OPTIMIZE
CALL LIMIT ' SUBROUTINE ALPHA RATE
CALL EULER ' SUBROUTINE INTEGRATE
CALL ATMOS ' SUBROUTINE ATMOSPHERE
CALL PRINTS ' SUBROUTINE PRINT
IF ALT < 0 THEN EXIT FOR
NEXT ICL%
PRINT "RUN IS COMPLETE"
PRINT "TYPE " + CHR$(&H22) + "D" + CHR$(&H22) + " FOR RUN DATA"
a$ = ""
DO WHILE a$ = "" ' Wait for key to be pressed
a$ = INKEY$
LOOP
VIEW PRINT: COLOR 15, 4: CLS
IF a$ = "D" OR a$ = "d" THEN
a$ = ""
LOCATE 2, 2: PRINT "DATA FROM CURRENT RUN"
LOCATE 4, 2: PRINT "-------------------------------------------------------------"
LOCATE 6, 2: PRINT "GROSS WEIGHT: "; WG; " POUNDS"
LOCATE 7, 2: PRINT "ISA DEVIATION: "; ISA; " DEG C"
LOCATE 8, 2: PRINT "FLAP POSITION: "; FLPS%; " DEGREES"
LOCATE 9, 2: PRINT "GEAR POSITION: "; GEAR$
LOCATE 11, 2: PRINT "CONTROL LAW: "; LAW%
LOCATE 12, 2: PRINT "GAMMA REFERENCE: "; GAMREF
LOCATE 13, 2: PRINT "PITCH LIMITING: "; PL$
IF PL$ = "YES" THEN
LOCATE 14, 2: PRINT "MAXIMUM PITCH: "; HP * 57.3; " DEGREES"
LOCATE 15, 2: PRINT "MINIMUM PITCH: "; LP * 57.3; " DEGREES"
END IF
LOCATE 16, 2: PRINT "TIME OF RUN: "; TTT * DT; " SECONDS"
IF DFW = 1 THEN
LOCATE 17, 2: PRINT "DALLAS/FW Wind Model"
ELSE
LOCATE 17, 2: PRINT "HORIZ. WIND MAGNITUDE "; WXO; " KNOTS"
LOCATE 18, 2: PRINT "HORIZ. SHEAR MAGNITUDE: "; WXDTO; " KNOTS/SECOND"
LOCATE 19, 2: PRINT "HORIZ. SHEAR DURATION: "; TDX; " SECONDS"
```

```
LOCATE 20, 2: PRINT "VERT. WIND MAGNITUDE: "; WZO * 1.689; " FT/SECOND"
LOCATE 21, 2: PRINT "VERT. WIND DURATION: "; TDZ; " SECONDS"
LOCATE 22, 2: PRINT "-----------------------------------------------------------------"
END IF
IF LEN(OUTFILE$) = 0 THEN OUTFILE$ = "NONE"
LOCATE 23, 2: PRINT "OUTPUT FILE: "; OUTFILE$
LOCATE 24, 2: PRINT "Press Any Key to Continue...."
DO: LOOP WHILE INKEY$ = "" 'Wait for key to be pressed
END IF
GOTO START
END
SUB ATMOS STATIC
'*******************************************************
' SUBROUTINE ATMOSPHERE *
'*******************************************************
STATIC THETA
L% = ALT > 36089!
FISA = 1.8 * ISA
IF ALT > 36089 THEN
TMP = .7519 * T0
DELTA = .2234 * EXP((36089! - ALT) / 20806)
ELSE
TMP = T0 - .0035662 * ALT
DELTA = (TMP / T0) ^ 5.256
END IF
TAMB = TMP + FISA 'TAMBient in deg. R
TAMF = TAMB - 459.7 ' " " F
THETA = TAMB / T0
SQRTH = SQR(THETA)
SPDSND = A0 * SQRTH
IF VT > 0 THEN MACH = VT / SPDSND
VC = A0 * SQR(5 * (((1 + MACH * MACH / 5) ^ 3.5 - 1) * DELTA + 1) ^ .28571 - 5)
TAX = (TMP + FISA) * (1 + .2 * MACH * MACH) 'Deg. R
TAT = 5 * (TAX - 459.7 - 32) / 9 'Deg. C
IF INKEY$ < > "" THEN PRINT : INPUT "Press ENTER to continue...."; XXX
END SUB
SUB BEGIN STATIC
CLS : VIEW PRINT
'<---------------------------------- DATA_INPUT ------------------------------>
PRINT
INPUT "OUTPUT FILE (DEFAULT IS NO FILE) "; OUTFILE$
IF OUTFILE$ = " " THEN
NOSAVE = 1
ELSE
NOSAVE = 0
END IF
' CONSTANTS USED IN CALCULATIONS:
A0 = 661.478599# 'Speed of sound at sea level in knots
G = 19.07583 'Gravitational constant in knots/sec
T0 = 518.67 'Standard temperature at SL in deg Rankine
DT = .25 'Simulation time step in seconds
' ---------------------------------- INITIALIZATION OF VARIABLES--------------------------
GMIN = 0
VDOT = 0
ALT1 = 0
INPUT "TAKEOFF OR APPROACH (T/A) (Default is T)....."; ANS$
IF ANS$ = "a" OR ANS$ = "A" THEN
INPUT "ENTER ALTITUDE IN FEET (Default is 1000' . "; ALT1
IF ALT1 = 0 THEN ALT1 = 1000
APPFLG% = 1
TFCT = 1
END IF
ALT = ALT1
' ----------------------- CONFIGURTATION CONSTANTS-----------------------------------------
ASS = 16.5 'Stick Shaker alpha in degrees
ASS = ASS / 57.3 ' " " " "radians
' ------------------------------------------ GROSS WEIGHT ENTRY------------------------------------------
PRINT : INPUT "ENTER GROSS WEIGHT IN POUNDS (Default is 110000) "; WG
IF WG = 0 THEN WG = 110000! ' DEFAULT SETTING
FL% = 0
WHILE (NOT FL%)
INPUT "ENTER FLAPS SETTING (Default is 0)............"; FLPS%
SELECT CASE FLPS%
CASE 0, 1, 2, 5, 15, 20, 25, 30, 40
```

```
FL% = -1
CASE ELSE
FL% = 0
PRINT "Invalid flaps setting"
PRINT "Only 0, 1, 2, 5, 15, 20, 25, 30, & 40 are supported"
PRINT
END SELECT
WEND
IF FLPS% < 15 THEN GEAR% = 1
IF FLPS% = 15 THEN INPUT "GEAR UP OR DOWN (1/0) (Default is Down)....."; GEAR%
IF GEAR% = 1 THEN
GEAR$ = " UP"
ELSE
GEAR$ = " DOWN"
END IF
INPUT "ENTER ISA DEV. IN DEGREES C (Default is 0)......"; ISA
PRINT
CALL VSHAKER ' COMPUTE V2+10 FOR FLAPS<33 OR 1.3Vs FOR FLAPS>32
PRINT " CONTROL LAW SELECTION:"
PRINT
PRINT " Speed = 1.1* V_stall = 1"
PRINT " Alpha = Stick Shaker Alpha = 2"
PRINT " Horizontal Acceleration = 0 = 3"
PRINT " 15_Degree Pitch = 4"
PRINT " Theoretical HONEYWELL/SPERRY = 5"
PRINT " User Defined = 6"
PRINT
INPUT " SELECT CONTROL LAW ....................... "; LAW%
IF LAW% = 0 THEN LAW% = 5
PRINT : PRINT
' ------------------------------------ GAMMA REFERENCE INPUT----------------------------------
IF LAW% > 4 THEN
INPUT "ENTER GAMMA REFERENCE IN DEGREES (Default is 0)........."; GMR
PRINT
GAMREF = GMR
GMR = GMR / 57.3: GMIN = GMR
END IF
' ---------------------------------------- PITCH LIMITING SELECTION---------------------------------------------
INPUT "PITCH LIMITING DESIRED (y/n) (Default is NO)..............."; PL$
IF PL$ = "Y" OR PL$ = "y" THEN
PL$ = "YES"
INPUT " MAXIMUM PITCH ALLOWED IN DEGREES "; HP
INPUT " MINIMUM PITCH ALLOWED IN DEGREES "; LP
HP = HP / 57.3: LP = LP / 57.3: PL% = 1
ELSE
HP = 100
LP = -100
PL% = 0
PL$ = "NO"
END IF
CLS
' ------------------------------------------------ TIME FOR RUN-----------------------------------------------------------------
PRINT
INPUT "ENTER TIME OF RUN IN SECONDS (Default is 45).............."; TTT
TTT = TTT / DT
IF TTT = 0 THEN TTT = 45 / DT ' DEFAULT SETTING
' -------------------------------------- WINDSHEAR SET UP-----------------------------------------------------
INPUT "DALLAS/FW Wind Model (y/n)...(Default is constant Shear)....."; ANS$
IF ANS$ = "Y" OR ANS$ = "y" THEN
DFW = 1
ELSE
DFW = 0
PRINT
INPUT "MAGNITUED OF HORZ. WIND IN KNOTS......(Head wind < 0)......"; WXO
INPUT "MAGNITUED OF HORZ. SHEAR IN KT/SEC. (Dec. Perf. > 0)......"; WXDTO
INPUT "DURATION OF HORZ. SHEAR IN SEC.............(Default is 0)......"; TDX
INPUT "TIME FOR SHEAR TO START IN SEC.............(Default is 0)......"; TSH
PRINT
INPUT "MAGNITUED OF VERT. WIND IN FT/SEC. (Down Draft < 0)......"; WZO
WZO = WZO / 1.689 'Convert to knots
INPUT "DURATION OF VERT. WIND IN SEC...........(Default is 0)........"; TDZ
INPUT "TIME FOR SHEAR TO START IN SEC...........(Default is 0)......"; TSV
PRINT
END IF
```

```
' -------------------- OTHER SET UPS----------------------------------------------------
VT = VTO
WX = WXO
CALL ATMOS ' SUBROUTINE ATMOSPHERE
' ---------------------------------- HEADERS FOR SCREEN DISPLAY----------------------------------------------------
CLS : PRINT
PRINT "TIME ALT HDOT VT ALPHA GAMMA PITCH GREF WXDT WZ VDOT ALRT"
PRINT "(SEC) (FT) (FPM) (KTS) (DEG) (DEG) (DEG) (DEG) (KT/S) (FPS) (KT/S)"
PRINT STRING$(75, "-"): VIEW PRINT 5 TO 25
'**************************************
' SUBROUTINE INIT_OUTPUT FILE *
'**************************************
IF NOSAVE THEN ' CREATE OUTPUT FILE
ELSE
OPEN "O", 2, OUTFILE$
FMT$ = " ###.## ##### ##### #### #### ## ###.## ###.## ###.##"
FMT$ = FMT$ + " ###.## ###.# ###.# ##.## "
END IF
END SUB
SUB COST STATIC
'***************************************************************
' SUBROUTINE COST *
'***************************************************************
CALL DRAGS ' SUBROUTINE DRAG & LIFT
CALL RATES ' SUBROUTINE RATES
IF LC% = 0 THEN 'Constant gamma segment
FCT = (GM + GDOT * DT - GMO) ^ 2
GREFF = 57.3 * GMO
ELSE 'All guidance laws
SELECT CASE LAW%
CASE 1 ' ---------------------------- 1.1*Vstall-----------------------------------
CST = (VT + VDOT * DT - 1.1 * 135) ^ 2
CASE 2 ' ---------------------------- Alpha = Ass-----------------------------------
CST = (ALPHA - ASS) ^ 2
CASE 3 ' ---------------------------- Ax = 0-----------------------------------
CST = (VDOT - VT * GDOT * GM + WXDT) ^ 2
CASE 4 ' ---------------------------- 15 Degrees-----------------------------------
CST = (GM + 3 * GDOT * DT + ALPHA - 15 / 57.3) ^ 2
CASE 5 ' ---------------------------- User Defined-----------------------------------
PRINT "Not defined"
STOP
CASE 6 ' ---------------------------- User Supplied-----------------------------------
'User must supply a subroutine called GUIDE
'which must reside in the WNDSHR.QLB Library
'GUIDE can have a list of arguments
'As an example
'ALF = 57.3*ALPHA
'PTH = 57.3 * (ALPHA + GM)
' units : ft fpm kt deg deg g's g's *
'CALL GUIDE(ALT, HDOT, VC, ALF, PTH, AU, AZ, CST)
END SELECT
END IF
' CST is the Cost Function to be minimized
END SUB
SUB DRAGS STATIC
'*****************************************************
' SUBROUTINE DRAG FOR B737/200 *
'*****************************************************
X = 57.3 * ALPHA + 1
CF5 = 0: CF4 = 0: CF3 = 0: CF2 = 0
SELECT CASE FLPS%
CASE 0
CF1 = .091
CF0 = .0156
CASE 1
CF3 = -1.164058E-04
CF2 = 2.48561E-03
CF1 = .0905781
CF0 = .062114
CASE 2
CF0 = .101198
CF1 = .110993
CF2 = -.0015162
CF3 = 1.8931E-04
```

```
CF4 = -7.1427E-06
CF5 = -4.2776E-09
CASE 5
CF0 = .192638
CF1 = .123509
CF2 = -.0051477
CF3 = 6.4968E-04
CF4 = -3.0891E-05
CF5 = 4.1291E-07
CASE 10
CF0 = .249855
CF1 = .114005
CF2 = 7.1207E-04
CF3 = -9.9541E-05
CF4 = 7.0431E-06
CF5 = -2.3773E-07
CASE 15
CF0 = .40149
CF1 = .118723
CF2 = -6.4877E-04
CF3 = 6.6281E-05
CF4 = -1.6113E-07
CF5 = -1.4278E-07
CASE 25
CF0 = .592655
CF1 = .122433
CF2 = -.0026365
CF3 = 3.5963E-04
CF4 = -1.5579E-05
CF5 = 1.0894E-07
CASE 30
IF X < 4 THEN
CF1 = .12
CF0 = .72
ELSE
CF3 = -1.651192E-04
CF2 = 4.16461E-03
CF1 = 8.337061E-02
CF0 = .8350316
END IF
CASE 40
IF X < 4 THEN
CF1 = .12
CF0 = 1.08
ELSE
CF3 = -1.689903E-04
CF2 = 3.733285E-03
CF1 = 8.483822E-02
CF0 = 1.201596
END IF
CASE ELSE
PRINT "Flaps "; FLPS%; " not available....."
END
END SELECT 'For CL computation
CL = ((((CF5 * X + CF4) * X + CF3) * X + CF2) * X + CF1) * X + CF0
SELECT CASE FLPS% 'Low Speed Drag Polars
CASE 0
D0 = .013285: D1 = .052868: D2 = -.07182: D3 = .071561
CASE 1
D0 = .026143: D1 = .022358: D2 = -.00083: D3 = .016338
CASE 2
D0 = .070346: D1 = -.0852: D2 =.097453: D3 = -.01207
CASE 5
D0 = .045214: D1 = -.0178: D2 =.04373: D3 = .002101
CASE 10
D0 = -.04266: D1 = .19643: D2 = -.1152: D3 = .03966
CASE 15
IF GEAR% = 0 THEN
D0 = .034954: D1 = .098892: D2 = -.04187: D3 = .020496
ELSE
D0 = -.02822: D1 = .174631: D2 = -.0874: D3 = .029566
END IF
CASE 25
D0 = -.10416: D1 = .327506: D2 = -.17059: D3 = .043313
```

```
CASE 30
D0 = .124697: D1 = -.03348: D2 =.055295: D3 = -.00311
CASE 40
D0 = .124925: D1 = .052537: D2 =.006912: D3 = .0058
CASE ELSE
PRINT "Flaps "; FLPS% " not available...."
END
END SELECT
CD = ((D3 * CL + D2) * CL + D1) * CL + D0
Q = 1451770 * MACH * MACH * DELTA 'B737/200
LIFT = Q * CL
DRAG = Q * CD
END SUB
SUB EULER STATIC
'*****************************************************************
' SUBROUTINE EULER'S PREDICTOR/CORRECTOR *
' (INTEGRATION SUBROUTINE) *
'*****************************************************************
DTH = DT / 3600: DTM = DT / 60: SEC = SEC + DT: VTP = VT
CALL RATES ' SUBROUTINE RATES <<PREDICTOR>>
ALT1 = ALT: HDOT1 = HDOT: ALT = ALT + HDOT * DTM
GM1 = GM: GDOT1 = GDOT: GM = GM + GDOT * DT
DST1 = DST: XDOT1 = XDOT: DST = DST + XDOT * DTH
VT1 = VT: VDOT1 = VDOT: VT = VT + VDOT * DT
CALL RATES ' SUBROUTINE RATES <<CORRECTOR>>
ALT = ALT1 + (HDOT1 + HDOT) * DTM / 2
GM = GM1 + (GDOT1 + GDOT) * DT / 2
DST = DST1 + (XDOT1 + XDOT) * DTH /2
VT = VT1 + (VDOT1 + VDOT) * DT / 2
END SUB
SUB LIMIT STATIC
'******************************************************************************
' SUBROUTINE ALPHA DOT AND PITCH LIMIT *
'******************************************************************************
ALPHA = OLDALF + .25 * (ACMD - OLDALF) 'Pitch dynamics
CALL DRAGS ' SUBROUTINE DRAG (REQ'D FOR RATE SUB CALL)
IF PLMFLG% = 0 THEN EXIT SUB
OLDGM = GM
PLIM% = 0
DO WHILE (PLIM% = 0)
CALL RATES ' SUBROUTINE RATES
X = ALPHA + OLGM + GDOT * DT
IF X > HP THEN ALPHA = .9 * ALPHA
IF X < LP THEN ALPHA = 1.1 * ALPHA
IF ALPHA > ALFLIM THEN
ALPHA = ALFLIM
PLIM% = 1
END IF
LOOP
END SUB
SUB MCRBRST STATIC
IF MU1 = 0 THEN
MU1 = -37141!
AV = 5500: H1 = 2500: G3 = 3: J1 = -700: J2 = 800: J3 = 6.5
MU2 = -20000
BV = 12000: H2 = 2000: N1 = 200: N2 = 2500: N3 = 4
WX = 5
IF ALT > 1000 THEN
PRINT
PRINT " DFW data not available above 1000'"
PRINT " Please start at or below 1000'"
END
END IF
END IF
X = 6078 * DST: Y = ALT: A1 = AV: A2 = BV
NX1 = Y - H1: DENX1 = (Y - H1) ^ 2 + (X - A1) ^ 2
NY1 = X + J2 - A1: DENY1 = (Y + J1 - H1) ^ 2 + (X + J2 - A1) ^ 2
NX2 = Y - H2: DENX2 = (Y - H2) ^ 2 + (X - A2) ^ 2
NY2 = X + N2 - A2: DENY2 = (Y + N1 - H2) ^ 2 + (X + N2 - A2) ^ 2
NX3 = Y + H1: DENX3 = (Y + H1) ^ 2 + (X - A1) ^ 2
NY3 = X + J2 - A1: DENY3 = (Y + J1 + H1) ^ 2 + (X + J2 - A1) ^ 2
NX4 = Y + H2: DENX4 = (Y + H2) ^ 2 + (X - A2) ^ 2
NY4 = X + N2 - A2: DENY4 = (Y + N1 + H2) ^ 2 + (X + N2 - A2) ^ 2
XX = MU1 * (-NX1 / DENX1 + NX3 / DENX3) + MU2 * (NX2 / DENX2 - NX4 / DENX4)
```

```
WX = WX + .65 * (XX – WX) + 2 * G3
IF DST = 0 THEN WXP = WX
ZZ = MU1 * (NY1 / DENY1 – NY3 / DENY3) * J3 + MU2 * (–NY2 / DENY2 + NY4 / DENY4) * N3
WZ = WZ + .65 * (ZZ – WZ)
IF DST = 0 THEN WZP = WZ
WX5 = WX4: WX4 = WX3: WX3 = WX2: WX2 = WX1: WX1 = WX
WZ5 = WZ4: WZ4 = WZ3: WZ3 = WZ2: WZ2 = WZ1: WZ1 = WZ
IF WCNT% < 4 THEN WXDT = (WX – WXP) / DT: WXP = WX
IF WCNT% < 4 THEN WZDT = (WZ – WZP) / DT: WZP = WZ
IF WCNT% > 3 THEN WXDT = (26 * WX5 – 27 * WX4 – 40 * WX3 – 13 * WX2 + 54 * WX1) / (70 * DT)
IF WCNT% > 3 THEN WZDT = (26 * WZ5 – 27 * WZ4 – 40 * WZ3 – 13 * WZ2 + 54 * WZ1) / (70 * DT)
IF ABS(WXDT) > 15 THEN WXDT = 15 * SGN(WXDT)
IF ABS(WZDT) > 15 THEN WZDT = 15 * SGN(WZDT)
WCNT% = WCNT% + 1
END SUB
SUB MIN (DM, M2, C1, C2, C3, M) STATIC
'*************************************************************
'SUBROUTINE MIN_CST BY LEAST SQUARES PARABOLA *
'*************************************************************
ALPHA = M2 + DM 'INCREMENT ALPHA
CALL COST 'SUBROUTINE COST
IF DM < 0 THEN
C4 = CST
ELSE
SWAP C1, C3
C5 = CST
END IF
ALPHA = M2 – DM 'DECREMENT ALPHA
CALL COST 'SUBROUTINE COST
IF DM < 0 THEN
C5 = CST
ELSE
C4 = CST
END IF
M = ABS(DM) * (14 * C1 + 7 * C4 – 7 * C5 – 14 * C3) / (20 * C1 – 10 * C4 – 20 * C2 – 10 * C5 + 20 * C3)
END SUB
SUB OPT STATIC
'****************************************************************************
'SUBROUTINE OPTALF – DETERMINES THE ALPHA REQD FOR CMD GAMMA *
'****************************************************************************
OLDALF = ALPHA: GM1 = GM
CALL ATMOS ' SUBROUTINE ATMOSPHERE
CALL RATES ' SUBROUTINE RATES
DM = 1 / 57.3 ' SET ALPHA INCREMENT TO 1 DEGREE
C1 = 1E+20
C2 = 1E+20
C3 = 1E+20
OPTFLG% = 0
WHILE (OPTFLG% = 0)
CALL COST ' SUBROUTINE COST
C3 = C2: C2 = C1: C1 = CST
M3 = M2: M2 = M1: M1 = ALPHA
LGC% = C1 > C2 AND C3 = 1E+20
IF LGC% THEN
DM = –DM ' Reverse search direction
C1 = C2: C2 = CST: M1 = M2: M2 = ALPHA
ALPHA =ALPHA + 2 * DM
ELSE
IF C1 < C2 THEN
L% = ABS(OLDALF – ALPHA) / DT > ALFRTE OR ALPHA > ALFLIM OR ALPHA < –.08
IF L% THEN OPTFLG% = 1
ALPHA = ALPHA + DM
ELSE
DM = DM / 2
CALL MIN(DM, M2, C1, C2, C3, M)'Fit parabola & find minimum
ALPHA = M2 + M 'This is the optimum alpha
OPTFLG% = 1 'Set flag to terminate
END IF
END IF
WEND
ALFLIM = ASS 'SET ALPHA LIMIT TO ALPHA STICK SHAKER
SELECT CASE LAW%
CASE 4
ALFLIM = ASS – .035 'LIMIT TO SS MINUS 2 DEG
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CASE 5, 6
ALFLIM = ASS - KF2
CASE ELSE
END SELECT
IF ALPHA < -.08 THEN ALPHA = -.08
IF ALPHA > ALFLIM THEN ALPHA = ALFLIM
ACMD = ALPHA 'SET ALPHA COMMAND TO COMPUTED ALPHA
END SUB
SUB PLOT
'*****************************************************************************************
'* PLOT ROUTINE *
'*****************************************************************************************
REM $DYNAMIC
' TWO DIMENSIONAL PLOTTER
DEFINT I-L, N
DIM F$(3) ' file name array
DIM DTA(3, 250, 15) ' data array
DIM TY$(14) ' title array (dependant variable)
TITLE$ = "HONEYWELL WINDSHEAR SIMULATION" ' main title
TX$ = "Time (s)" ' X title
TY$(1) = "Altitude ft "
TY$(2) = "Alt Rate fpm "
TY$(3) = "T A S kts "
TY$(4) = "Alpha deg "
TY$(5) = "Gamma deg "
TY$(6) = "Pitch deg "
TY$(7) = "G_ref deg "
TY$(8) = "Hz Shear kps "
TY$(9) = "Vt Wind fps "
TY$(10) = "Vt rate kps "
TY$(11) = "W/S Flag "
NV = 12
CLS
LOCATE 3, 15: PRINT "Enter the names of the data files you wish to plot."
FOR NC = 1 TO 3
LOCATE 6 + 2 * NC, 25 ' input
PRINT "FILENAME "; NC; " "; ' filenames
INPUT ; F$(NC) ' containing
IF F$(NC) = " " THEN EXIT FOR ' data
NEXT NC
NC = NC - 1 ' number of curves to plot
LOCATE 20, 15: PRINT "Reading from disk........."
FOR I = 1 TO NC
CLOSE
OPEN "I", #1, F$(I) ' open file for input
NP = 0
DO
NP = NP + 1 ' number of points
FOR J = 1 TO NV
INPUT #1, DTA(I, NP, J) ' read data
NEXT J
LOOP UNTIL EOF(1)
CLOSE
NEXT I
DO ' display all selected parameters
DO ' prompt user until a valid parameter is selected
100 CLS
LOCATE 3, 20: PRINT "Select the parameter you wish to plot."
FOR I = 1 TO NV - 1
LOCATE 4 + I, 30: PRINT TY$(I); " = "; I
NEXT I
LOCATE 21, 30: INPUT "parameter number (0 to exit)"; PARAM%
IF PARAM% = 0 THEN
CLS
EXIT SUB ' return to calling program
END IF
LOOP UNTIL 1 <= PARAM% AND PARAM% <= 14 'end of select loop
PARAM% = PARAM% + 1
DX = 5 ' x axis grid increment
GOSUB 400 ' find maximum x and y values
IF PLTFLG% = 1 THEN
PRINT "No information to plot...."
PRINT "Press any key to continue..."
DO: LOOP WHILE INKEY$ = ""
```

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Date: ~~24.10.03~~ XX.XX.20XX

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GOTO 100
END IF
GOSUB 600 ' grid and titles
FOR I = 1 TO NC
GOSUB 1110 ' plot graph
NEXT I
DO
LOOP WHILE INKEY$ = ""
CLS : SCREEN 0
LOOP
'**************************************************************************************
400 '* MAX SUBROUTINE *
'**************************************************************************************
'
MAXX = DTA(1, 1, 1)
MAXY = DTA(1, 1, PARAM%)
MINY = DTA(1, 1, PARAM%)
FOR I = 1 TO NC
FOR J = 1 TO NP
IF DTA(I, J, 1) > MAXX THEN MAXX = DTA(I, J, 1)
IF DTA(I, J, PARAM%) > MAXY THEN MAXY = DTA(I, J, PARAM%)
IF DTA(I, J, PARAM%) < MINY THEN MINY = DTA(I, J, PARAM%)
NEXT J
NEXT I
PLTFLG% = 0
DY = (MAXY - MINY) / 15
IF DY = 0 THEN
PLTFLG% = 1
DY = 5
END IF
MAG = 10 ^ (INT(LOG(DY) / LOG(10))): DY = DY / MAG
IF DY <= 5 THEN
DY = 5
ELSE
DY = 10
END IF
DY = DY * MAG
IF INT(MAXX / DX) < > MAXX / DX THEN MAXX = INT(MAXX / DX + 1) * DX
IF INT(MAXY / DY) < > MAXY / DY THEN MAXY = INT(MAXY / DY + 1) * DY
IF INT(MINY / DY) < > MINY / DY THEN MINY = INT(MINY / DY) * DY
NUMX = MAXX / DX
NUMY = (MAXY - MINY) / DY
RETURN
600
'**************************************************************************************
'* GRID AND TITLES *
'**************************************************************************************
'
CLS
SCREEN 2 ' 640*200 monochrome graphics
KEY OFF
'
FOR J = 0 TO NUMX
Z = J * 580 / NUMX + 59
LINE (Z, 10) - (Z, 170) ' vertical grid line
Z = J * 71 / NUMX + 7
a = DX * J
IF a < > 0 THEN ' adjustment for
D = INT(LOG(a) / LOG(10)) + 1 ' large numbers
IF D > 1 THEN Z = Z - D + 1
END IF
LOCATE 23, Z
PRINT a;
NEXT J
FOR J = 0 TO NUMY
Z = J * 160 / NUMY + 10
LINE (60, Z) - (640, Z) ' horizontal grid line
Z = 22 - J * 20 / NUMY
LOCATE Z, 2
Z = DY * J + MINY
AZ = ABS(Z)
IF INT(Z) = Z THEN
G$ = "######"
ELSEIF AZ < .1 THEN
```

```
G$ = "#.####"
ELSEIF AZ >= .1 AND AZ < 1 THEN
G$ = "##.###"
ELSEIF AZ >= 1 AND AZ < 10 THEN
G$ = "###.##"
ELSEIF AZ >= 10 AND AZ < 100 THEN
G$ = "####.#"
ELSE
G$ = "######"
END IF
PRINT USING G$; Z;
NEXT J
Z = (80 - LEN(TITLE$)) / 2 + 2
LOCATE 1, Z: PRINT TITLE$ ' print main title
LOCATE 24, 36: PRINT TX$; ' X axis title
LOCATE 8, 1 ' Y
FOR J = 1 TO LEN(TY$(PARAM% - 1)) ' axis
PRINT MID$(TY$(PARAM% - 1), J, 1) ' title
NEXT J
LOCATE 25, 10: PRINT "1"; ' curve
LINE (90, 195) - (130, 195)
LOCATE 25, 20: PRINT "2"; ' labels
FOR J = 0 TO 40 STEP 8
XX = 170 + J
PSET (XX, 195)
CIRCLE (XX + 80, 195) , 2
NEXT J
LOCATE 25, 30: PRINT "3";
RETURN
'****************************************************************************************
'* PLOTTING ROUTINE *
'****************************************************************************************
'
1110 FOR J = 1 TO NP
XX = 580 * DTA(I, J, 1) / MAXX + 60' calculate pixel X position
YY = 170 - 160 * (DTA(I, J, PARAM%) - MINY) / (MAXY - MINY)
IF J = 1 THEN GOTO 1170
IF I = 1 THEN LINE (XXOLD, YYOLD) - (XX, YY) ' line 1170
1170 XXOLD = XX: YYOLD = YY
IF I = 2 THEN PSET (XX, YY) ' point
IF I = 3 THEN CIRCLE (XX, YY), 2 ' circle
NEXT J
RETURN
END SUB
REM $STATIC
DEFSNG I-L, N
SUB PRINTS
'*****************************************************************
' SUBROUTINE PRINT TO SCREEN AND FILE *
'*****************************************************************
ACMDG = 57.3 * ACMD
ALF = 57.3 * ALPHA
GAM = 57.3 * GM
PITCH = ALF + GAM
WZX = 1.689 * WZ
IF NOSAVE = 0 THEN PRINT #2, SEC, ALT, HDOT, VT, ALF, GAM, PITCH, GREFF, WXDT, WZX, VDOT, WSALERT%
FMT1$ = "###.## #### ##### ### ###.# ###.# ###.# ##.# ###.# ###.# ###.# #"
PRINT USING FMT1$; SEC, ALT, HDOT, VT, ALF, GAM, PITCH, GREFF, WXDT, WZX, VDOT, WSALERT%
END SUB
SUB RATES STATIC
'*****************************************************************
' SUBROUTINE RATES *
'*****************************************************************
SNGM = SIN(GM): CSGM = COS(GM): SNAL = SIN(ALPHA): CSAL = COS(ALPHA)
VDOT = G * ((THRST * CSAL - DRAG) / WG - SNGM) - WXDT * CSGM - WZDT * SNGM
GDOT = G * ((LIFT + THRST * SNAL) / WG - CSGM) + WXDT * SNGM - WZDT * CSGM
GDOT = GDOT / VT
HDOT = 101.28 * (VT * SNGM + WZ)
XDOT = VT * CSGM + WX
AWX = VDOT + WXDT * CSGM + WZDT * SNGM 'Inertial Acc. along Wind_x axis
AWZ = VT * GDOT - WXDT * SNGM + WZDT * CSGN 'Inertial Acc. along Wind_z axis
AU = (AWX * CSAL + AWZ * SNAL) / G 'LONG. ACCEL. ->=?
AZ = (AWX * SNGM + AWZ * CSGM) / G 'VERT. ACCEL. UP=?
VG = XDOT
```

```
GRND = (VT * GM + WZ) / (VT + WX) 'Gamma w/r ground
KF1 = 1
GHAT = GMIN * (1 + WX / VT)
IF WZ > -30 AND WZ < -20 THEN KF1 = 1 + .025 * (WZ + 20)
IF WZ <= -30 THEN KF1 = .75
DGAM = 57.3 * (20 * GDOT - (GHAT - GRND + (1 - KF1) * WZ / 152 + 20 * GDOT))
IF DGAM < 0 THEN
KF2 = (2 + .4 * DGAM)
ELSE
KF2 = 2
END IF
IF KF2 < 0 THEN KF2 = 0
KF2 = KF2 / 57.3
END SUB
SUB TAKEOFF STATIC
'********************************************************************
' SUBROUTINE INTIALIZE TAKEOFF *
'********************************************************************
IF APPFLG% = 0 THEN
ALPHA = .12
WHILE (LIFT <= WG)
CALL DRAGS
ALPHA = ALPHA + .01
WEND
GM = (THRST - DRAG) / WG 'COMPUTE POTENTIAL GAMMA
ELSE
GM = -3 / 57.3
ALPHA = 2 / 57.3
CALL DRAGS
TFCT = 1
CALL THRUST
T = DRAG - .052 * WG
IF T < 0 THEN T = .2 * THRST
TFCT = T / THRST
THRST = T
END IF
GMO = GM
CALL RATES
END SUB
SUB THRUST STATIC
'********************************************************************
' SUBROUTINE EPR/THRUST *
'********************************************************************
' TAKE-OFF THRUST FOR JT8D-17 ENGINES
VE = 1.668 * VT
R00 = 14688.74: R01 = -.65187546#: R02 = 6.7371E-05
R10 = -13.9295: R11 = .000751143#: R12 = -1.5405E-07
R20 = .014643: R21 = 5.3444E-07: R22 = -4.8907E-10
AA0 = (R02 * ALT + R01) * ALT + R00
AA1 = (R12 * ALT + R11) * ALT + R10
AA2 = (R22 * ALT + R21) * ALT + R20
THRST = 2 * ((AA2 * VT + AA1) * VT + AA0) 'Temp. = 100 F
IF APPFLG% = 1 THEN
IF LC% = 1 AND TFCT < 1 THEN
GMO = .136
TSPL = 5.5
'Engine Spool Up Time
TFCT = TFCT + DT / TSPL
END IF
IF TFCT > 1 THEN TFCT = 1
ELSE
TFCT = 1
END IF
THRST = TFCT * THRST
'' THRST = 2 * (((2.64159E-05 * VT + 5.110896E-03) * VT - 12.56476) * VT + 15550)
END SUB
SUB VSHAKER STATIC
'----------------------------------- COMPUTATION OF Vss AND V2------------------------
V2 = 145
VTO = V2 + 10' SETS INITAL SPEED EQUAL TO V2 + 10
SELECT CASE FLPS%
CASE 10
IF VTO < 150 THEN VTO = 150 ' TAKEOFF
CASE 18
```

```
IF VTO < 148 THEN VTO = 148 ' FLAP
CASE 22
IF VTO < 147 THEN VTO = 147 ' SETTINGS
CASE 33
VTO = 63.11225 + .222468 * WG / 1000 ' APPROACH
CASE 42 ' FLAP
VTO = 62.67386 + .21744 * WG / 1000 ' SETTINGS
CASE ELSE
END SELECT
END SUB
SUB WINDS STATIC
'*******************************************************************
' SUBROUTINE WINDS *
'*******************************************************************
'
IF TDX > 0 THEN
T1 = 4
T2 = TSH
T3 = T1 + T2
T4 = -4
T5 = T3 + TDX
T6 = T5 - T4
B1 = 3 * WXDTO / T1 ^ 2
A1 = -2 * B1 / (3 * T1)
B2 = 3 * WXDTO / T4 ^ 2
A2 = -2 * B2 / (3 * T4)
IF SEC > T2 AND SEC < = T3 THEN
X = SEC - T2
WXDT = (A1 * X + B1) * X * X
END IF
IF SEC > T5 AND SEC < = T6 THEN
X = SEC - T6
WXDT = (A2 * X + B2) * X * X
END IF
IF SEC > T6 THEN WXDT = 0
WX = WX + WXDT * DT
END IF
IF TDZ > 0 THEN
T1 = 4
T2 = TSV
T3 = T1 + T2
T4 = - 4
T5 = T3 + TDZ
T6 = T5 - T4
B1 = 3 * WZO / T1 ^ 2
A1 = -2 * B1 / (3 * T1)
B2 = 3 * WZO / T4 ^ 2
A2 = -2 * B2 / (3 * T4)
IF SEC > T2 AND SEC <= T3 THEN
X = SEC - T2
WZ = (A1 * X + B1) * X * X
WZC = WZ
END IF
IF SEC > T5 AND SEC <= T6 THEN
X = SEC - T6
WZ = (A2 * X + B2) * X * X
WZC = WZ
END IF
KALT = (-.0000011 * ALT + .00212) * ALT - .0251
IF KALT < 0 OR ALT <= 0 THEN KALT = 0
KALT = 1
WZ = KALT * WZC
IF SEC > T6 THEN WZ = 0
WZDT = (WZ - WZ1) / DT
WZ1 = WZ
END IF
IF DFW = 1 THEN CALL MCRBRST 'DALLAS Model
END SUB
```

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: COCKPIT VOICE RECORDER SYSTEMS

1 — Applicability

This ETSO provides the requirements that cockpit voice recorder (CVR) systems that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The Aapplicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4, excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device that is used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable Sstandards are those set forth provided in EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, that pertain to the CVR type, except Chapters I-1 and I-6, and Sections 2-1.1 , 2-1.5 , 2-1.6 , 2-1.11 , 2-1.12 , 2-3.1 , 2-5 , 3 3-1.1, 3-1.2, 3-1.3, 3-1.4, 3-1.5 , 3-1.7, Annex I-A, Annex I-C, and other ED-112A requirements related to installation, flight testing, aircraft maintenance and as modified in Appendix 1 of this ETSO.
Table 1 lists CVR types and the ED-112A section and part containing the MPS for each type:

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Table 1. — CVR MPS Requirements

CVR Type	ED-112A Reference
Single-function CVR in a non-deployable recorder	Section 2 and Part I.
CVR function in a deployable recorder	Section 2 (except for tests covered by ETSO-2C517), ~~Section 3~~ and Part I. The recorder shall also comply with ETSO-2C517.
CVR function in a combined non-deployable recorder	Section 2, Section 4, and Part I.
CVR function in a combined deployable recorder	Section 2 (except for tests covered by ETSO-2C517), Section 4 and Part I. The recorder shall also comply with ETSO-2C517.

Note: ~~a~~A CVR article may cover multiple types. A CVR may be a combined CVR and may also be deployable, in which case the applicable MOPS are Sections 2, 3, 4 and Part I, following the table above.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

A ~~L~~loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

The applicant must develop the system to at least the development assurance level that is commensurate with these failure conditions.

Note: ~~t~~The failure classification requirement is driven by the use of CVRs in accident investigations.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

4.2.1 — Lettering identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 2-1, paragraph 2-1.16.3, if it is fixed, and Section 3-1, paragraph 3-1.8.3, if it is deployable.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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Date: ~~24.10.03~~ XX.XX.20XX

APPENDIX 1

MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

The standard EUROCAE ED-112a, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A for ADFR systems

Location	**Initial ED-112A text**	**Amending text**
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 ft) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 ft) for a period of 90 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by the deep-sea pressure test. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of + 25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a nominal temperature of at least + 25.0 °C for a period of 90 days.

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Date: ~~23.02.2018~~ XX.XX.20XX

European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: FLIGHT DATA RECORDER SYSTEMS

1 — Applicability

This ETSO provides the requirements that flight data recorder (FDR) systems that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

~~None~~

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4 excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~ provided in the applicable sections of EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, that pertain to the FDR type, except Chapters II-1 and II-6, and Sections 2-1.1, 2-1.5, 2-1.6, 2-1.11, 2-1.12, 2-3.1, 2-5, 3 ~~3-1.1, 3-1.2, 3-1.3, 3-1.4, 3-1.5 , 3-1.7~~, Annex II-A, Annex II-B, and other ED-112A requirements related to aircraft-level equipment installation, flight testing, and aircraft maintenance and as modified in Appendix 1 of this ETSO.
Table 1 lists FDR types and the ED-112A section and part containing the MPS for each type:

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Table 1~~.~~ — Recorder MPS Requirements

Recorder Type	ED-112A Reference
Single-function FDR in a non-deployable recorder	Section 2 and Part II.
FDR function in a deployable recorder	Section 2 (except for tests covered by ETSO-2C517)~~, Section 3~~ and Part II. The recorder shall also comply with ETSO-2C517.
FDR function in a combined non-deployable recorder	Section 2, Section 4, and Part II.
FDR function in a combined deployable recorder	Section 2 (except for tests covered by ETSO-2C517), Section 4 and Part I. The recorder shall also comply with ETSO-2C517.

Note: ~~a~~An FDR article may cover multiple types. An FDR may be a combined FDR and may also be deployable, in which case the applicable MOPS are Sections 2, 3, 4 and Part I, following the table above.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

A ~~L~~loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

The applicant must develop the system to at least the development assurance level that is commensurate with this failure condition.

Note: The failure classification requirement is driven by the use of FDRs in accident investigations.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

4.2.1 — Lettering Identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 2-1, paragraph 2-1.16.3, if it is fixed, and Section 3-1, paragraph 3-1.8.3, if it is deployable.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

The standard EUROCAE ED-112a, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A for ADFR systems

Location	**Initial ED-112A text**	**Amending text**
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 ft) for a period of 90 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by the deep-sea pressure test. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of +25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a nominal temperature of at least + 25.0 °C for a period of 90 days.

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Date: ~~05.08.2016~~ XX.XX.20XX

European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: ~~406 and 121.5 MHz~~ EMERGENCY LOCATOR TRANSMITTER

1 — Applicability

This ETSO provides the requirements which ~~406 and 121.5 MHz~~ Emergency Locator Transmitters that are designed and manufactured on or after the applicability date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~ provided in ~~the~~ EUROCAE ED-62B~~A~~, ~~Minimum Operational Performance Specification~~ MOPS for Aircraft Emergency Locator Transmitters 406 MHz ~~and 121.5 MHz (Optional 243 MHz)~~, dated ~~February 2009~~December 2018. ELT(DT)s shall also meet the additional minimum performance specification for internal/integral GNSS receivers described in Appendix 1 of this ETSO.

~~Additionally, the use of hook and loop fasteners is not an acceptable means of attachment in complying with the Crash Safety requirements of section 4.5.7.3 of EUROCAE ED-62A for automatic fixed (AF) and automatic portable (AP) ELTs.~~

~~The shock and crash safety tests in EUROCAE ED-62A, section 4.5.7.3, require testing coincident with each orthogonal axes individually. Additionally, to better simulate more realistic aircraft crash scenarios, it is recommend that shock and crash safety testing be accomplished with simultaneous longitudinal and vertical cross-axis forces.~~

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1 and EUROCAE ED-62B.

3.1.3 — ~~Computer~~ Software

See CS-ETSO, Subpart A, paragraph 2.2.

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3.1.4 — Airborne Electronic Hardware ~~Qualification~~

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

~~The battery used in the Emergency Locator Transmitter authorised under this ETSO must be appropriate for the intended operational environment, not pose a hazard to the aircraft, and meet the requirements of acceptable battery standards.~~

~~If non-rechargeable lithium cells and batteries are used to power the Emergency Locator Transmitter, ETSO-C142a 'Non-Rechargeable Lithium Cells And Batteries — Lithium Batteries' provides MPS for such lithium batteries.~~

~~If rechargeable lithium cells and batteries are used to power the Emergency Locator Transmitter, ETSO-C179a 'Permanently Installed Rechargeable Lithium Cells, Batteries, and Battery Systems' provides MPS for such batteries.~~

~~If nickel-cadmium, nickel metal-hydride or lead acid batteries are used to power the Emergency Locator Transmitter, ETSO-C173a 'Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid Batteries' provides MPS for such batteries.~~

~~If batteries with a different chemistry are used to power the Emergency Locator Transmitter, the applicant must propose to EASA an appropriate MPS to be used for such batteries.~~

None.

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in paragraph 3.1 that results ~~resulting~~ in signal outputs that do not meet~~ing~~ the requirements of paragraph 3 is a minor failure condition. A ~~L~~loss of the function defined in paragraph 3.1 is a minor failure condition.

A transmission of an erroneous encoded location for an ELT(DT) is a minor failure condition.

An unintended deployment of an ELT(AD) is a major failure condition.

3.2.2 — Documentation

The DDP shall list the type, class, categories and capabilities of the ELT, as well as the applicable version of the COSPAS-SARSAT beacon standards.

A copy of the COSPAS-SARSAT approval shall be provided to EASA.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

~~None.~~

As per EUROCAE ED-62 Sections 3.10, 3.3.3, 2.9.3.2 and 3.8.2.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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Date: ~~05.08.2016~~ XX.XX.20XX

APPENDIX 1

ADDITIONAL MINIMUM PERFORMANCE SPECIFICATION FOR INTERNAL/INTEGRAL GNSS RECEIVERS

In addition to the EUROCAE ED-62B requirements, the internal or integral GNSS receiver shall permit the ELT(DT) system to transmit a correct encoded location in the following flight parameter ranges:

— pitch: ± 60°,
— roll: ± 60°,
— pitch rate: ± 20°/s,
— roll rate: ± 30°/s,
— yaw rate: ± 20°/s,
— altitude: 0 to 14 000 m,
— longitude: ± 180°,
— latitude: ± 90°,
— speed: 0 to 260 m/s,
— vertical speed: 80 m/s.

The internal or integral GNSS receiver of an ELT(DT) shall be tested in a GNSS simulator using the protocol of COSPAS-SARSAT documents C/S T.007, Annex K, or C/S T.021, Annex D, Section 3, as appropriate. The GNSS receiver should be tested along the trajectory attached to this ETSO, which could be summarised as follows:

— 5 minutes of stationary (static position) with the beacon in 'ARMED' mode and then approximately 15 seconds before the end of this time, turn the ELT(DT) to the 'ON' mode;

— accelerate due North at a rate of 5.55 m/s^2 for 60 seconds in a straight line, while climbing to 5 000 m;

— maintain a horizontal speed of 333 m/s for 60 seconds while climbing to 10 000 m;

— level out (pitch, roll and heading set to 0) and at a constant horizontal speed of 333 m/s apply the following for 30 seconds:

  - roll: bank right by + 30°/s until + 30° is reached, then bank left by – 30°/s until – 30° is reached; continue this sequence until the end of the 30-second sequence;

  - heading, pitch, altitude and speed remain unchanged;

— still maintaining the same altitude, and at a constant horizontal speed of 333 m/s, simultaneously apply the following for 2 seconds:

  - pitch: pitch down by – 10°/s until – 20° is reached;

  - roll: bank left by – 30°/s until – 60° is reached;

  - heading, altitude and speed remain unchanged;

— from this point until the impact at sea level, maintain a constant speed of 333 m/s while implementing a trajectory with the following characteristics until the impact:

  - maintain pitch: – 20°;

  - and decrease the altitude using a vertical speed of – 80 m/s;

  - and simultaneously repeat the following sequence:

    ○ for 17.5 seconds:

        ▪ maintain roll at – 60°,
        ▪ and decrease the heading at a yaw rate of – 10°/s;
    o for 4 seconds:
        ▪ increase roll at 30°/s until + 60° is reached,
        ▪ increase yaw rate at + 5°/s² until + 10°/s is reached;
    o for 17.5 seconds:
        ▪ maintain roll at + 60°,
        ▪ and increase the heading at a yaw rate of + 10°/s;
    o for 4 seconds:
        ▪ decrease roll at – 30°/s until – 60° is reached,
        ▪ decrease yaw rate at – 5°/s² until – 10°/s is reached,

— once impact with the ground occurs, maintain a stationary position for 60 seconds.

Pass criteria:

— the last encoded position which is transmitted before the impact is within 6 NM of the impact location;

— for a crash-survivable ELT(DT): an encoded position within 200 m of the impact position is transmitted not later than 15 seconds after the impact.

Attached file:

The trajectory that is attached to this ETSO is provided in earth-centred, earth-fixed (ECEF) coordinates.

ECEF_Trajectory_ETSO_C126c.csv

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: NON-RECHARGEABLE LITHIUM CELLS AND BATTERIES

1 — Applicability

This ETSO gives provides the requirements which non-rechargeable lithium cells and batteries that are intended to provide power for aircraft equipment, including emergency systems, that are designed and manufactured on or after the effective date of this ETSO must meet in order to be identified with the applicable ETSO marking.

This ETSO is not applicable to coin or button cells that contain containing less than 2 Wattwatt-hours (Wh) of capacity, and that is are compliant to with the requirements of UL 1642 and the UN transport regulations.

Note: Lithium sulphur dioxide (LiSO2) batteries approved under ETSO-C97 '*Lithium Sulphur Dioxide Batteries*' dated 24/10/2003 may still be manufactured under the provisions of their original approval, but new applications for non-rechargeable lithium sulphur dioxide batteries must meet the MPS of this new ETSO. If there are major design changes to lithium cells and batteries approved under current version of ETSO-C97, they must comply with this ETSO-C142a.

2 — Procedures

2.1 — General

The Aapplicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

RTCA DO-227A 'Minimum Operational Performance Standards (MOPS) for Non-Rechargeable Lithium Batteries' from June 199521 September 2017, as amended per unless otherwise specified by Appendix 1 of this ETSO.

3.1.2 — Environmental Standard

Non-rechargeable lithium cells and batteries must be tested according to RTCA DO-227A Section 2.03 unless otherwise specified by Appendix 1 of this ETSO.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

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3.1.4 — Airborne Electronic Hardware
See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific
3.2.1 — Failure Condition Classification
See CS-ETSO, Subpart A, paragraph 2.4.

~~None~~

4 — Marking
4.1 — General
~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.
4.2 — Specific
Each lithium cell or battery must be marked in accordance with RTCA DO-227A, Section ~~1.4.6~~2.1.10.
In addition, the non-rechargeable lithium cell, battery or end item must be marked as ETSO-C142b-X as described in the following table:

X	Cell, Battery or End Item
– 1	Cell
– 3	Battery
– 5	End Item
– 7	< 5 Wh within End Item Cells and batteries must meet at a minimum UL1642 and UN 38.3 certification. (see Note below)

Note: For ETSO-C142b-7 approvals, the ETSO marking must be on the End Item. The cell or battery within the End Item must be part marked and identified as a component within the End Item. The cell or battery must have a notation in the manufacturer’s documentation that the cell or battery is not to be used in another End Item unless it is tested separately in the new End Item. The End Item is required in order to meet the requirement of this ETSO, and the configuration control documentation must state that the cell or battery is approved based solely on the fact that it is tested and validated within the approved End Item. Only cells or batteries that are approved under the ETSO-C142b End Item article may be used. Do not use any cells or batteries that are not approved by the manufacturer of the article. If a different cell or battery is to be used with this End Item, the manufacturer must submit a new ETSO application (for the End Item) to EASA.

5 — Availability of Referenced Documents
See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1.

MINIMUM PERFORMANCE STANDARD FOR LITHIUM BATTERIES

~~**PURPOSE.**~~

This ~~appendix~~ Appendix prescribes the MPS for lithium batteries, as modified by this ETSO.

~~**REQUIREMENTS.**~~

~~The standards applicable to this ETSO are provided in the industry standard, RTCA/DO-227 'Minimum Operational Performance Standard for Lithium Batteries' dated June 23, 1995.~~

The standard is modified as follows:

Table 1. — Modifications to RTCA/ DO-227A

RTCA DO-227A Section and title:	***Current wording:***	**Modified wording:**
1.4 Specific Exclusions from this document	c. Cells or batteries containing less than 2 Watt-hours (Wh) of capacity have sufficiently low energy that the possible hazard is considered low and therefore these cells and batteries are assessed as presenting an acceptably low risk for installation as long as they are compliant with the requirements of UL 1642 [Reference 9]. If compliant with UL 1642 and the UN transport regulations [Reference 10], no other requirements from this MOPS will apply to cells or batteries with less than 2 Wh of capacity.	c. Coin or button cells that contain less than 2 watt-hours (Wh) of capacity have sufficiently low energy that the possible hazard is considered to be low, and therefore these cells and batteries are assessed as presenting an acceptably low risk for installation as long as they are compliant with the requirements of UL 1642 [Reference 9]. If they are compliant with UL 1642 and the UN transport regulations [Reference 10], no other requirements from this MOPS will apply to <u>coin or button</u> cells with less than 2 Wh of capacity.
For non-rechargeable cells and/or batteries that are less than 5 Wh and have not been tested to RTCA document RTCA DO-227A, Sections 1.0 and 2.0		The requirement for this ETSO can be accomplished under the End Item testing. Use RTCA document, RTCA DO-227A, Minimum Operational Performance Standards for Non-Rechargeable Lithium Batteries, dated 21 September 2017, Section 2.2.3 and 2.4.3. Mark the cell

		or battery per Section 4.2 of this ETSO (ETSO-C142b-7). Note: For ETSO-C142b-7 approvals, the ETSO marking must be on the End Item and the cell or battery as well. The cell or battery must have a notation in the manufacturer's documentation that the cell or battery is not to be used in another End Item. The End Item is needed in order to meet the requirement of this ETSO, and the configuration control documentation must state that the cell or battery is approved based solely on the fact that it is tested and validated within the approved End Item. Only cells or batteries that are approved under the ETSO-C142b End Item article may be used. Do not use any cells or batteries that are not approved by the manufacturer of the article. If a different cell or battery is to be used with this End Item, a new ETSO application must be submitted to EASA.

~~***RTCA/DO-227 section and title:***~~	~~***Required modification:***~~
~~**1.5.11, Design Life**~~	~~**TO ADD at the end of the paragraph**~~
	~~'Equipment manufacturers are responsible for ensuring that the integrity of date coding systems used by the cell/battery supplier(s) will support design life criteria.'~~
~~**1.7.3, Lot Acceptance Test Goals**~~	~~**TO ADD at the end of the paragraph**~~
	~~'It is recommended that the manufacture's lot acceptance testing include the discharge tests described by paragraph 2.4.1.1 Capacity Verification Test.'~~
~~**2.1.2 b, Performance Requirements**~~	~~**TO ADD at the end of the paragraph**~~
	~~'If the battery is required to operate in temperatures outside this envelope, test the battery using the more severe temperatures.'~~
~~**Table 2-1, Cell evaluation criteria**~~	~~**TO DELETE the superscript '4' on the**~~

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Internal Short-Circuit Test row under the 'FIRE' column. The superscript '4' is only used under the Forced-Discharge, External Short-Circuit, and Charging tests, and then only under the 'LEAK' and 'VENT' columns.

2.1.8.2, Test Tolerances — **TO ADD new paragraphs after 2.1.8.2**

Rated Capacity and Current

Except as otherwise specified in the test methods in subsections 2.3 and 2.4, the rated capacity and current must be the same for all testing in this standard.

Warning - Hazards of Testing

When subjected to electrical testing specified in this document, cells or batteries may leak or vent hazardous materials, burn, or in exceptional cases, vent violently.

2.3.1, Vibration Test — **TO REPLACE** Figure 2-3 with the modified Figure 2-3

STANDARD RANDOM VIBRATION Figure 2-3 in appendix 1 of this ETSO. This revised figure depicts different limit lines.

2.3.1, Vibration Test — **TO REPLACE** Figure 2-4 with the modified Figure 2-4

STANDARD RANDOM VIBRATION Figure 2-4 in appendix 1 of this ETSO.. This revised figure depicts different limit lines.

2.3.1, Vibration Test — **TO ADD** before the last sentence in the eighth paragraph

'Measure the open circuit voltage (OCV) before, during, and after the tests.'

2.3.2, Shock Test — **TO REPLACE** the wording with

'For the battery shock test, mount samples in the equipment in which they will be used. Perform this test using undischarged sample cells or batteries. Secure the sample to a shock table by a mechanically secured device. The shock test machine must be capable of imparting a series of calibrated shock impulses to the sample. The shock impulse waveform distortion at any point on the waveform may not be greater than 15 percent of the peak value of the shock pulse. The duration of the shock pulse is specified with reference to the zero points of the wave. The shock forces are specified in terms of peak amplitude g values. Measure the shock impulse using a calibrated accelerometer and associated instrumentation having a 3db response over a range of at least 5 to 250 Hz. Mount the sample on the shock test machine so that the shock impulses can be applied in both directions of the three orthogonal axes. For general purposes, use the following test parameters. Apply a 75 g saw tooth wave shock impulse with a duration of 11 +2 ms in both directions of the three orthogonal axes. Measure the open circuit voltage before and after the test. Examine each sample to determine if it meets the requirements of Table 2-1 and 2-2.

For applications with shock requirements in excess of the general test (that is, where crashworthiness, ELTs, or survivability is an issue), use the following more stringent requirements. Apply a 100

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	~~g half sine wave shock impulse with a duration of 23 +2 ms in both directions of the three orthogonal axes. Measure the open circuit voltage (OCV) before, during and after the test. Examine each sample to determine if it meets the requirements of Table 2-1 or Table 2-2.'~~
~~**2.3.3, Temperature Cycling Test**~~	~~**TO CHANGE** 10 times to 9 times~~
~~**2.3.3, Temperature Cycling Test**~~	~~**TO ADD** to the end of the paragraph,~~ ~~'…for either method.'~~
~~**2.4.1.2, Discharge Test**~~	~~**TO ADD** after the second sentence in the first paragraph, 'Set the DC power supply to a voltage limit equal to the number of cells per series string in the battery times the OCV of an individual cell.'~~
~~**2.4.1.2, Discharge Test**~~	~~**TO ADD** to the end of the first paragraph~~ ~~'If the sample contains one or more protective devices, set the test current to just below (by no more than 10 percent) the current at which any protective device will activate during the forced discharge test.'~~
~~**2.4.1.3, Forced Discharge Test**~~	~~**TO DELETE** the fourth sentence: If the sample contains one or more protective devices, the test current is just below (by no more than 10%) that at which any protective device will activate during the forced discharge test.~~
~~**2.4.1.3, Forced Discharge Test**~~	~~**TO ADD** to the end of the paragraph~~ ~~'This test is not required for single cell batteries. Test the cells up to and (possibly) including the maximum rate of discharge specified by the manufacturer. Rate any protective device at or below the discharge rate specified by the manufacturer. Perform all testing according to this rating.'~~
~~**2.4.2.1, Internal Short-circuit Test**~~	~~**TO REPLACE** the first paragraph with~~ ~~'This test is designed to determine the effects of an internal short circuit in undischarged cells. At 24 °C, deform the sample between a rod with a hard insulating surface and an insulated plate. Each cell is deformed until the open circuit voltage drops abruptly or is reduced to at least one third. At the point where the cell voltage drops, remove the applied force. Allow the sample to cool to 24 °C and then hold for a minimum of 24 hours. Examine each sample to determine if it meets the requirements of Table 2-1'~~
~~**3.4, Test Procedures for Installed Equipment Performance**~~	~~**TO ADD** new paragraph after 3.4.~~ ~~**Toxic Gas Venting Precautions**~~ ~~Do not install or use batteries that can vent toxic gases in the aircraft cockpit, because of an increased probability of immediate flight crew impairment. Batteries that can vent toxic gases may be installed or used in an aircraft passenger compartment, if the installer shows that this would not create a safety hazard. You can prevent a safety hazard by:~~

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~~a. Installing a system for overboard venting, absorption, or containment, or~~

~~b. Showing that, if venting occurs, permissible exposure limits do not exceed those maintained by safety-standard organizations (Occupational Safety and Health Administration and the American Conference of Governmental Industrial Hygienists, Inc.).~~

~~**3.4, Test Procedures for Installed Equipment Performance**~~	~~**TO ADD** new paragraph after 3.4~~

~~(a) Because lithium batteries have ignited, vented gas or exploded, we require additional performance standards governing the use of lithium batteries or equipment incorporating lithium cells or batteries on airplanes.~~

~~Airplane and equipment manufacturers incorporating lithium cells or batteries must ensure that if there is a fire within a single cell of the battery, the equipment unit will contain the fragments and debris (but not smoke/gases/vapors) from a battery explosion and fire. Fire within the equipment, such as from wires and electrical components, must self-extinguish.~~

~~(b) See Table 2, appendix 1 of this ETSO. for tests to ensure that the manufacturer has met the fire safety requirements for equipment incorporating lithium cells or batteries.~~

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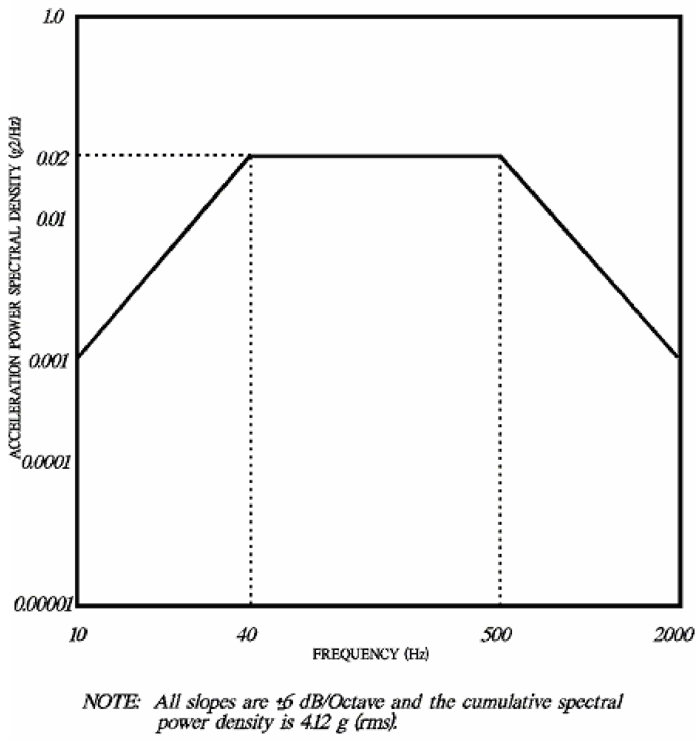
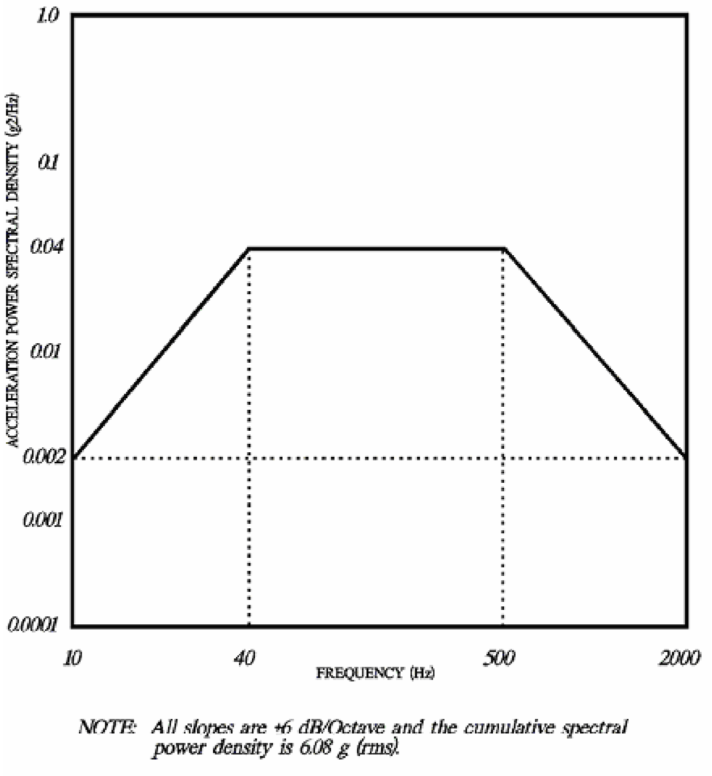
~~**Figure 2-3. Standard Random Vibration Test Curves for Equipment Installed in Fixed Wing Aircraft with Turbojet Engines**~~



~~**Figure 2-4. Robust Random Vibration Test Curves for Equipment Installed in Fixed Wing Aircraft with Turbojet Engines**~~



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~~Table 2. TESTS FOR FIRE SAFETY REQUIREMENTS~~		
~~Test~~	**~~Procedures~~**	**~~Criteria to Pass~~**
~~External Short Circuit~~	~~Measure direct connection between terminals through electric wire with resistance of 2m-ohm.~~ ~~State of Charge (SoC) of a cell : 100%~~	~~No venting of gases/vapors.~~ ~~No smoke produced.~~ ~~No ignition or fire. No explosion.~~
~~Crush~~	~~Test battery by dropping an iron ball (9.1 kg) from the height of 61cm~~ ~~SoC of a cell : 50%~~	~~No venting of gases/vapors.~~ ~~No smoke produced.~~ ~~No ignition or fire. No explosion.~~
~~Over discharge~~	~~Test battery by discharging with a current of 1C for 1 hour (or to the maximum discharge time for the battery operation).~~ ~~SoC of a cell : 0%~~	~~No venting of gases/vapors.~~ ~~No smoke produced.~~ ~~No ignition or fire. No explosion.~~
~~Overheat~~	~~Test battery by heating up to 115 degrees C in the oven.~~ ~~SoC of a cell : 100%~~	~~No venting of gases/vapors.~~ ~~No smoke produced.~~ ~~No ignition or fire. No explosion.~~
~~Fire~~	~~Test equipment unit with battery in place for fire penetration by igniting a single unit.~~ ~~SoC of a cell : 100%~~	~~Unit must contain the fragments/debris from explosion but not gases/vapors/smoke. Fire within the unit must self-extinguish. Note that the presence of a fire extinguishing or suppression system outside the battery (such as in the equipment compartment) may be used to provide this feature if the system is designed to handle this fire threat.~~

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AIRBORNE NAVIGATION SENSORS USING THE GLOBAL POSITIONING SYSTEM AUGMENTED BY THE SATELLITE-BASED AUGMENTATION SYSTEM

1 — Applicability

This ETSO provides the requirements which airborne navigation sensors using the Global Positioning System (GPS) augmented by the Satellite-Based Augmentation System (SBAS) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

The standards of this ETSO apply to equipment intended to provide position information to a navigation management unit that outputs deviation commands referenced to a desired flight path. Pilots or autopilots will use these deviations to guide the aircraft.

Note: Revision A1 provides applicants with an option to use an ETSO-2C204a SBAS circuit card assembly (CCA) functional sensor as part of their ETSO application. There is no change to the technical MOPS in comparison with ETSO-C145e.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

~~None~~

This section applies only for ETSO articles that use an ETSO-2C204a Beta CCA.

Applicants who use an ETSO-2C204a Beta CCA will need to coordinate with their Beta CCA supplier at least for the following aspects:

2.2.1 — Access to the Information of the Selected ETSO-2C204a CCA

The applicant is responsible for establishing the necessary communication channels with the ETSO-2C204a holder company. Applicants who use an ETSO-2C204a SBAS CCA will need to coordinate with their SBAS CCA supplier to obtain the documentation that supports ETSO-2C204a.

The applicant’s organisation shall establish a means of communication to obtain timely notifications of design changes, open problem reports (at least the ones that impact the usage of the circuit card assembly), occurrence reports and airworthiness directives that affect or are related to the ETSO-2C204a article.

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2.2.2 — Assessment of Design Changes

The applicant shall perform an impact analysis of the design changes to the ETSO-2C204a article, and shall perform the necessary development life-cycle activities that are impacted by the ETSO-2C204a changes.

Note: When a major change (as assessed per point 21.A.611) is applied to the ETSO-2C204a article, which is installed in the ETSO-C145e article, it is systematically also considered to be a major change for the ETSO-C145e function.

2.2.3 — Assessment and Reporting of Open Problem Reports (OPRs)

The applicant shall perform the assessment of the ETSO-2C204a CCA OPRs. The applicant shall report the resulting open problem reports that affect the ETSO-C145e article.

3 — Technical ~~c~~Conditions

3.1 — Basic

3.1.1 — Minimum ~~p~~Performance ~~s~~Standard

The applicable ~~S~~standards are those ~~set forth~~ provided for functional equipment Class Beta in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December ~~15,~~ 2016, Section 2, as modified by Appendix 2 and 4 of this ETSO.
Class Beta equipment is defined in DO-229E, Section 1.4.
The test procedures are defined in DO-229E, Section 2.5.

The standards in this ETSO apply to equipment intended to provide position, velocity, and time information for a navigation management unit application that outputs deviation commands keyed to a desired flight path, or a non-navigation application such as an ~~automatic dependent surveillance-broadcast~~ automatic dependent surveillance — broadcast (ADS-B) or terrain awareness and warning system (TAWS). In navigation applications, pilots or autopilots will use the deviations output by the navigation management unit to guide the aircraft. In non-navigation applications, the position, velocity, and time outputs will provide the necessary inputs for the end-use equipment. These ETSO standards do not address integration issues with other avionics.

<u>Use of an ETSO-2C204a SBAS CCA functional sensor</u>

ETSO-145e applicants have the option to use an ETSO-2C204a SBAS CCA functional sensor. Applicants who choose to use an ETSO-2C204a SBAS CCA functional sensor can take credit for certification compliance by virtue of the ETSO-2C204a ETSOA for:

— meeting the MPS Section 2.1 requirements;

— the development assurance of the hardware/software;

— the classification of the failure conditions; and

— the MPS Section 2.5 performance testing (functional qualification) except those tests that are specified in Appendix 1 of this document;

— the partial environmental testing performed on the ETSO-2C204a CCA.

After the integration of the ETSO-2C204a CCA into the ETSO-145e article, the applicant shall perform the testing described in Appendix 1. The applicant shall also complete the

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environmental qualification testing. The testing shall include the detailed functional test procedures delivered by the ETSO-2C204a CCA provider. This testing is required to address the paragraphs of this ETSO that are not covered by the points listed above.

Note: The manufacturer of end-use equipment that uses an ETSO-2C204a SBAS CCA functional sensor assumes full responsibility for its design and function under their ETSO-C145e authorisation.

3.1.2 — Environmental ~~s~~Standard

See CS-ETSO, Subpart A, paragraph 2.1.
The required performance under test conditions is defined in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December ~~15,~~ 2016, Section 2.4.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

Applicants who use an ETSO-2C204a SBAS CCA functional sensor may use the ETSO-2C204a authorisation as substantiation for compliance with the software development assurance aspects of the CCA.

3.1.4 — Airborne ~~e~~Electronic ~~h~~Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

Applicants who use an ETSO-2C204a SBAS CCA functional sensor may use the ETSO-2C204a authorisation as substantiation for compliance with the hardware development assurance aspects of the CCA.

3.2 — Specific

3.2.1 — Failure ~~c~~Condition ~~c~~Classification

See CS-ETSO, Subpart A, paragraph 2.4.
Failure of the function defined in paragraph 3.1.1 of this ETSO is a:

— *major* failure condition for a loss of function ~~and~~ or malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data,

— *major* failure condition for a loss of function of approach localiser performance without vertical guidance (LP), and of approach localiser performance with vertical guidance (LPV) position data, and

— *hazardous* failure condition for a malfunction of approach (LP and LPV) position data ~~resulting in~~ that results in misleading information.

Note: These failure condition classifications are considered to be the minimum classifications. Guidance for the installation of navigation systems at the aircraft level (e.g. Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS-ACNS)) could require a different failure condition classification.

3.2.2 — Additional Specific

If the equipment can satisfy the requirements of RTCA~~/~~ DO-229E only when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation.
This requirement shall be included in the installation manual ~~(IM)~~ as a limitation.

The applicant shall have all the data necessary to evaluate the geostationary (GEO) satellite bias as defined in RTCA~~/~~ DO-229E, Section 2.1.4.1.5, available for review by EASA.

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If the equipment uses barometric-aiding to enhance the ~~FDE~~ availability of FDE, then the equipment shall meet the requirements in RTCA~~/~~ DO-229E, Appendix G.

~~3.3. - Functional qualifications.~~

~~None.~~

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

At least one major component must be permanently and legibly marked with the operational equipment class as defined in Section 1.4.2 of RTCA document DO-229E (e.g.~~,~~ Class 2). ~~A marking of Class 4 indicates compliance to Delta-4 requirements.~~ The functional equipment class defined in Section 1.4.1 of RTCA document DO-229E (e.g. ~~Gamma, Delta~~ Beta) is not required to be marked.

It is sufficient to declare the proper functional equipment class in the ~~DDP (~~declaration of design and performance (DPP).

5 — Availability of referenced documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

~~Reserved.~~

END-USE EQUIPMENT MANUFACTURER TESTS FOR SBAS CCA FUNCTIONAL POSITION, VELOCITY, TIME (PVT) SENSORS USED FOR NAVIGATION AND NON-NAVIGATION APPLICATIONS

1 — Scope.

This Appendix describes the required supplementary equipment level testing, in addition to the environmental testing of RTCA DO-229E, Section 2.4, that is required to be conducted by the manufacturer of the end-use equipment to receive an ETSO-C145e Class Beta authorisation when using an ETSO-2C204a SBAS CCA functional sensor.

To perform functional tests and measure the performance in the environment, the applicant will use the detailed functional test procedures delivered with the ETSO-2C204a CCA. These test procedures are intended to streamline and simplify the ETSO-C145e authorisation process for the manufacturer of the end-use equipment by allowing credit for the design and selected testing performed at the SBAS CCA functional sensor level. However, the manufacturer of the end-use equipment remains fully responsible for the design and control of the article per their ETSO-C145e ETSOA.

2 — General principles.

(a) Testing methods for GPS/SBAS equipment have been standardised by RTCA DO-229E, and serve as the basis for ETSO-C145e. RTCA DO-229E was written to cover equipment that can be installed on aircraft. Section 2.4 specifically addresses the issues of the environment in which the equipment operates and provides the approved test methods to validate the performance of the equipment in this environment. Section 2.4 represents the RTCA consensus in identifying which RTCA DO-229E requirements are sensitive to environmental effects. These requirements are listed in the environmental tables referenced in Section 2.4.1.

(b) The determination that an MOPS requirement is susceptible to the environment does not depend on whether or not the implementation is a CCA installed within an ETSO-C145e article. This is the same concept as an equipment enclosure that is designed to protect against a benign environment compared with one that is designed for a severe environment; the identification of the susceptible requirements is the same.

(c) Therefore, this Appendix uses the tables of RTCA DO-229E Section 2.4.1 to identify the MOPS requirements that are susceptible to environmental affects for an SBAS CCA functional sensor in the end-use equipment. The focus is on the change in environment seen by the SBAS CCA functional sensor as a result of its installation in the end-use equipment. For example, other components inside the end-use equipment may radiate RF energy that could interfere with the GPS functions; therefore, the ambient testing performed at the CCA level is not equivalent to tests performed in the end-use equipment. This is the basis for defining the RTCA DO-229E Section 2.5 performance tests that need to be repeated by the manufacturer of the end-use equipment.

(d) The Class Beta environmental table referenced in RTCA DO-229E Section 2.4.1 is the prime source to determine the MOPS performance requirements that are susceptible to environmental conditions. Based on the table, the susceptible requirements can be grouped into two categories: those that are susceptible to most types of environmental conditions (described in Section 3) and those that are susceptible to only a few (described in Section 4).

Note: The tables for Class Beta-1, -2, and -3 equipment identify similar requirements that are susceptible to the installed environment. The only difference is the applicable MOPS requirements that are consistent with the operational class (i.e. Class -1, - 2, or -3).

3 — Performance requirements that are susceptible to most types of environmental conditions.

The RTCA DO-229E requirements for accuracy (Sections 2.1.3.1, 2.1.4.1, and 2.1.5.1) and sensitivity and dynamic range (Section 2.1.1.10) are sensitive to most types of environmental conditions. However, these requirements are linked to the message loss rate requirement in 2.1.1.3.2. Sections 3.1 and 3.2 below identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the SBAS CCA functional sensor continues to meet the accuracy, dynamic range, and message loss rate performance requirements after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.

3.1 — RTCA DO-229E – 2.5.8 Accuracy Test.

(a) The accuracy test described in Section 2.5.8 is actually a joint test that covers accuracy, sensitivity and dynamic range. This joint testing also applies under the environment as stated in Section 2.4.1.1.5, with environmental adaptations as described in Section 2.4.1.1.1.

(b) The demonstration of accuracy is performed in accordance with Section 2.5.8.1 only for the test case with broadband external interference noise. This test must be repeated when the CCA is installed in the end-use equipment, and it is sufficient to perform it using broadband interference.

(1) The environmental testing is limited to broadband interference, as it represents the worst-case signal-to-noise condition, which is the most sensitive to environmental effects. This applies equally to the environment for the CCA that is created by the end-use equipment.

(2) Section 2.5.8 contains a measurement accuracy test in 2.5.8.1, with the detailed test procedure in Section 2.5.8.2. The Section 2.5.8.1 test must be run under the worst-case environment identified in the 'Additional Considerations for Internal Interference Sources' section below. The measurement accuracy testing can be combined with the message loss rate testing described in Section 2.5.2.1.

(3) Section 2.5.8.3 is a 24-hour actual satellite accuracy test. The Section 2.5.8.3 test exposes the equipment to a variety of signal conditions and data-processing conditions over varying satellite geometries that will increase the confidence that no unforeseen interactions between components within the end-use equipment and the SBAS CCA functional sensor will go undetected. The 24-hour testing in Section 2.5.8.3 can be combined with the 24-hour message loss rate testing described in Section 2.5.2.4 (see the section on Additional Considerations for Internal Interference Sources).

(4) Section 2.5.8.4 (SBAS Tracking Bias) is an analysis of the GPS hardware, and it is therefore not necessary to repeat it at the end-use equipment level provided that no extra RF components that affect the RF filtering response are inserted in the RF path. Otherwise the manufacturer of the end-use equipment must also repeat the SBAS Tracking Bias test.

(c) The test threshold is relaxed from 110 to 125 % as specified in Table 2-25 of the 2.5.8.2.1 test procedure to shorten the duration of the test. However, the Section 2.5.8 testing (excluding the SBAS Tracking Bias test in Section 2.5.8.4) for the CCA in the end-use equipment shall be under ambient conditions per Section 2.5 with the 110-% test pass threshold for the maximum test sensitivity.

(d) The Section 2.5.8 testing (excluding the SBAS Tracking Bias test in Section 2.5.8.4) will be repeated against the accuracy requirements that are consistent with the desired operational class (i.e. the Section 2.1.3.1, 2.1.4.1, and 2.1.5.1 accuracy requirements, as appropriate).

(e) Only the broadband external interference noise test case using minimum satellite power will be executed in most cases, to shorten the duration of the test. The Section 2.5.8.1 testing will be repeated for both the minimum and the maximum satellite power only for the worst-case environment.

3.2 — RTCA DO-229E – 2.5.2 Message Loss Rate Test.

(a) Section 2.5.2 specifies the message loss rate test for the Section 2.1.1.3.2 message loss rate requirement. This test is conducted in conjunction with the Section 2.5.8 accuracy testing. Section 2.5.2.2 defines the test procedure to collect data to verify the SBAS message loss rate in the presence of interference using the test cases in which the SBAS satellite is at minimum power. Section 2.5.2.3 defines the pass-fail criteria.

(b) The test in Section 2.5.2.2 is performed during the measurement accuracy broadband interference test case described in paragraph 3.1.

(c) The test procedure in Section 2.5.2.4.1 is run in conjunction with the Section 2.5.8.3 24-hour accuracy test. Section 2.5.2.4.2 defines the pass-fail criteria for the test case described in paragraph 3.1(b)(3).

4 — Performance requirements that are partially susceptible to environmental conditions.

(a) The Class Beta tables (Tables 2-14, 2-16, and 2-18) in Section 2.4.1 of RTCA DO-229E indicate that the requirements for the initial acquisition time (2.1.1.7) and the satellite reacquisition time (2.1.1.9) are sensitive to four environmental conditions: icing; lightning-induced transient susceptibility; lightning direct effects; and normal/abnormal operating conditions. The requirements for loss of navigation (2.1.1.13.2, 2.1.4.12.2, and 2.1.5.12.2) and loss of integrity (2.1.1.13.1, 2.1.4.12.1, and 2.1.5.12.1) are sensitive to low and high operating temperatures.

(b) The lightning-induced transient susceptibility, lightning direct effects, or icing environmental conditions are not pertinent to the environment that is created by the end-use equipment relative to the SBAS CCA functional sensor. However, the manufacturer of the end-use equipment remains responsible for meeting the overall environmental qualification requirements at the end-use equipment level.

(c) The loss of navigation and loss of integrity indications are limited to temperature testing, and the information in RTCA DO-229E, Sections 2.4.1.1.2 and 2.4.1.1.3, is appropriate. The purpose is to ensure that the interface used to indicate the loss of navigation is functional under the environmental conditions that are present after the SBAS CCA functional sensor is installed in the end-use equipment. Sections 2.4.1.1.2 and 2.4.1.1.3 indicate that any source that generates the indication can be used, since it is the interface and not the detection mechanism that is verified. The temperature testing performed at the end-use equipment level is the worst-case scenario. It is not necessary to repeat the CCA-level test at room temperature in the end-use equipment, since the environmental qualification adequately addresses the testing for these requirements.

(d) EUROCAE ED-14 Section 16 relates to aircraft power supplies (refer to ETSO Section 3.1.2 for the environmental qualification requirements). Sections 16.5.1.2 and 16.6.1.2 are for supply voltage modulation (AC)/ripple (DC). Given the potential susceptibility of the SBAS CCA functional sensor to power supply noise, it is prudent to repeat the tests at the end-use equipment level on this basis.

(e) Sections 4.1 and 4.2 identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the SBAS CCA functional sensor continues to meet the acquisition time and reacquisition time performance requirements relative to the normal/abnormal operating conditions after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled, to create the worst-case environment.

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4.1 RTCA DO-229E – 2.5.4 — Initial acquisition test procedures.

The information in RTCA DO-229E, Section 2.4.1.1.4, on the initial acquisition test in Section 2.5.4 applies. The manufacturer of the end-use equipment shall repeat the initial acquisition testing described in RTCA DO-229E, Section 2.5.4.

4.2 RTCA DO-229E – 2.5.6 — Satellite reacquisition time test.

The manufacturer of the end-use equipment is required to repeat the satellite reacquisition time testing in RTCA DO-229E, Section 2.5.6.

5 — Additional considerations for internal interference sources.

(a) Installing an SBAS CCA functional sensor into end-use equipment that also includes other functions requires a careful evaluation of the potential internal radiated and conducted interference. The manufacturer of the end-use equipment must evaluate each operating mode to determine whether the mode changes the environment for the installed SBAS CCA functional sensor. If there is only one environment, or there is clearly one worst-case environment, then the accuracy and message loss rate testing in Section 3 can be run in that operating mode only. For example, if the end-use equipment includes an RF transmitter that radiates at one frequency, one could reasonably argue that setting the transmitter at full power with maximum data throughput would generate a clear worst-case environment in which to run all the testing.

(b) In the case of multiple environments, the accuracy and message loss rate tests can either be run in each environment, or the methodology in RTCA DO-229E, Section 2.4.1.2.3, can be used to run an aggregate test with approximately equal time in each mode. The methodology in Section 2.4.1.2.3 must be used to identify the modes with the greatest susceptibility under which the combined accuracy and message loss rate tests are repeated in addition to the aggregate test. For example, the methodology of Section 2.4.1.2.3 is appropriate for end-use equipment that contains a high power transmitter that operates on a large number of frequencies such that it is impractical to run a test at each frequency. This is analogous to the large number of frequencies that need to be tested during EUROCAE ED-14 RF and induced signal susceptibility testing, and this is the reason why the methodology of Section 2.4.1.2.3 was developed.

(c) It is sufficient to identify one worst-case environment when performing acquisition and 24-hour accuracy testing.

6 — Summary.

(a) The manufacturer of end-use equipment that incorporates an SBAS CCA functional sensor is required to repeat the following RTCA DO-229E Section 2.5 testing under ambient conditions (see Section 5) after installing the SBAS CCA functional sensor in the end-use equipment:

- The Section 2.5.8 accuracy test (excluding the SBAS Tracking Bias test in 2.5.8.4) adapted per Section 2.4.1.1.1, except that the 110-% test pass threshold is used.

  Note: Excluding the SBAS Tracking Bias test is acceptable, provided that the end-use equipment does not insert into the RF signal path any components that affect the filtering response. Otherwise, the manufacturer of the end-use equipment must repeat the SBAS Tracking Bias test as well.

- The Section 2.5.2 message loss rate test.
- The Section 2.5.4 initial acquisition test.
- The Section 2.5.6 satellite reacquisition time test.

(b) The manufacturer of the end-use equipment remains responsible for completing a full environmental qualification evaluation (ETSO Section 3.1.2) at the end-use equipment level. The manufacturer of end-use equipment that incorporates an SBAS CCA functional sensor is required to repeat the loss of navigation indication and loss of integrity indication tests as part of the environmental qualification according to RTCA DO-229E Sections 2.4.1.1.2 and 2.4.1.1.3 respectively.

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APPENDIX 2
ADDITION TO RTCA/ DO-229E SECTION 1.

This Appendix describes the required modifications and additions to RTCA DO-229E for compliance with this TSO. This Appendix adds a new Section 1.8.3 on cybersecurity and GPS spoofing mitigation to RTCA/ DO-229E and corrects a long-standing mistake in the Section 2.4 environmental requirement tables.

The new section provides information for cybersecurity and spoofing mitigation to make RTCA/ DO-229E consistent with the new RTCA MOPS template and RTCA/ DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment.

1.8.3 Cybersecurity and GPS Spoofing Mitigation

This section contains information to address intentional interference with the GPS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive a receiver's operation when they are processed. Spoofing may be unintentional, such as effects from the signals of a GPS repeater, or may be intentional and even malicious. There are two classes of spoofing:

— Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of time of arrival or frequency of arrival or their rates of change;
— Data spoofing introduces incorrect digital data to the target receiver for its use in processing of signals and the calculation of positioning, navigation and timing (PNT).

Either class of spoofing can cause a range of effects, from incorrect outputs of PNT to receiver malfunctions. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or installed GNSS re-radiators act like spoofers. Re-radiators, replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognise and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GPS equipment can be found in the U.S. Department of Homeland Security document 'Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure'[12] and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003, 28 July 2016.

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 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered to be vulnerable only through RF signals and OEM and/or aircraft operator controlled processes for maintenance and updates. In some cases, aircraft GNSS receivers may be field-loadable by approved personnel, requiring physical access and physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment manufacturers to update installed avionics software, to update databases,

[12] https://ics-cert.us-cert.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_(GPS)_Equipment_Used_by_Critical_Infrastructure_S508C.pdf

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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 'authorised 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' connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit the input of ~~externally -supplied~~ externally supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerabilities ~~vulnerability through equipment design~~ through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important ~~that~~ for manufacturers to 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 the MOPS, it is recommended that manufacturers ~~look at~~ consider 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, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering, although navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer ~~is~~ outsources ~~outsourcing~~ the development of software code ~~development~~, are the contractor and its staff properly vetted?

Civil ~~A~~aviation ~~A~~authorities (CAAs) have a regulatory interest when an applicant's design makes use of a non-trusted connection through which ~~connectivity where~~ the installation can potentially introduce aircraft information security vulnerabilities. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerabilities 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 of the equipment so that the applicant can consider them in meeting the ~~installation~~ regulatory requirements of the installation.

Table 2-14 through Table 2-20

The tables incorrectly reference and label RTCA DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding '2.1.1.7 Acquisition Time' and '2.1.1.9 Reacquisition Time'. Change the table references as follows:

The MOPS initial acquisition time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (DO-160E Section 16.5.2 and 16.6.2) and the satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (DO-160E Sections 16.5.1 and 16.6.1).

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APPENDIX 3

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APPENDIX 4

This Appendix prescribes EASA modifications to RTCA document DO-229E, Section 2.

In Section 2.1.1.2, after the first sentence, add the following:

> 'The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II of IS-GPS-200D, 'Navstar GPS Space Segment / Navigation User Interfaces', December 2004, provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising~~utilizing~~ the coarse/acquisition (C/A) code.'

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and that no CNAV data, which is defined in Appendix III of IS-GPS-200D, is used, for which the SBAS does not provide integrity.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: STAND-ALONE AIRBORNE NAVIGATION EQUIPMENT USING THE GLOBAL POSITIONING SYSTEM AUGMENTED BY THE SATELLITE-BASED AUGMENTATION SYSTEM

1 — Applicability

This ETSO provides the requirements which stand-alone airborne navigation equipment using the Global Positioning System (GPS) augmented by the Satellite-Based Augmentation System (SBAS) that is~~are~~ designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

Note: Revision A1 provides applicants with an option to use an ETSO-2C205a Class Delta circuit card assembly (CCA) functional sensor as part of their ETSO application. There is no technical MOPS change in comparison with ETSO-C146e.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

~~None~~

This section only applies to ETSO articles that use an ETSO-2C205a CCA.

Applicants that use an ETSO-2C205a CCA will need to coordinate with their CCA supplier for at least the following aspects:

2.2.1 — Access to the Information on the Selected ETSO-2C205a CCA

The applicant is responsible for establishing the necessary communication channels with the ETSO-2C205a holder company. Applicants who use an ETSO-2C205a SBAS CCA will need to coordinate with their SBAS CCA supplier to obtain the documentation that supports ETSO-2C205a.

The applicant's organisation shall establish a means of communication to obtain timely notifications of design changes, open problem reports (at least the ones that impact the usage of the CCA), occurrence reports and airworthiness directives that affect or relate to the ETSO-2C205a article.

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2.2.2 — Assessment of Design Changes

The applicant shall perform an impact analysis of the design changes to the ETSO-2C205a article, and shall perform the necessary development life-cycle activities that are impacted by the ETSO-2C205a changes.

Note: When a major change (as assessed per point 21.A.611) is applied to the ETSO-2C205a article, which is installed into the ETSO-C146e article, it is systematically also considered to be a major change for the ETSO-C146e function.

2.2.3 — Assessment and Reporting of Open Problem Reports (OPRs)

The applicant shall perform the assessment of the ETSO-2C205a CCA OPRs. The applicant shall report the resulting OPRs that affect the ETSO-C146e article.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~provided for functional equipment Class Gamma or Delta in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December ~~15,~~ 2016, Section 2, ~~except~~ as modified by Appendix 2 and 4 of this ETSO.

Classes Gamma and Delta of equipment are defined in DO-229E, Section 1.4.

The test procedures are defined in DO-229E, Section 2.5.

The standards in this ETSO apply to equipment intended to accept a desired flight path and provide deviation commands keyed to that path. Pilots and autopilots will use these deviations to guide the aircraft. Except for automatic dependent surveillance with Class Gamma, these ETSO standards do not address integration issues with other avionics.

Use of an ETSO-2C205a Class Delta CCA functional sensor

Applicants for Class Delta-4 ETSO-146e have the option to use an ETSO-2C205a Delta-4 CCA functional sensor. Applicants who choose to use an ETSO-2C205a Delta-4 CCA can take credit for certification compliance by virtue of the ETSO-2C205a ETSOA for:

— meeting the Class Delta-4 MPS requirements in Sections 2.1.1, 2.1.5, and 2.3;

— the development assurance of the hardware/software;

— the classification of failure conditions;

— the MPS Section 2.5 performance testing (functional qualification), except that specified in Appendix 1 of this document; and

— the partial environmental testing performed on the ETSO-2C205a CCA.

After the integration of the ETSO-2C205a CCA into the ETSO-146e article, the applicant shall perform the testing described in Appendix 1. The applicant shall also complete the environmental qualification testing. The testing shall include the detailed functional test procedures delivered by the ETSO-2C205a CCA provider. This testing is required to address the paragraphs of this ETSO that are not covered by the items listed above.

Note: An end-use manufacturer that uses an ETSO-2C205a SBAS CCA functional sensor assumes full responsibility for the design and its function under their ETSO-C146e authorisation.

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3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1. The required performance under test conditions is defined in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December~~15,~~ 2016, Section 2.4.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

Applicants who use an ETSO-2C205a Class Delta CCA functional sensor may use the ETSO-2C205a authorisation as substantiation for compliance with the software development assurance aspects of the CCA.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

Applicants who use an ETSO-2C205a Class Delta CCA functional sensor may use the ETSO-2C205a authorisation as substantiation for compliance with the hardware development assurance aspects of the CCA.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

Failure of the function defined in paragraph 3.1.1 of this ETSO is a:

— major failure condition for a loss of function ~~and~~ or malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data,

— major failure condition for a loss of function of approach localiser performance without vertical guidance (LP), and of approach localiser performance with vertical guidance (LPV) position data, and

— hazardous failure condition for a malfunction of approach (LP and LPV) position data ~~resulting in misleading~~ that results in misleading information.

Note: These failure condition classifications are considered to be the minimum classifications. Guidance for the installation of navigation systems at the aircraft level (e.g. Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS-ACNS)) could require different failure condition classifications.

3.2.2 — Additional Specific

If the equipment can satisfy the requirements of RTCA~~/~~ DO-229E only when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation. This requirement shall be included in the installation manual ~~(IM)~~ as a limitation.

Applicants shall have all the data necessary to evaluate the geostationary (GEO) satellite bias as defined in RTCA~~/~~ DO-229E, Section 2.1.4.1.5, available for review by EASA.

If the equipment uses barometric-aiding to enhance ~~FDE availability~~ the availability of FDE, then the equipment shall meet the requirements in RTCA~~/~~ DO-229E, Appendix G.

~~**3.3. - Functional Qualifications.**~~

~~None~~

4 — Marking

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4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

At least one major component shall be permanently and legibly marked with the operational equipment class as defined in Section 1.4.2 of RTCA document DO-229E (e.g.~~,~~ Class 2). A marking of Class 4 indicates compliance with the Delta-4 requirements. The functional equipment class defined in Section 1.4.1 of RTCA document DO-229E (e.g. Gamma, Delta) is not required to be marked.

It is sufficient to declare the proper functional equipment class in the declaration of design and performance (DDP)).

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

~~Reserved~~

END-USE EQUIPMENT MANUFACTURER TESTS AFTER INTEGRATION OF DELTA CCA FUNCTIONAL SENSORS USED FOR NAVIGATION APPLICATIONS

1 — Scope.

This Appendix describes the required supplementary equipment level testing, in addition to the environmental testing of RTCA DO-229E, Section 2.4, that the manufacturer of end-use equipment is required to conduct to receive an ETSO-C146e Class Delta-4 authorisation when using an ETSO-2C205a Delta CCA functional sensor.

To perform functional tests and to measure the performance in the environment, the applicant will use the detailed functional test procedures delivered with the ETSO-2C205a CCA. These test procedures are intended to streamline and simplify the ETSO-C146e authorisation process for the manufacturer of the end-use equipment by allowing credit for the design and for selected testing performed at the Delta CCA functional sensor level. However, the manufacturer of the end-use equipment remains fully responsible for the design and control of the article per their ETSO-C146e ETSOA.

2 — General principles.

(a) Testing methods for GPS/SBAS equipment have been standardised by RTCA DO-229E, and serve as the basis for ETSO-C146e. RTCA DO-229E was written to cover equipment that can be installed on aircraft. Section 2.4 specifically addresses the issues of the environment in which the equipment operates, and provides the approved test methods to validate its performance in this environment. Section 2.4 represents the RTCA consensus in identifying which RTCA DO-229E requirements are sensitive to environmental effects. These requirements are listed in the environmental tables referenced in Section 2.4.1.

(b) The determination that an MOPS requirement is susceptible to the environment does not depend on whether or not the implementation is a CCA installed within ETSO-C146 article. This is the same concept as an equipment enclosure that is designed to protect against a benign environment compared with one designed for a severe environment; the identification of the susceptible requirements is the same.

(c) Therefore, this Appendix uses the tables of RTCA DO-229E, Section 2.4.1, to identify the MOPS requirements that are susceptible to environmental conditions for a Delta CCA functional sensor in the end-use equipment. The focus is on the change in environment seen by the Delta CCA functional sensor as a result of its installation in the end-use equipment. For example, other components inside the end-use equipment may radiate RF energy that could interfere with the GPS functions; therefore, the ambient testing performed at the CCA level is not equivalent to tests performed in the end-use equipment. This is the basis for defining the RTCA DO-229E Section 2.5 performance tests that need to be repeated by the manufacturer of the end-use equipment.

(d) The Class Delta-4 environmental table referenced in RTCA DO-229E, Section 2.4.1, is the prime source to determine the MOPS performance requirements that are susceptible to environmental conditions. Based on that table, Class Delta-4 has the same susceptible requirements as Class Beta, but adds two additional requirements for navigation displays and databases that are optional capabilities for Class Delta-4. Those Delta-4 requirements that are similar to those for Class Beta can be grouped in two categories: those that are susceptible to most types of environmental conditions (described in Section 3) and those that are susceptible to only a few (described in Section 4).

(e) The options for databases and navigation displays in Delta-4 equipment do not present any repeat MOPS testing requirements for a manufacturer who incorporates an ETSO-2C205a Delta CCA functional sensor in its ETSO-C146e article. The environmental qualification performed by the end-use equipment manufacturer according to ETSO-C146e is sufficient. The rationale is stated below.

(1) The database requirement testing in the environment is meant to ensure that the database storage hardware, which may be separate, is fully functional during the environmental testing. As the pass criterion for such testing is that the retrieved data is correct, the test procedures in the environment are as sensitive to hardware issues as any ambient environment test. Therefore, nothing justifies repeating the tests under ambient conditions in the end-use equipment.

(2) Manufacturers of end-use equipment that includes a database must perform the environmental qualification specified by ETSO-C146e and MOPS Section 2.4 irrespective of whether the database is hosted in the Delta CCA functional sensor or elsewhere in the equipment.

(3) It is impossible for the Delta CCA functional sensor to incorporate a display or to be a display.

3 — Performance requirements that are susceptible to most environmental conditions.

The RTCA DO-229E requirements for accuracy (Section 2.1.5.1), and sensitivity and dynamic range (Section 2.1.1.10) are sensitive to most environmental conditions. However, these requirements are linked to the message loss rate requirement in Section 2.1.1.3.2. Sections 3.1 and 3.2 below identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the Delta CCA functional sensor continues to meet the accuracy, dynamic range and message loss rate performance requirements after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.

3.1 — RTCA DO-229E- 2.5.8 Accuracy Test.

(a) The accuracy test described in Section 2.5.8 is actually a joint test that covers accuracy, sensitivity and dynamic range. This joint testing also applies in the environment as stated in Section 2.4.1.1.5, with the environmental adaptations as described in Section 2.4.1.1.1.

(b) The demonstration of accuracy is performed in accordance with Section 2.5.8.1 only for the test case with broadband external interference noise. This test must be repeated when the CCA is installed in the end-use equipment, and it is sufficient to perform it using broadband interference.

(1) The environmental testing is limited to broadband interference, as it represents the worst-case signal-to-noise condition, which is the most sensitive to environmental effects. This applies equally to the environment for the CCA that is created by the end-use equipment.

(2) Section 2.5.8 contains a measurement accuracy test in Section 2.5.8.1, with the detailed test procedure in Section 2.5.8.2. The Section 2.5.8.1 test must be run under the worst-case environment identified in the section on 'Additional considerations for internal interference sources' below. The measurement accuracy testing can be combined with the message loss rate testing in Section 2.5.2.1.

(3) Section 2.5.8.3 is a 24-hour actual satellite accuracy test. The Section 2.5.8.3 test exposes the equipment to a variety of signal conditions and data-processing conditions over varying

satellite geometries that will increase the confidence that no unforeseen interactions between the components within the end-use equipment and the Delta CCA functional sensor will go undetected. The 24-hour testing in Section 2.5.8.3 can be combined with the 24-hour message loss rate testing in Section 2.5.2.4 (see the section on additional considerations for internal interference sources).

(4) Section 2.5.8.4 (SBAS Tracking Bias) is an analysis of the GPS hardware, and it is therefore not necessary to repeat it at the end-use equipment level provided that no extra RF components that affect the RF filtering response are inserted into the RF path. Otherwise, the manufacturer of the end-use equipment must also repeat the SBAS Tracking Bias test.

(c) The test threshold is relaxed from 110 to 125 % as specified in Table 2-25 of the Section 2.5.8.2.1 test procedure to shorten the duration of the test. However, the Section 2.5.8 testing (excluding the SBAS Tracking Bias test in 2.5.8.4) for the CCA in the end-use equipment shall be under ambient conditions per Section 2.5, with the 110-% test pass threshold for maximum test sensitivity.

(d) The Section 2.5.8 testing (excluding the SBAS Tracking Bias test in Section 2.5.8.4) should be repeated against the accuracy requirement in Section 2.1.5.1.

(e) Only the test case for broadband external interference noise using minimum satellite power will be executed in most cases to shorten the duration of the test. The Section 2.5.8.1 testing will be repeated for both the minimum and the maximum satellite power only for the worst-case environment.

3.2 — RTCA DO-229E - 2.5.2 Message Loss Rate Test.

(a) Section 2.5.2 specifies the message loss rate test for the 2.1.1.3.2 message loss rate requirement. This test is conducted in conjunction with the Section 2.5.8 accuracy testing. Section 2.5.2.2 defines the test procedure to collect data that verifies the SBAS message loss rate in the presence of interference using the test cases in which the SBAS satellite is at minimum power. Section 2.5.2.3 defines the pass-fail criteria.

(b) The test in Section 2.5.2.2 will be performed during the measurement accuracy broadband interference test case described in paragraph 3.1.

(c) The test procedure in Section 2.5.2.4.1 is run in conjunction with the 2.5.8.3 24-hour accuracy test. Section 2.5.2.4.2 defines the pass-fail criteria for the test case described in paragraph 3.1(b)(3).

4 — Performance Requirements Partially Susceptible to Environmental Conditions.

(a) The Class Delta-4 Table 2-20 in Section 2.4.1 of RTCA DO-229E indicates that the requirements for initial acquisition time (2.1.1.7) and satellite reacquisition time (2.1.1.9) are sensitive to four environmental conditions: icing; lightning-induced transient susceptibility; lightning direct effects; and normal/abnormal operating conditions. The requirements for loss of navigation (Sections 2.1.1.13.2, 2.1.5.12.2, and 2.3.6.2) are sensitive to low and high operating temperatures.

Note: Class Delta-4 provides deviation guidance only during the final approach segment of an LP/LPV approach, in which a loss of integrity is treated as a loss of navigation capability.

(b) The lightning-induced transient susceptibility, lightning direct effects or icing environmental conditions are not pertinent to the environment created by the end-use equipment relative to the Delta CCA functional sensor. However, the manufacturer of the end-use equipment remains responsible for meeting the overall environmental qualification at the end-use equipment level.

(c) Loss of navigation indications are limited to temperature testing, and the information in RTCA DO-229E, Sections 2.4.1.1.2 and 2.4.1.1.3, is appropriate. The purpose is to ensure that the interface that is used to indicate the loss of navigation is functional under the environmental conditions that are present after the Delta CCA functional sensor is installed in the end-use equipment. Sections 2.4.1.1.2 and 2.4.1.1.3 indicate that any source that generates the indication can be used, since it is the interface, and not the detection mechanism, that is verified. The temperature testing performed at the end-use equipment level is the worst-case scenario. It is not necessary to repeat the CCA level test at room temperature in the end-use equipment since the environmental qualification adequately addresses testing for these requirements.

Note: The Class Delta table requires more than just temperature testing under environment to support the optional display component of Class Delta. Since a CCA cannot be a display or incorporate a display, the additional testing in the environment does not apply.

(d) EUROCAE ED-14 Section 16 relates to aircraft power supplies (refer to ETSO paragraph 3.1.2 for the environmental qualification requirements). Sections 16.5.1.2 and 16.6.1.2 are for supply voltage modulation (AC)/ripple (DC). Given the potential susceptibility of the Delta CCA functional sensor to power supply noise, it is prudent to repeat the tests at the end-use equipment level on this basis.

(e) Sections 4.1 and 4.2 identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the Delta CCA functional sensor continues to meet the acquisition time and reacquisition time performance requirements relative to the normal/abnormal operating conditions after installation in the end-use equipment.

All tests shall be run under conditions where the functions of the end-use equipment are fully enabled to create the worst-case environment.

4.1 — RTCA DO-229E - 2.5.4 Initial acquisition test procedures.

The information in RTCA DO-229E, Section 2.4.1.1.4, on the initial acquisition test in Section 2.5.4 applies. The manufacturer of the end-use equipment shall repeat the initial acquisition testing described in RTCA DO-229E, Section 2.5.4.

4.2 — RTCA DO-229E - 2.5.6 Satellite reacquisition time test.

The manufacturer of the end-use equipment is required to repeat the satellite reacquisition time testing in RTCA DO-229E, Section 2.5.6.

5 — Additional considerations for internal interference sources.

(a) Installing a Delta CCA functional sensor into end-use equipment that also includes other functions requires a careful evaluation of the potential internally radiated and conducted interference. The manufacturer of the end-use equipment must evaluate each operating mode to determine whether the mode changes the environment for the installed Delta CCA functional sensor. If there is only one environment or there is clearly one worst-case environment, then the accuracy and message loss rate testing in Section 3 can be run in that operating mode only. For example, if the end-use equipment includes an RF transmitter that radiates at one frequency, one could reasonably argue that setting the transmitter at full power with maximum data throughput would generate a clear worst-case environment in which to run all the testing.

(b) In the case of multiple environments, the accuracy and message loss rate tests can either be run under each environment or the methodology in RTCA DO-229E, Section 2.4.1.2.3, can be used to run an aggregate test with approximately equal time in each mode. The methodology in Section 2.4.1.2.3 must be used to identify the modes with the greatest susceptibility under which the combined accuracy and message loss rate tests are repeated in addition to the aggregate test. For example, the methodology of Section 2.4.1.2.3 is appropriate for end-use equipment that contains a high power transmitter that operates on a large number of frequencies such that it is impractical to run a test at each frequency. This is analogous to the large number of frequencies that need to be tested during the EUROCAE ED-14 RF and Induced Signal Susceptibility testing, and this is the reason why the methodology of Section 2.4.1.2.3 was developed.

(c) It is sufficient to identify one worst-case environment when performing the acquisition and 24-hour accuracy testing.

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6 — Summary.

(a) The manufacturer of the end-use equipment that incorporates a Delta CCA functional sensor is required to repeat the following RTCA DO-229E Section 2.5 testing under ambient conditions (see Section 5) after installing the Delta CCA functional sensor in the end-use equipment:

— The Section 2.5.8 Accuracy testing (excluding the SBAS Tracking Bias test in 2.5.8.4) adapted per Section 2.4.1.1.1, except that the 110-% test pass threshold is used.

Note: Excluding the SBAS Tracking Bias test is acceptable, provided that the end-use equipment does not insert into the RF signal path any components that affect the filtering response. Otherwise, the manufacturer of the end-use equipment must also repeat the SBAS Tracking Bias test.

— The Section 2.5.2 message loss rate test.

— The Section 2.5.4 initial acquisition test.

— The Section 2.5.6 satellite reacquisition time test.

(b) The manufacturer of the end-use equipment remains responsible for completing a full environmental qualification evaluation (see ETSO Section 3.1.2) at the end-use equipment level. The manufacturer of end-use equipment that incorporates a Delta CCA functional sensor is required to repeat the loss of navigation indication and loss of integrity indication testing as part of the environmental qualification according to RTCA DO-229E, Sections 2.4.1.1.2 and 2.4.1.1.3.

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APPENDIX 2

MPS FOR STAND-ALONE AIRBORNE NAVIGATION EQUIPMENT USING GPS AUGMENTED BY SBAS

This Appendix describes required modifications and additions to RTCA/ DO-229E for compliance with this ETSO. This Appendix adds a new Section 1.8.3 on cybersecurity and GPS spoofing mitigation, and additional required leg types in Section 2.2.1.3 of ~~to~~ RTCA/ DO-229E.

The new Section, 1.8.3, contains no new requirements, but provides information for cybersecurity and spoofing mitigation to make RTCA/ DO-229E consistent with the new RTCA MOPS template and RTCA/ DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment.

The new 2.2.1.3 leg type requirements are applicable to Class Gamma equipment only and are necessary to properly execute published instrument procedures designed to provide maximum efficiency, flexibility, and aircraft eligibility. These instrument procedure designs may include RNAV components and/or leg types associated with conventional procedures. The modifications and additions to Section 2.2.1.3 are necessary to ensure Class Gamma equipment can properly execute current and future instrument procedure designs.

1.8.3 Cybersecurity and GPS Spoofing Mitigation.

This section contains information to address intentional interference with the GPS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive a receiver's operation when they are processed. Spoofing may be unintentional, such as effects from the signals of a GPS repeater, or may be intentional and even malicious. There are two classes of spoofing. Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of time of arrival or frequency of arrival or their rates of change. Data spoofing introduces incorrect digital data to the target receiver for its use in processing of signals and the calculation of PNT. Either class of spoofing can cause a range of effects, from incorrect outputs of PNT to receiver malfunctions. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or installed GNSS re-radiators act like spoofers. Re-radiators, replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognise and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GPS equipment can be found in the U.S. Department of Homeland Security document 'Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure'[13] and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003 28 July 2016.

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 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to

[13] https://ics-cert.us-cert.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_(GPS)_Equipment_Used_by_Critical_Infrastructure_S508C.pdf

navigation receivers has been controlled such that they are considered to be vulnerable only through RF signals and OEM and/or aircraft operator controlled processes for maintenance and update. In some cases, aircraft GNSS receivers may be field loadable by approved personnel, requiring physical access and physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. 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 'authorised 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' connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit input of ~~externally-supplied~~ externally supplied data into aircraft systems. A manufacturer may expose aircraft information ~~vulnerability~~ vulnerabilities ~~through equipment design~~ through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important ~~that~~ for manufacturers to 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 the MOPS, it is recommended that manufacturers ~~look at~~ consider 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, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering~~;~~ — although navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer ~~is outsourcing~~ outsources the development of software code ~~development~~, ~~is~~ are the contractor and its staff properly vetted?

Civil ~~A~~aviation ~~A~~authorities (CAAs) have a regulatory interest when an applicant's design makes use of a non-trusted connection through which ~~connectivity where~~ the installation can potentially introduce aircraft information security vulnerabilities. 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~~ vulnerabilities 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 of the equipment so that the applicant can consider them in meeting the ~~installation~~ regulatory requirements of the installation.

2.2.1.3 Path Definition

Replace the list of required leg types in the first paragraph after the last sentence as shown:

The desired path shall be defined according to the following leg types:

Leg Type	**Description**
IF	Initial Fix
CF	Course to Fix leg
DF	Direct to Fix leg

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Leg Type	Description
TF	Track to Fix leg
FA	Fix to Altitude leg
FM	Fix to Manual Termination
VA	Heading to Altitude leg
VI	Heading to Intercept
VM	Heading to Manual Termination
CA	Course to Altitude Leg

Holding legs

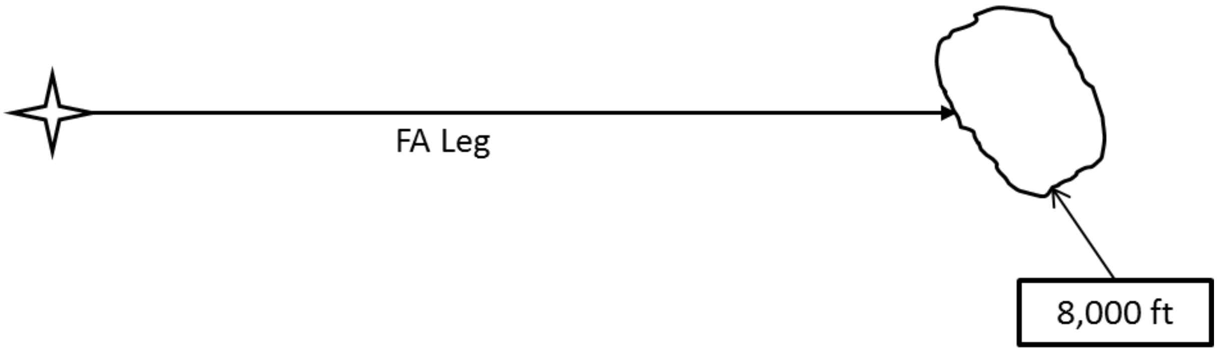
Leg Type	Description
HA	Terminates at an altitude
HF	Terminates at a fix after one orbit
HM	Manual termination

Note: There is no intent to require a heading or altitude source connected to the equipment to automatically execute leg types with heading or altitude components. Manual equipment inputs for heading/altitude with manual aircraft control methods are acceptable for these leg types.

Replace Section 2.2.1.3.6 as shown and add the following leg type descriptions. ~~Re-number~~Renumber existing paragraphs (starting with 2.2.1.3.7) to account for the newly added sections:

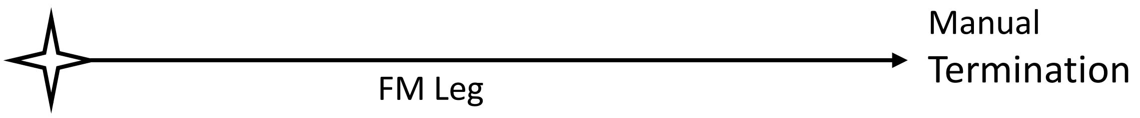
2.2.1.3.6 Fix to Altitude (FA).

An FA leg shall be defined as a specified track over the ground from a database waypoint to a specified altitude at an unspecified position.



2.2.1.3.7 Fix to Manual Termination (FM).

An FM leg shall be defined as a specified track over the ground from a database fix until a manual termination of the leg.



2.2.1.3.8 Heading to Altitude (VA).

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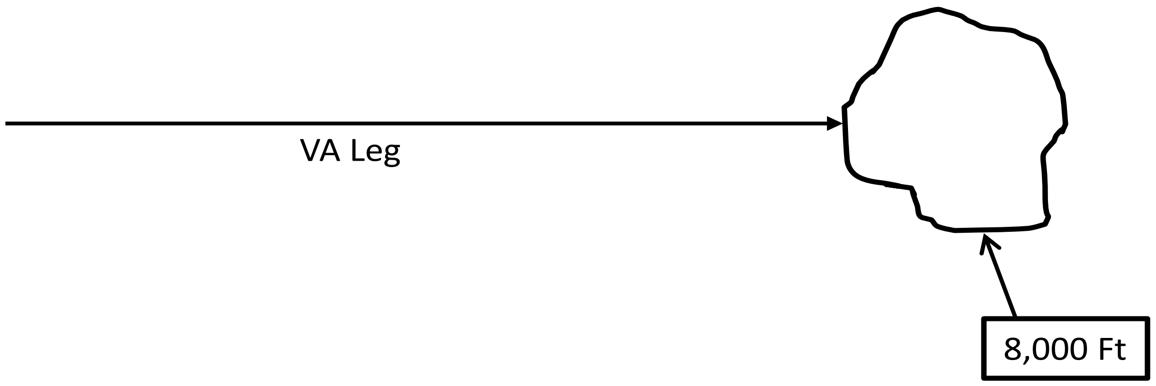
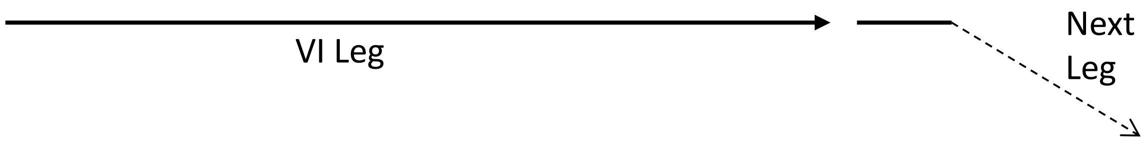
A VA leg shall be defined as a specified heading to a specific altitude termination at an unspecified position. No correction is made for wind.



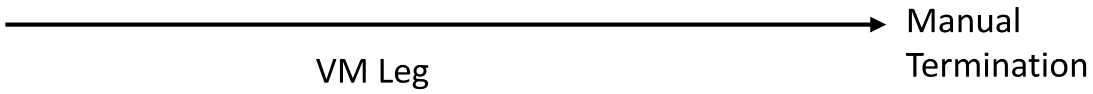
2.2.1.3.9 Heading to Intercept (VI).

A VI leg shall be defined as a specified heading to intercept a subsequent leg at an unspecified position. No correction is made for wind.



2.2.1.3.10 Heading to Manual Termination (VM).

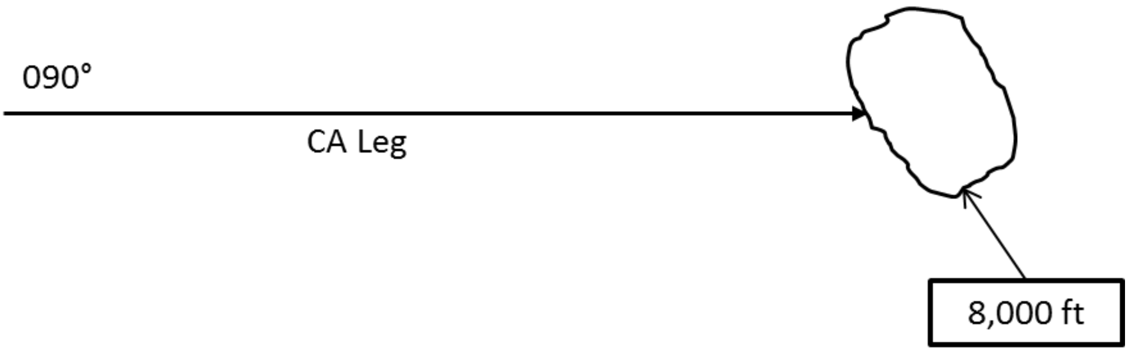
A VM leg shall be defined as a specified heading until a manual termination of the leg. No correction is made for wind.



[…]

2.2.1.3.12 Course to Altitude (CA).

A CA leg shall be defined as a specified course to a specific altitude at an unspecified position. The course is flown making adjustment for wind.


090°
CA Leg
8,000 ft

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2.2.1.3.13 Hold to Altitude (HA).

An HA leg is a holding pattern which terminates at the next crossing of the hold fix when the aircraft altitude is at or above the specified altitude. The altitude is provided by the navigation database. The source of the magnetic variation needed to convert magnetic courses to true courses is detailed in Section 2.2.1.3.12.

2.2.1.3.14 Hold to Fix (HF).

An HF leg is a holding pattern which terminates at the first crossing of the hold fix after becoming established on the inbound course. This is typically after the entry procedure is performed. The source of the magnetic variation needed to convert magnetic courses to true courses is detailed in Section 2.2.1.3.12.

2.2.1.3.14 Hold for Clearance (manual termination) (HM).

An HM leg is a holding pattern which terminates only after flight crew action. The source of the magnetic variation needed to convert magnetic courses to true courses is detailed in Section 2.2.1.3.12.

Table 2-14 through Table 2-20.

The tables incorrectly reference and label RTCA~~/~~ DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding ~~'~~'2.1.1.7 Acquisition Time' and ~~'~~'2.1.1.9 Reacquisition Time~~.~~'. Change the table references as follows:

The MOPS Initial Acquisition Time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (DO-160~~E~~ Sections 16.5.2 and 16.6.2) and the ~~Satellite Reacquisition Time~~ satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (DO-160~~E~~ Sections 16.5.1 and 16.6.1).

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APPENDIX 3

Reserved.

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APPENDIX 4

This Appendix prescribes EASA modifications to RTCA document DO-229E, Section 2.

At Section 2.1.1.2, after the first sentence, add the following:

> 'The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II of IS-GPS-200D, ~~'~~"Navstar GPS Space Segment/Navigation User Interfaces"~~'~~, December 2004 provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising~~utilizing~~ the coarse/acquisition (C/A) code.'

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and no CNAV data, which is defined in Appendix III of IS-GPS-200D, is used, for which the SBAS does not provide integrity.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)

1 — Applicability

This ETSO provides the requirements which Terrain Awareness and Warning Systems (TAWS) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~provided in ~~the~~RTCA DO-367, Minimum Operational Performance Standard (MOPS) for Terrain Awareness and Warning Systems (TAWS) Airborne Equipment, Section 2, dated 31 May 2017. Requirements for Class A, Class B and Class C equipment are provided in RTCA DO-367 Sections 2.2.1, 2.2.2 and 2.2.3 respectively and amended as follows:

In Section 2.2.1.1.6.3.1 Aural Alert — Caution

The sentence *'For a caution level FLTA alert clue to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_051) be capable of generating or triggering an aural message of at least one of 'Terrain Ahead' and 'Caution Terrain'. The requirement does not imply that Class A Equipment must be able to support both aural messages, although it is permissible for Class A Equipment to support both messages.'*

should be replaced by

'For a caution level FLTA alert clue to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_051) be capable of generating or triggering both types of aural messages: ~~at least one of~~ 'Terrain Ahead' and 'Caution Terrain'.

~~The requirement does not imply that Class A Equipment must be able to support both these aural messages, although it is permissible for Class A Equipment to support both messages.~~

[…]

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In Section 2.2.1.1.6.3.2 Aural Alert — Warning

The sentence *'For a warning level FLTA alert due to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_053) be capable of generating or triggering an aural message of at least one of 'Terrain Ahead. Pull up' and 'Terrain. Terrain, Pull up'.*

'The requirement does not imply that Class A Equipment must be able to support both aural messages. although it is permissible for Class A Equipment to support both messages.'

should be replaced by

'For a warning level FLTA alert due to a predicted terrain conflict, Class A Equipment shall (TAWS_MOPS_053) be capable of generating or triggering both types of aural messages: of ~~at least one of~~ 'Terrain Ahead. Pull up' and 'Terrain. Terrain, Pull up'.

~~'The requirement does not imply that Class A Equipment must be able to support both these aural messages. although it is permissible for Class A Equipment to support both messages.'~~

~~attached Appendix 1 'Minimum Performance Standard for a Terrain Awareness and Warning System for Classes A and B' and in Appendix 3 'Minimum Performance Standard for a Terrain Awareness and Warning System for Class C'.~~

This equipment is intended for fixed-wing aircraft only.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — ~~Computer~~ Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware ~~Qualification~~

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

None.

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4. For Class A and B ETSO articles, a ~~F~~failure of the function defined in paragraph 3.1.1 due to a TAWS computer malfunction resulting in false terrain warnings, an ~~un-annunciated~~ unannunciated loss of function, or the presentation of hazardously misleading information ~~as defined in paragraph 2.12 of Appendix 1~~ is a major failure condition.

For Class C ETSO articles, a failure of the function defined in paragraph 3.1.1 due to a TAWS computer malfunction resulting in false terrain warnings, an unannunciated loss of function, or the presentation of hazardously misleading information is a minor failure condition.

A ~~L~~loss of the function defined in paragraph 3.1.1 is a minor failure condition.

Note: Hazardously misleading information is defined as an incorrect depiction of the terrain threat relative to the aeroplane during an alert condition.

3.2.2 — ~~Functional Qualifications~~Operating Instructions

Operating instructions and article limitations that are sufficient to describe the operational capability of the equipment, including the coverage of the database (geographical areas and airport characteristics), should be documented and made available to the user. The operating instructions must include information on the effects of a loss of GNSS on the TAWS function if the TAWS relies on the GPS. Additionally, the instructions must contain processes for updating the terrain database.~~The required performance shall be demonstrated under the test conditions specified in Appendix 2 of this ETSO for Class A and B equipment, or Appendix 3 of this ETSO for Class C equipment.~~

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4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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~~APPENDIX 1~~

~~MINIMUM PERFORMANCE STANDARD FOR A TERRAIN AWARENESS AND WARNING SYSTEM FOR CLASSES A AND B~~

~~1.0 INTRODUCTION~~

~~**1.1 PURPOSE.** This standard provides the MPS for a Terrain Awareness and Warning System (TAWS).~~

~~**1.2 SCOPE.** This Appendix sets forth the standard for two classes of TAWS equipment: Class A and Class B.~~

~~**1.3 SYSTEM FUNCTION AND OVERVIEW.** The system must provide the flight crew with sufficient information and appropriate alerts to detect a potentially hazardous terrain situation that, in turn, prevents a CFIT event. The basic TAWS functions for all TAWS systems approved under this ETSO include the following:~~

~~**a.** A forward looking terrain avoidance (FLTA) function. The FLTA function looks ahead of the aeroplane along and below the aeroplane's lateral and vertical flight path and provides suitable alerts if a potential CFIT threat exists.~~

~~**b.** A premature descent alert (PDA) function. The PDA function of the TAWS uses the aeroplane's current position and flight path information, as determined from a suitable navigation source and airport database, to determine if the aeroplane is hazardously below the normal (typically three-degree) approach path for the nearest runway as defined by the alerting algorithm.~~

~~**c.** An appropriate visual and aural discrete signal for both caution and warning alerts.~~

~~**d.** Class A TAWS equipment must provide terrain information, which is presented on a display system.~~

~~**e.** Class A TAWS equipment must provide indications of imminent contact with the ground for the following conditions as further defined in RCTA/DO-161A, Minimum Performance Standards -Airborne Ground Proximity Warning Equipment, dated May 27, 1976, and section 3.3 of this Appendix. Deviations from RTCA/DO-161A are acceptable providing the nuisance alert rate is minimised, the deviation is approved under the provision of Part-21, 21.A.610, and an equivalent level of safety for the following conditions is provided.~~

- ~~**Mode 1:** Excessive rates of descent~~
- ~~**Mode 2:** Excessive closure rate to terrain~~
- ~~**Mode 3:** Negative climb rate or altitude loss after takeoff~~
- ~~**Mode 4:** Flight into terrain when not in landing configuration~~
- ~~**Mode 5:** Excessive downward deviation from an Instrument Landing System (ILS) glideslope, Localizer Performance and Vertical Guidance (LPV), or Global Navigation Satellite System (GNSS) Landing System (GLS) glidepath.~~

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~~**Note:** RTCA/DO-161A glideslope requirements are incorporated for GLS and LPV glidepaths for TAWS Class A systems, reference paragraph 3.3f. It is desirable to provide a glidepath/glideslope warning function on any approach with vertical guidance.~~

~~— **Altitude Callout:** A voice callout ('Five Hundred') when the aeroplane descends to 500 feet above terrain or nearest runway elevation. All TAWS equipment must provide a 500 foot voice call out.~~

~~**Note:** The altitude callout is not defined in RTCA/DO-161A but is a requirement for the TAWS system. The altitude callout requirements are defined in paragraph **3.3.c.** of this Appendix.~~

~~**f.** Class B equipment basic TAWS functions include functions listed in paragraphs 1.3.a through 1.3.c and it must provide indications of imminent contact with the ground during the following aeroplane operations as defined in paragraph **3.4** of this Appendix:~~

~~— **Mode 1:** Excessive rates of descent~~

~~— **Mode 3:** Negative climb rate or altitude loss after takeoff~~

~~— **Altitude Callout:** A voice callout ('Five Hundred') when the aeroplane descends to 500 feet above the nearest runway elevation. All TAWS equipment must provide the 500 foot voice call out.~~

~~**1.4 ADDED FEATURES.** If the manufacturer elects to add features to the TAWS equipment, those features must at least meet the same qualification testing, software verification, and validation requirements as provided under this ETSO. Additional information, such as human-made obstacles, may be added as long as they do not adversely alter the terrain functions.~~

~~**1.5 OTHER TECHNOLOGIES.** Although this ETSO envisions a TAWS based on the use of on-board terrain and airport databases, other technologies such as the use of radar are not excluded. Other concepts and technologies may be approved under this ETSO's provisions for non-ETSO functionality.~~

~~**2.0 DEFINITIONS**~~

~~**2.1 Advisory Alerts.** The level or category of alert for conditions that require flight crew awareness and may require subsequent flight crew response.~~

~~**2.2 Alert.** A visual, aural, or tactile stimulus presented to attract attention and convey information regarding system status or condition.~~

~~**2.3 Aural Alert.** A discrete sound, tone, or verbal statement used to annunciate a condition, situation, or event.~~

~~**2.4 Caution Alert**. The level or category of alert for conditions that require immediate flight crew awareness and subsequent flight crew response.~~

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~~**2.5 Controlled Flight Into Terrain (CFIT).** An accident or incident in which an aircraft, under the full control of the pilot, is flown into terrain, obstacles, or water.~~

~~**2.6 Failure.** The inability of the equipment or any sub-part of that equipment to perform within previously specified limits.~~

~~**2.7 False Alert.** An inappropriate alert that occurs as result of a failure within the TAWS or when the design alerting thresholds of the TAWS are not exceeded.~~

~~**2.8 Forward-Looking Terrain Avoidance (FLTA).** Looks ahead of the aeroplane along and below the aeroplane's lateral and vertical flight path and provides suitable alerts if a potential CFIT exists.~~

~~**2.9 Global Navigation Satellite System (GNSS).** A world-wide position, velocity, and time determination system that includes one or more satellite constellations, receivers, and system integrity monitoring, augmented as necessary to support the required navigation performance for the actual phase of operation.~~

~~**2.10 Ground-Based Augmentation System (GBAS) Landing System (GLS).** GLS provides precision navigation guidance for exact alignment and descent of aircraft on approach to a runway. GLS uses the Ground Based Augmentation System (GBAS) to augment the Global Navigation Satellite System(s) and to provide locally relevant information to the aircraft, including the definition of the approach path.~~

~~**2.11 Hazard.** A state or set of conditions that together with other conditions in the environment can lead to an accident.~~

~~**2.12 Hazardously Misleading Information (HMI).** An incorrect depiction of the terrain threat relative to the aeroplane during an alert condition (excluding source data).~~

~~**2.13 Localizer Performance with Vertical Guidance (LPV).** A wide area augmentation system (WAAS) approach that provides vertical guidance to as low as 200 feet above ground level (AGL).~~

~~**2.14 Nuisance Alert.** An inappropriate alert, occurring during normal safe procedures, which is the result of a design performance limitation of TAWS.~~

~~**2.15 Required Obstacle Clearance (ROC).** Required vertical clearance expressed in feet between an aircraft and an obstruction. (Per Order 8260.3B, Change 20)~~

~~**2.16 Search Volume.** A volume of airspace around the aeroplane's current and projected path that is used to define a TAWS alert condition.~~

~~**2.17 Terrain Cell.** A grid of terrain provided by the TAWS database which identifies the highest terrain elevation within a defined geographical area. Terrain cell dimensions and resolution can vary depending on the needs of the TAWS system and availability of data. If a supplier desires, obstacle height can be included in the terrain elevation.~~

~~**2.18 Visual Alert.** The use of projected or displayed information to present a condition, situation, or event.~~

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~~**2.19 Warning Alert.** The level or category of alert for conditions that require immediate flight crew awareness and immediate flight crew response.~~

~~**3.0 REQUIRED TAWS FUNCTIONS**~~

~~**3.1 Class A and Class B Requirements for FLTA.** The majority of CFIT accidents occur because flight crews do not have adequate situational information regarding the terrain in the vicinity of the aeroplane and its projected flight path. Class A and Class B equipment is required to look ahead of the aeroplane, within the design search volume, and provide timely alerts in the event terrain is predicted to penetrate the search volume. The FLTA function should be available during all airborne phases of flight including turning flight. The search volume consists of a computed look ahead distance, a lateral distance on both sides of the aeroplane's flight path, and a specified look down distance based upon the aeroplane's vertical flight path. This search volume should vary as a function of phase flight, distance from runway, and the required obstacle clearance (ROC) in order to perform its intended function and to minimise nuisance alerts. The lateral search volume should expand as necessary to accommodate turning flight. The TAWS search volumes should consider the accuracy of the TAWS navigation source. The TAWS lateral search area should be less than the protected area defined by the United States Standard for Terminal Instrument Procedures (TERPS), FAA Order 8260.3B and International Civil Aviation Organization (ICAO) Procedures for Air Navigation Services — Aircraft Operations (PAN-OPS) 8168, volume 2, in order to prevent nuisance alerts.~~

~~**3.1.1 Reduced Required Terrain Clearance (RTC).** Class A and Class B equipment must provide suitable alerts when the aeroplane is above the terrain in the aeroplane's projected flight path, but the projected amount of terrain clearance is considered unsafe for the particular phase of flight. The required obstacle (terrain) clearance (ROC), as specified in TERPS and the Aeronautical Information Manual (AIM), has been used to define the minimum requirements for obstacle/terrain clearance (ROC) appropriate to the FLTA function. These requirements are specified in Table **3.1.1.** The FLTA function must be tested to verify that the alerting algorithms meet the test conditions specified in Appendix 2, Tables **A, B, C, D, E, and F.**~~

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Table 3.1.1 — TAWS REQUIRED TERRAIN CLEARANCE (RTC) BY PHASE OF FLIGHT

Phase of Flight	TERPS (ROC)	TAWS (RTC) Level Flight	TAWS (RTC) Descending
Enroute	1 000 feet	700 feet	500 feet
Terminal (Intermediate Segment)	500 feet	350 feet	300 feet
Approach	250 feet	150 feet	100 feet
Departure (See Note 1)	48 feet/nautical mile (NM)	100 feet	100 feet

Note 1: During the departure phase of flight, the FLTA function of Class A and B equipment must alert if the aeroplane is projected to be within 100 feet vertically of terrain. However, Class A and Class B equipment should not alert if the aeroplane is projected to be more than 400 feet above the terrain.

Note 2: As an alternate to the stepped-down reduction from the terminal to approach phase as shown in Table 3.1.1, a linear reduction of the RTC as the aircraft comes closer to the nearest runway is allowed, provided the requirements of Table 3.1.1 are met.

Note 3: During the visual segment of a normal instrument approach (typically about 1 NM from the runway threshold), the RTC should be defined/reduced to minimise nuisance alerts. Below a certain altitude or distance from the runway threshold, logic may be incorporated in order to inhibit the FLTA function. Typical operations below minimum descent altitude (MDA), decision altitude (DA), decision height (DH), or the visual descent point (VDP) should not generate nuisance alerts.

Note 4: The specific RTC values are reduced slightly for descending flight conditions to accommodate the dynamic conditions and pilot response times.

3.1.2 Imminent Terrain Impact. Class A and Class B equipment must provide suitable alerts when the aeroplane is below the elevation of a terrain cell along the aeroplane's lateral projected flight path and, based upon the vertical projected flight path, the equipment predicts that the terrain clearance will be less than the value given in the RTC column of Table 3.1.1. See **Appendix 2** for test conditions that must be conducted (Table G).

3.1.3 FLTA Turning Flight. Class A and Class B equipment must provide suitable alerts for the functions specified in paragraphs 3.1.1 and 3.1.2 when the aeroplane is in turning flight.

3.2 Class A and Class B Equipment Requirements for Detection and Alerting for Premature Descent Along the Final Approach Segment. Class A and Class B equipment must provide a suitable alert when it determines that the aeroplane is significantly below the normal approach flight path to a runway. Approximately one-third of all CFIT accidents occur during the final approach phase of flight, when the aeroplane is properly configured for landing and descending at a normal rate. For a variety of reasons, which include poor visibility, night time operations, loss of situational awareness, operating below minimums without adequate visual references, and deviations from the published approach procedures, many aeroplanes have crashed into the ground short of the runway. Detection of this condition and alerting the flight crew is an essential safety requirement of this ETSO, and there are numerous ways to accomplish these overall objectives. Alerting criteria may be based upon height above runway elevation and distance to runway. It may be based upon height above the terrain and distance to runway or other suitable means. This ETSO will not define the surfaces for which alerting is required. Instead, it specifies some general requirements for alerting and some cases when alerting is inappropriate. See Appendix 2, Table **H**, for test requirements.

a. The PDA function must be available for all types of instrument approaches. This includes both straight-in approaches and circling approaches.

b. The TAWS equipment must not generate PDA alerts for normal visual flight rules (VFR) operations in the airport area. Aeroplanes routinely operate at traffic pattern altitudes of 800 feet above field/runway elevation when within 5 NM of the airport.

c. Aeroplanes routinely operate in VFR conditions at 1 000 feet above ground level (AGL) within 10–15 NM of the nearest airport, and these operations must not generate alerts.

d. Aeroplanes routinely operate in the visual segment of a circling approach within 2 NM of the airport/runway of intended landing, with 300 feet of obstacle clearance. Operations at circling minimums must not cause PDA or FLTA alerts.

3.3 Class A Requirements for Ground Proximity Warning System (GPWS) Alerting. In addition to the TAWS FLTA and PDA functions, the equipment must provide the Mode 1 through Mode 5 GPWS functions listed below in accordance with ETSO-C92c and the altitude callout function in accordance with paragraph **3.3.c.** of this Appendix. However, it is essential to retain the independent protective features provided by both the GPWS and FLTA functions. In each case, all of the following modes must be covered. Some GPWS alerting thresholds may be adjusted or modified to be more compatible with the FLTA alerting function and to minimise GPWS nuisance alerts. Modifications to the GPWS requirements require an approved deviation in accordance with Part-21, 21.A.610. The failure of the ETSO-C92c equipment functions, except for power supply failure, input sensor failure, or failure of other common portions of the equipment, must not cause a loss of the FLTA, PDA, or terrain display.

— **Mode 1:** Excessive rate of descent

— **Mode 2:** Excessive closure rate to terrain

— **Mode 3:** Negative climb rate or altitude loss after takeoff

— **Mode 4:** Flight into terrain when not in landing configuration

— **Mode 5:** Excessive downward deviation from an ILS glideslope, LPV, and/or GLS glidepath

— **Altitude Callout:** Five-Hundred-Foot Voice Callout

a. **Flap Alerting Inhibition.** A separate, guarded control may be provided to inhibit Mode 4 alerts based on flaps being other than landing configuration.

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b. **Speed.** Airspeed or groundspeed must be included in the logic that determines basic GPWS alerting time for 'excessive closure rate to terrain' and 'flight into terrain when not in landing configuration' to allow maximum time for the flight crew to react and take corrective action.

c. **Altitude Callouts.** Class A equipment must provide a voice callout of 'five hundred' or equivalent when descending through 500 feet above terrain or 500 feet above the nearest runway elevation during nonprecision approaches, but are recommended for all approaches. Additional altitude callouts, such as 'one hundred' or 'two hundred' are acceptable, but not required. This voice callout will not be made at ascent, for example on a missed approach or departure.

d. **Sweep Tones 'Whoop-Whoop'.** If a two-tone sweep is used to comply with RTCA/DO-161A, paragraph 2.3, the complete cycle of two-tone sweeps plus annunciation may be extended from '1.4' to '2' seconds.

e. **Mode 5 Glidepath Deviation Alerting.** Class A TAWS equipment must provide Mode 5 alerting for localizer performance with vertical guidance (LPV) glidepath and GNSS landing system (GLS) glidepath, as well as the ILS glideslope. The LPV and GLS envelope, deactivation, reactivation, arming, disarming, alert requirements must follow the Mode 5 requirements in RTCA/DO-161A. The FAA recommends that the glidepath aural alert for LPV and GLS approaches say 'glidepath' or equivalent, but the use of 'glideslope' is also acceptable. Follow test guidance in RTCA/DO-161A.

3.4 Class B Requirements for GPWS Alerting

a. Class B equipment must provide alerts for excessive descent rates. The Mode 1 alerting envelope of RTCA/DO-161A was modified to accommodate a larger envelope for both caution and warning alerts. Height above terrain may be determined by using the terrain database elevation and subtracting it from the QNH (corrected) barometric altitude, or GNSS altitude (or equivalent). In addition, since the envelopes are not limited by a radio altitude measurement to a maximum of 2 500 feet AGL, the envelopes are expanded to include higher vertical speeds. The equipment must meet either the requirements provided in Appendix **2**, paragraph **7.0**, or those specified in RTCA/DO-161A.

b. Class B equipment must provide alerts for 'negative climb rate after takeoff or missed approach' or 'altitude loss after takeoff,' as specified in RTCA/DO-161A. The alerting envelopes are identical to the Mode 3 alerting envelopes in RTCA/DO-161A. Height above terrain may be determined by comparison of aircraft altitude (GNSS or barometric) with runway threshold elevation or by radio altimeter.

c. This feature also has an important CFIT protection function. In the event the aeroplane is operated unintentionally close to terrain when not in the airport area or the area for which PDA protection is provided, this voice callout will alert the flight crew to hazardous conditions. The equipment must meet the requirements specified in Appendix **2**, section **9.0**. Class B TAWS equipment must provide a 500 foot voice call–out when descending through 500 feet above the runway threshold elevation for landing. This feature is primarily intended to provide situational awareness to the flight crew when the aeroplane is being operated properly, per normal procedures. During a normal approach, it is useful to provide the flight crew with a voice callout at 500 feet, relative to the runway threshold elevation for the runway of intended landing. The Class B TAWS equipment must also provide a 500 foot voice call out above terrain when not landing. This 500-foot voice call-out above terrain when not landing is an important CFIT protection function. In the event the aeroplane is operated unintentionally close to terrain when not in the airport area or the area for which PDA protection is provided, this voice callout will indicate hazardous conditions to the flight crew.

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~~**3.5 Class A Equipment Requirements for a Terrain Display.** Class A equipment must be designed to interface with a colour terrain display, and may be designed to also interface to a monochromatic terrain display. Class A equipment for TAWS must also be capable of providing the following terrain-related information to a display system:~~

~~**a.** The terrain must be depicted relative to the aeroplane's position such that the pilot can estimate the relative bearing to the terrain of interest.~~

~~**b.** The terrain must be depicted relative to the aeroplane's position such that the pilot may estimate the distance to the terrain of interest.~~

~~**c.** The terrain depicted must be oriented to either the heading or the track of the aeroplane. In addition, a north-up orientation may be added as a selectable format.~~

~~**d.** Variations in terrain elevation must be depicted relative to the aeroplane's current or projected elevation (above and below) and be visually distinct. Terrain that is more than 2 000 feet below the aeroplane's elevation can be excluded.~~

~~**e.** Terrain that generates alerts must be displayed in a manner to distinguish it from non-hazardous terrain, consistent with the caution and warning alert level.~~

~~**3.6 Class B Equipment Requirements for a Terrain Display.** Operators required to install Class B equipment are not required to include a terrain display. However, Class B TAWS equipment must be capable of driving a terrain display function in the event the installer wants to include the terrain display function.~~

~~**4.0 AURAL AND VISUAL ALERTS**~~

~~**4.1** The TAWS is required to provide aural and visual alerts for each of the functions described in section **3.0** of this Appendix.~~

~~**4.2** The TAWS must provide the required aural and visual alerts in a manner that clearly indicates to the flight crew that they represent a single event. The TAWS may accomplish the entire alerting function, or provide alert inputs to an external aircraft alerting system. Exceptions to this requirement are allowed when suppression of aural alerts is necessary to protect pilots from nuisance aural alerting, but a visual alert is still appropriate.~~

~~**4.3** Each aural alert must identify the reason for the alert, such as 'too low terrain', 'glideslope', or another acceptable annunciation.~~

~~**4.4** The system must remove the visual and aural alert once the situation has been resolved.~~

~~**4.5** The system must be capable of accepting and processing aeroplane performance-related data or aeroplane dynamic data and providing the capability to update aural and visual alerts at least once per second.~~

~~**4.6** The aural and visual outputs as defined in Table **4-1** must be compatible with the standard cockpit displays and auditory systems.~~

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~~**4.7** The aural and visual alerts should be selectable to accommodate operational commonality among aeroplane fleets.~~

~~**4.8** The visual display of alerting information must be immediately and continuously displayed until the situation is resolved or no longer valid.~~

~~**4.9** At a minimum, the TAWS must be capable of providing aural alert messages described in Table **4-1**. In addition to this minimum set, other voice alerts may be provided.~~

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~~Table 4-1~~

~~STANDARD SET OF VISUAL AND AURAL ALERTS~~		
~~Alert Condition~~	**~~Caution~~**	**~~Warning~~**
~~FLTA Functions~~ ~~Reduced Required Terrain Clearance and Imminent Impact with Terrain~~ ~~Class A & Class B~~	**~~Visual Alert~~** ~~Amber text message that is obvious, concise, and must be consistent with the aural message.~~ **~~Aural Alerts~~** ~~Minimum selectable voice alerts: 'Caution, Terrain; Caution, Terrain' **and** 'Terrain Ahead; Terrain Ahead'~~	**~~Visual Alert~~** ~~Red text message that is obvious, concise and must be consistent with the aural message.~~ **~~Aural Alerts~~** ~~Minimum selectable voice alerts: 'Terrain, Terrain; Pull-Up, Pull-Up' **and** 'Terrain Ahead, Pull-Up; Terrain Ahead, Pull-Up'~~
~~Premature Descent Alert (PDA)~~ ~~Class A & Class B~~	**~~Visual Alert~~** ~~Amber text message that is obvious, concise, and must be consistent with the aural message.~~ **~~Aural Alert~~** ~~'Too Low Terrain'~~	**~~Visual Alert~~** ~~None Required~~ **~~Aural Alert~~** ~~None Required~~
~~Ground Proximity Envelope 1, 2, or 3~~ ~~Excessive Descent Rate Mode 1~~ ~~Class A & Class B~~	**~~Visual Alert~~** ~~Amber text message that is obvious, concise, and must be consistent with the aural message.~~ **~~Aural Alert~~** ~~'Sink Rate'~~	**~~Visual Alert~~** ~~Red text message that is obvious, concise, and must be consistent with the Aural message.~~ **~~Aural Alert~~** ~~'Pull-Up'~~
~~Ground Proximity Excessive Closure Rate (Flaps not in Landing Configuration)~~ ~~Mode 2A~~ ~~Class A~~	**~~Visual Alert~~** ~~Amber text message that is obvious, concise, and must be consistent with the aural message.~~ **~~Aural Alert~~** ~~'Terrain, Terrain'~~	**~~Visual Alert~~** ~~Red text message that is obvious, concise, and must be consistent with the aural message.~~ **~~Aural Alert~~** ~~'Pull-Up'~~

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STANDARD SET OF VISUAL AND AURAL ALERTS		
Alert Condition	**Caution**	**Warning**
Ground Proximity Excessive Closure Rate (Landing Configuration) Mode 2B Class A	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alert** 'Terrain, Terrain'	**Visual Alert** Red text message that is obvious, concise, and must be consistent with the aural message for gear up. **Aural Alert** 'Pull-Up'—for gear up None Required—for gear down
Ground Proximity Altitude Loss after Takeoff Mode 3 Class A & Class B	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alerts** 'Don't Sink' and 'Too Low Terrain'	**Visual Alert** None Required **Aural Alert** None Required
Ground Proximity Envelope 1 (Gear and/or flaps other than landing configuration) Mode 4 Class A	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alerts** 'Too Low Terrain' **and** 'Too Low Gear'	**Visual Alert** None Required **Aural Alert** None Required
Ground Proximity Envelope 2 Insufficient Terrain Clearance (Gear and/or flaps other than landing configuration) Mode 4 Class A	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alerts** 'Too Low Terrain' **and** 'Too Low Flaps'	**Visual Alert** None Required **Aural Alert** None Required
Ground Proximity Envelope 3 Insufficient Terrain Clearance (Gear and/or flaps other than landing configuration) Mode 4 Class A	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alert** 'Too Low Terrain'	**Visual Alert** None Required **Aural Alert** None Required

~~STANDARD SET OF VISUAL AND AURAL ALERTS~~		
~~**Alert Condition**~~	~~**Caution**~~	~~**Warning**~~
~~Ground Proximity Excessive Glideslope or Glidepath Deviation Mode 5~~ ~~Class A~~	~~**Visual Alert**~~ ~~Amber text message that is obvious, concise, and must be consistent with the aural message.~~ ~~**Aural Alert**~~ ~~'Glideslope' or 'Glidepath'~~	~~**Visual Alert**~~ ~~None Required~~ ~~**Aural Alert**~~ ~~None Required~~
~~Ground Proximity Altitude Callout (See Note 1)~~	~~**Visual Alert**~~ ~~None Required~~	~~**Visual Alert**~~ ~~None Required~~
~~Class A & Class B (See Note 3)~~	~~**Aural Alert**~~ ~~'Five Hundred'~~	~~**Aural Alert**~~ ~~None Required~~

~~**Note 1:** The call out for ground proximity altitude is considered advisory.~~

~~**Note 2:** Visual alerts may be put on the terrain situational awareness display, if doing so fits with the overall human factors alerting scheme for the flight deck. This does not eliminate the visual alert color requirements, even in the case of a monochromatic display. Typically in such a scenario, adjacent colored annunciator lamps meet the alerting color requirements.~~

~~**Note 3:** Additional callouts can be made by the system, but the system is required to make the 500 foot voice callout.~~

~~**4.10 Prioritisation**~~

~~**a. Class A Equipment.** Class A Equipment must have an interactive capability with other external alerting systems so that an alerting priority can be executed automatically. This prevents confusion or chaos on the flight deck during multiple alerts from different alerting systems. Typical alerting systems that may be interactive with TAWS include predictive wind shear (PWS), reactive wind shear (RWS), and traffic alert collision and avoidance system (TCAS). The TAWS system must include an alert prioritisation scheme for Class A equipment. Table **4-2** provides an example prioritisation scheme for Class A equipment. If the PWS, RWS, or TCAS functions are provided within TAWS, the alert prioritisation scheme in Table **4-2** also applies. The FAA will consider alert prioritisation schemes other than the one included in Table **4-2**.~~

~~**b. Class B Equipment**~~

~~**1.** Class B Equipment does not require prioritisation with external systems such as TCAS, RWS, and PWS. If prioritisation with those functions is provided, the prioritisation scheme should be in accordance with the scheme in Table **4-2**.~~

~~**2.** Class B Equipment must establish an internal priority alerting system (scheme) for each of the functions. The priority scheme must ensure that the more critical alerts override alerts of lesser~~

priority. Table **4-3** provides a example internal priority scheme for Class B equipment. Class B Equipment need only consider the TAWS functions required for Class B Equipment.

Table 4-2

Legend: W = Warning, C = Caution, I = Non-Alert Information

ALERT PRIORITISATION SCHEME			
Priority	**Description**	**Level**	**Comments**
1	Reactive Windshear Warning	W	
2	Sink Rate Pull-Up Warning	W	Continuous
3	Excessive Closure Pull-Up Warning	W	Continuous
4	RTC Terrain Warning	W	
5	V_1 Callout	I	
6	Engine Fail Callout	W	
7	FLTA Pull-up Warning	W	Continuous
8	PWS Warning	W	
9	RTC Terrain Caution	C	Continuous
10	Minimums	I	
11	FLTA Caution	C	7 s period
12	Too Low Terrain	C	
13	PDA (‘Too Low Terrain’) Caution	C	
14	Altitude Callouts	I	
15	Too Low Gear	C	
16	Too Low Flaps	C	
17	Sink Rate	C	
18	Don’t Sink	C	
19	“Glideslope” or “Glidepath”	C	3 s period
20	PWS Caution	C	
21	Approaching Minimums	I	
22	Bank Angle	C	
23	Reactive Windshear Caution	C	
Mode 6	TCAS RA *(‘Climb’, ‘Descend’, etc.)*	W	Continuous
Mode 6	TCAS TA (‘*Traffic, Traffic*’)	C	Continuous

Note: These alerts can occur simultaneously with TAWS voice callout alerts.

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Table 4-3

TAWS INTERNAL ALERT PRIORITIZATION SCHEME	
Priority	**Description**
1	Sink Rate Pull-Up Warning
2	Terrain Awareness Pull-Up Warning
3	Terrain Awareness Caution
4	PDA (‘*Too Low Terrain*’) Caution
5	Altitude Callout ‘500’
6	Sink Rate
7	Don’t Sink (Mode 3)

4.11 During ILS glideslope, LPV, GLS glidepath, or other localizer-based approach operations, TAWS should not cause an alert for a terrain/obstacle located outside the TERPS-protected airspace. Special design considerations may be necessary to address this issue.

5.0 TAWS Position Requirements. TAWS relies on horizontal position, vertical position, velocity, and vertical rate information. This information can be generated internally to the TAWS, or acquired by interfacing to other installed avionics on the aircraft.

5.1 External Sources. When the TAWS interfaces to external sources for position, velocity, or rate information, the TAWS installation manual must define the performance requirements for the interface.

5.2 Internal Sources. When the TAWS includes internal sources for position, velocity, or rate information, these sources must meet the performance requirements in the applicable ETSO, if an applicable ETSO exists. The performance of the internal source must be sufficient for the TAWS to meet its intended function. Examples of applicable ETSOs include:

a. GNSS equipment: ETSO-C129a *Airborne Supplemental Navigation Equipment Using the Global Positioning System* (or subsequent), or any revision of ETSO-C145 *Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite-Based Augmentation System*, ETSO-C146 *Stand-Alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite-Based Augmentation System*, or ETSO-C196 *Airborne Supplemental Navigation Sensors for Global Positioning System Equipment Using Aircraft-Based Augmentation*.

b. Barometric altitude equipment: ETSO-C10b *Altimeter, Pressure Actuated, Sensitive Type*, or ETSO-C106 *Air Data Computer*.

c. Radio altimeter equipment: ETSO-C87a *Airborne Low-Range Radio Altimeter* (or subsequent), ETSO-2C87 *Low Range Radio Altimeters*, or RTCA/DO-155 *Minimum Performance Standards Airborne Low-Range Radar Altimeters*.

d. Vertical velocity equipment: ETSO-C8 *Vertical Velocity Instruments* (or subsequent), or ETSO-C106 *Air Data Computer* (or subsequent).

5.3 Primary Horizontal Position Sources. Horizontal position for TAWS must come from a GNSS source meeting ETSO-C129a or any revision of ETSO-C145, ETSO-C146, or ETSO-C196 (or subsequent). As an exception, TAWS equipment limited to installation in aircraft where the EU Regulation on Air Operations does not require such equipment may be configurable to operate solely on a non-GNSS position source.

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~~**5.4 Alternate Horizontal Position Sources.** Retaining TAWS functionality during GNSS outage or unavailability provides a safety benefit. It is acceptable and recommended to incorporate a secondary, non GNSS position source, to provide horizontal position when the GNSS is not available or reliable.~~

~~**5.5 Vertical Position Sources.** Vertical position for TAWS may come from a barometric source, such as an altimeter or an air data computer, or from a geometric source, such as GNSS. GNSS vertical accuracy, at a minimum, must meet RTCA/DO-229D, section 2.2.3.3.4. Designs that cross check barometric and geometric altitude are recommended. Class A TAWS also requires a radio altimeter.~~

~~**5.6 Position Source Faults**. If a position source generates a fault indication or any flag indicating the position is invalid or does not meet performance requirements, the TAWS must stop utilizing that position source. The TAWS may revert to an alternate position source, and must provide indications, as appropriate, regarding loss of function associated with the loss of the position source. The TAWS must inhibit FLTA and PDA alerts when the position source in use is faulted or invalid.~~

~~**6.0 CLASS A AND CLASS B REQUIREMENTS FOR A TERRAIN AND AIRPORT DATABASE**~~

~~**6.1 Minimum Geographical Consideration.** At a minimum, terrain and airport information must be provided for the expected areas of operation, airports, and routes flown.~~

~~**6.2 Development and Methodology.** The manufacturer must present the development methodology used to validate and verify the terrain and airport information.~~
~~RTCA/DO-200A/ED-76 *Standards for Processing Aeronautical Data* should be used as a guideline.~~

~~**6.3 Resolution.** Terrain and airport information must be accurate and of acceptable resolution in order for the system to perform its intended function. Terrain data should be gridded at 30 arc seconds with 100-foot resolution within 30 NM of all airports with runway lengths of 3 500 feet or greater, and whenever necessary (particularly in mountainous environments), 15 arc seconds with 100-foot resolution (or even 6 arc seconds) within 6 NM of the closest runway. It is acceptable to have terrain data gridded in larger segments over oceanic and remote areas around the world.~~

~~**Note:** Class B equipment may require information relative to airports with runways less than 3 500 feet whether public or private. Small aeroplane owners and operators will likely be the largest market for Class B equipment and they frequently use airports of less than 3 500 feet. Those TAWS manufacturers who desire to sell to this market must be willing to customize their terrain databases to include selected airports used by their customers.~~

~~**6.4 Continued Airworthiness Updates.** The system must be capable of accepting updated terrain and airport information. Updating of terrain, obstacle, and airport databases does not require a change to the ETSO authorization.~~

~~**7.0 CLASS A AND CLASS B FAILURE INDICATION.** Class A and Class B equipment must include a failure monitor function that provides reliable indications of equipment condition during operation. It must monitor the equipment itself, input power, input signals, and aural and visual outputs. A means to inform the flight crew whenever the system has failed or can no longer perform the intended function must be provided.~~

~~**8.0 CLASS A AND CLASS B REQUIREMENTS FOR SELF-TEST.** Class A and Class B equipment must have a self-test function to verify system operation and integrity. It must monitor the equipment itself, input power, input signals, and aural and visual outputs. Failure of the system to successfully pass the self-test must be annunciated.~~

~~**Note:** Flight crew verification of the aural and visual outputs during a self-test is an acceptable method for monitoring aural and visual outputs.~~

~~**9.0 CLASS A EQUIPMENT REQUIREMENTS FOR INHIBITING THE FLTA FUNCTION, THE PREMATURE DESCENT ALERT FUNCTION, AND THE TERRAIN DISPLAY**~~

~~**9.1 Manual Inhibit.** The TAWS system must have a capability (e.g. a control switch to the flight crew) to manually inhibit the TAWS (FLTA/PDA) aural alerts, visual alerts, and the terrain display. The switch must not inhibit any of the GPWS alerts defined in section 1.3.e. If the TAWS system incorporates an automatic inhibit function that automatically inhibits TAWS (FLTA/PDA) aural alerts, visual alerts, and terrain display when a position source is faulted or unavailable, then the manual inhibit may be designed to only inhibit aural and visual alerts. This alternate manual inhibit functionality will allow pilots to disable the TAWS (FLTA/PDA) alerting without removing the terrain display when landing at a site not included in the database or landing at a site that generates known nuisance alerts. Inhibit status must be annunciated to the flight crew.~~

~~**9.2 Automatic Inhibit.** The capability of automatically inhibiting Class A functions within TAWS equipment is acceptable when utilizing the conditions described in paragraph **7.0**. If auto inhibit capability is provided, the 'inhibit status' must be annunciated to the flight crew.~~

~~**10.0 CLASS A and B PHASE OF FLIGHT DEFINITIONS.** The TAWS equipment search volumes and alerting thresholds should vary as necessary in order to be compatible with TERPS and other operational considerations. For this reason, a set of definitions is offered for enroute, terminal, approach and departure phases of flight. Other definitions for enroute, terminal, and approach may be used by TAWS provided they are compatible with TERPS and standard instrument approach procedures and comply with the test criteria specified in Appendix **2**. If other definitions for enroute, terminal, and approach are used by TAWS, they must be submitted to EASA in the form of a deviation as per Part 21 21.A.610.~~

~~**10.1 Enroute Phase.** The enroute phase exists when the aeroplane is more than 15 NM from the nearest airport or whenever the conditions for terminal, approach, and departure phases are not met.~~

~~**10.2 Terminal Phase.** The terminal phase exists when the aeroplane is 15 NM or less from the nearest runway while the range to the nearest runway threshold is decreasing and the aeroplane is at or lower than a straight line drawn between the two points specified in Table **10** relative to the nearest runway.~~

~~**Note:** If the aircraft is accomplishing a procedure turn as part of an instrument approach procedure, the system may remain in the terminal phase, even though the distance to the runway threshold may be temporarily increasing and the conditions for the approach phase may be temporarily met.~~

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~~**Table 10**~~

~~**HEIGHT ABOVE RUNWAY VERSUS DISTANCE TO RUNWAY**~~	
~~**Distance to Runway**~~	~~**Height above Runway**~~
~~15 NM~~	~~3 500 Feet~~
~~5 NM~~	~~1 900 Feet~~

~~**10.3 Approach Phase.** The approach phase exists when the distance to the nearest runway threshold is equal to or less than 5 NM; and the height above the nearest runway threshold location and elevation is equal to or less than 1900 feet; and the distance to the nearest runway threshold is decreasing.~~

~~**10.4 Departure Phase.** The departure phase should be defined by some reliable parameter that initially determines that the aeroplane is on the ground upon initial power-up. If, for example, the equipment can determine that the aeroplane is 'on the ground' by using some logic such as ground speed less than 35 knots and altitude within ± 75 feet of field elevation or nearest runway elevation and 'airborne' by using some logic such as ground speed greater than 50 knots and altitude 100 feet greater than field elevation, then the equipment can reliably determine that it is in the 'Departure Phase'. Other parameters to consider are climb state and distance from departure runway. Once the aeroplane reaches 1 500 feet above the departure runway, the departure phase is ended.~~

~~**10.5 Nearest Airport or Runway.** The enroute phase considers distance to the nearest airport, and the terminal and approach phases consider distance to the nearest runway in determining the appropriate phase of flight, and thus the appropriate terrain alerting requirements. The phase of flight may also be determined by basing the phase of flight on the intended landing airport or runway, if the TAWS has the intended landing airport or runway information available. The phase of flight determination may also exclude airports or runways which are unsuitable for landing of a particular type of aircraft. For example, the TAWS could be configurable at installation on a large transport category aircraft to only change the phase of flight based on runways of a certain minimum length.~~

~~**11.0 CLASS A AND CLASS B SUMMARY REQUIREMENTS**~~
~~(Reserved)~~

~~**Table 11**~~
~~(reserved)~~

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APPENDIX 2

TEST CONDITIONS

1.0 FORWARD-LOOKING TERRAIN AVOIDANCE — REDUCED REQUIRED TERRAIN CLEARANCE (RTC) TEST CONDITIONS. These conditions exist when the aeroplane is currently above the terrain, but the combination of current altitude, height above terrain, and projected flight path indicates that there is a significant reduction in the RTC.

1.1 Phase of Flight Definitions. For the following test conditions, refer to Appendix **1**, paragraph **10.0**, for an expanded explanation of the definitions of the phases of flight.

1.2 En route Descent Requirement. A terrain alert must be provided in time to ensure that the aeroplane can level off (L/O) with a minimum of 500 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane. The test conditions assume a descent along a flight path with terrain that is 1 000 feet below the expected L/O altitude. If the pilot initiates the L/O at the proper altitude, no TAWS alert is expected. However, if the pilot is distracted or otherwise delays the L/O, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

Note: The L/O initiation height of 20 % of the vertical speed was chosen (as a minimum standard for nuisance alarm-free operations) because it is similar to typical autopilot or flight director L/O (altitude capture) algorithms. In contrast, the technique of using 10 %of the existing vertical speed as a L/O initiation point is usually considered a minimum, appropriate only to manual operations of smaller general aviation (GA) aeroplanes. With high rates of descent, experienced pilots often use a manual technique of reducing the vertical speed by one half when reaching 1 000 feet above/below the L/O altitude. This technique will significantly reduce the likelihood of nuisance alerts. In the event that using 20 %of the vertical speed as a minimum standard for nuisance-free operations is shown not to be compatible with the installed autopilot or flight director L/O (altitude capture) algorithms, consideration should be given to setting the alert logic closer to the 10 %vertical speed criteria to minimize nuisance alerts.

a. Table A, column A, represents the test condition. Columns B, C, and D are for information purposes only. Column E represents the minimum altitude for which TAWS alerts must be posted to perform their intended function. Column F represents the maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See Appendix **2**, paragraph **4.0**.

b. For each of the descent rates specified below, recovery to level flight at or above 500 feet terrain clearance is required.

c. Test conditions for enroute descent requirement:

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Assumed pilot response time	3.0 seconds (minimum)
Assumed constant G pull-up	0.25 g's
Minimum allowed terrain clearance	500 feet AGL
Descent rates	1 000, 2 000, 4 000, and 6 000 feet per minute (FPM)
Assumed pilot task for column F	L/O at 1 000 feet above the terrain per TERPS ROC

Note1: The actual values for the aeroplane altitude, distance, and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

Note 2: Enroute operations are considered to exist beyond 15 NM from the departure runway until 15 NM from the destination airport. Use of the nearest runway logic is permissible provided suitable logic is incorporated to ensure that the transitions to the terminal logic will typically occur only when the aeroplane is in terminal airspace.

Note 3: The values shown in column E may be reduced by 100 feet (to permit a L/O to occur at 400 feet above the obstacle) provided that it can be demonstrated that the basic TAWS Mode 1 alert (sink rate) is issued at or above the altitude specified in column E for typical terrain topographies.

Note 4: **Class B Equipment Considerations.** The values shown in Column F are appropriate for autopilot or flight director operations with an altitude capture function typical of many CS-25-certified aeroplanes (Transport Category Aircraft). The values are based upon 20 %of the aeroplane's vertical velocity. If TAWS is installed on an aeroplane without such an autopilot or flight director function, consideration should be given to computing the alerts based upon 10 %of the vertical velocity, which is more appropriate to manual flight and small, GA aeroplane operations.

TABLE A

ENROUTE DESCENT ALERTING CRITERIA					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 3-SEC PILOT DELAY	ALT REQ'D TO L/O WITH 0.25G	TOTAL ALT LOST DUE TO RECOVERY MANEUVER	MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN)	MAXIMUM TAWS CAUTION ALERT HEIGHT (ABOVE TERRAIN)
1 000	50	17	67	567	1 200
2 000	100	69	169	669	1 400
4 000	200	278	478	978	1 800

1.3 Enroute Level Flight Requirement. During level flight operations (vertical speed is ± 500 FPM), a terrain alert should be posted when the aeroplane is within 700 feet of the terrain and is predicted to be equal to or less than 700 feet within the prescribed alerting time or distance. See Table B for test criteria.

Note: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

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TABLE B

ENROUTE LEVEL FLIGHT ALERTING CRITERIA			
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL MEAN SEA LEVEL (MSL)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA
200	5 000	6 000	NO ALERT
250	5 000	5 800	NO ALERT
300	5 000	5 800	NO ALERT
200	5 000	5 700 (+ 0/– 100)	MUST ALERT
250	5 000	5 700 (+ 0/– 100)	MUST ALERT
300	5 000	5 700 (+ 0/– 100)	MUST ALERT
400	5 000	5 700 (+ 0/– 100)	MUST ALERT
500	5 000	5 700 (+ 0/– 100)	MUST ALERT

1.4 Terminal Area (Intermediate Segment) Descent Requirement. A terrain alert must be provided in time to ensure that the aeroplane can L/O with a minimum of 300 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane. The test conditions assume a descent along a flight path with terrain that is 500 feet below the expected L/O altitude. If the pilot initiates the L/O at the proper altitude, no TAWS alert is expected. However, if the pilot is distracted or otherwise delays the L/O, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

a. Table C, column A, represents the test condition. Columns B, C, and D are for information purposes only. Column E represents the minimum altitude for which TAWS alerts must be posted to perform their intended function. Column F represents the maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See Appendix **2**, paragraph **4.0**.

b. For each of the descent rates specified below, recovery to level flight at or above 300 feet terrain clearance is required.

c. Test conditions for terminal area descent requirement:

Assumed pilot response time	1.0 second (minimum)
Assumed constant G pull-up	0.25 g's
Minimum allowed terrain clearance	300 feet AGL
Descent rates	1 000, 2 000, and 3 000 FPM
Assumed pilot task for column F	L/O at 500 feet above the terrain per TERPS ROC

Note 1: The actual values for the aeroplane altitude, distance, and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

Note 2: **For Class B Equipment Considerations.** The values shown in Column F are appropriate for autopilot or flight director operations with an altitude capture function typical of many CS-25-

certificated aeroplanes (Transport Category Aircraft). The values are based upon 20 %of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an autopilot or flight director function, consideration should be given to computing the alerts upon 10 %of the vertical velocity, which is more appropriate to manual flight and small, GA aeroplane operations.

Table C

TERMINAL DESCENT AREA ALERTING CRITERIA					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 1SEC PILOT DELAY	ALT REQ'D TO L/O WITH 0.25G	TOTAL ALT LOST DUE TO RECOVERY MANEUVER	MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN)	MAXIMUM TAWS CAUTION ALERT HEIGHT (ABOVE TERRAIN)
1 000	17	17	34	334	700
2 000	33	69	102	402	900
3 000	50	156	206	506	1 100

1.5 Terminal Area (Intermediate Segment) Level Flight Requirement. During level flight operations (vertical speed less than ± 500 feet per minute), a terrain alert should be posted when the aeroplane is less than 350 feet above the terrain and is predicted to be within less than 350 feet within the prescribed alerting time or distance. See Table D for test criteria.

Note: The actual values for the aeroplane altitude, distance, and time from the terrain cell when caution and warning alerts are posted must be recorded.

Table D

TERMINAL AREA LEVEL FLIGHT ALERTING CRITERIA			
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA
150	1 000	1 500	NO ALERT
200	1 000	1 500	NO ALERT
250	1 000	1 500	NO ALERT
100	1 000	1 350	MUST ALERT
150	1 000	1 350	MUST ALERT
200	1 000	1 350	MUST ALERT
250	1 000	1 350	MUST ALERT

1.6 Final Approach Segment Descent Requirement. A terrain alert must be provided in time to ensure that the aeroplane can L/O with a minimum of 100 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane.

a. Table E, column A, represents the test condition. Columns B, C, and D are for information purposes only. Column E represents the minimum altitude for which TAWS alerts must be posted to perform their intended function. Column F represents the maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See appendix **2**, paragraph **4.0**.

b. For each of the descent rates specified below, recovery to level flight at or above 100 feet terrain clearance is required.

c. Test conditions for final approach segment descent requirement:

Assumed pilot response time	1.0 seconds (minimum)
Assumed constant G pull-up	0.25 g's
Minimum allowed terrain clearance	100 feet AGL
Descent rates	500, 750, 1 000, and 1 500 FPM
Assumed pilot task for column F	L/O at 250 feet above the terrain per TERPS ROC

Note: 1: The actual values for the aeroplane altitude, distance, and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

Note: 2: For Class B Equipment Considerations. The values shown in column F are appropriate for autopilot or flight director operations with an altitude capture function typical of many CS-25-certificated aeroplanes (Large Aeroplanes). The values are based upon 20 %of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an autopilot or flight director function, consideration should be given to computing the alerts based upon 10 %of the vertical velocity, which is more appropriate to manual flight and small, GA aeroplane operations.

Table E

A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 1SEC PILOT DELAY	ALT REQ'D TO L/O WITH 0.25G	TOTAL ALT LOST DUE TO RECOVERY MANEUVER	MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN)	MAXIMUM TAWS CAUTION ALERT HEIGHT (ABOVE TERRAIN)
500	8	4	12	112	350
750	12	10	22	122	400
1 000	17	18	35	135	450
1 500	25	39	64	164	550

1.7 Final Approach Level Flight Requirement. During level flight operations at the minimum descent altitude (MDA), a terrain alert should be posted when the aeroplane is within 150 feet of the terrain and is predicted to be within less than 150 feet within the prescribed alerting time or distance.

See Table F for test criteria.

Note: The actual values for the aeroplane altitude, distance, and time from the terrain cell when caution and warning alerts are posted must be recorded.

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Table F

FINAL APPROACH LEVEL FLIGHT ALERT CRITERIA				
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	DISTANCE TERRAIN FROM RWY (NM)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA
120	400	2.0	650	NO ALERT
140	400	2.0	650	NO ALERT
160	400	2.0	650	NO ALERT
120	400	2.0	600	MAY ALERT
140	400	2.0	600	MAY ALERT
160	400	2.0	600	MAY ALERT
100	400	2.0	550	MUST ALERT
120	400	2.0	550	MUST ALERT
140	400	2.0	550	MUST ALERT
160	400	2.0	550	MUST ALERT

2.0 FORWARD-LOOKING TERRAIN AVOIDANCE IMMINENT TERRAIN IMPACT TEST CONDITIONS. The following test conditions must be conducted to evaluate level flight performance during all phases of flight:

Note: 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

Note: 2: Based upon a one-second pilot delay and a 0.25g incremental pull to constant 6.0-degree climb gradient, compute and record the aeroplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the aeroplane position and time (after the alert), when the alert envelope is cleared.

2.1 Test Criteria. For each of the test cases below, a positive clearance of the terrain cell of interest is required.

2.2 Additional Test Criteria. Repeat each of the test cases below with the altitude error of – 200 feet). A positive clearance of the terrain cell of interest is required.

Table G

IMMINENT TERRAIN IMPACT ALERTING CRITERIA				
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	DISTANCE TERRAIN FROM RWY (NM)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA
200	10 000	30	9 000	MUST ALERT
250	10 000	30	9 000	MUST ALERT
300	10 000	30	9 000	MUST ALERT
400	10 000	30	8 000	MUST ALERT
500	10 000	30	8 000	MUST ALERT
150	2 000	10	1 500	MUST ALERT
200	2 000	10	1 500	MUST ALERT
250	2 000	10	1 500	MUST ALERT

100	600	5	500	MUST ALERT
120	600	5	500	MUST ALERT
140	600	5	500	MUST ALERT
100	600	4	200	MUST ALERT
120	600	4	200	MUST ALERT
140	600	4	200	MUST ALERT
160	600	4	200	MUST ALERT
160	600	5	500	MUST ALERT

3.0 PDA TEST CONDITIONS. The purpose of this test is to verify that the pilot will be alerted to a 'low altitude condition' at an altitude defined by the specific design PDA alert surface. This ETSO does not define specific pass/fail criteria since, as stated in paragraph **3.2** of appendix **1**, it does not define the surface for which alerting is required. The applicant must provide the proposed pass/fail criteria along with the proposed recovery procedures for the specific alerting criteria proposed by the applicant. In developing the test plan, the applicant should refer to paragraph **3.2** of appendix **1** for general requirements for alerting (if alerting is applicable). The applicant may also want to consider the recovery procedures specified in paragraphs **1.2**, **1.4**, and **1.6** of paragraph **1** of appendix **2**. The following test conditions must be conducted to evaluate PDA performance:

Descent rates (FPM)	750, 1 500, and 2 000, 3 000
Assumed runway elevation	Sea level, Level terrain

Note: For each test condition listed in table **H**, compute and record the PDA alert altitude and the recovery altitude to level flight.

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Table H

PREMATURE DESCENT ALERTING CRITERIA				
GROUND SPEED (KT)	VERT. SPEED (FPM)	DISTANCE FROM RWY THRESHOLD (TOUCHDOWN) (NM)	PDA ALERT HEIGHT (MSL)	RECOVERY ALTITUDE (MSL)
80	750	15		
100	1 500	15		
120	750	15		
140	1 500	15		
160	750	15		
200	1 500	15		
250	2 000	15		
80	750	12		
100	1 500	12		
120	750	12		
140	1 500	12		
160	750	12		
80	750	4		
100	1 500	4		
120	750	4		
140	1 500	4		
80	750	2		
100	1 500	2		
120	750	2		
140	1 500	2		

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~~**4.0 NUISANCE ALERT TEST CONDITIONS — GENERAL.** The following test conditions must be conducted to evaluate TAWS performance during all phases of flight. The following general criteria apply:~~

~~**4.1 4 000 FPM.** Descent must be possible at 4 000 FPM in the enroute airspace and pilots must be able to L/O 1 000 feet above the terrain using a normal L/O procedure (leading by 20 %of the vertical speed) without a caution or warning alert. See Table A.~~

~~**4.2 2 000 FPM.** Descent must be possible at 2 000 FPM in the terminal area and pilots must be able to L/O 500 feet above the terrain using the normal L/O procedure described in paragraph **4.1** above, without a caution or warning alert. See Table C.~~

~~**4.3 1 000 FPM.** Descent must be possible at 1 000 FPM in the final approach segment and pilots must be able to L/O at the MDA using the normal L/O procedure described in paragraph **4.1** above, without a caution or warning alert. See Table E.~~

~~**5.0 NUISANCE TEST CONDITIONS FOR HORIZONTAL AND VERTICAL FLIGHT TECHNICAL ERRORS.** It must be shown by analysis, simulation, or flight testing, that the system will not produce nuisance alerts when the aeroplane is conducting normal flight operations in accordance with published instrument approach procedures. This assumes the normal range in variation of input parameters.~~

~~**5.1 Test Cases.** At a minimum, the following cases listed in Table **I** must be tested twice: one set of runs conducted with no lateral or vertical errors while another set is conducted with both lateral and vertical flight technical errors (FTE). Certain conditions must be simulated, such as: a lateral FTE of 0.3 NM and a vertical FTE of – 100 feet (such as when the aircraft is closer to terrain) up to the final approach fix (FAF), as well as a lateral FTE of 0.3 NM and a vertical FTE of – 50 feet from the FAF to the missed approach point (MAP). For all listed VHF omni- directional range navigation system (VOR), VOR/distance measuring equipment (DME) and localizer-based approaches, from the FAF to the MAP, the aeroplane descends at 1 000 FPM until reaching either MDA (run #1) or MDA – 50 feet (run #2). The aeroplane then levels off and flies level until reaching the MAP. Localizer updating of lateral position errors (if provided) may be simulated.~~

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~~**Table I**~~

~~**NUISANCE ALERT TEST CONDITIONS FOR HORIZONTAL AND VERTICAL FLIGHT TECHNICAL ERRORS**~~		
~~**Case**~~	~~**Location**~~	~~**Operation**~~
~~1~~	~~Quito, Ecuador~~	~~VOR 'QIT' ILS Rwy 35~~
~~2~~	~~Katmandu, Nepal~~	~~VOR-DME Rwy 2~~
~~3~~	~~Windsor Locks, CT~~	~~VOR Rwy 15~~
~~4~~	~~Calvi, France~~	~~LOC DME Rwy 18/Circle~~
~~5~~	~~Tegucigalpa, Honduras~~	~~VOR DME Rwy 1/Circle~~
~~6~~	~~Eagle, CO~~	~~LOC DME-C~~
~~7~~	~~Monterey, CA~~	~~LOC DME Rwy 28L~~
~~8~~	~~Juneau, AK~~	~~LDA-1 Rwy 8~~
~~9~~	~~Chambery, France~~	~~ILS Rwy 18~~

~~**6.0 TEST CONDITIONS USING KNOWN ACCIDENT CASES.** The aircraft configuration and flight trajectory for each case may be obtained from the FAA Regulatory and Guidance Library site. Click 'Technical Standards and Orders and Index', click 'Current', and then click 'TSO-C151c'.~~

~~**6.1 Test Report.** The test report should include as many of the following parameters as possible used to recreate the events: (1) latitude; (2) longitude; (3) altitude; (4) time from terrain at caution and warning alerts; (5) distance from terrain at caution and warning alerts; (6) ground speed; (7) true track; (8) true heading; (9) radio altitude (height above terrain); (10) gear position; and (11) flap position.~~

~~**6.2 Computation and Recording.** In addition to the parameters above, when the warning is posted for each test case, based upon a one second pilot delay and a 0.25 g incremental pull to a constant 6.0 degree climb gradient, do the following: compute and record the aeroplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the aeroplane position and time (after the alert) when the alert envelope is cleared.~~

~~**Note:** The terrain cell of interest is the one associated with the accident and not necessarily the terrain cell that caused the warning.~~

~~**6.3 Test Criteria.** For each of the test cases below in **table J**, demonstrate that the aeroplane profile clears the terrain of interest.~~

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~~**Table J**~~

~~LOCATION~~	~~DATE~~	~~AIRCRAFT REGISTRATION NUMBER~~
~~La Paz, Bolivia~~	~~1/1/1985~~	~~N819EA~~
~~Flat Rock, NC~~	~~8/23/1985~~	~~N600CM~~
~~Windsor, MA~~	~~12/10/1986~~	~~N65TD~~
~~Eagle, CO~~	~~3/27/1987~~	~~N31SK~~
~~Tegucigalpa, Honduras~~	~~10/21/1989~~	~~N88705~~
~~Halawa Point, HI~~	~~10/28/1989~~	~~N707PV~~
~~San Diego, CA~~	~~3/16/1991~~	~~N831LC~~
~~Rome, GA~~	~~12/11/1991~~	~~N25BR~~
~~Gabriels, NY~~	~~1/3/1992~~	~~N55000~~
~~Alamogordo, NM~~	~~6/24/1992~~	~~N108SC~~
~~E. Granby, CT~~	~~11/12/1995~~	~~N566AA~~
~~Buga, Columbia~~	~~12/20/1995~~	~~N651AA~~
~~Nimitz Hill, Guam~~	~~8/6/1997~~	~~H7468~~

~~**7.0 CLASS B EQUIPMENT TEST REQUIREMENTS FOR EXCESSIVE DESCENT RATE.** Use the following performance envelopes down to a 'height above terrain' value of 100 feet. If a radar altimeter input is unavailable, determine the height of terrain by subtracting the terrain elevation (as obtained from the terrain database) from the current QNH (corrected) barometric altitude, the GNSS altitude, or an equivalent source. GNSS vertical accuracy must meet RTCA/DO-229D Section 2.2.3.3.4. The curve in figure 1 represents the minimum heights at which alerting must occur.~~

~~**Note:** Class B equipment may be designed to meet the requirements of RTCA/DO-161A, Mode 1, for excessive descent rate in lieu of the requirements of paragraph **7.0**.~~

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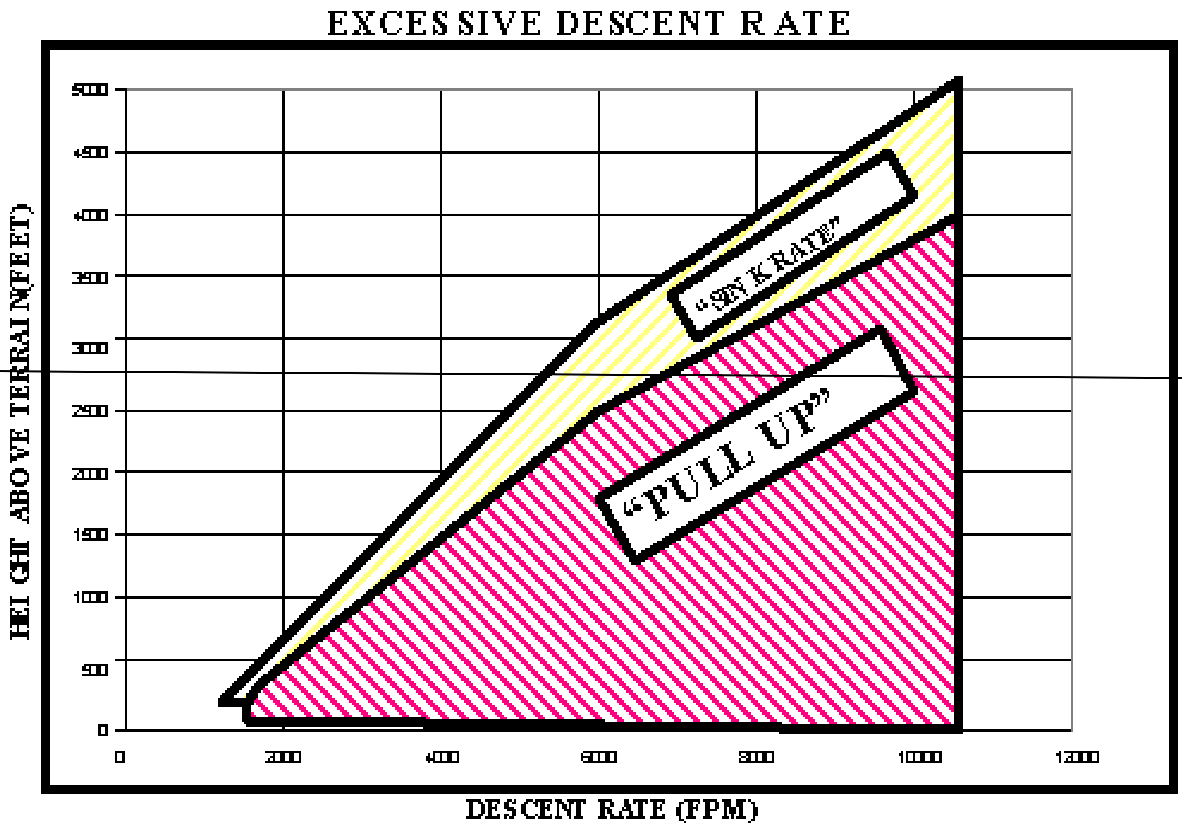
~~Figure 1~~



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~~**8.0 CLASS B EQUIPMENT TEST REQUIREMENTS FOR NEGATIVE CLIMB RATE OR ALTITUDE LOSS AFTER TAKEOFF.** Use the existing performance envelopes specified in RTCA/DO-161A based upon a 'height above runway' using barometric altitude, GNSS altitude, or equivalent, and runway elevation in lieu of radio altimeter inputs, if radio altimeter inputs are unavailable.~~

~~**9.0 ALTITUDE CALLOUT TEST REQUIREMENTS**~~

~~**9.1 CLASS A EQUIPMENT ALTITUDE CALLOUT TEST REQUIREMENTS.** With the landing gear in landing configuration test for approach to an airport with a 1 500 FPM descent rate. Ensure the TAWS provides a single aural callout of 'Five Hundred' or equivalent within one second of the aircraft descending through 500 feet above terrain or the runway threshold elevation (when comparing the aircraft's barometric or geometric altitude against the database runway elevation).~~

~~**9.2 CLASS B EQUIPMENT ALTITUDE CALLOUT TEST REQUIREMENTS.** Instead of using height of terrain as determined by a radio altimeter, determine height above runway by subtracting the runway elevation (from the airport database) from the current barometric altitude, GNSS altitude, or equivalent, if a radio altimeter input is unavailable. When the height above the runway value first reaches 500 feet, a single voice callout ('Five Hundred') or equivalent must be provided.~~

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~~**APPENDIX 3**~~

~~**MINIMUM PERFORMANCE STANDARD (MPS) FOR A TERRAIN AWARENESS AND WARNING SYSTEM FOR CLASS C**~~

~~**1.0 INTRODUCTION**~~

~~**1.1** This Appendix describes modifications to this ETSO for the GA category of aircraft that is not required to have TAWS equipment installed. Class C equipment is intended for small GA aeroplanes that are not required to install Class B equipment.~~

~~**1.2** This Appendix contains only modifications to existing requirements in this ETSO. It is intended that Class C meet all Class B requirements that are not modified or addressed here. The paragraph numbers below relate directly to the paragraphs in **Appendices 1** and **2.**~~

~~**2.0** Class C TAWS equipment must meet all of the requirements of a Class B TAWS with the modifications described herein. If the equipment is designed only to function as Class C, per these modifications, it should be appropriately marked as Class C so that it can be uniquely distinguished from the Class A and Class B TAWS required by the EU Regulation on Air Operations.~~

~~**MODIFICATIONS TO APPENDIX 1 FOR CLASS C TAWS.**~~

~~**Minimum Performance Standards, MPS**~~

~~**1.1 Phase of Flight Definitions.** For **Appendix 3**, the terms 'takeoff', 'cruise', and 'landing' are used instead of 'departure', 'enroute', and 'approach' because they are more suitable to the GA environment.~~

- ~~*Takeoff* — positive ROC, inside traffic area, distance to nearest runway threshold is increasing, and aeroplane is below 1 000 feet.~~
- ~~*Cruise* — anytime the aeroplane is outside the airport traffic control area.~~
- ~~*Landing* — inside traffic area and distance to nearest runway threshold is decreasing, and aeroplane is below 1 000 feet.~~

~~**1.2 Altitude Accuracy and Display.** A means must be provided to compute an actual MSL aircraft altitude value that is immune to temperature errors and manual correction mis-sets that would otherwise prevent the TAWS from performing its intended function. This type of altitude is derived primarily from geometric sources such as GPS, and referenced to MSL typically via a database correction. If the TAWS includes a terrain display, this reference altitude value used for the TAWS alerts should also be indicated to the pilot on the display. The altitude value should be labelled according to AC 20-163, *Displaying Geometric Altitude Relative to Mean Sea Level*, which recommends 'GSL'.~~
~~**1.3 (f)(3) System Function and Overview.** This data is pilot selectable for both 'altitude' and 'inhibit'.~~

~~**3.1.1 Reduced Required Terrain Clearance (RTC).** The required terrain clearance in the alternate **table 3.1.1** applies to small aircraft flying visually, and the TERPS criteria need not apply to TAWS. Thus, ROC numbers that are more appropriate to low level flight have been chosen.~~

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~~**Alternate Table 3.1.1**~~

~~TAWS REQUIRED TERRAIN CLEARANCE (RTC) BY PHASE OF FLIGHT~~			
~~**Phase of Flight**~~	~~**Small Aircraft ROC**~~	~~**TAWS (RTC) Level Flight**~~	~~**TAWS (RTC) Descending**~~
~~Cruise~~	~~500 Feet~~	~~250 Feet~~	~~200 Feet~~
~~Takeoff~~	~~48 Feet/NM~~	~~100 Feet~~	~~100 Feet~~
~~Landing (See Note 1)~~	~~250 Feet~~	~~150 Feet~~	~~100 Feet~~

~~**Note: 1:** During the takeoff phase of flight, the FLTA function must alert if the aircraft is projected to be within 100 feet vertically of terrain. However, the equipment should not alert if the aircraft is projected to be more than 250 feet above the terrain.~~

~~**3.3.c Voice Callouts.** This data is pilot selectable for both 'altitude' and 'inhibit'.~~

~~**4.0 Aural and Visual Alerts**~~

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Table 4-1

STANDARD SET OF VISUAL AND AURAL ALERTS		
Alert Condition	**Caution**	**Warning**
FLTA Functions Terrain Awareness Reduced Required Terrain Clearance and Terrain Awareness Imminent Impact with Terrain	**Visual Alert** Amber text message that is obvious, concise, and consistent with the aural message. **Aural Alert** Minimum selectable voice alert: 'Caution, Terrain; Caution, Terrain'	**Visual Alert** Red text message that is obvious, concise, and consistent with the aural message. **Aural Alert** Minimum selectable voice alert: 'Terrain; Terrain'
Terrain Awareness Premature Descent Alert (PDA)	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alert** 'Too Low; Too Low'	**Visual Alert** None Required **Aural Alert** None Required
Ground Proximity Excessive Descent Rate	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alert** 'Sink Rate'	**Visual Alert** Red text message that is obvious, concise, and must be consistent with the aural message. **Aural Alert** 'Pull-Up'
Ground Proximity Altitude Loss after Takeoff	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the aural message. **Aural Alert** 'Don't Sink'	**Visual Alert** None Required **Aural Alert** None Required
Ground Proximity Voice Callout (See Note 1)	**Visual Alert** None Required **Aural Alert** 'Five Hundred' or selected altitude	**Visual Alert** None Required **Aural Alert** None Required

Note: 1: The aural alert for ground proximity voice callout is considered advisory.

Note: 2: Visual alerts may be put on the terrain situational awareness display, if this fits with the overall human factors alerting scheme for the flight deck. This does not eliminate the visual alert color requirements, even in the case of a monochromatic display. Typically in such a scenario, adjacent

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colored enunciator lamps meet the alerting color requirements. Audio alerts are still required regardless of terrain display visual alerts.

MODIFICATIONS TO APPENDIX 2 , TEST CONDITIONS.

Note: 1: **Paragraph 1.1** of this ETSO is not applicable; for small aircraft, only the 'takeoff,' 'cruise,' and 'final approach to landing' phases of flight are considered.

Note: 2: **Paragraph 1.2** of this ETSO is changed to specify altitude levels, test speeds, and pull-ups more appropriate for small aircraft.

1.2 Cruise Descent Requirements. A terrain alert must be provided in time to ensure that the aeroplane can L/O with a minimum of 200 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane. The test conditions assume a descent along a flight path with terrain that is 500 feet below the expected L/O altitude. If the pilot initiates the L/O at the proper altitude, no TAWS alert is expected. However, if the pilot is distracted or otherwise delays the L/O, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

a. Table A, column A, represents the test condition. Columns B, C, and D are for information purposes only. Column E represents the minimum altitude for which TAWS alerts must be posted in order to perform their intended function. Column F represents the maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See **Appendix 2, paragraph 4.0.**

b. For each of the descent rates specified below, recovery to level flight at or above 200 feet terrain clearance is required.

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~~c. Test Conditions for cruise descent requirements:~~

~~Assumed pilot response time~~	~~3.0 seconds (minimum)~~
~~Assumed constant G pull-up~~	~~1.0 g~~
~~Minimum allowed terrain clearance~~	~~200 feet AGL~~
~~Descent rates~~	~~500, 1 000, and 2 000 FPM~~
~~Assumed pilot task for column F~~	~~L/O at 500 feet above the terrain per appendix 3, table 3.1.1 (ROC Column)~~

~~**Note: 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted, and the minimum terrain clearance altitude must be recorded.**~~

~~**Note: 2: Cruise operations are considered to exist beyond the airport control area until inside the destination airport control area for VFR operations. Distances may extend to 10 NM from the airport (takeoff and landing) for IFR operations. Use of the nearest runway logic is permissible provided suitable logic is incorporated to ensure that the transitions to the terminal logic will typically occur only when the aeroplane is in terminal airspace.**~~

~~**Note: 3: The values shown in column E may be reduced by 50 feet (to permit a L/O at 150 feet above the obstacle) provided that it demonstrates that the basic TAWS Mode 1 alert (sink rate) is issued at or above the altitude specified in column E for typical terrain topographies.**~~

~~**Note: 4: The values shown in column F are appropriate for an aeroplane without an autopilot or flight director function, and are based upon 10–15 %of the vertical velocity, which is appropriate to manual flight and small, GA aeroplane operations.**~~

Table A

ENROUTE DESCENT ALERTING CRITERIA

Alerting for Premature Descent during Cruise					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 3SEC PILOT DELAY	ALT REQ'D TO L/O WITH 1 G PULLUP	TOTAL ALT LOST DUE TO RECOVERY MANEUVER	MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN)	MAXIMUM CAUTION ALERT HEIGHT (ABOVE TERRAIN)
500	25	1	26	226	550
1 000	50	4	54	254	600
2 000	100	17	117	317	800

Note: Paragraph 1.3 in this ETSO is changed to specify altitude levels, test speeds, and pull-ups more appropriate to small aircraft.

1.3 Cruise Level Flight Requirement. During level flight operations (vertical speed is ± 200 feet per minute), a terrain alert should be posted when the aeroplane is within 250 feet of the terrain and is predicted to be equal to or less than 200 feet within the prescribed test criteria. See Table B for test criteria.

Note: The actual values for the aeroplane altitude, distance, and time from the terrain cell when caution and warning alerts are posted must be recorded.

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Table B

LEVEL CRUISE FLIGHT ALERTING CRITERIA			
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA
100	5 000	5 340 (+ 0/– 50)	NO ALERT
150	5 000	5 340 (+ 0/– 50)	NO ALERT
200	5 000	5 340 (+ 0/– 50)	NO ALERT
100	5 000	5 240 (+ 0/– 50)	MUST ALERT
150	5 000	5 240 (+ 0/– 50)	MUST ALERT
200	5 000	5 240 (+ 0/– 50)	MUST ALERT

1.4 Terminal Area (Intermediate Segment) Descent Requirement. Not applicable.

1.5 Terminal Area (Intermediate Segment) Level Flight Requirement. Not applicable.

1.6 Final Approach Descent Requirements. Revised to specify altitude levels, test speeds, and pull-ups more appropriate to small aircraft:

a. Table E, column A, represents the test conditions. Columns B, C, and D are for information purposes only. Column E represents the minimum altitude for which TAWS alerts must be posted in order to perform their intended function. Column F represents the maximum altitude for which TAWS alerts may be provided in order to meet the nuisance alert criteria. See **Appendix 2, paragraph 4.0.**

b. For each of the descent rates specified below, recovery to level flight at or above 100 feet terrain clearance is required.

c. Test conditions for 1.6:

Assumed pilot response time	1.0 seconds (minimum)
Assumed constant G pull-up	1.0 g
Minimum allowed terrain clearance	100 feet AGL
Descent rates	500, 750, and 1 000 FPM
Assumed pilot task for column F	L/O at 250 feet above the terrain per appendix 3, table 3.1.1 (ROC Column)

Note 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted, and the minimum terrain clearance altitude must be recorded.

Note 2: The values shown in column F are appropriate for an aeroplane without an autopilot or flight director function, and are based upon 10 %of the vertical velocity that is appropriate for manual flight and small, GA aeroplane operations.

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Table E

APPROACH DESCENT ALERTING CRITERIA					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 1SEC PILOT DELAY	ALT REQ'D TO L/O WITH 1 G PULLUP	TOTAL ALT LOST DUE TO RECOVERY MANEUVER	MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN)	MAXIMUM TAWS CAUTION ALERT HEIGHT (ABOVE TERRAIN)
500	8	1	9	109	300
750	12	2	14	114	325
1 000	17	4	21	121	350

1.7 Landing Flight Requirements. Applies as written.

2.0 through 2.2 FORWARD-LOOKING TERRAIN AVOIDANCE IMMINENT INPACT TEST CONDITIONS. Apply using Table G for speed cases of 100 through 250 knots; however, change the incremental pull from 0.25g to 1.0g as described in note 2.

3.0 through 3.1 PREMATURE DESCENT ALERT TEST CONDITIONS. Apply as written.

4.0 NUISANCE ALERT TEST CONDITIONS — GENERAL. Apply as written.

4.1 4 000 FPM. Not applicable.

4.2 2 000 FPM. Descent must be possible at 2 000 FPM and pilots must be able to L/O at 500 feet above the terrain using a normal L/O procedure (leading by 10 %of the vertical speed), without a caution or warning alert.

4.3 1 000 FPM. Descent must be possible at 1 000 FPM in a final approach segment and pilots must be able to L/O at 250 feet using the normal L/O procedure described in 4.2 above, without a caution or warning alert.

5.0 NUISANCE TEST CONDITIONS FOR HORIZONTAL AND VERTICAL FLIGHT TECHNICAL ERRORS. Applicable as written.

5.1 Test Cases. Is applicable as written; however, test cases are limited to locations 3, 6, 7, and 8 in **table I.**

6.0 TEST CONDITIONS USING KNOWN ACCIDENT CASES. Paragraphs 6.0 through 6.3 of Appendix 2 are to be determined by the applicant using actual National Transportation Safety Board (NTSB) or national equivalent entity GA accidents. Since detailed data is usually not available, reasonable constructed scenarios matching the actual known accident data may be demonstrated. Pulls of up to 1.0g may be used instead of the 0.25g as specified in **paragraph 6.2**, *computation and recording*.

7.0 CLASS C EQUIPMENT TEST REQUIREMENTS FOR EXCESSIVE DESCENT RATE. Apply Class B as written.

8.0 CLASS C EQUIPMENT TEST REQUIREMENTS FOR NEGATIVE CLIMB RATE OR ALTITUDE LOSS AFTER TAKEOFF. Apply Class B as written.

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~~**9.0 CLASS C EQUIPMENT TEST REQUIREMENTS FOR THE ALTITUDE CALLOUTS.** Apply Class B as written.~~

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: NEXT GENERATION SATELLITE SYSTEMS (NGSS) EQUIPMENT

1 — Applicability

This ETSO provides the requirements which next generation satellite systems (NGSS) equipment that ~~are~~ is designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The ~~S~~standards are those ~~set forth~~ provided in ~~the~~ EUROCAE ED-243~~RTCA DO-262B~~, Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (NGSS), dated April, 2017~~June 17, 2014; except that they are not required to meet any requirement of RTCA DO-326, Airworthiness Security Process Specification, in Normative Appendix D or E (as applicable) where referenced~~.

Note: There are no MPS security requirements for NGSS equipment. However, a security risk assessment may be required at the time of installation, and if needed, security controls may be implemented in connected aircraft systems or addressed by flight crew procedures.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3

3.2 — Specific

The MPS allows for different equipment classes and subclasses as defined by EUROCAE ED-243~~RTCA DO-262B~~. There are 6 applicable equipment classes and 13 equipment subclass components identified as shown in Tables 1A, 1B and Tables 2A, 2B of this ETSO. Tables 1A and 2A show the requirements for satellite communication (short burst data) (SATCOM (SBD)) equipment classes and subclass components, and Tables 1B and 2B show the requirements for satellite communication (swiftbroadband) (SATCOM (SBB)) equipment classes and subclass components~~(see RTCA DO-262B, Appendix D and Appendix E)~~. The manufacturer must declare the equipment class requirements from those identified in the applicable ~~appendix~~ table of this ETSO. The equipment configuration shall satisfy the relevant requirements of the EUROCAE ED-243 ~~RTCA DO-262B~~ minimum operational performance standards (MOPS) as identified in Tables 1A and 1B and 2A and 2B ~~in Appendix 1~~ of this ETSO.

Table 1A — Equipment Class Identifiers supporting SATCOM (SBD)

Equipment Class Identifier	**Description**	**Requirement**
AES1	AES using a single channel Satellite Data Unit (SDU) that contains one transceiver for data only applications. AES1 is a Short Burst Data (SBD)-only transceiver and cannot support voice calling. A passive Low Gain Antenna (LGA) is required for use with the AES1.	Appendix D, Section 2.2.1.1 and Section 2.4 for the applicable Test Requirements
AES2	AES2 is capable of multiple services using a single or dual channel SDU that contains one or two transceivers for data and/or voice applications. A passive LGA is required for use with the AES2.	Appendix D, Section 2.2.1.2 and Section 2.4 for the applicable Test Requirements
AES3	AES using two or more transceivers for multiple data and/or voice applications. A passive LGA is required for use with the AES3.	Appendix D, Section 2.2.1.3 and Section 2.4 for the applicable Test Requirements

Table 1B — Equipment Class Identifiers supporting SATCOM (SBB)

Equipment Class Identifier	**Description**	**Requirement**
AES4	AES using an Enhanced Low Gain Antenna (ELGA). AES4 configured as a complete system.	Appendix E, Section 2.2.1.1.1 and Section 2.4 for the applicable Test Requirements
AES6	AES using a High Gain Antenna (HGA), transceiver, and Diplexer Low Noise Amplifier (DLNA).	Appendix E, Section 2.2.1.1.2 and Section 2.4 for the applicable Test Requirements
AES7	AES using an Intermediate Gain Antenna (IGA), transceiver, and DLNA.	Appendix E, Section 2.2.1.1.3 and Section 2.4 for the applicable Test Requirements

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Table 2A — Equipment Subclass Identifiers supporting SATCOM (SBD)

Subclass Identifier	**Description**	**Requirement**
LGA	Passive LGA for use with AES1, AES2 or AES3.	Appendix D, Section 2.2.3.1.1

Table 2B — Equipment Subclass Identifiers supporting SATCOM (SBB)

Subclass Identifier	**Description**	**Requirement**
HGA	HGA for AES6.	Appendix E, Section 2.2.3.1.2
IGA	IGA for AES7.	Appendix E, Section 2.2.3.1.2
6MA	Transceiver, SDU Configuration Module (SCM), SDU, Modified Type A (DMA) Diplexer Low Noise Amplifier (DLNA), and HGA for use with AES6.	Appendix E, Section 2.2.1.1.4
7MA	Transceiver, SDU, SCM, DMA DLNA, and IGA for use with AES7.	Appendix E, Section 2.2.1.1.6
6D	Transceiver and DLNA combination includes SDU, High Power Amplifier (HPA), DLNA, SCM, and HGA functions for use with AES6.	Appendix E, Section 2.2.1.1.8
7D	Transceiver and DLNA combination includes SDU, HPA, DLNA, SCM, and IGA functions for use with AES7.	Appendix E, Section 2.2.1.1.9
6F	Transceiver and Type F (DF) DLNA includes SDU, HPA, SCM, and HGA functions for use with AES6.	Appendix E, Section 2.2.1.1.5
7F	Transceiver and DF DLNA includes SDU, HPA, SCM, and IGA functions for use with AES7.	Appendix E, Section 2.2.1.1.7
DMA	DLNA with standard Transmitter (Tx) filter configures with 6MA transceiver and HGA for use with AES6, or 7MA transceiver and IGA for use with AES7.	Appendix E, Section 2.2.1.1.10
DF	DLNA with enhanced Tx filter configures with 6MA or 6F transceiver and HGA for use with AES6, or with 7MA or 7F	Appendix E, Section 2.2.1.1.11

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Subclass Identifier	Description	Requirement
	transceiver and IGA for use with AES7.	

This ETSO standard applies to equipment intended for long-range communication services, procedural and continental communication services, aeronautical mobile satellite (route) services (AMS(R)S) by means of satellite communications between AES, corresponding satellites, and ground earth stations (GES). The NGSS supports voice and data communications~~, or data and voice communications,~~ between aircraft users and ground-based users, such as air navigation service providers (ANSPs) and aircraft operators.

~~Equipment class AES1 supports data communications only. All other equipment classes support both data and voice communications.~~

~~(1)~~The functionality of an NGSS supports four categories of communication service in the aircraft control domain (ACD) and/or aircraft information services domain (AISD). Two are ~~in the~~ safety of flight ~~category:~~ communication used for air traffic services (ATS) and aeronautical operational control (AOC) communication. The other two are ~~in the non-safety of flight category:~~ aeronautical administrative communication (AAC) and special-purpose aeronautical passenger communication (APC) under the physical or virtual access control of the flight crew.

EUROCAE ED-243, Normative Appendix E, also contains provisions for supporting a non-priority communications service known as passenger information and entertainment services (PIES). EUROCAE ED-243, Normative Appendix E, states that non-priority services are outside the scope of that Appendix. However, PIES communications, if supported, must be partitioned from communications in the ACD and AISD for security reasons. Therefore, PIES communications are non-ETSO functions, and equipment that supports shared ACD and PIES communications must provide security partitioning of the PIES functionality from priority communications services in the ACD and AISD in accordance with this ETSO.

See paragraphs 3.1.3, 3.1.4, 3.2.1, 3.2.2 and 3.2.3 of this ETSO for specific additional data, design/security assurance and verification requirements related to the required security partitioning for equipment intended to support shared ACD/AISD and PIES communications.

~~(2)~~ NGSS equipment is intended for procedural/continental airspace area operations. The failure conditions specified in paragraph 3.2.1 of this ETSO have been determined based on NGSS equipment that supplements or complements primary HF/VHF voice or data communications in procedural/continental airspace area operations, and on equipment that provides 'Segregation & arbitration' as described in EUROCAE ED-243, Appendix E, Section 1.3.4, or the equivalent functionality~~operating as an approved Long-Range Communication System (LRCS) in oceanic airspace area environments~~. Use of NGSS equipment in other operating environments (for example, high density terminal/en route airspace) may impact equipment performance and safety considerations.

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A loss or malfunction of the security partitioning required by paragraph 3.2 of this ETSO that enables unauthorised or inadvertent access to ACD or AISD communications from outside the ACD or AISD is a major failure condition.

~~Failure~~ A loss or malfunction of the functions defined in paragraph 3.~~b~~1 of this ETSO, except for a loss or malfunction of the security partitioning required by paragraph 3.2 of this ETSO, is a minor failure condition.

~~Loss of the function as defined in paragraph 3.b of this ETSO is a minor failure condition.~~

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Note: The use of NGSS equipment as the sole means of routine ATS communication may change the classification of the failure conditions. ~~for primary voice or data communications may necessitate the development of the NGSS equipment to a higher design assurance level than required for the failure criticality levels specified above and may drive a revision to this ETSO.~~

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

~~The NGSS class and subclass markings shall include the complete equipment identifier reference (such as AES1, AES4, or AES7). An example subclass component (such as a high-gain antenna (HGA), Transceiver, or Diplexer/Low Noise Amplifier(DLNA)) marking would display AES6-2/HGA, Type A Transceiver AES7-7/7MA, or Type F Diplexer AES6-3/DF, etc.~~

For valid combinations of system component markings, see ~~t~~Table 3 below ~~in Appendix 1 to this ETSO~~.

Table 3 — Valid Combinations of System Components

Valid Combinations		EUROCAE ED-243Normative Appendix	Transceiver						Transceiver & DLNA		DLNA		Antenna			Complete System
			SBD	LBT	6MA	6F	7MA	7F	6D	7D	DMA	DF	LGA (passive)	HGA	IGA	
AES 1	1	D														x
	2	D	x										x			
AES 2	3	D														
	4	D		x									x			
AES 3	5	D														x
	6	D	x	x									x			
AES 4	1	E														x
AES 5	2	E			x						x			x		
	3	E				x						x		x		
	4	E							x					x		
	5	E			x							x		x		
	6	E														x
AES 7	7	E					x				x				x	
	8	E						x				x			x	
	9	E								x					x	
	10	E				x						x			x	
	11	E														x

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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~~Appendix 1~~

~~Tables~~

~~Table 1: Equipment Class Identifiers~~

~~Equipment Class Identifier~~	~~Description~~	~~Requirement~~
~~AES1~~	~~AES using a single channel Satellite Data Unit (SDU) that contains one transceiver for data only applications. AES1 is a Short Burst Data (SBD)-only transceiver and cannot support voice calling. A passive Low Gain Antenna (LGA) is required for use with the AES1.~~	~~Appendix D, Section 2.2.1.1~~
~~AES2~~	~~AES2 is capable of multiple services using a single or dual channel SDU that contains one or two transceivers for data and/or voice applications. A passive LGA is required for use with the AES2.~~	~~Appendix D, Section 2.2.1.2~~
~~AES3~~	~~AES using two or more transceivers for multiple data and/or voice applications. Passive or active (powered) antennas may be configured such as a LGA Omni, Intermediate Gain Antenna (IGA) switched beam or IGA/High Gain Antenna (HGA) phased steering array.~~	~~Appendix D, Section 2.2.1.3~~
~~AES4~~	~~AES using an Enhanced Low Gain Antenna (ELGA). AES4 is configured as a complete system.~~	~~Appendix E, Section 2.2.1.1.1~~
~~AES6~~	~~AES using an HGA, transceiver, and Diplexer Low Noise Amplifier (DLNA).~~	~~Appendix E, Section 2.2.1.1.2~~

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~~**Table 2: Equipment Sub-Class Identifiers**~~

~~Sub-Class Identifier~~	~~Description~~	~~Requirement~~
~~LGA~~	~~Passive LGA for use with AES1, AES2 or AES3.~~	~~Appendix D, Section 2.2.3.1.1~~
~~IGA~~	~~Active IGA for AES3.~~	~~Appendix D, Section 2.2.3.1.1~~
~~HGA~~	~~Active HGA for AES3.~~	~~Appendix D, Section 2.2.3.1.1~~
~~HGA~~	~~HGA for AES6.~~	~~Appendix E, Section 2.2.3.1.2~~
~~IGA~~	~~IGA for AES7.~~	~~Appendix E, Section 2.2.3.1.2~~
~~6MA~~	~~Transceiver, SDU Configuration Module (SCM), SDU, Modified Type A (DMA) DLNA, and HGA for use with AES6.~~	~~Appendix E, Section 2.2.1.1.5~~
~~7MA~~	~~Transceiver, SDU, SCM, DMA DLNA, and IGA for use with AES7.~~	~~Appendix E, Section 2.2.1.1.7~~
~~6D~~	~~Transceiver and DLNA combination includes SDU, High Power Amplifier (HPA), DLNA, SCM, and HGA functions for use with AES6.~~	~~Appendix E, Section 2.2.1.1.9~~
~~7D~~	~~Transceiver and DLNA combination includes SDU, HPA, DLNA, SCM, and IGA functions for use with AES7.~~	~~Appendix E, Section 2.2.1.1.10~~
~~6F~~	~~Transceiver and Type F (DF) DLNA includes SDU, HPA, SCM, and HGA functions for use with AES6.~~	~~Appendix E, Section 2.2.1.1.6~~
~~7F~~	~~Transceiver and DF DLNA includes SDU, HPA, SCM, and IGA functions for use with AES7.~~	~~Appendix E, Section 2.2.1.1.8~~
~~DMA~~	~~DLNA with standard Transmitter (Tx) filter configures with 6MA transceiver and HGA for use with AES6, or 7MA transceiver and IGA for use with AES7.~~	~~Appendix E, Section 2.2.1.1.11~~
~~DF~~	~~DLNA with enhanced Tx filter configures with 6MA or 6F transceiver and HGA for use with AES6, or with 7MA or 7F transceiver and IGA for use with AES7.~~	~~Appendix E, Section 2.2.1.1.12~~

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~~Table 3: Valid Combinations of System Components~~

~~Valid Combi-nations~~		~~System~~	~~Transceiver~~						~~Trans-ceiver & DLNA~~		~~DLNA~~		~~Antenna~~					~~Complete System~~
			~~SBD~~	~~LBT~~	~~6MA~~	~~6F~~	~~7MA~~	~~7F~~	~~6D~~	~~7D~~	~~DMA~~	~~DF~~	~~LGA (passive)~~	~~IGA switched beam~~	~~IGA/HGA phased steering array~~	~~HGA~~	~~IGA~~	
~~AES1~~	~~1~~	~~Appendix D~~																~~X~~
	~~2~~	~~Appendix D~~	~~X~~										~~X~~					
~~AES2~~	~~3~~	~~Appendix D~~																~~X~~
	~~4~~	~~Appendix D~~		~~X~~									~~X~~					
~~AES3~~	~~5~~	~~Appendix D~~																~~X~~
	~~6~~	~~Appendix D~~	~~X~~	~~X~~									~~X~~					
	~~7~~	~~Appendix D~~	~~X~~	~~X~~										~~X~~				
	~~8~~	~~Appendix D~~	~~X~~	~~X~~											~~X~~			
~~AES 4~~	~~1~~	~~Appendix E~~																~~X~~
~~AES 6~~	~~2~~	~~Appendix E~~			~~X~~						~~X~~					~~X~~		
	~~3~~	~~Appendix E~~				~~X~~						~~X~~				~~X~~		
	~~4~~	~~Appendix E~~							~~X~~							~~X~~		
	~~5~~	~~Appendix E~~			~~X~~							~~X~~				~~X~~		
	~~6~~	~~Appendix E~~																~~X~~
~~AES 7~~	~~7~~	~~Appendix E~~					~~X~~				~~X~~						~~X~~	
	~~8~~	~~Appendix E~~						~~X~~				~~X~~					~~X~~	
	~~9~~	~~Appendix E~~								~~X~~							~~X~~	
	~~10~~	~~Appendix E~~					~~X~~					~~X~~					~~X~~	
	~~11~~	~~Appendix E~~																~~X~~

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: VDL MODE 2 COMMUNICATIONS EQUIPMENT

1 — Applicability

This ETSO ~~gives~~ provides the requirements which VDL Mode 2 communications equipment that is~~are~~ designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical ~~c~~Conditions

3.1 — Basic

3.1.1 — Minimum ~~p~~Performance ~~s~~Standard

The applicable ~~S~~standards are those ~~set forth~~ provided in ~~the~~ EUROCAE ED-92B, Minimum Operational Performance Standards for Aircraft VDL Mode 2 Physical, Link, and Network Layer, dated 21 ~~/03/~~March 2012, or in EUROCAE ED-92C, Minimum Operational Performance Standards for an Airborne VDL Mode-2 System Operating in the Frequency Range 118-136.975 MHz, dated September 2018. ED-92B is identical to RTCA DO-281B. ED-92C is identical to RTCA DO-281C.

Compliance shall be demonstrated entirely with one of the versions of the applicable minimum operational performance standards.

3.1.2 — Environmental ~~s~~Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne ~~e~~Electronic ~~h~~Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure ~~c~~Condition ~~c~~Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of referenced documents

See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: ELECTRONIC MAP SYSTEMS FOR GRAPHICAL DEPICTION OF AIRCRAFT POSITION

1 — Applicability

This ETSO gives provides the requirements that any electronic map system for the graphical depiction of aircraft position (own-ship), designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

This ETSO applies to equipment that is intended to provide a graphical depiction of advisory information on a display (e.g. navigation, traffic, weather, obstacles, graphical taxi routing, etc.). The system is intended to improve flight crew positional awareness of the aircraft own-ship position relative to other items depicted on the display.

2 — Procedures

2.1 — General

The Aapplicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

Applications to certify only the software without certifying the hardware and/or the operating system will be accepted. Nevertheless, the applicant has to specify the requirements for the hardware and/or the operating system to be used, the tests to be performed once the software is integrated into the final system, and the environment which has been used to demonstrate the functionality of the system functionality.

2.3 — Databases

If the article includes database(s), each database must be processed in accordance with the requirements in EUROCAE ED-76A, Standards For Processing Aeronautical Data, dated June 2015, or RTCA DO-200B, Standards for Processing Aeronautical Data, dated 18 June 2015.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard (MPS)

New models of electronic map systems that are to be so identified and that are manufactured on or after the effective date of this ETSO must meet the The applicable standards are those set forth provided for moving map equipment in Section 2 of RTCA document DO-257BA, 'Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps', dated 22 March 2018June, 25, 2003 as amended by Appendix 1 to this ETSO.

Electronic map systems may include displays, controls, and processing equipment that is intended to provide a graphical depiction of navigation information on the display (e.g. flight

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plans, fixes, navaids, electronic charts, terrain, weather, obstacles, aerodrome surfaces, graphical taxi routing, etc.). The electronic map system improves flight crew positional awareness of the aircraft relative to other items depicted on the display. The standards were updated to support required navigation performance (RNP) systems, specifically when the in-flight (plan view) and vertical situation display (VSD) maps are displaying defined paths that are generated by the RNP system.

~~1) Electronic Map Systems for use in flight must meet the MPS in Sections 2.1 and 2.2 of RTCA/DO-257A as amended by Appendix 1 to this ETSO;~~

~~2) Electronic Map Systems for use on the airport surface – AMMD applications - must meet the MPS in Sections 2.1, 2.2, and 2.3 of RTCA/DO-257A as amended by Appendix 1 to this ETSO; and~~

~~3) Electronic Map Systems including Vertical Situation Displays (VSD) for use in facilitating pilot's awareness of the aircraft's vertical flight path must meet the MPS in Sections 2.1, 2.2, and 2.4 of RTCA/DO-257A as amended by Appendix 1 to this ETSO.~~

Table 1 provides the RTCA DO-257B requirements that are applicable to each specific function of the ~~summarises the functional description and applicable MPS requirements for~~ electronic map systems.

	Applicable Requirements Sections in RTCA~~/~~ DO-257B~~A~~ ~~(as amended by Appendix 1 to this ETSO)~~				
Electronic Map System functional description	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**
In flight	X	X	X		
~~Airport~~ Aerodrome surface (AMMD)	X	X	~~X~~	X	
Vertical Situation Display (VSD)	X	X		~~X~~	X

Table 1

~~Demonstrate the required functional performance under the test conditions specified in RTCA/DO-257A, Section 2.6 as modified by appendix 1 of this ETSO.~~

Displays that are part of the electronic map system must also be approved in accordance with ETSO-C113 at the latest revision.

3.1.2 — Environmental Standard

~~Demonstrate the required performance under the test conditions specified in RTCA/DO-257A, Section 2.5, using standard environmental conditions and test procedures appropriate for airborne equipment as defined in~~ See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Computer Software

See CS-ETSO, Subpart A, paragraph 2.2.

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3.1.4 — Electronic Hardware Qualification

See CS-ETSO, Subpart A, paragraph 2.3

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4. ~~For the definitions of the intended functions see RTCA/DO-257A section 1.4.~~ RTCA DO-257B Section 2.1.8 defines the minimum failure condition classifications for the specific electronic map system functions that are summarised in Table 1, except for the loss of the aerodrome moving map display, which is a minor failure condition.

~~Failure of the functions defined in paragraph 3.1.1 of this ETSO for Electronic Map Systems used in flight and VSD equipment (airborne applications) have been determined to be a major failure condition for malfunctions causing the incorrect depiction of aircraft position (own-ship).~~

~~Loss of function for Electronic Map Systems used in flight and VSD equipment (airborne applications) has been determined to be a minor failure condition.~~

~~Failure of the function defined in paragraph 3.1.1 of this ETSO for Electronic Map Systems used on the airport surface (ground applications) have been determined to be a minor failure condition for malfunctions causing the incorrect depiction of aircraft position (own-ship).~~

~~Loss of function for Electronic Map Displays used on the airport surface (ground applications) is determined to be a no safety effect failure condition.~~

~~Table 2 summarises the failure condition classifications.~~

~~**Electronic Map System functional description**~~	~~**Failure condition classification –Incorrect Depiction of Aircraft Position**~~	~~**Failure condition classification – Loss of function**~~
~~In flight~~	~~Major~~	~~Minor~~
~~Vertical Situation Display (VSD)~~	~~Major~~	~~Minor~~
~~Airport surface (AMMD)~~	~~Minor~~	~~No Safety Effect~~

~~**Table 2**~~

3.2.2 — Documentation

Installation procedures and limitations must include:

— a description of the intended function of the electronic map system;

— a description of the data quality characteristics that are necessary for the electronic map system to perform its intended function (reference EUROCAE ED-76A Standards For Processing Aeronautical Data, dated June 2015, Section 2.3, or RTCA DO-200B, Standards for Processing Aeronautical Data, dated 18 June 2015, Section 2.3);

— a requirement to interface the electronic map system with a TSO or ETSO-approved global navigation satellite system (GNSS) sensor, which is the source of position input data;

— if applicable, a description of how the electronic map system with AMMD meets the total system

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accuracy requirements of RTCA DO-257B, Section 2.4.1.1; and

— a requirement stating that the aeronautical database(s) associated with the electronic map system, whether internal or external to the electronic map system, must demonstrate compliance with EUROCAE ED-76A/RTCA DO-200B, or its subsequent revisions as required in paragraph 2.3 of this ETSO.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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~~**Appendix 1**~~

~~**Additional Requirements for Electronic Map Systems**~~

~~This appendix defines changes to the Minimum Operational Performance Standards (MOPS) for Electronic Map Systems specified in RTCA/DO-257A, *Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps*, dated June, 25, 2003.~~

~~Some changes replace sections of RTCA/DO-257A. Other just add additional text; in this latter case the additional text is underlined.~~

~~**DO-257A MOPS is modified as follows:**~~

~~**1. Display Operating Characteristics and Status Indications**~~

~~2.2.4 A new sub-section 25 to section 2.2.4 has been added:~~

~~25. A process activity monitor (watchdog) shall be implemented to detect frozen processes and to remove outdated/frozen information from the screen, or to clearly indicate the invalid data. The process activity monitor shall be able to detect the occurrence of the failure within 5 seconds.~~

~~**2. Database (Navigation)**~~

~~2.2.5 The first paragraph from 2.2.5 and the current sub-section 5 has been replaced, two new sub-sections to 2.2.5 have been added:~~

~~As an alternative to (or in addition to) an external data source, the EMD may use an internal database to store information such as flight plans, nearby fixes, airspace boundaries, raster aeronautical charts, or airport mapping information. If an internal or external database is being used, the following requirements apply: …~~

~~- Subsection 5 changes are underlined:~~

~~5. The processes of producing and updating aeronautical databases shall meet the standards specified in EUROCAE ED-76/RTCA DO-200A *Standards for Processing Aeronautical Data,* dated October 1998 or subsequent revisions.~~

~~- Add the following new subsections:~~

~~7. Specification of the Data Quality Requirements (DQRs) for the EMD system shall be developed and incorporated as part of the compliance documentation (Reference EUROCAE ED-76/RTCA DO-200A, section 2.3.2).~~

~~8. Corruption of the map database shall be detected and annunciated to the flight crew clearly and in a timely manner.~~

~~**3. Runways**~~

~~2.3.1.1.1 The current sub-section 6 of section 2.3.1.1.1 has been deleted and replaced by:~~

~~6. The aerodrome database accuracy for runway data elements shall meet medium category data quality as defined in EUROCAE ED-99C/RTCA DO-272C *User Requirements for Aerodrome Mapping Information,* dated September 2011, or subsequent revisions.~~

~~- The following new subsection is added:~~

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7. ~~The total system accuracy shall be sufficient for the AMMD intended function, and shall not exceed 50 meters (95 %). The position source accuracy (36 m) and total database accuracy (5 m) may be reallocated, if the total system accuracy remains less than or equal to 50 meters. The formula for calculating total system accuracy is:~~

$$\sqrt{[(\text{Position Source Accuracy})^2 + (\text{Total Database Accuracy})^2 + (\text{Latency Effects})^2 + (\text{Display Errors})^2]} + |Uncompensated\ GPS\ Antenna\ Offset| = \text{Total System Accuracy}$$

~~4. Taxiways~~

~~2.3.1.1.2 In page 32, the current sub-section 4 of section 2.3.1.1.2 has been deleted and replaced by:~~

4. ~~When depicted, the aerodrome database accuracy for taxiway data elements shall meet medium category data quality as defined in RTCA DO-272C/ED-99C, or subsequent revisions.~~

   ~~*Note: For airports where no known taxiway data is published and errors are noted, operators using the moving map will report database errors to the database supplier as described in section 2.3.5.*~~

~~The following new subsection is added:~~

5. ~~The total system accuracy shall be sufficient for the AMMD intended function, and shall not exceed 50 meters (95 %). The position source accuracy (36 m) and total database accuracy (5 m) may be reallocated, if the total system accuracy remains less than or equal to 50 meters. The formula for calculating total system accuracy is:~~

$$\sqrt{[(Position\ Source\ Accuracy)^2 + (Total\ Database\ Accuracy)^2 + (Latency\ Effects)^2 + (Display\ Errors)} |Uncompensated\ GPS\ Antenna\ Offset| = Total\ System\ Accuracy$$

~~5. Depiction of Ownship Position~~

~~2.3.1.2 New sub-sections 7 and 8 to section 2.3.1.2 have been added:~~

7. ~~The AMMD shall provide a means to compensate for installation dependent GPS antenna offset (i.e., along track aircraft reference point bias associated with GNSS antenna position relative to the nose of the aircraft).~~

   ~~*Note: Acceptable means of compliance include the use of system calibration or a limitation on the GNSS antenna installation position in relation to the nose of the aircraft.*~~

8. ~~AMMD applications limited to the airport surface (ground applications) and having only a minor failure classification, shall remove the own-ship position symbol at a ground speed above 80 knots. A means to allow lower values is recommended to adjust for actual aircraft performance or to mitigate installation dependant horizontal position latency.~~

~~6. Database (AMMD)~~

~~2.3.5 The following paragraph is inserted before subsection 1:~~

Both internal and external EMD databases shall meet the following requirements: …

- By keeping the notes sub-section 2 of section 2.3.5 has been deleted and replaced by:

2. The processes of producing and updating aerodrome databases shall meet the standards specified in EUROCAE ED-76/RTCA DO-200A or subsequent revisions. Description of the data quality requirements (DQRs) for the EMD database shall be specified (Reference EUROCAE ED-76/RTCA DO-200A, section 2.3.2).

- Add the following new subsection:

3. Corruption of the EMD database shall be detected and annunciated to the flight crew clearly and in a timely manner.

7. Bench Test Procedures

Section 2.6 is modified so as to include all additional and modified requirements stated above in the applicable test sections.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AVIATION VISUAL DISTRESS SIGNALS

1 — Applicability

This ETSO provides the requirements which aviation visual distress signals that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

For handheld, high-intensity, stroboscopic light sources that can be added to aviation survival kits to supplement pyrotechnic devices, the standards are those provided in SAE International's Aerospace Standard AS5134A, Aviation Distress Signal, dated 27 September 2007.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

3.2.2 — Others

These light sources must:

— eliminate the significant potential equipment and personnel hazards that are posed by untrained personnel using pyrotechnics in inflatable life rafts; and

— provide an equivalent level of safety to pyrotechnics that aid in locating and rescuing aviation accident survivors.

4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AIRCRAFT COCKPIT IMAGE RECORDER SYSTEMS

1 — Applicability

This ETSO provides the requirements that aircraft cockpit image recorder (CIR) systems (CIR) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The Aapplicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4, excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable Sstandards are those set forth provided in the applicable sections of EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, that pertain to the cockpit image recorder (CIR) type, except Chapters III-1 and III-6, and Sections 2-1.1, 2-1.5, 2-1.6, 2-1.11, 2-1.12, 2-3.1, 2-5, 3, 3-1.1, 3-1.2, 3-1.3, 3-1.4, 3-1.5 , 3-1.7 Annex III-A, Annex III-B, and other ED-112A requirements related to aircraft-level equipment installation, flight testing, and aircraft maintenance as modified in Appendix 1 of this ETSO.

The table below lists the types of recorder types and the ED-112A section or part with that contains the MPS for each of them:

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Table 1~~.~~ — CIR MPS Requirements

CIR Type	ED-112A Reference
Single CIR in a non-deployable recorder	Section 2 and Part III.
CIR function in a deployable recorder	Section 2~~, Section 3~~ (except for tests covered by ETSO-2C517) and Part III. The recorder shall also comply with ETSO-2C517.
CIR function in a combined non-deployable recorder	Section 2, Section 4 and Part III.
CIR function in a combined deployable recorder	Section 2 (except for the tests covered by ETSO-2C517), Section 4 and Part I. The recorder shall also comply with ETSO-2C517.

Note: ~~a~~A CIR article may cover multiple types. A CIR may be a combined CIR and may also be deployable, in which case the applicable MOPS are in Sections 2, 3, 4 and Part I, following the table above.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

A ~~L~~loss of the function defined in paragraph 3.1.1 of this ETSO is a minor failure condition.

Note: ~~t~~The failure classification requirement is driven by the use of recorders in accident investigations.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

4.2.1 — Lettering Identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 2-1, paragraph 2-1.16.3, if it is fixed, and Section 3-1, paragraph 3-1.8.3, if it is deployable.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

The standard EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A for ADFR systems

Location	**Initial ED-112A text**	**Amending text**
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 90 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by the deep-sea pressure test. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself, together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of +25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a nominal temperature of at least + 25.0 °C for a period of 90 days.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: DATA LINK RECORDER EQUIPMENT

1 — Applicability

This ETSO ~~gives~~ provides the requirements that new models of data link recorder systems that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

~~None~~

All the information specified in EUROCAE ED-112A, Section 2-1, 2-1.3.4, excluding item 6, shall be documented in a manual and be made available to the accident investigation authorities on request. In addition, if special tools or recovery techniques are used to retrieve recorded information from any memory device used within the crash-protected memory module removed from a crash-damaged recorder, these tools/recovery techniques shall be also made available to the accident investigation authorities on request.

Note: Requests from accident investigation authorities can be independent of any ongoing investigation.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~ provided in the applicable sections of EUROCAE document ED-112A ~~'~~Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems~~'~~ dated September 2013, that pertain to the types of data link recorder ~~types~~ as defined in table 1 below, except for the following exclusions: Chapters IV-1 and IV-6, and Sections 2-1.1, 2-1.5, 2-1.6, 2-1.11, 2-1.12, 2-3.1, 2-5, 3 ~~3-1.1, 3-1.2, 3-1.3, 3-1.4, 3-1.5, 3-1.7, 3-4~~ and Annex IV-B and other ED-112A requirements related to aircraft-level equipment installation, flight testing and aircraft maintenance and as modified in Appendix 1 of this ETSO.

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Recorder Type	ED-112A Reference
Single DLR in a non-deployable recorder	Section 2 and Part IV.
DLR function in a deployable recorder	Section 2 (except for the tests covered by ETSO-2C517), Section 3 and Part IV. The recorder shall also comply with ETSO-2C517.
DLR function in a combined non-deployable recorder	Section 2, Section 4 and Part IV.
CVR function in a combined deployable recorder	Section 2 (except for the tests covered by ETSO-2C517), Section 4 and Part I. The recorder shall also comply with ETSO-2C517.

Table 1 —: MPS Requirements per recorder type

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Computer Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware Qualification.

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A Lloss or erroneous behaviour of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

Note: tThe failure classification is driven by the accident investigation need the use of recorders in accident investigations.

4 — Marking

4.1 — General

Marking as detailed in See CS-ETSO, Subpart A, paragraph 1.2

4.2 — Specific

See EUROCAE document ED-112A Section 2-1, paragraph 2-1.16.3, if the recorder is fixed, and Section 3-1, paragraph 3-1.8.3, if it is deployable.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3

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APPENDIX 1

MPS FOR CRASH-PROTECTED AIRBORNE RECORDER SYSTEMS

The standard EUROCAE ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A for ADFR systems

Location	**Initial ED-112A text**	**Amending text**
2-4.2.7 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 30 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by sea water. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the sea water in which the recorder is immersed.	Unless it can be shown that the recording medium can withstand the conditions associated with deep-sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in seawater at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 ft) for a period of 90 days. This period may be reduced to 24 hours provided that the methods and materials used to protect the recording medium have been shown to be unaffected by the deep-sea pressure test. To avoid damage to the test equipment, this test may be performed using any suitable liquid in the pressure chamber itself together with a means to separate this liquid from the seawater in which the recorder is immersed.
2-4.2.7 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of +25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a nominal temperature of at least + 25.0 °C for a period of 90 days.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: ~~PERMANENTLY INSTALLED~~ RECHARGEABLE LITHIUM CELLS, BATTERIES, AND BATTERY SYSTEMS

1 — Applicability

This ETSO ~~gives~~ provides the requirements which ~~permanetly installed~~ rechargeable lithium cells, batteries, and battery systems that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

For equipment with rechargeable lithium cells, lithium batteries and battery systems that are intended to provide power for aircraft equipment, including emergency systems, ~~permanently installed rechargeable lithium cells, batteries and lithium battery systems intended to provide power for aircraft equipment S~~ the applicable standards are those ~~set forth~~ provided in ~~Sections 2 and 3 of~~ Radio Technical Commission for Aeronautics (RTCA) Document DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems, dated 19 December 2017~~March 13, 2008. Refer to Table 4-1 of DO-311 for test schedule information.~~ However, the demonstration of compliance with this ETSO may not rely on Appendix C of DO-311A.

3.1.2 — Environmental Standard

Test the equipment according to Section 3 of RTCA~~/~~ DO-311A, *Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems* document dated 19 December 2017~~March 13, 2008~~.

3.1.3 — ~~Computer~~ Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware ~~Qualification~~

See CS-ETSO, Subpart A, paragraph 2.3.

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3.2 — Specific

3.2.1 —Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

~~Failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition.~~

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

The ~~S~~specific marking requirements are detailed in Section ~~1.9.7~~2.13 of RTCA~~/~~ DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems document, dated 19 December 2017~~March 13, 2008~~.

In addition, the article must be marked with:

— its serial number;

— 'ETSO-C179b-CLASS A-XY' or 'ETSO C179b-CLASS B-XY' as shown below (where X stands for the energy category and Y stands for the venting category as listed in the table below and defined in RTCA DO-311A Sections 1.4.1 and 1.4.2):

- ETSO-C179b CLASS A — During the RTCA DO-311A Section 2.4.5.5 Battery Thermal Runaway Containment Test, all the cells within the battery must undergo thermal runaways.
- ETSO-C179b CLASS B — During the RTCA DO-311A Section 2.4.5.5 Battery Thermal Runaway Containment Test, not all the cells within the battery undergo thermal runaways.

Energy Category (X)	Venting Category (Y)
1	A
1	B
1	C
2	A
2	B
2	C
3	A
3	B
3	C
4	A
4	B
4	C

(For example: ETSO-C179b CLASS B-1A would be a rechargeable lithium battery and battery system that is of energy category 1 and a venting category of A, and not all the cells underwent thermal runaways during the RTCA DO-311A Section 2.4.5.5 testing.)

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AIRBORNE SUPPLEMENTAL NAVIGATION SENSORS FOR GLOBAL POSITIONING SYSTEM EQUIPMENT USING AIRCRAFT-BASED AUGMENTATION

1 — Applicability

This ETSO ~~gives~~ provides the requirements which airborne supplemental navigation sensors for Global Positioning System equipment using aircraft-based augmentation that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

~~This ETSO cancels ETSO-C129a *Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS)*~~

Note: Revision b provides applicants with the option to use an ETSO-2C206 ~~GPS~~ GNSS circuit card assembly (CCA) as part of their ETSO application. There is no technical change to the MOPS in comparison with ETSO-C196a.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

~~None~~

This section applies only for ETSO articles that use an ETSO-2C206 GNSS CCA.

Applicants who use an ETSO-2C206 GNSS CCA will need to coordinate with their GNSS CCA supplier for at least the following aspects:

2.2.1 — Access to the Information of the Selected ETSO-2C206 CCA

The applicant is responsible for establishing the necessary communication channels with the ETSO-2C206 holder company. Applicants who use an ETSO-2C206 SBAS CCA will need to coordinate with their SBAS CCA supplier to obtain the documentation that supports ETSO-2C206.

The applicant's organisation shall establish a means of communication to obtain timely notifications of design changes, open problem reports (at least the ones that impact the usage of the CCA), occurrence reports and airworthiness directives that affect or relate to the ETSO-2C206 article.

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2.2.2 — Assessment of Design Changes

The applicant shall perform an impact analysis of the design changes to the ETSO-2C206 article, and shall perform the necessary development life-cycle activities that are impacted by the ETSO-2C206 changes.

Note: If a major change (as assessed per point 21.A.611) is applied to the ETSO-2C206 article, which is installed in the ETSO-C196b article, it is also systematically considered to be major for the ETSO-C196b function.

2.2.3 — Assessment and Reporting of Open Problem Reports (OPRs)

The applicant shall perform the assessment of the ETSO-2C206 CCA OPRs. The applicant shall report the resulting OPRs that affect the ETSO-C196b article.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable Sstandards are those set forth provided in the Radio Technical Commission for Aeronautics (RTCA) document DO-316, Minimum Operational Performance Standards (MOPS) for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, dated 14 /04/April 2009, Section 2.

Use of an ETSO-2C206 GNSS CCA functional sensor

ETSO-196b applicants have the option to use an ETSO-2C206 GNSS CCA functional sensor. Applicants who choose to use an ETSO-2C206 GNSS CCA can take credit for certification compliance by virtue of the ETSO-2C206 ETSOA for:

— meeting the MPS Section 2.1 requirements;

— the development assurance of the hardware/software;

— the classification of the failure conditions;

— the MPS Section 2.5 performance testing (functional qualification), except that specified in Appendix 1 of this ETSO; and

— partial environmental testing performed on the ETSO-2C206 GNSS CCA.

After the integration of the ETSO-2C206 CCA in the ETSO-196b article, the applicant shall perform the testing described in Appendix 1. The applicant shall also complete the environmental qualification testing. The testing shall include the detailed functional test procedures delivered by the ETSO-2C206 GNSS CCA provider. This testing is required to address the paragraphs of this ETSO that are not covered by the items listed above.

Note: An end-use equipment manufacturer that uses an ETSO-2C206 SBAS CCA functional sensor assumes full responsibility for the design and the function under their ETSO-C196b authorisation.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

Tests to EUROCAE ED-14( ) Sections 9 and 26 are considered to be optional. Tests to Sections 10, 11, 12, 13, and 14 are required only when the component is installed on the outside of the aircraft, like such as the antenna.

3.1.3 — Computer Software

See CS-ETSO, Subpart A, paragraph 2.2.

Applicants who use ETSO-2C206 GNSS CCA functional sensors may use the ETSO-2C206 authorisation as substantiation for compliance with the software development assurance aspects of the CCA.

3.1.4 — Airborne Electronic Hardware ~~Qualification~~

See CS-ETSO, Subpart A, paragraph 2.3.

Applicants who use ETSO-2C206 GNSS CCA functional sensors may use the ETSO-2C206 authorisation as substantiation for compliance with the hardware development assurance aspects of the CCA.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a major failure condition for a malfunction of oceanic/remote, en route and terminal navigation and lateral navigation (LNAV) approaches.

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition for a loss of navigation of oceanic/remote, en route and terminal navigation and lateral navigation (LNAV) approaches.

Note: These failure condition classifications are considered to be the minimum classifications. Guidance for the installation of navigation systems at the aircraft level (e.g. Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS-ACNS)) could require a different failure condition classification.

3.2.2 — Additional Specific

Barometric-aided Fault Detection and Exclusion (FDE). If the equipment uses barometric-aiding to enhance the availability of FDE ~~availability,~~ then the equipment must meet the requirements in RTCA~~/~~ DO-316, Appendix G.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

END-USE EQUIPMENT MANUFACTURER TESTS FOR GNSS CCA FUNCTIONAL PVT SENSORS USED FOR NAVIGATION AND NON-NAVIGATION APPLICATIONS

1 — Scope

This Appendix describes the required supplementary equipment level testing, in addition to the environmental testing of RTCA DO-316, Section 2.2, that the manufacturer of the end-use equipment is required to conduct in order to receive an ETSO-C196b authorisation if they use an ETSO-2C206 GNSS CCA functional sensor. These test procedures are intended to streamline and simplify the ETSO-C196b authorisation process for the manufacturer of the end-use equipment by allowing credit for the design and selected testing performed at the GNSS CCA functional sensor level. However, the manufacturer of the end-use equipment remains fully responsible for the design and control of the article per their ETSO-C196b authorisation.

2 — General principles

(a) The testing methods for GPS equipment have been standardised by RTCA DO-316, and these serve as the basis for ETSO-C196b. RTCA DO-316 was written to cover equipment that can be installed on aircraft. Section 2.2 specifically addresses the issues of the environment in which the equipment operates, and provides the approved test methods to validate its performance in this environment. Section 2.2 represents the RTCA consensus in identifying which RTCA DO-316 requirements are sensitive to environmental effects. These requirements are listed in Table 2-2 referenced in Section 2.2.1.

(b) The determination that an MOPS requirement is susceptible to the environment does not depend on whether or not the implementation is a GNSS CCA within an ETSO-C196b article. Only the sensitivity to the environment is affected. This is the same concept as an equipment enclosure that is designed to protect against a benign environment compared with one that is designed for a severe environment; the identification of the susceptible requirements is the same.

(c) Therefore, this Appendix uses Table 2-2 of RTCA DO-316, Section 2.2.1, to identify the MOPS requirements that are susceptible to environmental conditions for a GNSS CCA functional sensor in the end-use equipment. The focus is on the change in environment seen by the GNSS CCA functional sensor as a result of its installation in the end-use equipment. For example, other components inside the end-use equipment may radiate RF energy that could interfere with the GPS functions; therefore, the ambient testing performed at the CCA level is not equivalent to the tests performed in the end-use equipment. This is the basis for defining the Section 2.3 performance tests that need to be repeated by the manufacturer of the end-use equipment.

(d) Table 2-2 referenced in RTCA DO-316, Section 2.2.1, is the prime source to determine the MOPS performance requirements that are susceptible to environmental conditions. Based on that table, the susceptible requirements can be grouped into two categories: those that are susceptible to most types of environmental conditions (described in Section 3) and those that are susceptible to only a few (described in Section 4).

3 — Performance requirements that are susceptible to most environmental conditions.

3.1 — RTCA DO-316: Accuracy, sensitivity and dynamic range.

The RTCA DO-316 requirements for accuracy (2.1.3.1) and for sensitivity and dynamic range (2.1.1.10) are sensitive to most environmental conditions. Section 3 identifies the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the GNSS CCA functional sensor continues to meet the accuracy and dynamic range performance requirements after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.

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3.2 — RTCA DO-316: Section 2.3.6 Accuracy Test.

(a) The accuracy test described in Section 2.3.6 is actually a joint test that covers accuracy, sensitivity and dynamic range. This joint testing also applies under the environment as stated in Section 2.2.1.1.5, with the environmental adaptations as described in Section 2.2.1.1.1.

(b) The demonstration of accuracy is performed in accordance with Section 2.3.6 only for the test case with broadband external interference noise. This test must be repeated when the GNSS CCA functional sensor is installed in the end-use equipment, and it is sufficient to perform it using broadband interference.

(1) The environmental testing is limited to broadband interference, as it represents the worst-case signal-to-noise condition, which is the most sensitive to environmental effects. This applies equally to the environment for the GNSS CCA functional sensor that is created by the end-use equipment.

(2) Section 2.3.6 contains a measurement accuracy test in 2.3.6.1, with the simulator and interference conditions described in 2.3.6.2, and the detailed test procedure in 2.3.6.2.1. The Section 2.3.6 test must be run under the worst-case environment identified in Section 5 ‘Additional considerations for internal interference sources’ below.

(3) Section 2.3.6.3 is a 24-hour actual satellite accuracy test. The Section 2.3.6.3 test exposes the equipment to a variety of signal conditions and data-processing conditions over varying satellite geometries that will increase the confidence that no unforeseen interactions between the components within the end-use equipment and the GNSS CCA functional sensor will go undetected.

(c) The test threshold is relaxed from 110 to 125 %, as specified in Table 2-6 of the 2.3.6.2.1 test procedure, to shorten the duration of the test. However, the Section 2.3.6 testing for the GNSS CCA functional sensor in the end-use equipment shall be under the ambient conditions per Section 2.3 with the 110-% test pass threshold for maximum test sensitivity.

(d) Only the broadband external interference noise test case using the minimum satellite power will be executed in most cases to shorten the duration of the test. The testing of Sections 2.3.6.1 and 2.3.6.2 will be repeated for both the minimum and the maximum satellite power only for the worst-case environment.

4 — Performance requirements that are partially susceptible to environmental conditions.

(a) Table 2-2 in RTCA DO-316 indicates that the acquisition time (2.1.1.7) and the reacquisition time (2.1.1.9) requirements are sensitive to four environmental conditions: icing; lightning-induced transient susceptibility; lightning direct effects; and normal/abnormal operating conditions. The requirements for loss of navigation (2.1.1.11.2) and loss of integrity (2.1.1.11.1) are sensitive to low and high operating temperatures.

Note: RTCA DO-316 Table 2-2 contains a typo that erroneously numbers the loss of navigation and loss of integrity requirements as 2.1.1.13.2 and 2.1.1.13.1.

(b) The lightning-induced transient susceptibility, lightning direct effects, or icing environmental conditions are not pertinent to the environment that is created by the end-use equipment relative to the GNSS CCA functional sensor. However, the manufacturer of the end-use equipment remains responsible for meeting the overall environmental qualification at the end-use equipment level.

(c) Loss of navigation and loss of integrity indications are limited to temperature testing and the information in RTCA DO-316, Sections 2.2.1.1.2 and 2.2.1.1.3, is appropriate. The purpose is to ensure that the interface that is used to indicate the loss of navigation or integrity is functional under the environmental conditions that are present after the GNSS CCA functional sensor is installed in the end-use equipment. Sections 2.2.1.1.2 and 2.2.1.1.3 indicate that any source that generates the indication can be used, since it is the interface and not the detection mechanism that is verified. The temperature testing performed at the end-use equipment level is the worst-case scenario. It is not necessary to repeat the GNSS CCA level test at room temperature in the end-use equipment since the environmental qualification adequately addresses the testing for these requirements.

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(d) EUROCAE ED-14 Section 16 relates to aircraft power supplies (refer to ETSO Section 3.1.2 for the environmental qualification requirements). Sections 16.5.1.2 and 16.6.1.2 are for normal/abnormal operating conditions. Given the potential susceptibility of the GNSS CCA functional sensor to power supply noise, it is prudent to repeat the tests at the end-use equipment level on this basis. Table 2-2 referenced in RTCA DO-316, Section 2.2.1, does not guarantee the execution of specific acquisition testing.

(e) Sections 4.1 and 4.2 identify the testing that manufacturers of end-use equipment are required to repeat to demonstrate that the GNSS CCA functional sensor continues to meet the acquisition time and reacquisition time performance requirements relative to the normal/abnormal operating conditions after installation in the end-use equipment. All the tests shall be run under conditions in which the functions of the end-use equipment are fully enabled to create the worst-case environment.

4.1 — RTCA DO-316: Section 2.3.3 Initial Acquisition Test Procedures.

The information in RTCA DO-316, Section 2.2.1.1.4, on the initial acquisition test in Section 2.3.3, applies. The manufacturer of the end-use equipment shall repeat the initial acquisition testing described in RTCA DO-316, Section 2.3.3.

4.2 — RTCA DO-316: Section 2.3.4 Satellite Reacquisition Time Test.

The manufacturer of the end-use equipment is required to repeat the satellite reacquisition time testing in RTCA DO-316, Section 2.3.4.

5 — Additional considerations for internal interference sources.

(a) Installing a GNSS CCA functional sensor into end-use equipment that also includes other functions requires a careful evaluation of the potential internally radiated and conducted interference. The manufacturer of the end-use equipment must evaluate each operating mode to determine whether the mode changes the environment for the installed GNSS CCA functional sensor. If there is only one environment or there is clearly one worst-case environment, then the accuracy and message loss rate testing in Section 3 can be run in that operating mode only. For example, if the end-use equipment includes an RF transmitter that radiates at one frequency, one could reasonably argue that setting the transmitter at full power with maximum data throughput would generate a clear worst-case environment in which to run all the testing.

(b) In the case of multiple environments, the accuracy and message loss rate tests can either be run under each environment, or the methodology in RTCA DO-316, Section 2.2.1.2.3, can be used to run an aggregate with approximately equal time in each mode. The methodology in Section 2.2.1.2.3 must be used to identify the modes of greatest susceptibility under which the combined accuracy and message loss rate tests are repeated in addition to the aggregate test. For example, the 2.2.1.2.3 methodology is appropriate for end-use equipment that contains a high power transmitter that operates on a large number of frequencies such that it is impractical to run a test at each frequency. This is analogous to the large number of frequencies that need to be tested during the EUROCAE ED-14() RF and Induced Signal Susceptibility testing, and this is the reason why the Section 2.2.1.2.3 methodology was developed.

(c) It is sufficient to identify one worst-case environment when performing acquisition and 24-hour accuracy testing.

6 — Summary.

(a) The manufacturer of end-use equipment that incorporates a GNSS CCA functional sensor is required to repeat the following RTCA DO-316 Section 2.3 testing under ambient conditions (see paragraph 5) after installing the GNSS CCA functional sensor in the end-use equipment:

— The Section 2.3.6 accuracy test adapted per Section 2.2.1.1.1, except that the 110-% test pass threshold is used.

Note: Refer to Section 5 'Additional considerations for internal interference sources' of this Appendix, which could affect the test methodology.

— The Section 2.3.3 initial acquisition test.

— The Section 2.3.4 satellite reacquisition time test.

(b) The manufacturer of the end-use equipment remains responsible for completing a full environmental qualification evaluation (see ETSO Section 3.1.2) at the end-use equipment level. The manufacturer of the end-use equipment that incorporates a GNSS CCA functional sensor is required to repeat the Loss of Navigation and Loss of Integrity indication environmental testing according to RTCA DO-316, Sections 2.2.1.1.2 and 2.2.1.1.3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: TRAFFIC AWARENESS BEACON SYSTEM (TABS)

1 — Applicability

This ETSO provides the requirements for the applicable equipment class defined by this ETSO which ~~t~~Traffic ~~a~~Awareness ~~b~~Beacon ~~s~~Systems (TABSs) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

TABS devices are distinctly different from other transponders. TABS devices are intended for voluntary equipage on aircraft that are exempted from carrying a transponder or ~~a~~Automatic ~~d~~Dependent ~~s~~Surveillance~~-~~ — ~~b~~Broadcast (ADS-B) equipment, such as gliders, balloons and aircraft without electrical systems. TABS devices do not meet the transponder or ADS-B requirements defined in Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky. TABS equipment built to the minimum requirements of this ETSO will enable an aircraft to be visible to other aircraft equipped with:

— a Traffic Advisory System (TAS) as defined in ETSO-C147();

— a Traffic Alert and Collision Avoidance System I (TCAS I) as defined in ETSO-C118();

— a Traffic Alert and Collision Avoidance System II (TCAS II) as defined in ETSO-C119d;

— ADS-B IN capability as defined in ETSO-C154c, ETSO-C166b(), and ETSO-C195b.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical ~~c~~Conditions

3.1 — Basic

3.1.1 — Minimum ~~p~~Performance ~~s~~Standard

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TABS requirements are derived from existing transponder and ADS-B requirements. Equipment that only meets ~~meeting only~~ the minimum TABS requirements will provide the capability to be seen by other aircraft equipped with traffic advisory systems, but may not support its detection by ground surveillance systems that rely on full transponder functionality. A designer who builds ~~building~~ equipment to meet this ETSO may decide to incorporate more capability than what is outlined in this ETSO, as long as it meets the applicable requirements in the referenced standards (e.g.~~,~~ EUROCAE ED-73E, MOPS for Secondary Surveillance Radar Mode S Transponders, as amended by Appendix 1 to ETSO-C112e).

TABS functionality is divided into four categories: the transponder function, the altitude source function, the ADS-B OUT function, and the position source function.

A Class A TABS:

— includes the transponder, altitude source, and ADS-B OUT functionality; refer to ~~S~~subparagraphs (1), (2), and (3) below;

— consists of a Class A device, or an ETSO-C112e and an ETSO-C166b compliant device.

A Class B TABS:

— includes the Global Navigation Satellite System (GNSS) position source functionality; refer to ~~S~~subparagraph (4) below;

— consists of a Class B device, or an ETSO-C129a (cancelled), ETSO-C145c or later revision, ETSO-C146c or later revision, or an ETSO-C196b-compliant GPS.

A TABS may include an ADS-B IN function, but it is not required. If it is implemented, the ADS-B IN function shall meet the performance specified in ETSO-C195b as well as ETSO-C154c, or ETSO-C166b, or all three. A TABS is intended to make the aircraft a valid TIS-B and ADS-R client.

(a) The transponder functionality must meet a subset of the requirements in document RTCA~~/~~ DO-181E, MOPS for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated 17 March ~~17,~~ 2011, Section 2, for a Level 2, Class 2 transponder as modified by Appendix 1.

(b) The altitude source functionality must meet the requirements of ETSO-C88a or later revision, Automatic Pressure Altitude Reporting Code Generating Equipment, dated 5 August ~~5,~~ 2016.

(c) The ADS-B OUT function must meet a subset of the requirements found in document EUROCAE ED-102A, Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance ~~–~~— Broadcast (ADS-B) and Traffic Information Services~~-~~ — Broadcast (TIS-B), dated December~~,~~ 2009, including Corrigendum-1, Section 2, dated January~~,~~ 2012, Class B0 as modified by Appendix 1. The system must be built such that it transmits Navigation Integrity Code (NIC), Navigation Accuracy Category for Position (NACp), Navigation Accuracy Category for Velocity (NACv), Geometric Vertical Accuracy (GVA), and Safety Integrity Level (SIL) values that are appropriate for the GNSS receiver used.

(d) The position source function must use a GNSS receiver that meets the requirements defined in Appendix 1. The intent of this ETSO is to allow the use of commercially available GNSS position sources. The receiver must be capable of using SBAS-provided corrections and health messages, as defined in Appendix 1, in order to provide a means to prevent the TABS from transmitting false or misleading information. The receiver may continue to provide position when outside of SBAS coverage or when using unmonitored satellites. TABS Class B position sources may not be used for certified navigation equipment.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

For Class A equipment, demonstrate the required performance under the test conditions specified in RTCA~~/~~ DO-181E Section 2.3 and EUROCAE ED-102A, including Corrigendum-1, Section 2.3, dated January~~,~~ 2012.~~,~~

For Class B equipment, demonstrate the required performance under the test conditions specified in Appendix 3.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

This requirement applies to Class A equipment only. Class B equipment is exempt from the software qualification defined in this paragraph.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

This requirement applies to Class A equipment only. Class B equipment is exempt from the electronic hardware qualification defined in this paragraph.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO that results ~~resulting~~ in misleading information is a minor failure condition.

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO that results ~~resulting~~ in a loss of function is a minor failure condition.

Class B equipment is intended to be met by commercially available GNSSs and is unlikely to be designed specifically to support a minor hazard classification. The suitability of Class B equipment ~~suitability~~ for supporting the function in paragraph 3.1.1 of this ETSO is established by performing the functional and environmental testing in Appendix 2 and Appendix 3 of this ETSO, with no further analysis required.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

EUROCONTROL Documents: EUROCONTROL, STA/R/460/0001/1, Study to Address the Detection and Recognition of Light Aircraft in the Current and Future ATM Environment, Issue 1.0, Final Report, dated 31 March 2005.

~~EUROCONTROL Surveillance Document Library:~~

~~https://www.eurocontrol.int/articles/surveillance-library~~

FCC Documents: Federal Communication Commission document OET Bulletin 65 Ed 97-01, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields is available on the internet at: http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

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~~US Code of Federal Regulations (CFR) Documents: order copies of 14 CFR parts 21, 45 and 91 from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also download copies online at: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/~~

UK Public Health Documents Public Health England document HPA-RPD-031, Exposure to EMFs from Lightweight Aviation Transponders, dated September 2007, ISBN 978-0-85951-605-1 ~~978–0-85951-605-1~~, can be obtained on line by going to:

http://www.hpa.org.uk/Publications/Radiation/HPARPDSeriesReports/HpaRpd031/

Global Positioning System Signals, Measurements, and Performance, Ganga-Jamuna Press, by Pratap Misra and Per Enge. ISBN: 0-9709544-0-9

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APPENDIX 1

TRAFFIC AWARENESS BEACON SYSTEM (TABS) REQUIREMENTS

A1 Introduction

A1.1 TABS Intent

A1.1.1 The intent of a TABS is to increase safety by encouraging the voluntary equipage of a low-cost, compact, easy-to-install device that will allow other aircraft equipped with collision avoidance systems and traffic advisory systems to track and display the TABS aircraft. TABSs are intended to be used on aircraft that are exempted from carrying a transponder or Automatic Dependent Surveillance —~~-~~ Broadcast (ADS-B) equipment, such as gliders, balloons and aircraft without electrical systems. TABS devices do not meet the transponder requirements defined in Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky. A TABS will allow these exempted aircraft to be visible to other aircraft equipped with:

— a Traffic Advisory System (TAS) as defined in ETSO-C147();

— a Traffic Alert and Collision Avoidance System I (TCAS I) as defined in ETSO-C118();

— a Traffic Alert and Collision Avoidance System II (TCAS II) as defined in ETSO-C119d;

— ADS-B IN capability as defined in ETSO-C166b, and ETSO-C195b;

— ADS-B IN capability as defined in ETSO-C154c in airspace where UAT is used.

A1.1.2 A TABS is designed to:

— reply to ATCRBS Mode C, and Mode S UF = 0, 4, 5, 20 and 21 interrogations;

— not reply to ATCRBS Mode A interrogations;

— not reply to Mode S UF = 11~~,~~ and 16 interrogations;

— incorporate ETSO-C88b, Automatic Pressure Altitude Reporting Code-Generating Equipment;

— transmit ADS-B Messages: Aircraft Identification and Category, Airborne Position, Airborne Velocity, Emergency Priority Status Message, and Aircraft Operational Status;

— optionally provide Surface Position Messages;

— optionally use a commercial GNSS source meeting the requirements of this ETSO.

A1.1.3 A TABS can potentially act as a low-cost platform for other aviation applications. Although additional capabilities are beyond the scope of this ETSO, TABSs may include additional functions such as data loggers, search and rescue transmitter, or provide flight information services.

A1.2 Requirements

A1.2.1 TABS requirements are derived from existing Mode S transponder and 1090 MHz Extended Squitter ADS-B requirements. A designer who builds ~~building~~ equipment to meet this ETSO may decide to incorporate the full transponder and ADS-B capability by using a device that meets ETSO-C112e and ETSO-C166b. If they elect to implement the full functionality, they must demonstrate that functionality against the unmodified test procedures in EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, that are required by ETSO-C112e and ETSO-C166b respectively. Designers that wish to take advantage of the reduced transponder requirements afforded to ETSO-C199 Class A devices must meet the modified requirements outlined in paragraphs A1.2.3 Transponder Function Requirements, A1.2.4 Altitude Source Function Requirements, and A1.2.5 ADS-B OUT Function Requirements in this Appendix in their entirety. Designers who wish ~~wishing~~ to take advantage of the Class B reduced GNSS requirements will need to meet the requirements outlined in paragraph~~s~~ A1.2.6 GNSS Position Source Function Requirements.

A1.2.2 MOPS text is used here with the permission of the RTCA. Table 1 provides notes in italics and parentheses explaining how to read the tables that modify the text in the source documents.

(Source document reference)	Modified text for this ETSO
(This is a copy of the original text from the source document. Material to be deleted from this original text is marked with ~~strikethrough formatting~~.)	(This is the requirement for this ETSO. Modifications to the source text are marked in **<u>bold and underlined</u>** to assist in identifying changes).

Table 3 — (Source document reference) (type of change)

A1.2.3 Transponder Function Requirements Derived From DO-181E (For Class A Devices)

A1.2.3.1 The transponder function must meet the Minimum Performance Standards (MPS) qualification and documentation requirements in RTCA, Inc. document RTCA~~/~~ DO-181E, Section 2, for a Level 2, Class 2, transponder as modified below.

A1.2.3.1.1 Flight Crew Control Function Changes

A1.2.3.1.2 A cost factor in any device is the control and display functions to interface with the human operator. TABS display and control requirements are a subset of those required for transponders. Some user controls are allowed via an external device prior to flight (e.g.~~,~~ a personal electronic device (PED)). If the system is powered by batteries, display of available battery life is recommended. Table 2 provides an overview of flight crew control functions.

Operation mode	**Required Controls**	**Required Indicators**
In flight (i.e.~~,~~ control head)	- Power, - Emergency (3/A code 7700), - IDENT (optional)	Power on, Transponder Fail, ADS-B Fail, Battery indicator (optional)
Non-flight (optional in flight) (i.e. Personal Electronic Device PED)	- Set 4096 code, - Set Flight ID	Display of 4096 code, Display of Flight ID
Maintenance actions (allowed in non-flight conditions only)	- Set ICAO 24-bit aircraft address, - Set implementation specific configuration	Display of ICAO 24-bit aircraft address, Display of implementation specific configuration,~~.~~ Display software version (optional)

Table 4 — Summary of Control and Indication Requirements by Operation Mode

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A1.2.3.1.3 RTCA~~/~~ DO-181E, Section 2.1.7.a, Flight Crew Control Functions, is amended as shown in Table 3.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided a. A means of selecting each of the ATCRBS 4096 reply code~~s, and of~~ indicating the code selected.	The following functions SHALL be provided **as indicated in items a-f.** a. A means of selecting **and displaying** the ATCRBS 4096 code **on the ground SHALL be provided. A means of selecting and displaying the ATCRBS 4096 code in flight is optional. A means of setting the Mode 3/A code to 7700 (emergency), either by entering in the value or an automated means such as a switch, SHALL be provided. A means of setting an alternate 4096 code other than the primary 4096 code, either by entering in the value or an automated means such as a switch, SHALL be provided.**

Table 5 — DO-181E Section 2.1.7.a amendment

A1.2.3.1.4 RTCA~~/~~ DO-181E, Section 2.1.7.b, Flight Crew Control Functions, is amended as shown in Table 4.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided b. A means of selecting the air/ground state: 1) An automatic means ~~Shall be the only acceptable means~~ to determine the air/ground state. 2) If an automatic means is not ~~available~~, the transponder Shall ensure that the air/ground state is Airborne	The following functions SHALL be provided **as indicated in items a-f.** b. A means of selecting the air/ground state: 1) An automatic means to determine the air/ground state **is recommended.** 2) If an automatic means is not **implemented,** the transponder SHALL ensure that the air/ground state is Airborne.

Table 6 — DO-181E Section 2.1.7.b amendment

A1.2.3.1.5 RTCA~~/~~ DO-181E, Section 2.1.7.c, Flight Crew Control Functions, is amended as shown in Table 5.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided c. A means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e., the Standby condition). Return to normal operation from this condition Shall be possible within five seconds.	The following functions SHALL be provided **as indicated in items a-f.** c. A means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e. the Standby condition) **is not required. However, if provided,** return to normal operation from Standby condition SHALL be possible within **5** ~~five~~seconds.

Table 7 — DO-181E Section 2.1.7.c amendment

A1.2.3.1.6 RTCA~~/~~ DO-181E, Section 2.1.7.d, Flight Crew Control Functions, is amended as shown in Table 6.

DO-181E text	Modified text for this ETSO
The following functions Shall be provided d. A means of initiating the IDENT (SPI) feature.	The following functions SHALL be provided **as indicated in items a-f.** d. A means of initiating the IDENT (SPI) feature **is optional.**

Table 8 — DO-181E Section 2.1.7.d amendment

A1.2.3.2 Reply Rate Capability Changes

A1.2.3.2.1 This section reduces the minimum reply rate capability of the TABS consistently with the interrogation acceptance based on two assumptions. The following rationale describes how the modified reply rates were chosen.

A1.2.3.2.1.1 Assumption 1. The worst-case Mode C interrogation count in a 100-millisecond interval from ~~one~~1 ATCRBS radar is approximately 14 interrogations. ~~Four~~ 4 ATCRBS radar overlapping beam dwells in ~~a~~ 1 second is approximately 53 Mode C interrogations. The Mode C interrogation acceptance rate from 10 TCAS I units is approximately 15 interrogations per second. This represents a total demand on the TABS of 68 Mode C replies per second for this example.

A1.2.3.2.1.2 Assumption 2. The worst-case Mode S reply rate is primarily derived from the expected interrogation pattern of a set of 50 nearby TCAS II units all equipped with hybrid surveillance. The radar load from only roll-call interrogations would be small and would require networked sensors, otherwise the Mode S ground interrogation acceptance rate from radar systems would be 0 (zero).

A1.2.3.2.2 Based on assumptions 1 and 2, RTCA~~/~~ DO-181E Section 2.2.3.4 Reply Rate Capability is changed as follows:

A1.2.3.2.2.1 RTCA~~/~~ DO-181E, Section 2.2.3.4.1.a, ATCRBS Reply Rate Capability, is amended as shown in Table 7.

DO-181E text	Modified text for this ETSO
The transponder **Shall** be able to continuously generate at least **~~500~~** ATCRBS 15-pulse replies per second.	The transponder Shall be able to continuously generate at least **100** ATCRBS 15-pulse replies per second.

Table 9 — DO-181E Section 2.2.3.4.1.a amendment

A1.2.3.2.2.2 RTCA~~/~~ DO-181E, Section 2.2.3.4.1.c, ATCRBS Reply Rate Capability, is amended as shown in Table 8.

DO-181E text	Modified text for this ETSO
For Class 2 equipment, the transponder **Shall** be capable of a peak reply rate of **~~1000~~** ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.	For Class 2 equipment, the transponder **SHALL** be capable of a peak reply rate of **150** ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.

Table 10 — DO-181E Section 2.2.3.4.1.c added

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A1.2.3.2.2.3 RTCA~~/~~ DO-181E, Section 2.2.3.4.2.a, Mode S Reply Rate Capability, is amended as shown in Table 9.

DO-181E text	**Modified text for this ETSO**
A transponder equipped for only short Mode S downlink formats (DF), Shall have the following minimum reply rate capabilities: ~~**50**~~ Mode S replies in any 1-second interval. ~~**18**~~ Mode S replies in a 100-millisecond interval. ~~**8**~~ Mode S replies in a 25-millisecond interval. ~~**4**~~ Mode S replies in a l.6-millisecond interval.	A transponder equipped for only short Mode S downlink formats (DF), **SHALL** have the following minimum reply rate capabilities: **29** Mode S replies in any 1-second interval. **10** Mode S replies in a 100-millisecond interval. **5** Mode S replies in a 25-millisecond interval. **3** Mode S replies in a l.6-millisecond interval.

Table 11 — DO-181E Section 2.2.3.4.2.a amendment

A1.2.3.2.2.4 RTCA~~/~~ DO-181E, Section 2.2.3.4.2.b, Mode S Reply Rate Capability, is amended as shown in Table 10.

DO-181E text	Modified text for this ETSO
A transponder equipped for long Mode S reply formats Shall be able to transmit as long replies: At least ~~**16**~~ of the 50 Mode S replies in any 1-second interval. At least ~~6~~ of the 18 Mode S replies in a 100 millisecond interval. At least 4 of the 8 Mode S replies in a 25 millisecond interval. At least 2 of the 4 Mode S replies in a l.6 millisecond interval.	A transponder equipped for long Mode S reply formats SHALL be able to transmit as long replies: At least **10** of the 29 Mode S replies in any 1-second interval. At least **4** of the 10 Mode S replies in a 100-millisecond interval. At least **3** of the 5 Mode S replies in a 25-millisecond interval. At least 2 of the 4 Mode S replies in a l.6-millisecond interval.

Table 12 — DO-181E Section 2.2.3.4.2.b amendment

A1.2.3.3 Reply Rate Limiting Changes

A1.2.3.3.1 The modifications in this section address reply rate limiting for ATCRBS and Mode S reply rates consistently with the previous section.

A1.2.3.3.2 RTCA~~/~~ DO-181E, Section 2.2.7.3.1, ATCRBS Reply Rate Limiting, is amended as shown in Table 11.

DO-181E text	**Modified text for this ETSO**
A sensitivity-reduction reply rate limit Shall be incorporated in the transponder for ATCRBS replies. The limit Shall be capable of being adjusted between ~~**500**~~ continuous ATCRBS ~~Mode A and~~ Mode C replies per second and the maximum continuous rate of which the transponder is capable, or ~~**2000**~~ replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction Shall apply only to the receipt of ATCRBS~~, ATCRBS/Mode S All-Call, and ATCRBS-Only All-Call~~ interrogations.	A sensitivity-reduction reply rate limit SHALL be incorporated in the transponder for ATCRBS replies. The limit **SHALL** be capable of being adjusted between **100** continuous ATCRBS Mode C replies per second and the maximum continuous rate of which the transponder is capable, or **200** replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction SHALL apply only to the receipt of ATCRBS interrogations.

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Table 13 — DO-181E Section 2.2.7.3.1 amendment

A1.2.3.4 RTCA~~/~~ DO-181E, Section 2.2.13.1.2.c, Variable Direct Data, is amended as shown in Table 12.

DO-181E text	Modified text for this ETSO
c. <u>On-the-Ground Condition</u> The transponder **~~Shall~~** report the automatically determined on-the-ground state as determined by the aircraft in the Flight Status (FS), Vertical Status (VS), and Capability (CA) fields (see §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6), except when reporting airborne status when on-the-ground is reported to the transponder under the conditions specified in §2.2.18.2.7.	c. <u>On-the-Ground Condition</u> The transponder <u>**may**</u> report the automatically determined on-the-ground state as determined by the aircraft in the Flight Status (FS), Vertical Status (VS), and Capability (CA) fields (see paragraphs 2.2.14.4.15, 2.2.14.4.42, and 2.2.14.4.6), except when reporting airborne status when on-the-ground is reported to the transponder under the conditions specified in paragraph 2.2.18.2.7.

Table 14 — DO-181E Section 2.2.13.1.2.c amendment

A1.2.3.5 RTCA~~/~~ DO-181E, Section 2.2.13.1.2.d, Variable Direct Data, is amended as shown in Table 13.

DO-181E text	Modified text for this ETSO
d. Special Position Identification (SPI) ~~In the ATCRBS mode, an SPI pulse **Shall** be transmitted upon request, following a Mode A reply.~~ In the FS field of Mode S replies, an equivalent of the ATCRBS SPI pulse **Shall** be transmitted upon ~~the same request~~. The code is transmitted for 18 ±1.0 seconds after initiation and can be reinitiated at any time.	d. Special Position Identification (SPI) In the FS field of Mode S replies, an equivalent of the ATCRBS SPI pulse **shall** be transmitted upon <u>**request if the optional IDENT flight crew control is implemented per A1.2.3.1.6 of this ETSO.**</u> The code is transmitted for 18 ± 1.0 seconds after initiation and can be reinitiated at any time.

Table 15 — DO-181E Section 2.2.13.1.2.c amendment

A1.2.3.6 RTCA~~/~~ DO-181E, Section 2.2.13.1.2.e, Variable Direct Data, is amended as shown in Table 14.

DO-181E text	Modified text for this ETSO
e. Aircraft Identification Data If the aircraft uses a flight number for aircraft identification, a means **Shall** be provided for the variable aircraft identification to be inserted by the pilot while on the ground~~, or during flight. The means for modifying and displaying aircraft identification **Shall** be a simple crew action independent of the entry of other flight data.~~	e. Aircraft Identification Data If the aircraft uses a flight number for aircraft identification, a means <u>**SHALL**</u> be provided for the variable aircraft identification to be inserted by the pilot while on the ground. <u>**A means may be provided for modifying aircraft identification in flight.**</u>

Table 16 — DO-181E Section 2.2.13.1.2.e amendment

A1.2.3.7 Interrogation Acceptance Protocol Changes (All-Call reply capability)

A1.2.3.7.1 The transponder All-Call interrogation reply acceptance requirements are reduced to reply only to ATCRBS Mode C (P1-P3) interrogations. The purpose is to reduce the reply rate of TABS while maintaining TCAS and TAS interoperability. The requirements of this ETSO are identical to RTCA~~/~~ DO-181E except for the changes shown below.

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A1.2.3.7.2 RTCA~~/~~ DO-181E, Section 2.2.18.2.2.b, Interrogation Acceptance Protocol (Figure 2-12), is amended as shown in Table 15.

DO-181E text	Modified text for this ETSO
All-Call Address – If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation Shall **be** accepted ~~according to "i" below unless the lockout protocol is in effect. Mode S-Only All-Call Shall not be accepted (no replies) when in the on-the-ground state (consistent with the CA, VS and FS fields)~~	All-Call Address — If the address extracted from the received interrogation consists of 24 ONEs and UF = 11, the transmission is a Mode S-Only All-Call and the received interrogation SHALL **not** be accepted.

Table 17 — DO-181E Section 2.2.18.2.2.b amendment

A1.2.3.7.3 RTCA~~/~~ DO-181E, Section 2.2.18.2.2.c, Interrogation Acceptance Protocol (Figure 2-12), is amended as shown in Table 16.

DO-181E text	Modified text for this ETSO
ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds P4) Shall be ~~accepted unless the TD timer is running or side lobe suppression is in effect or when in the "on-the-ground" state (consistent with the CA, VS and FS fields).~~	ATCRBS/Mode S All-Call — An ATCRBS/Mode S All-Call interrogation (1.6 microseconds P4) SHALL **not** be accepted.

Table 18 — DO-181E Section 2.2.18.2.2.c amendment

A1.2.3.8 RTCA~~/~~ DO-181E, Section 2.2.18.2.2.g, Interrogation Acceptance Protocol, ~~paragraph g,~~ All-Call Lockout Conditions, is amended as shown in Table 17.

DO-181E text	Modified text for this ETSO
All-Call Lockout Conditions – On receipt of a Mode S-Only All-Call (UF=11) ~~containing an Interrogator Code (IC and CL fields) corresponding to the designator of a running TL~~ timer, the interrogation Shall not be accepted. ~~unless the contained PR code is 8 through 12 and the "on-the-ground" report (CA, VS or FS field) does not include the ground condition. Upon receipt of a Mode S-Only All-Call (UF=11) containing II=0, the interrogation **Shall** be accepted if the TD timer is not running or if the received PR code is 8 through 12 and the "on-the-ground" report (CA, VS or FS field) does not include the ground condition.~~	All-Call Lockout Conditions — On receipt of a Mode S-Only All-Call (UF = 11), the interrogation SHALL **not** be accepted.

Table 19 — DO-181E Section 2.2.18.2.2.g amendment

A1.2.3.9 RTCA~~/~~ DO-181E, Section 2.2.18.2.2.i, Interrogation Acceptance Protocol Stochastic All-Calls, should not be implemented in Class A TABS.

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A1.2.3.10 Two new sections are added here to explicitly define interrogation acceptance criteria for TABS.

A1.2.3.10.1 RTCA~~/~~ DO-181E, Section 2.2.18.2.2.L, Interrogation Acceptance Protocol (Figure 2-12), is added as shown in Table 18.

DO-181E text	Modified text for this ETSO
None	**<u>ATCRBS Mode A Rejection</u> — ATCRBS Mode A interrogations (P1-P3 spacing 8 microseconds) SHALL not be accepted. Recovery from a Mode A interrogation shall adhere to the requirements of Section 2.2.7.2 defined for recovery from a desensitising pulse.**

Table 20 — DO-181E Section 2.2.18.2.2.L addition

A1.2.3.10.2 RTCA~~/~~ DO-181E, Section 2.2.18.2.2.m, Interrogation Acceptance Protocol (Figure 2-12), is added to as shown in Table 19. This change reduces the range at which addressed Mode S ground interrogations would be replied to. The intent is to reduce the reply rate of the TABS. Sensitivity to TCAS interrogations ~~are~~ is not affected.

DO-181E text	Modified text for this ETSO
None	**<u>Ground-to-Air Mode S Acceptance</u> — Mode S interrogations, excluding UF = 0, SHALL be accepted at the Mode S MTL (paragraph 2.2.2.4 b) + 3 dB ± 1 dB.**

Table 21 — DO-181E Section 2.2.18.2.2.m addition

A1.2.3.11 RTCA~~/~~ DO-181E, Section 2.2.18.2.3, Interrogation Reply Coordination, is amended as shown in Table 20.

DO-181E text		Modified text for this ETSO	
The transponder SHALL generate replies as follows, except when in the on-the-ground state:		The transponder SHALL generate replies as follows, except when in the on-the-ground state:	
Interrogations	Replies	Interrogations	Replies
ATCRBS Mode A	4096 Codes	ATCRBS Mode A	**<u>SHALL not reply</u>**
ATCRBS Mode C	Altitude Codes	ATCRBS Mode C	Altitude Codes
ATCRBS Mode A/Mode S All-Call	Reply is DF=11	ATCRBS Mode A/Mode S All-Call	**<u>SHALL not</u>** reply
ATCRBS Mode C/Mode S All-Call	Reply is DF=11	ATCRBS Mode C/Mode S All-Call	**<u>SHALL not</u>** reply
Mode S-only All-Call (UF=11)	Reply is DF=11	Mode S-only All-Call (UF=11)	**<u>SHALL not</u>** reply

Table 22 — DO-181E Section 2.2.18.2.3 amendment

A1.2.3.12 RTCA~~/~~ DO-181E, Section 2.2.18.2.4, Lockout Protocol, should not be implemented in Class A TABS.

A1.2.3.13 RTCA~~/~~ DO-181E, Section 2.2.18.2.5, Multisite Lockout Protocol, should not be implemented in Class A TABS.

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A1.2.3.14 RTCA~~/~~ DO-181E, Section 2.2.18.2.7, Flight Status and Vertical Status Protocols, is~~are~~ amended as shown in Table 21.

DO-181E text	Modified text for this ETSO
Mode S-equipped aircraft Shall report details of their flight status. The source of and the rules for such reports are as follows: a. Alert – The transponder Shall transmit the 4096 identification code ~~in ATCRBS Mode A replies~~ and in the ID field of downlink format DF=5. ~~This code can be changed by the pilot, and~~ when a change is made an alert condition Shall be established. If the identification code is changed to 7500, 7600 or 7700, the alert condition Shall be permanent. If the identification code is changed to any other value, the alert condition Shall be temporary and self-canceling after 18 ± 1 seconds (TC timer). The TC timer Shall be retriggered and continued for 18 ± 1 seconds after any change has been accepted by the transponder function. The alert condition Shall be reported in the FS field. The permanent alert condition Shall be terminated and replaced by a temporary alert condition when the identification code is set to a value other than 7500, 7600 or 7700.	Mode S-equipped aircraft SHALL report details of their flight status. The source of and the rules for such reports are as follows: a. Alert — The transponder SHALL transmit the 4096 identification code in the ID field of downlink format DF=5. When a change is made, an alert condition SHALL be established. If the identification code is changed to 7500, 7600 or 7700, the alert condition SHALL be permanent. If the identification code is changed to any other value, the alert condition SHALL be temporary and self-cancelling after 18 ± 1 seconds (TC timer). The TC timer SHALL be retriggered and continued for 18 ± 1 seconds after any change has been accepted by the transponder function. The alert condition SHALL be reported in the FS field. The permanent alert condition SHALL be terminated and replaced by a temporary alert condition when the identification code is set to a value other than 7500, 7600 or 7700.

Table 23 — DO-181E Section 2.2.18.2.7 amendment

A1.2.3.15 RTCA~~/~~ DO-181E, Section 2.2.18.2.9, All-Call Reply Protocol, should not be implemented in Class A TABS.

A1.2.3.16 RTCA~~/~~ DO-181E, Section 2.2.19.1, Minimum Level 2 Transponder Requirements, is amended as shown in Table 22.

DO-181E text	Modified text for this ETSO
The operational functions described in §1.4.3.2 require that this transponder Shall, in addition to the functions of the Level 1 transponder: a. Process uplink and downlink formats DF=16, UF=DF=20 and 21 (Figure 2-14). The format UF=16 ~~is optional.~~ ~~Note: UF=16 is supported by transponders connected to an on-board operational TCAS (see §2.2.22).~~ ~~b. Receive broadcast transmissions from sensors (§2.2.19.1.11).~~ c. Follow the protocols for: ~~Comm-A (see §2.2.19.1.10).~~ Comm-B (see §2.2.19.1.12).	The operational functions described in paragraph 1.4.3.2 require that this transponder SHALL, in addition to the functions of the Level 1 transponder: a. Process uplink and downlink formats DF=16, UF=DF=20 and 21 (Figure 2-14). The format UF=16 **<u>SHALL not be accepted. TABS SHALL not be installed with an on-board TCAS system.</u>** b. **<u>Requirement Deleted.</u>** c. Follow the protocols for: Comm-B (see paragraph 2.2.19.1.12.1 through 2.2.19.1.12.3).

~~Comm-U/V (air-air) (see §2.2.19.1.16).~~ ~~Multisite message operation (see §2.2.19.2).~~ Report Codes 4 through 7 in the CA field (see §2.2.14.4.6). TCAS crosslink capability (see §2.2.19.1.18).	Report Codes 4 through 7 in the CA field (see paragraph 2.2.14.4.6). TCAS crosslink capability (see paragraph 2.2.19.1.18).

Table 24 — DO-181E Section 2.2.19.1 amendment

A1.2.3.17 RTCA~~/~~ DO-181E, Section 2.2.19.1.3, Information Transfer, should not be implemented in Class A TABS.

A1.2.3.18 RTCA~~/~~ DO-181E, Section 2.2.19.1.4, Interrogation-Reply Coordination, is amended per Table 23. Equipment using Minimum Level 2 Transponder Requirements~~,~~ SHALL follow the text in DO-181E as written.

DO-181E text		**Modified text for this ETSO**	
The transponder SHALL generate replies to interrogations as follows:		The transponder SHALL generate replies to interrogations as follows:	
Interrogation	Reply	Interrogation	Reply
ATCRBS Mode A (see Note)	~~4096 code~~	ATCRBS Mode A (see Note)	**SHALL not reply**
ATCRBS Mode C (see Note)	Altitude Code	ATCRBS Mode C (see Note)	Altitude Code
ATCRBS/Mode S All-Calls (see Note)	~~DF = 11~~	ATCRBS/Mode S All-Calls (see Note)	**SHALL not reply**
UF=4 and UF=5	as below	UF=4 and UF=5	as below
UF=11 (see Note)	~~DF = 11~~	UF=11 (see Note)	**SHALL not reply**
UF=20 and UF=21	as below	UF=20 and UF=21	as below
Broadcast	None	Broadcast	None

Table 25 — DO-181E Section 2.2.19.1.4 amendment

A1.2.3.19 The Lockout Protocol described in RTCA~~/~~ DO-181E, Section 2.2.19.1.5, should not be implemented in Class A TABS.

A1.2.3.20 The UM Protocol described in RTCA~~/~~ DO-181E, Section 2.2.19.1.9, should not be implemented in Class A TABS.

A1.2.3.21 The Comm-A Protocol described in RTCA~~/~~ DO-181E, Section 2.2.19.1.10, should not be implemented in Class A TABS.

A1.2.3.22 The Broadcast Protocol described in RTCA~~/~~ DO-181E, Section 2.2.19.1.11, should not be implemented in Class A TABS.

A1.2.3.23 The Air-Initiated Comm-B Protocol described in RTCA~~/~~ DO-181E, Section 2.2.19.1.12.4, should not be implemented in Class A TABS.

A1.2.3.24 The Comm-B Broadcast Protocol described in RTCA~~/~~ DO-181E, Section 2.2.19.1.12.5, should not be implemented in Class A TABS.

A1.2.3.25 The Updating the Data Link Capability Report described in RTCA~~/~~ DO-181E, Section 2.2.19.1.12.6.3, should not be implemented in Class A TABS.

A1.2.3.26 The Change of Aircraft Identification described in RTCA~~/~~ DO-181E, Section 2.2.19.1.13.e, should not be implemented in Class A TABS.

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A1.2.3.27 Linked Comm-A Coding described in RTCA/ DO-181E, Section 2.2.19.1.14, should not be implemented in Class A TABS.

A1.2.3.28 The Comm-U/V Protocol described in RTCA/ DO-181E, Section 2.2.19.1.16, should not be implemented in Class A TABS.

A1.2.3.29 The Data Handling Interfaces described in RTCA/ DO-181E, Section 2.2.19.1.17, should not be implemented in Class A TABS.

A1.2.3.30 The Multisite Message Protocol described in RTCA/ DO-181E, Section 2.2.19.2, should not be implemented in Class A TABS.

A1.2.3.31 Surveillance Identifier (SI) requirements contained in RTCA/ DO-181E, Section 2.2.24.2, should not be implemented in Class A TABS.

A1.2.3.32 The Elementary Surveillance (ELS) Compliant Transponder requirements in RTCA/ DO-181E, Section 2.2.24, do not apply to TABS equipment. TABS SHALL not claim ELS compliance. Changes made to ELS registers do not need to be indicated via a Comm-B broadcast. If one or more of the ELS registers are supported, then Section 2.2.24 requirements SHALL apply except Sections 2.2.24 b 4, 2.2.24 c, 2.2.24.2, 2.2.24.3.2.5, and 2.2.24.3.4, which do not apply.

A1.2.3.33 The Enhanced Surveillance (EHS) Compliant Transponders requirements in RTCA/ DO-181E, Section 2.2.25, do not apply to TABS. TABS equipment SHALL not claim EHS compliance. Changes made to EHS registers do not need to be indicated via a Comm-B broadcast. If one or more of the EHS registers are supported, then Section 2.2.25 requirements SHALL apply except Sections 2.2.25.1.2.4 and 2.2.25.2.3, which do not apply. Also, Section 2.2.25, paragraph 6 'Transponder capable of supporting EHS…', must support ELS per A1.2.3.32 of this ETSO.

A1.2.4 Altitude Source Function Requirements (For Class A Devices)

A1.2.4.1 The altitude source function shall meet the performance requirements of ETSO-C88b, Automatic Pressure Altitude Reporting Code-Generating Equipment, dated 5 August5, 2016. It is recommended that the altitude source provide 25 ft or better resolution.

A1.2.5 ADS-B OUT Function Requirements Derived From EUROCAE ED-102A, including Corrigendum-1, (For Class A Devices)

A1.2.5.1 The ADS-B OUT function must be 1090 Extended Squitter (ES) OUT, to support TCAS surveillance. The 1090 ES OUT function must meet the Minimum Performance Standards (MPS) qualification and documentation requirements in EUROCAE ED-102A, MOPS for 1090 MHz Extended Squitter Automatic Dependent Surveillance — Broadcast (ADS-B) and Traffic Information Services — Broadcast (TIS-B), dated December, 2009, including Corrigendum-1, Section 2, dated January, 2012, for a Class B0 ADS-B OUT transmitter with the following modifications.

A1.2.5.2 EUROCAE ED-102A, including Corrigendum-1, Section 2, dated January, 2012, Paragraph 2.2.2.1.c, Mode S Transponder Based Transmitters, is amended as shown in Table 24.

ED-102A text	Modified text for this ETSO
If the ADS-B transmitter is based on Mode S transponders, then for transponder functions it Shall comply with RTCA/ DO-181D (EUROCAE ED-73C) for each class of transponder specified in the latest version of FAA TSO C112 (ETSO 2C112)	If the ADS-B transmitter is based on Mode S transponders, then for **The** transponder functions SHALL comply with RTCA/ DO-181**E** (EUROCAE ED-73**E**) for each class of transponder specified in the latest version of ETSO-C112 (FAA TSO C112), except where modified by **Appendix 1** of this ETSO.

Table 26 — ED-102A Section 2.2.2.1.c amendment

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A1.2.5.3 The output power SHALL be as specified in EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, Section 2.2.2.2.10.1.a., for Class A0 and B0 equipment. The RF Peak Output power SHALL be at least 18.5 dBW (70 watts).

A1.2.5.4 Broadcast of the ADS-B Surface Position Messages defined in EUROCAE ED-102A including Corrigendum-1, Section 2.2.3.2.4, is optional.

A1.2.5.5 EUROCAE ED-102A including Corrigendum-1, Section 2.2.3.2.7.2, Aircraft Operational Status Messages, is amended as shown in Table 25.

ED-102A text	Modified text for this ETSO
The 'Aircraft Operational Status Message' is used to provide the current status of the aircraft. The format of the Aircraft Operational Status Message shall be as specified in Figure 2-11, while further definition of each of the subfields is provided in the subsequent paragraphs.	The 'Aircraft Operational Status Message' is used to provide the current status of the aircraft. The format of the Aircraft Operational Status Message shall be as specified in Figure 2-11, while further definition of each of the subfields is provided in the subsequent paragraphs. **Broadcast of Aircraft Operational Status Message subtype=1, Surface Messages, is optional.**

Table 27 — Aircraft Operational Status Message

A1.2.5.6 When TABS is installed with a position source meeting the Class B requirements of this ETSO and transmitting a valid position, the transmitted NIC SHALL be set to 6 (0.5 NM), reference EUROCAE ED-102A including Corrigendum-1, dated January~~,~~ 2012, Section 2.2.8.1.16. The transmitted SIL SHALL be set to 1~~,~~ (1~~x~~×1E-3/ hr), reference EUROCAE ED-102A including Corrigendum-1, dated January~~,~~ 2012, Section 2.2.5.1.40. When TABS is installed with a position source compliant with ETSO-C145, ETSO-C146 or ETSO-C196, NIC and SIL SHALL be set in accordance with EUROCAE ED-102A including Corrigendum-1, dated January~~,~~ 2012. When the position is not valid, NIC and SIL SHALL be set to 0 (zero).

A1.2.5.7 The System Design Assurance (SDA)~~,~~ SHALL be set to 1, reference EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, Section 2.2.5.1.50. The probability of an undetected fault causing transmission of false or misleading information SHALL be less than or equal to 1E-3.

A1.2.5.8 Navigation Accuracy Category for Position~~,~~ (NACp) SHALL be derived from the Horizontal Figure of Merit (HFOM) in accordance with EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, Section A.1.4.9.9;~~,~~ however, TABS Class B position sources may not provide HFOM directly. When HFOM is not available directly, HFOM SHALL be derived from Horizontal Dilution of Precision (HDOP) according to the following formula: HFOM = 2 * HDOP * User Equivalent Range Error (UERE), where the UERE is 6 metres. This UERE is based on typical single frequency (L1) receiver performance and an assumption of mid-latitude atmospheric propagation. Although the real-time UERE may fluctuate, this assumption is sufficient to support the TABS use case. (Ref. Global Positioning System Signals, Measurements and Performance, by Pratap Misra and Per Enge, copyright 2001).

A1.2.5.9 When a TABS is installed with a position source meeting the Class B requirements of this ETSO and transmitting a valid position, the transmitted Navigation Accuracy Category for Velocity, (NACv) SHALL be set to 1 (10 m/s), reference EUROCAE ED-102A including Corrigendum-1, dated January~~,~~ 2012, Section 2.2.5.1.19. When position is not valid, NACv SHALL be set to 0 (zero).

A1.2.5.10 Geometric Vertical Accuracy (GVA) SHALL be derived from Vertical Figure of Merit~~,~~ (VFOM) in accordance with EUROCAE ED-102A including Corrigendum-1, dated January~~,~~ 2012, Section 2.2.3.2.7.2.8. Class B position sources may not provide VFOM directly. When VFOM is not available directly, VFOM SHALL be derived from Vertical Dilution of Precision (VDOP) according to the following formula: VFOM = 2 * VDOP * UERE, where the UERE is 6 metres.

A1.2.5.11 The Type Code 31, Operational Status Message, subfield 'Airborne Capability Class Code', SHALL be changed to indicate the device is a TABS.

A1.2.5.11.1 The Operational Status Message SHALL be modified to indicate that it meets the performance standards of this ETSO. ED-102A, including Corrigendum-1, dated January~~,~~ 2012, paragraph 2.2.18.4.7 and Figure 2-40, is modified by this ETSO. Message bits 53-54~~,~~ (ME Bits 21-22)~~,~~ SHALL describe the capabilities of the TABS per Table 26. Set bit 54 to 1 (one) to indicate that either TABS Class A, Class B, or both classes of equipment are installed.

Bit 53	Bit 54	Description
0	0	Not TABS equipped
0	1	TABS Equipped
1	0	TABS device (reserved for future use)
1	1	TABS device (reserved for future use)

Table 28 — ED-102A Airborne Capability Class Message format

A1.2.6 GNSS Position Source Function Requirements (For Class B Devices)

A1.2.6.1 Manufacturers may use commercial off-the-shelf (COTS) GNSS position sources to meet the performance of this ETSO as long as the sensor meets the requirements in this section. The position source shall be capable of using ~~S~~satellite-~~B~~based ~~A~~augmentation ~~S~~system (SBAS) corrections and health messages to exclude satellites from the position solution or to correct satellite range errors. In areas where the SBAS is available, the TABS shall use the SBAS corrections and health messages to exclude satellites from the position solution or to correct satellite range errors. In areas where the SBAS is not available or out of service, the TABS may continue to operate. The regional airspace authority will determine what operational impacts this may have on air-to-ground usage of TABS equipment. According to the FAA, the GPS constellation experiences a significant ramp error approximately once a year. During these events, a chipset which uses the SBAS will, depending on the received SBAS messages, either correct or exclude the faulty satellite. Refer to RTCA~~/~~ DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, when interpreting SBAS-related requirements.

A1.2.6.2 The GNSS position source SHALL provide a GPS-only solution for use by the TABS ADS-B function. The FAA and EASA have not evaluated the performance of other GNSS systems for use in support of aviation-intended functions. This ETSO will be updated once sufficient analysis has been ~~done~~ performed to show that other GNSS are appropriate for use by TABS equipment. Note, the GPS-only solution refers to the use of the GPS satellite constellation, it does not exclude augmentation of the GPS solution, such as provided by SBAS or GBAS systems.

A1.2.6.3 The GNSS horizontal position error SHALL not exceed 30 metres, 95th percentile, when the Horizontal Dilution of Precision (HDOP) is 2.5 or less. The GNSS position source SHALL either transmit a Horizontal Figure of Merit (95 %) (HFOM) or an HDOP metric.

Note: The 30-metre horizontal position fixing error requirement assumes a UERE of 6 metres, consistent with Section A1.2.5.8.

A1.2.6.4 Removed.

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A1.2.6.5 The GNSS position source SHALL be capable of transmitting horizontal velocity measurements more accurate than 10 m/s, 95th percentile.

A1.2.6.6 The GNSS position source SHALL not transmit false or misleading data in the presence of broadband interference. There is no minimum interference rejection requirement for TABS equipment and loss of position in the presence of interference is acceptable behaviour.

A1.2.6.7 The GNSS position source SHALL not use SBAS corrections when the SBAS satellite is broadcasting message type 0.

A1.2.6.8 The GNSS position source SHALL exclude satellites with UDREI = 15 reported in the SBAS fast corrections.

A1.2.6.9 The GNSS position source SHALL apply SBAS fast and long-term corrections when available.

A1.2.6.10 The GNSS position source SHALL be capable of transmitting geometric altitude, Height Above the Ellipsoid (HAE) measurements more accurate than 45 metres, 95th percentile, when the Vertical Dilution of Precision (VDOP) is 3.7 or less. The GNSS position source SHALL either transmit a Vertical Figure of Merit (95 %) (VFOM) or a Vertical Dilution of Precision (VDOP) metric.

Note: The 45-metre vertical position fixing error requirement assumes a UERE of 6 metres, consistent with Section A1.2.5.10.

A1.2.7 Antenna Function Requirements

A1.2.7.1 The requirements for transponder antennas are specified in ETSO-C112e. The requirements for GNSS antennas are specified in ETSO-C190 and ETSO-C144a. The antennas should be designed to meet the performance specified in the applicable ETSO. However, the TABS may benefit significantly in installation costs from implementations where the antennas are integrated in the TABS equipment. Small degradations in antenna performance may be acceptable as a trade-off for installation cost.

A1.2.7.2 Antennas may be installed internally on aircraft that are transparent to radio frequencies. An internal antenna may not be appropriate on aircraft with a metal hull. If an antenna is installed internally, testing will need to be conducted to ensure the TABS is not negatively impacted and installation guidance must accompany the unit to ensure the system is properly fitted to the aircraft.

A1.2.7.3 Because TABS may be installed on a radio frequency (RF) transparent fuselage near a pilot or passenger, or in a cockpit in close proximity to a pilot or passenger, consideration must be given to antenna placement to ensure it does not pose a hazard to humans or combustible materials. Manufacturers must provide installation guidance describing the minimum safe distance the antenna can be to the nearest human body or, if applicable, combustible material. Appendix 3 of this ETSO provides a more in-depth discussion of this subject based on FCC and European documents.

A1.2.8 Form factor and power

A1.2.8.1 An ideal implementation of the TABS would be a single integrated unit with minimal connections to the airframe, such as: ~~;~~ mechanical mounting, power, and static air source. Where the equipment might be shared between multiple airframes, the mechanical mounting could incorporate an airframe-specific configuration module (containing such items as the ICAO 24-bit aircraft address), and be designed such that no tools are required to remove or install the TABS.

A1.2.8.2 Low power consumption design is important. Designs specifically intended for long-term battery operation are ideal. If the TABS is battery powered, it should be designed to provide system integrity commensurate with the failure condition category/classification stated in paragraph 3.2.1.

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APPENDIX 2~~.~~

TEST REQUIREMENTS

A2 Testing Introduction

A2.1 Testing Intent

A2.1.1 This ~~appendix~~ Appendix provides an acceptable means to verify the major functions of the TABS.

A2.1.2 The TABS is not intended to accept and reply to any UF=11 All-Call interrogations. RTCA~~/~~ DO-181E tests like 2.4.2.1 Step 6 that use the Mode S Only All-Call interrogation (UF=11) will need to use a different interrogation, such as a UF=0 interrogation.

A2.2 Testing Requirements

A2.2.1 The tests defined here are derived from tests in the reference documents or written here to ensure compliance with the intended capabilities of TABS equipment. These tests are one acceptable means to demonstrate that the equipment meets the functional requirements defined in Appendix 1 of this ETSO. Functionality not modified by Appendix 1 should be verified by the test outlined in the applicable standards, e.g. RTCA~~/~~ DO-181E.

A2.2.2 Table 27 provides notes in italics and parenthesis explaining how to read the tables that modify the text in the source documents.

(Source document reference)	Modified text for this ETSO
(This is a copy of the original text from the source document. Material to be deleted from this original text is marked with ~~strikethrough formatting~~.)	(This is the requirement for this ETSO. Modifications to the source text are marked in **<u>bold and underlined</u>** to assist in identifying changes).

Table 29 — (Source document reference) (type of change)

A2.2.3 Testing Transponder Function Requirements Derived From DO-181E (For Class A Devices)

A2.2.3.1 Testing of the transponder function of the TABS should follow the tests outlined in document RTCA~~/~~ DO-181E, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated 17 March~~17,~~ 2011, Sections 2.3, 2.4, and 2.5, with the following exceptions:

A2.2.3.1.1 Testing of Flight Crew Control Functions

A2.2.3.1.2 Testing should verify that the requirements of RTCA~~/~~ DO-181E, as modified by paragraph A1.2.3.1.2 of this ETSO, have been properly incorporated.

A2.2.3.1.3 Testing should verify that changes made to paragraph 2.1.7 a, in RTCA~~/~~ DO-181E, per Section A1.2.3.1.3, have been properly incorporated.

A2.2.3.1.3.1 Testing should verify the requirements of A1.2.3.1.3, by performing the test outlined in RTCA~~/~~ DO-181E Section 2.5.4.11. Test results should verify that the 4096 code can be set while on the ground. If the 4096 code can be set in flight, testing should verify that the 4096 code can be set while in the air (weight-off-wheels condition) per RTCA~~/~~ DO-181E Section 2.5.4.11.

A2.2.3.1.3.2 Testing should verify the requirements of A1.2.3.1.3, by performing the test outlined in RTCA~~/~~ DO-181E Section 2.5.4.11. Testing should verify that a means of selecting and transmitting Mode 3/A code 7700 (emergency) is provided and tested per RTCA~~/~~ DO-181E Section 2.5.4.11.

A2.2.3.1.3.3 Testing should verify the requirements of A1.2.3.1.3, by performing the test outlined in RTCA/ DO-181E Section 2.5.4.11. Testing should also verify that a means of selecting and transmitting an alternate Mode 3/A codes is provided and tested per RTCA/ DO-181E Section 2.5.4.11.

A2.2.3.1.4 Testing should verify the requirements of A1.2.3.1.4, by performing the test outlined in RTCA/ DO-181E Section 2.5.4.3.b. Test results should verify that aircraft without a means of determining air/ground state, ~~reports~~report ~~in-the-air~~in the air at all times. Aircraft with an automatic means to determine the air/ground state, must verify that the air/ground state is set properly. Perform the test outlined in RTCA/ DO-181E 2.5.4.3.b. If capable of determining the ~~air-ground~~ air/ground state, test results should verify that the aircraft reports in the air~~in-the-air~~ when in the air, and on the ground~~on-the-ground~~ when on the ground.

A2.2.3.1.5 Testing should verify that the requirements of A1.2.3.1.5, have been properly incorporated. If a means of selecting the Sstandby condition is provided, testing should verify return to normal operation from standby condition is within ~~five~~ 5 seconds.

A2.2.3.1.6 Testing should verify that the requirements of A1.2.3.1.6, have been properly incorporated. If a means of initiating the IDENT (SPI) feature is installed, testing shall verify it functions properly per RTCA/ DO-181E Section 2.5.4.3. (see Also A1.2.3.5and A2.2.3.5).

A2.2.3.2 Testing Reply Rate Capability Changes

A2.2.3.2.1 This section provides test criteria for the reply rate changes based on assumptions made in Section A1.2.3.2.1.

A2.2.3.2.2 Testing should verify that changes made to A1.2.3.2.2, have been correctly incorporated into TABS equipment.

A2.2.3.2.2.1 Testing should verify that the requirements of A1.2.3.2.2.1, of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 1, should verify that the transponder be able to continuously generate at least 100 ATCRBS 15-pulse replies per second.

A2.2.3.2.2.2 Testing should verify that the requirements of A1.2.3.2.2.2, of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 3, should verify that the transponder is capable of a peak reply rate of 150 ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.

A2.2.3.2.2.3 Testing should verify that changes made to RTCA/ DO-181E Section 2.2.3.4.2.a have been correctly incorporated into TABS equipment per A1.2.3.2.2.3.

A2.2.3.2.2.3.1 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 2, should verify that the transponder provide at least 29 short Mode S replies in any 1-second interval.

A2.2.3.2.2.3.2 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 3, should verify that the transponder provide at least 10 short Mode S replies in a 100-millisecond interval.

A2.2.3.2.2.3.3 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 4, should verify that the transponder provide at least 5 short Mode S replies in a 25-millisecond interval.

A2.2.3.2.2.3.4 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.a, as modified by paragraph A1.2.3.2.2.3 of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 5, should verify that the transponder provide at least 3 short Mode S replies in a l.6-millisecond interval.

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A2.2.3.2.2.4 Testing should verify that changes made to RTCA/ DO-181E, Section 2.2.3.4.2.b, have been correctly incorporated into TABS equipment per A1.2.3.2.2.4.

A2.2.3.2.2.4.1 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4, of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 2, should verify that the transponder provide at least 10 of the 29 Mode S replies as long-format replies in any 1-second interval.

A2.2.3.2.2.4.2 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4, of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 3, should verify that the transponder provide at least 4 of the 10 Mode S replies as long-format replies in a 100-millisecond interval.

A2.2.3.2.2.4.3 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4, of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 4, should verify that the transponder provide at least 3 of the 5 Mode S replies as long-format replies in a 25-millisecond interval.

A2.2.3.2.2.4.4 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.3.2.4.2.b, as modified by paragraph A1.2.3.2.2.4, of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.3.2.2.3 step 5, should verify that the transponder provide at least 2 of the 4 Mode S replies as long-format replies in a l.6-millisecond interval.

A2.2.3.3 Testing Reply Rate Limiting Changes

A2.2.3.3.1 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.7.3.1, as modified by paragraph A1.2.3.3.~~1~~, of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.4.2.2.5 step 1, should be performed to verify that the unit does not reply to Mode A interrogations.

A2.2.3.3.2 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.7.3.1, as modified by paragraph A1.2.3.3.2 of this ETSO have been satisfied. Testing outlined in DO-181E, Section 2.4.2.2.5 step 1, should be performed to verify that the unit is capable of between 100 continuous ATCRBS Mode C replies per second and the maximum continuous rate of which the transponder is capable, or 200 replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction SHALL apply only to the receipt of ATCRBS interrogations.

A2.2.3.4 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.13.1.2.c, as modified by paragraph A1.2.3.4 of this ETSO have been satisfied. Testing should show that airborne status is set to in the air unless the aircraft is air/ground determination capable. If the aircraft can determine air/ground state, testing should show this capability is determined ~~determines~~ on the ground when on the ground and in the air when in the air.

A2.2.3.5 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.13.1.2.d, as modified by paragraph A1.2.3.5 of this ETSO have been satisfied. If the aircraft is capable of providing SPI, follow the test outlined in A2.2.3.1.6 of ~~the~~ this ETSO to verify it functions properly per RTCA/ DO-181E Section 2.5.4.3~~.~~ (~~S~~see also~~,~~ Section A1.2.3.1.6 and A2.2.3.1.6).

A2.2.3.6 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.13.1.2.e, as modified by paragraph A1.2.3.6 of this ETSO have been satisfied. Testing should show the ~~A~~aircraft ID loaded while on the ground is broadcast. If aircraft ID can be changed in flight, testing should verify that aircraft ID can be changed in flight and the new aircraft ID is broadcast.

A2.2.3.7 Testing of Interrogation Acceptance Protocol Changes (All-Call reply capability)

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A2.2.3.7.1 Except where noted here, testing of the Interrogation Acceptance Protocol capability should follow that called out in RTCA/ DO-181E. Testing of the Interrogation Acceptance Protocol capability should be modified from those called out in RTCA/ DO-181E to meet the changes made in A1.2.3.7.1.

A2.2.3.7.2 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.18.2.2.b, as modified by paragraph A1.2.3.7.2 of this ETSO have been satisfied. Various tests in RTCA DO-181E, Section 2.4, utilise ~~utilize~~ the Mode S Only All-Call interrogation and the expected reply to execute the test procedure. A discrete interrogation should be used as a substitute for these test procedures. Testing outlined in RTCA/ DO-181E, Section 2.5.4.2, should verify that UF=11 interrogations are not accepted.

A2.2.3.7.3 Testing should verify that the requirements of RTCA/ DO-181E, Section 2.2.18.2.2.c, as modified by paragraph A1.2.3.7.3 of this ETSO have been satisfied. Testing outlined in RTCA/ DO-181E, Section 2.5.4.2, should verify that an ATCRBS/Mode S All-Call interrogation (1.6-microseconds P4) is not accepted. The pulse decoder tests in Section 2.4.2.5 for ATCRBS/Mode S All-Call interrogation acceptance shall be modified to verify that no ATCRBS/Mode S All-Call interrogations that meet the criteria for acceptance in RTCA DO-181E, Section 2.2.6.2, produce a reply.

A2.2.3.8 Testing of the requirements of RTCA/ DO-181E, Interrogation Acceptance Protocol, per Section 2.5.4.4 and 2.5.4.5, are not required per A1.2.3.8 of this ETSO.

A2.2.3.9 Testing of the requirements of RTCA/ DO-181E, Stochastic All-Calls, per Section 2.5.4.13, is not required per A1.2.3.9 of this ETSO.

A2.2.3.10 Testing should verify the modified Mode S MTL requirements added to RTCA/ DO-181E, per Section A1.2.3.10. Test to ensure that paragraphs 2.2.18.2.2.L, and 2.2.18.2.2.m, have been properly incorporated.

A2.2.3.10.1 Testing outlined in RTCA/ DO-181E, Section 2.4.2, should verify that ATCRBS Mode A interrogations (P1-P3 spacing 8 microseconds) are not accepted per A1.2.3.10.1. Various tests in RTCA DO-181E, Section 2.4, utilise ~~utilize~~ Mode A interrogations to execute the test procedure. Mode C interrogations should be used as a substitute for these test procedures. The pulse decoder tests in DO-181E, Section 2.4.2.5, for Mode A interrogation acceptance shall be modified to verify that no Mode A interrogations that meet the criteria for acceptance in DO-181E, Section 2.2.6.2, produce a reply. The ~~R~~requirement for recovery from a Mode A interrogation per A1.2.3.10.1 shall be tested according to DO-181E, Section 2.4.2.6, ~~S~~step 1, except using a Mode A interrogation from the master and a Mode C interrogation from the slave.

A2.2.3.10.2 Testing should verify the requirements added to RTCA/ DO-181E, paragraph 2.2.18.2.2.m, have been properly incorporated per Section A1.2.3.10.2. Verify the requirement added by this ETSO, by performing the test procedure in RTCA/ DO-181E, Section 2.4.2.1. step 6, using a UF=0 to verify the Mode S MTL in Section 2.2.2.4.b and UF=4, 5, 20 and 21 to verify the modified MTL per A1.2.3.10.2.

A2.2.3.11 Testing should verify that the requirements of RTCA/ DO-181E, Interrogation Reply Coordination, Section 2.2.18.2.3, as modified by A1.2.3.11 of this ETSO are satisfied. Testing outlined in DO-181E, Section 2.5.4.2, shall be modified to verify that the unit does not reply to ATCRBS Mode A interrogations. Test ATCRBS Mode A/Mode S All-Calls, ATCRBS Mode C/Mode S All-Calls or UF=11 interrogations per testing outlined in A2.2.3.7 and A2.2.3.10.

A2.2.3.12 Testing of RTCA/ DO-181E, Lockout Protocol, Section 2.2.18.2.4, is not required since TABS devices do not reply to All-Call interrogations per A1.2.3.12 of this ETSO. Testing using interrogations in

RTCA/ DO-181E, Section 2.5.4.4, should be performed to verify that the unit properly replies to interrogations containing lockout commands from ground interrogations.

A2.2.3.13 Testing of RTCA/ DO-181E, Multisite Lockout Protocol, Section 2.2.18.2.5, is not required since TABS devices do not reply to All-Call interrogations per A1.2.3.13 of this ETSO. Testing using interrogations in RTCA/ DO-181E, Section 2.5.4.5, should be performed to verify that the unit properly replies to interrogations containing multisite lockout commands from ground interrogations.

A2.2.3.14 Testing should verify that the requirements of RTCA/ DO-181E, Flight Status and Vertical Status Protocols, Section 2.2.18.2.7, as modified by A1.2.3.14 of this ETSO are satisfied. Testing outlined in DO-181E, Section 2.5.4.7, should be performed to verify that the unit sets the flight status bits properly consistently with the capabilities provided for Mode 3/A code entry per A1.2.3.1.3.

A2.2.3.15 Testing the requirement of RTCA/ DO-181E, All-Call Reply Protocol, Section 2.2.18.2.9, as modified by A1.2.3.15, is not required. Testing outlined in DO-181E, Section 2.5.4.8, does not need to be performed since the TABS does not support the All-Call Protocol.

A2.2.3.16 Testing should verify the Level 2 Transponder Requirements of RTCA/ DO-181E, Minimum Level 2 Transponder Requirements, Section 2.2.19.1, as modified by A1.2.3.16 of this ETSO are satisfied. Testing outlined in RTCA/ DO-181E, Section 2.5.3, should be performed to verify that the unit performs per design specifications. Also, testing outlined in RTCA/ DO-181E, Section 2.5.4.17, should be performed to verify that the unit does not process DF=16 messages.

A2.2.3.17 No test is required to verify the requirements of RTCA/ DO-181E, Information Transfer, Section 2.2.19.1.3, per A1.2.3.17.

A2.2.3.18 Testing should verify that the requirements of RTCA/ DO-181E, Interrogation-Reply Coordination, Section 2.2.19.1.4, as modified by A1.2.3.18 are met. Use tests in A2.2.3.7 and A2.2.3.10 in this ETSO to verify that the TABS does not reply to ATCRBS Mode A, ATCRBS/Mode S All-Calls and UF=11 interrogations.

A2.2.3.19 Testing of the requirements of RTCA/ DO-181E, Lockout Protocol, Section 2.2.19.1.5, per Section 2.5.4.4, are not required per A1.2.3.19 of this ETSO. Testing should verify that the TABS does not perform the UM Protocol per RTCA/ DO-181E, Section 2.5.4.18.

A2.2.3.20 Since TABSs do not support the Comm-B protocol except for GICB extraction requests, the requirements of RTCA/ DO-181E, UM Protocol, Section 2.2.19.1.9, do not apply, per A1.2.3.20. Using a subset of the interrogations identified in RTCA/ DO-181E, Section 2.5.4.18, select 12 interrogations with UF=4, 5, 20 and 21 and containing DI=0, 1 and 7 and verify that the reply contains UM field of 0 (zero)~~ZERO~~.

A2.2.3.21 Testing of the requirements of RTCA/ DO-181E, Comm-A Protocol, Section 2.2.19.1.10, per Section 2.5.4.15, ~~are~~ is not required per A1.2.3.21 of this ETSO. Testing should verify that the TABS does not perform the Com-A Protocol per RTCA/ DO-181E, Section 2.5.4.15.

A2.2.3.22 Testing of the requirements of RTCA/ DO-181E, Broadcast Protocol, Section 2.2.19.1.11, as modified by A1.2.3.22 is not required since TABSs do not support this protocol.

A2.2.3.23 Testing of the requirements of RTCA/ DO-181E, Air-Initiated Comm-B Protocol, Section 2.2.19.1.12.4, per Section 2.5.4.18 is not required per A1.2.3.23. To verify GICB extraction requirements, perform the portion of the test procedure of RTCA/ DO-181E, Section 2.5.4.18, using interrogation patterns 1 to 24, to test the transponder in state 1 of the test matrix to verify proper reply content.

A2.2.3.24 Testing the requirements of RTCA/ DO-181E, Comm-B Broadcast Protocol, Section 2.2.19.1.12.5, per 2.5.4.21 is not required per A1.2.3.24.

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A2.2.3.25 Testing should verify the requirements of RTCA~~/~~ DO-181E, Updating the Data Link Capability Report, Section 2.2.19.1.12.6.3, as modified by A1.2.3.25. Testing should verify that the TABS does not perform the Updating the Data Link Capability Report per RTCA~~/~~ DO-181E, Section 2.5.4.33.

A2.2.3.26 Testing should verify the requirements of RTCA~~/~~ DO-181E, Change of Aircraft Identification, Section 2.2.19.1.13.e, as modified by A1.2.3.26. Testing should verify that the TABS does not perform the Change of Identification per RTCA~~/~~ DO-181E, Section 2.5.4.19.

A2.2.3.27 Testing the requirements of RTCA~~/~~ DO-181E, Linked Comm-A Coding, Section 2.2.19.1.14, per 2.5.4.15, is not required per A1.2.3.27.

A2.2.3.28 Testing the requirements of RTCA~~/~~ DO-181E, Comm-U/V Protocol, Section 2.2.19.1.16, per 2.5.4.17, as modified by A1.2.3.28 is not required.

A2.2.3.29 Testing the requirements of RTCA~~/~~ DO-181E, Data Handling Interfaces, Section 2.2.19.1.17, per 2.5.4.20, as modified by A1.2.3.29 is not required.

A2.2.3.30 Testing the requirements of RTCA~~/~~ DO-181E, Multisite Message Protocol, Section 2.2.19.2, per Section 2.5.4.5, as modified by A1.2.3.30 is not required.

A2.2.3.31 Testing the requirements of RTCA~~/~~ DO-181E, Surveillance Identifier (SI), Section 2.2.24.2, per 2.6.2, as modified by A1.2.3.31 is not required.

A2.2.3.32 Testing the requirements of RTCA~~/~~ DO-181E, Elementary Surveillance Capability, Section 2.2.24, as modified by A1.2.3.32 is not required. If one or more ELS registers are supported, test per RTCA~~/~~ DO-181E, Section 2.6.

A2.2.3.33 Testing the requirements of RTCA~~/~~ DO-181E, Enhanced Surveillance Capability, Section 2.2.25.3.2, as modified by A1.2.3.33 is not required. If the unit is Enhanced Surveillance Capability capable, test per RTCA~~/~~ DO-181E, Section 2.7.

A2.2.4 Testing Altitude Source Function Requirements

A2.2.4.1 Testing of the Altitude Source Function should follow that called out in ETSO-C88b, Automatic Pressure Altitude Reporting Code Generating Equipment, dated 5 August 2016.

A2.2.5 Testing ADS-B OUT Function Requirements (For Class A Devices)

A2.2.5.1 Testing should verify the ADS-B system performs its intended function per EUROCAE ED-102A, MOPS for 1090 MHz Extended Squitter Automatic Dependent Surveillance —~~–~~ Broadcast (ADS-B) and Traffic Information Services —~~–~~ Broadcast (TIS-B), dated December~~,~~ 2009, including Corrigendum-1, dated January~~,~~ 2012, except as modified by Section A1.2.5. Testing should follow the tests outlined in EUROCAE ED-102A, including Corrigendum 1, dated January~~,~~ 2012, Sections 2.3 and 2.4, with the following exceptions:

A2.2.5.2 Per Section A1.2.5.2, testing of transponder functions should follow the requirements in Sections A1.2.3 and A2.2.3 of this ETSO.

A2.2.5.3 Testing should verify the System RF Peak Power Output has a peak output level of at least 18.5 dBW (70 watts) per A1.2.5.3, reference EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, RF Peak Power, Section 2.2.2.2.10.1.a. Testing outlined in ED-102A, Section 2.3.2.2.6.1 step 5, should verify that the unit under test provides a peak output power level of at least 18.5 dBW (70 watts).

A2.2.5.4 If the optional ADS-B Surface Position Messages function is provided, per Section~~,~~ A1.2.5.4, testing should verify that the ADS-B Surface Position Message is correctly populated and broadcast per EUROCAE ED-102A, Section 2.4.3.2.1.2.2.

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A2.2.5.5 If the optional Typecode 31~~,~~ subtype 1~~,~~ Aircraft Operational Status Messages is provided per Section A1.2.5.5, testing should verify that the Aircraft Operational Status Messages is correctly populated and broadcast per EUROCAE ED-102A, Section 2.4.3.2.7.2

A2.2.5.6 Per Section A1.2.5.6, testing should verify that NIC=6~~,~~ and SIL=1 when using position from a Class B position source using test procedures in EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, Sections 2.4.8.1.5~~,~~ and 2.4.5.1.40.

A2.2.5.7 Testing should verify that the System Design Assurance (SDA) is set to 1 to verify the requirement in Section A1.2.5.7, reference EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, System Design Assurance (SDA), Section 2.2.5.1.50.

A2.2.5.8 Per Section A1.2.5.8, testing should verify that Navigation Accuracy Category for Position (NACp) is set according to EUROCAE ED-102A including Corrigendum-1, dated January~~,~~ 2012, Section 2.4.3.2.7.1.3.8. Testing should verify that the NACp is set appropriately when the position source is providing HDOP and not HFOM.

A2.2.5.9 If a TABS Class B position source is installed, verify that Navigation Accuracy Category Velocity (NACv) is set to 1 (10 m/s) per A1.2.5.9.

A2.2.5.10 Verify that Geometric Vertical Accuracy (GVA) is set per A1.2.5.10. Testing outlined in EUROCAE ED-102A, including Corrigendum-1, dated January~~,~~ 2012, Section 2.4.3.2.7.2.8, should verify that GVA is set appropriately when the position source is providing VDOP and not VFOM.

A2.2.5.11 Verify Type Code 31, Airborne Capability Class Message, indicates that the unit under test is a TABS per A1.2.5.11.

A2.2.6 Testing of GNSS Position Source Function Requirements (For Class B Devices)

A2.2.6.1 A TABS incorporating a position source that is compliant with ETSO-C129, ETSO-C145, ETSO-C146 or ETSO-C196 must also meet the additional ADS-B criteria defined in AMC1 ACNS.D.ADSB.070 of CS-ACNS, to include any required testing. GNSS position sources that are not compliant with an existing GNSS ETSO will need to meet the requirements in paragraph A1.2.6 of this ETSO and verify it meets the minimum requirements by performing the tests outlined in Section A2.2.6 of this ETSO. The following tests were derived from a reduced set of requirements and associated tests found in RTCA~~/~~ DO-229E.

A2.2.6.2 GPS Only Solution.

A2.2.6.2.1 Per paragraph A1.2.6.2, verify that the position source provides a GPS-SBAS or GPS Only solution for use by Class A TABS.

A2.2.6.3 Position Accuracy Tests.

A2.2.6.3.1 Two tests are used to verify the horizontal position accuracy to ensure the requirement in paragraph A1.2.6.3 is met. The first test is a 24-hour static scenario using live satellite signals. The second test uses a GNSS simulator to generate a scenario incorporating both static and dynamic aircraft ~~manoeuvers~~manoeuvres.

A2.2.6.3.2 24-Hour Accuracy Test.

A2.2.6.3.2.1 The equipment SHALL be tested over a 24-hour period using live GPS satellite signals at a surveyed location. The equipment SHALL use an antenna representative of what will be used in an actual airborne installation. The horizontal position error SHALL be computed for each position estimate output by the equipment.

A2.2.6.3.2.2 Monitor the sensor-provided HFOM and VFOM, or HFOM and VFOM derived from the sensor-provided HDOP and VDOP per paragraphs A1.2.5.8 and A1.2.5.10. In order to pass the test, the horizontal position error must be less than 30 metres for at least 95 % of the samples and the horizontal accuracy reported must be greater than the actual position error for at least 95 % of the samples. In order to pass the test, the vertical position error must be less than 45 metres for at least 95 % of the samples and the vertical accuracy reported must be greater than the actual position error for at least 95 % of the samples.

A2.2.6.3.2.3 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.3.2.4 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. In order to pass the test, 99.9 % of the position outputs must be reported as valid, excluding those position reports prior to the first position fix.

A2.2.6.3.3 GPS Simulator-based Accuracy Tests.

A2.2.6.3.3.1 The equipment SHALL be tested using a GPS simulator scenario that includes both static and dynamic aircraft ~~manoeuvers~~manoeuvres. The horizontal and vertical position errors SHALL be computed for each position estimate output by the equipment.

A2.2.6.3.3.2 Monitor the sensor-provided HFOM and VFOM, or HFOM and VFOM derived from the sensor-provided HDOP and VDOP per paragraphs A1.2.5.8 and A1.2.5.10. In order to pass the test, the horizontal position error must be less than 30 metres for at least 95 % of the samples and the horizontal accuracy reported must be greater than the actual position error for at least 95 % of the samples. In order to pass the test, the vertical position error must be less than 45 metres for at least 95 % of the samples and the vertical accuracy reported must be greater than the actual position error for at least 95 % of the samples.

A2.2.6.3.3.3 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.3.3.4 Simulator Scenario Details

A2.2.6.3.3.4.1 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. In order to pass the test, 99.9 % of the position outputs must be reported as valid, excluding those position reports prior to the first position fix.

A2.2.6.3.3.4.2 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA~~/~~ DO-229E Appendix B. The initial position and time should be chosen to ensure the satellite geometry supports the test ~~Pass/Fail~~pass-fail criteria, and the HDOP is close to 2.5 and the VDOP is close to 3.7.

A2.2.6.3.3.4.3 The simulation SHALL include both stationary and dynamic portions, as follows:

A2.2.6.3.3.4.3.1 At least 10 minutes of stationary position.

A2.2.6.3.3.4.3.2 A sequence of different ~~manoeuvers~~manoeuvres, including acceleration to a constant velocity, climbs, descents, and turns.

A2.2.6.3.3.4.3.2.1 A series of turns should be included to ensure a constantly changing velocity to expose any effects of filtering on the position output.

A2.2.6.3.3.4.3.3 At least 10 minutes of accelerated ~~manoeuvers~~manoeuvres SHALL be simulated.

A2.2.6.3.3.4.3.4 Aircraft dynamics are as follows: ground speed = 200 kt, horizontal acceleration = 0.58 g, vertical acceleration of 0.5 g.

A2.2.6.3.3.4.4 The simulated satellite signals SHALL be set to - 134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

A2.2.6.3.3.4.5 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E, Appendix A, Section A.4.2.4 and IS-GPS-200G, dated 5 September~~5,~~ 2012.

A2.2.6.3.3.4.6 No interference needs to be simulated.

2.2.6.4 Reserved.

A2.2.6.5 Velocity Accuracy Tests.

A2.2.6.5.1 The velocity accuracy tests specified in AC 20-138D Appendix 4, Sections 4-2, 4-3 and 4-4, SHALL be performed per the requirement in A1.2.6.5 and show the unit provides an accuracy of 10 m/s or less, at least 95 % of the time. It is assumed that the GPS position source does not provide a velocity accuracy output and the TABS will broadcast NACv = 1. Only the tests required to demonstrate a NACv = 1 need be run.

A2.2.6.6 Interference Tests.

A2.2.6.6.1 The equipment SHALL be tested using simulated GPS signals mixed with an interfering signal of gradually increasing power until the equipment loses position to verify the requirement outlined in paragraph A1.2.6.6. The horizontal position accuracy will be evaluated.

A2.2.6.6.2 Simulator Scenario Details.

A2.2.6.6.2.1 Use the same simulator scenario set-up found in A2.2.6.3.3.4 with the following exceptions:

A2.2.6.6.2.2 The interfering signal SHALL be broadband noise with bandwidth of 20 MHz centred on 1575.42 MHz. The initial power spectral density SHALL be – 170.5 dBm/Hz (– 97.5 dBm total power).

A2.2.6.6.2.3 The scenario may need to be extended to allow sufficient time for increasing interference power.

A2.2.6.6.3 Test Procedure

A2.2.6.6.3.1 Step 1: The interfering signal SHALL initially be turned off.

A2.2.6.6.3.2 Step 2: The simulator scenario SHALL be engaged and the satellites' RF SHALL be turned on.

A2.2.6.6.3.3 Step 3: The equipment SHALL be powered on and initialised. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting these tests.

A2.2.6.6.3.4 Step 4: The receiver SHALL be allowed to reach steady state. When the receiver has reached steady state, an interfering broadband noise signal of – 170.5 dBm/Hz SHALL be applied.

A2.2.6.6.3.5 Step 5: The interference power SHALL be maintained until the accuracy has reached steady state~~steady-state~~. Position measurements and validity indications SHALL be recorded during this interval.

A2.2.6.6.3.6 Step 6: The power of the interfering signal SHALL be increased by 2 dB and maintained for 200 seconds.

A2.2.6.6.3.7 Step 7: Go to Step 5 and repeat until the receiver is unable to maintain a position fix.

A2.2.6.6.4 ~~Pass/Fail~~ Pass-Fail Criteria

A2.2.6.6.4.1 The horizontal position errors SHALL be computed for each position estimate output by the equipment.

A2.2.6.6.4.2 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.6.4.3 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. There is no minimum interference rejection requirement for TABS equipment, and loss of position in the presence of interference is acceptable behaviour.

A2.2.6.7 Verification of SBAS Message Type 0

A2.2.6.7.1 Test to verify that the GNSS position source does not use SBAS corrections when the SBAS satellite is broadcasting message type 0 per A1.2.6.7.

A2.2.6.7.2 Simulator Scenario Details

A2.2.6.7.2.1 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA~~/~~ DO-229E Appendix B.

A2.2.6.7.2.2 A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5) update rate of 6 seconds.

A2.2.6.7.2.3 At 500 seconds into the scenario, the SBAS satellite SHALL start broadcasting message type 0 for 60 seconds. The message type 0 broadcast SHALL contain message type 2 data (if appropriate for the SBAS service being simulated).

A2.2.6.7.2.4 The scenario SHALL have a static user position.

A2.2.6.7.2.5 The simulated satellite signals SHALL be set to a nominal power level (– 128 dBm).

A2.2.6.7.2.6 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E Appendix A Section A.4.2.4 and IS-GPS-200G, dated 5 September~~5,~~ 2012.

A2.2.6.7.2.7 No interference needs to be simulated.

A2.2.6.7.3 Test Procedure

A2.2.6.7.3.1 Step 1: The simulator scenario SHALL be engaged and the satellites' RF SHALL be turned on.

A2.2.6.7.3.2 Step 2: The equipment SHALL be powered on and initialised. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting the tests.

A2.2.6.7.3.3 Step 3: Monitor the receiver output for the indication of SBAS use. Verify that the receiver indicates that SBAS is not in use before an SBAS satellite has been acquired.

A2.2.6.7.3.4 Step 4: Allow the receiver to reach steady-state navigation. Verify that the receiver indicates that SBAS is in use before proceeding to the next step.

A2.2.6.7.3.5 Step 5: 500 seconds into the scenario, the SBAS satellite SHALL start broadcasting message type 0.

A2.2.6.7.3.6 Step 6: Monitor the receiver output for the indication of SBAS use. Verify that the receiver indicates that SBAS is not used within 8 seconds.

A2.2.6.8 Exclusion of satellites identified by SBAS as unhealthy

A2.2.6.8.1 Test to verify that the GNSS position source excludes satellites with UDREI = 15 reported in the SBAS fast corrections per A1.2.6.8. The ability of the position source to exclude unhealthy satellites based on the SBAS UDREI will be tested by injecting a ramp error on a satellite measurement and subsequently broadcasting an SBAS UDREI of 15 ('do not use') for that satellite.

A2.2.6.8.2 UDREI = 15 in fast corrections message (MT 2-5, 24)

A2.2.6.8.2.1 The equipment SHALL be tested to verify that the UDREI data contained in the SBAS fast corrections messages (MT 2-5, 24) is used to exclude unhealthy satellites.

Note: The test does not assume that the receiver outputs an indication that the unhealthy satellite has been removed from the position solution. Instead, it uses a pass criterion~~criteria~~ based on horizontal position error.

A2.2.6.8.2.2 Simulator Scenario Details

A2.2.6.8.2.2.1 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA~~/~~ DO-229E Appendix B.

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A2.2.6.8.2.2.2 A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5, 24) update rate of 6 seconds. The integrity information message (MT 6) SHALL not be broadcast.

A2.2.6.8.2.2.3 The simulation start time and location SHALL be such that the resulting HDOP is close to 5.0.

A2.2.6.8.2.2.4 The simulation SHALL use nominal aircraft dynamics, defined to be ground speed = 200 kt and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns.

A2.2.6.8.2.2.5 The scenario SHALL allow the receiver time to achieve steady-state navigation before introducing any satellite errors.

A2.2.6.8.2.2.6 The scenario SHALL introduce a ramp error on each simulated GPS satellite individually, as follows:

A2.2.6.8.2.2.6.1 Step 1: A 5-m/s ramp error SHALL be introduced on the simulated GPS satellite.

A2.2.6.8.2.2.6.2 Step 2: ~~Six~~ 6 seconds after the introduction of the ramp error, the simulated SBAS satellite SHALL broadcast a UDREI of 15 for the GPS satellite in the fast correction message.

A2.2.6.8.2.2.6.3 Step 3: The ramp error SHALL be applied until one of the following conditions occur:

— The horizontal position error of a valid position output exceeds 0.5 NM; or

— The ramp error exceeds 2 000 m; or

— The affected GPS satellite is excluded from the solution.

A2.2.6.8.2.2.6.4 Step 4: Allow the receiver time to return to steady state before repeating ~~s~~Steps 1 to 3 on the next satellite.

A2.2.6.8.2.2.7 The simulated satellite signals SHALL be set to - 134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

A2.2.6.8.2.2.8 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E~~,~~ Appendix A~~,~~ Section A.4.2.4 and IS-GPS-200G, dated 5 September~~5,~~ 2012.

A2.2.6.8.2.2.9 No interference needs to be simulated.

A2.2.6.8.2.3 ~~Pass/Fail~~ Pass-Fail Criteria

A2.2.6.8.2.3.1 The test SHALL be run on two different space-time scenarios. The two scenarios SHALL be sufficiently separated to ensure that different satellite geometry is presented to the receiver.

A2.2.6.8.2.3.2 The horizontal position errors SHALL be computed for each position estimate output by the equipment during the test.

A2.2.6.8.2.3.3 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.8.2.3.4 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation.

A2.2.6.9 Testing GNSS Position Source SBAS Fast and Long-Term Corrections

A2.2.6.9.1 Application of Fast Corrections (MT 2-5, 24) and Long-Term Corrections (MT 24, 25). The equipment SHALL be tested to verify that fast corrections and long-term corrections are applied properly per A1.2.6.9.

A2.2.6.9.2 Simulator Scenario Details

A2.2.6.9.2.1 The simulator scenario SHALL use the standard 24-satellite constellation in RTCA~~/~~ DO-229E Appendix B.

A2.2.6.9.2.2 A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5, 24) update rate of 6 seconds and standard long-term corrections (MT 24, 25) update rate of 120 seconds.

A2.2.6.9.2.3 The simulation start time and location SHALL be such that the resulting HDOP is close to 5.0.

A2.2.6.9.2.4 The simulation SHALL use nominal aircraft dynamics, defined to be ground speed = 200 kt and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns.

A2.2.6.9.2.5 The scenario SHALL introduce a bias and ramp error on a single satellite selected so that the range error will result in the maximum horizontal position error if not corrected by SBAS. The SBAS long-term corrections will be applied to correct the bias error. At each 6-second~~s~~ update, SBAS fast corrections will be provided to correct the ramp error for the affected satellite, as follows:

A2.2.6.9.2.5.1 Step 1: A 70-metre bias SHALL be introduced on the simulated GPS satellite. Provide SBAS long-term corrections to correct the bias term. The bias magnitude was chosen to approximate the maximum value that can be corrected by the δa_{f0} term in a type 25 message (using velocity code 0).

A2.2.6.9.2.5.2 Step 2: Start the scenario broadcasting MT 25 with the correction for the bias error introduced on the selected satellite.

A2.2.6.9.2.5.3 Step 3: Allow the receiver time to acquire the GPS and SBAS satellites and obtain a steady-state differential fix, including sufficient time to acquire a type 25 message for the selected GPS satellite.

A2.2.6.9.2.5.4 Step 4: Inject a 5-m/s ramp error on the selected satellite in the same direction as the bias error.

A2.2.6.9.2.5.5 Step 5: At each 6-second update, provide SBAS fast corrections equivalent to the size of the growing ramp error.

A2.2.6.9.2.5.6 Step 6: The ramp error SHALL be applied until the ramp error plus bias error reaches 325 metres. Maintain the error of 325 metres for 5 minutes.

A2.2.6.9.2.6 The simulated satellite signals SHALL be set to – 134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

A2.2.6.9.2.7 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229E Appendix A Section A.4.2.4 and IS-GPS-200G, dated 5 September 2012.

A2.2.6.9.2.8 No interference needs to be simulated.

A2.2.6.9.3 ~~Pass/Fail~~ Pass-Fail Criteria

A2.2.6.9.3.1 The horizontal and vertical position errors SHALL be computed for each position estimate output by the equipment during the test.

A2.2.6.9.3.2 Monitor the sensor-provided HFOM and VFOM, or HFOM and VFOM derived from the sensor-provided HDOP and VDOP per paragraphs A1.2.5.8 and A1.2.5.10. Compare the HFOM against the horizontal position error for each valid position estimate. Compare the VFOM against the vertical position error for each valid position estimate. In order to pass the test, the horizontal and vertical position accuracy output must be greater than the actual position error at least 95 % of the time. Analyse the position estimates to determine whether ~~if~~ the fast corrections and long-term corrections are being applied correctly.

A2.2.6.9.3.3 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation.

A2.2.6.9.3.4 The test only needs to be run using a single space/time scenario.

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A2.2.6.10 Test the GNSS position source requirements in Section 0 by running the test outlined in Section A2.2.6.3.3.

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APPENDIX 3~~.~~

ENVIRONMENTAL TESTING FOR CLASS B EQUIPMENT

A3 Environmental Test Considerations

A3.1 The environmental tests and performance requirements described in this subsection provide a laboratory means of determining the overall performance characteristics of the equipment under conditions that are representative of those that may be encountered in actual aeronautical operations.

A3.2 The following test procedures must be run when performing environmental testing on Class B ~~E~~equipment. Class B equipment only needs to be tested under DO-160D change 3 or later Environmental Test, Section 4 Temperature and Altitude, and Section 5 Temperature Variation Testing.

A3.3 The test procedure ~~set forth~~ provided below is considered satisfactory for use in determining the performance of the equipment ~~performance~~ under environmental conditions. Although specific test procedures are cited, it is recognised that other methods may be preferred. These alternative procedures may be used if the manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternative procedures.

Note: The intent of this section is to minimise the testing of commercial off-the-shelf (COTS) devices.

A3.4 Class B Equipment System Test

A3.4.1 Equipment Required: A representative antenna of what will be installed in an actual airborne TABS.

A3.4.2 Figure 1 provides a representation of the test set-up.

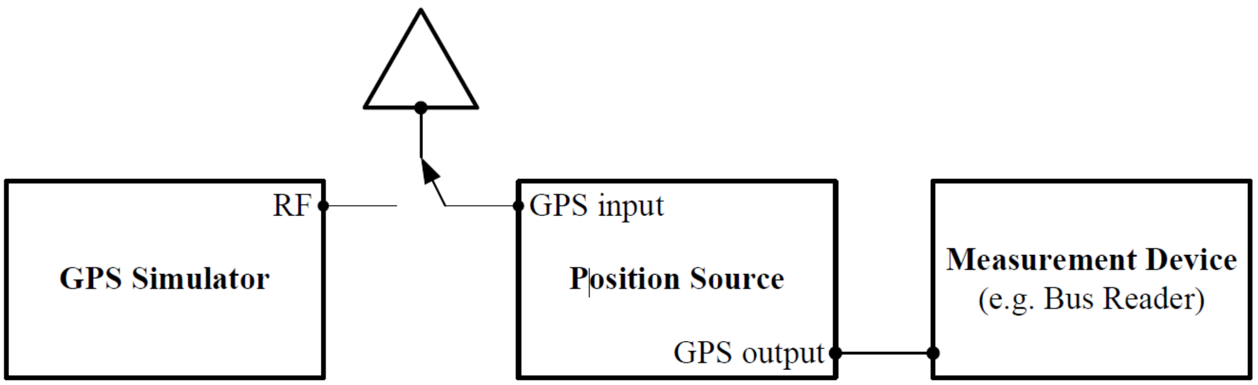

Figure 1 — Test Set-up

A3.4.3 Measurement Procedure:

A3.4.3.1 Set the test equipment to measure the output of the position source.

A3.4.3.1.1 Verify that the position information output by the GPS to the TABS is correct for:

A3.4.3.1.1.1 The latitude and longitude of the surveyed location when connecting the device to a live (e.g. rooftop) antenna, or~~;~~

A3.4.3.1.1.2 The output by the GPS simulator for the scenario outlined in Section A2.2.6.3.3.

A3.4.3.1.2 Using the test set-up in A3.4.2, monitor the sensor-provided HFOM, or HFOM derived from the sensor-provided HDOP per paragraph A1.2.5.8. This output SHALL be compared against the horizontal position error for each valid position estimate. In order to pass the test, the horizontal position accuracy output must be greater than the actual position error for at least 95 % of the samples. The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AERONAUTICAL MOBILE AIRPORT COMMUNICATION SYSTEM (AeroMACS)

1 — Applicability

This ETSO gives provides the requirements which aeronautical mobile airport communication systems (AeroMACSs) that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The Aapplicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical cConditions

3.1 — Basic

3.1.1 — Minimum pPerformance sStandard

The applicable Sstandards are those set forthprovided in the EUROCAE ED-223, Minimum Operational Performance Standard (MOPS) for Aeronautical Mobile Airport Communication System (AeroMACS), dated October 2013.

Note: AeroMACS equipment may provide access in the airport environment to one or more of the following services: air traffic services (ATS), aeronautical operational communication (AOC) including aeronautical information services and meteorological (AIS/MET) information, airline administrative communication (AAC), and airport authority communication, as well as aircraft access to system-wide information management (SWIM) services. AeroMACS AMS equipment is intended for use while on the airport surface only. Passenger information and entertainment service and passenger-owned devices are not included in this ETSO. AeroMACS is considered to be supplemental to the communication equipment required by the operational rules. AeroMACS provides data link communication services over spectrum reserved for aeronautical mobile route services (AMRS). This includes aeronautical operational control (AOC) and non-safety of flight airline administrative communication (AAC) via data link while on the airport surface only. air traffic services (ATS) are excluded from this ETSO. AeroMACS is considered supplemental equipment to communication equipment required by the operating rules. AeroMACS is based on the Institute of Electrical and Electronics Engineers 802.16-2009 standard: Air Interface for Broadband Wireless Access Systems, and can only operate on the airport surface.

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3.1.2 — Environmental ~~s~~Standard
See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software
See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne ~~e~~Electronic ~~h~~Hardware
See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific
None.

3.2.1 — Failure ~~c~~Condition ~~c~~Classification
See CS-ETSO, Subpart A, paragraph 2.4.
A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO that results in misleading data link communication is a minor failure condition. A ~~L~~loss of this function is a minor failure condition. The minor failure condition classification is based on the network protocol and/or application system layers above the AeroMACS AMS equipment to detect and annunciate errors that would result in misleading or missing ATS messages.

4 — Marking
4.1 — General
~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific
None.

5 — Availability of ~~r~~Referenced ~~d~~Documents
See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: PORTABLE WATER-SOLUTION TYPE HAND FIRE EXTINGUISHERS

1 — Applicability

This ETSO provides ~~gives~~ the requirements which ~~new models of~~ portable water-solution type hand fire extinguishers that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~ provided in ~~the~~ SAE International's Aerospace Standard ~~document AS245A~~ AS245B, ~~'~~Water Solution Type Hand Fire Extinguisher~~'~~, dated 1 November 1948, revised in April 2000~~ December 15, 1956~~, ~~and supplemented by this ETSO (revised) April 2004,~~ as modified in Appendix 1 of this ETSO.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1

3.1.3— ~~Computer~~ Software

None.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

~~None~~

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

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4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.
Instead of the optional serial number, the date of manufacture has to be marked.

4.2 — Specific

These are ~~A~~as specified in ~~the~~ SAE International's Aerospace Standard ~~document AS245A~~ AS245B, paragraph 3.2.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1~~.~~

MPS FOR PORTABLE WATER SOLUTION TYPE HAND FIRE EXTINGUISHERS

The applicable standard is SAE AS245B, Water Solution Type Hand Fire Extinguisher, dated (revised) April 2004, shall be modified as follows:

AS245B section	**Action**
Paragraph 4.1.2: Burst pressure	to be revised as follows: The ~~B~~burst pressure must be ~~equal or~~ greater than or equal to ‘b’ times the design pressure (see ~~t~~Table 1 below). The ~~D~~design pressure is compatible with the maximum pressure encountered in use of the extinguisher and ensures a long service life for~~of~~ equipment when charged.
Paragraph 5. Individual Performance Requirements:	to be revised as follows: All extinguishers, or extinguisher components, shall be subjected at a minimum to the following tests:
	Requirement to be added: the proof pressure must be ~~equal or~~ greater than or equal to ‘p’ times the design pressure (see ~~t~~Table 1 below). Table 1: the ~~‘~~‘b’~~‘~~ and ~~‘~~‘p’~~‘~~ factors indicated depend on the type of extinguisher ~~type~~

	b	p
Type I	2,7	1,5
Type II	2,4	1,2

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Date: ~~05.07.2012~~ XX.XX.20XX

European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: INFORMATION COLLECTION AND MONITORING SYSTEMS

1 — Applicability

This ETSO ~~gives~~ provides the requirements which information collection and monitoring systems that record cockpit audio, aircraft data, airborne images, or data link communications and that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

All the documents specified in EUROCAE ED-155, Section 2-1, 2-1.3.4, must be provided. In addition, a statement must be provided that tools are readily available for the retrieval of recorded information from any memory device used within the robust memory module removed from a crash-damaged recorder.

Note: The documents and tools/special recovery techniques required above are meant to be offered to any safety investigation authority, whether or not the request from that authority is made in the frame of an ongoing investigation.

~~None.~~

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3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~provided in ~~the~~ EUROCAE ED-155, Minimum Operational Performance Specification for Lightweight Flight Recording Systems, dated July 2009.

All ICMS must meet the requirements in ED-155 Chapters 2-1, 2-2, 2-3 and 2-4 of Section 2. All deployable ICMS must also meet the requirements in ED-155 Chapters 3-1, 3-2, 3-3 and 3-4 of Section 3. Additionally, each Type of ICMS must meet the requirements of ED-155 listed in the table below.

ICMS Type	Your design must also meet the following requirements in ED-155	Your design does not need to meet the following requirements in ED-155
I	Part I, Cockpit Audio Recording System	I-2.1.7 and I-6
II	Part II, Aircraft Data Recording System	II-2.1.7, II-2.1.9, II-2.1.12, and II-6
III	Part III, Airborne Image Recording System	III-2.2 and III-6
IV	Part IV, Data-link Recording System	IV-2.1.6, IV-2.1.11, and IV-6

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — ~~Computer~~ Software

See CS-ETSO Subpart A paragraph 2.2.

3.1.4 — Airborne Electronic Hardware ~~Qualification~~

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Minimum Dimensions for the Memory Module

The height (a), width (b), and depth (c) of the crash enclosure must each be 4 cm (1.5 inches) or greater.

3.2.2 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition. A ~~L~~loss of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

Note: ~~t~~The failure classification is driven by the use of the recorders in accident investigations ~~need~~.

4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: CIRCUIT CARD ASSEMBLY (CCA) FUNCTIONAL SENSORS USING SATELLITE-BASED AUGMENTATION SYSTEM (SBAS) FOR NAVIGATION AND NON-NAVIGATION POSITION/VELOCITY/TIME (PVT) OUTPUT

1 — Applicability

This ETSO provides the requirements that circuit card assembly (CAA) functional sensors that use satellite-based augmentation systems (SBASs) for navigation and non-navigation position/velocity/time (PVT) output, which are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.
ETSO-2C204a is intended as a means for manufacturers of end-use equipment to rationalise their ETSO-C145e applications for Class Beta PVT sensors by using ETSO-authorised SBAS CCAs for partial certification credit.

An ETSO-2C204a article has a limitation that requires the manufacturer of end-use equipment to repeat selected detailed functional tests in the end-use equipment and complete the environmental qualification tests in RTCA DO-229E (see paragraphs 3.1.2.2 and 3.2.2 below).

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are those provided for Class Beta functional equipment in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2, as modified by Appendices 1 and 3 of this ETSO standard.

Class Beta equipment is defined in DO-229E, Section 1.4.

The standards in this ETSO apply to CCAs that are intended to provide PVT information for navigation management unit applications that output deviation commands keyed to a desired flight path, or non-navigation applications such as automatic dependent surveillance — broadcast (ADS-B) or terrain awareness and warning systems (TAWS). In navigation applications, pilots or autopilots will use the deviations output by the navigation management unit to guide the aircraft. In non-navigation applications, the PVT outputs will provide the necessary inputs for the end-use equipment.

3.1.2 — Environmental Testing and Test Procedures

3.1.2.1 — Environmental Testing

For the applicable environmental standards, see CS-ETSO, Subpart A, paragraph 2.1.

Nevertheless, not all types of environmental test are required for this ETSO standard, as the ETSO article for this ETSO standard is a CCA that will be later integrated into an ETSO equipment. Therefore, a minimal set of the environmental test conditions of EUROCAE ED-14/RTCA DO-160 has been defined (refer to Table 1) in order to verify the performance of the ETSOA article under this minimal set of conditions. The required performance under a particular environmental test is defined in the related test section in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

This minimal set is defined in Table 1 below. The chosen test category, associated with the selectable parameters in the test conditions per EUROCAE ED-14/RTCA DO-160, should be documented in the installation manual as limitations for the installation.

The test sections that are identified as optional are not required for an ETSO-2C204a application. Nevertheless, the ETSO CCA article can be subjected to these test conditions on the applicant's voluntary basis. If optional sections are not tested, they shall be marked with X in the environmental testing summary.

Table 1 — Environmental Qualification Testing minimum set for ETSO-2C204a

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C204a
Temperature	4.5	Mandatory If the performance of the module under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended installation context. For example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), the temperature of the environment of the CCA (inside an equipment) may be much higher or lower than the equipment level condition

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Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C204a
		expressed in the aforementioned Section 4.0. Therefore, the applicant may qualify their CCA functional sensor based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA is guaranteed.
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory As for Section 4.5, if the performance of the CCA under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended CCA installation context. As for Section 4.5, for example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), in which the temperature of the environment of the CCA (inside an equipment) may be much higher or lower than the equipment level condition as expressed in Section 4.0 of EUROCAE ED-14/RTCA DO-160, the applicant can qualify their CCA based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA functional sensor is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	Optional
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Optional Note: The CCA technology should be assessed for further vibration qualification (EUROCAE ED-14/RTCA DO-160). This preliminary assessment could consider the technology diversity of the components of the CCA, as well as the integration density and number of layers of the circuit card. The assessment could be confirmed by tests conducted on a circuit card that is representative of the CCA technology used in the article under certification. This preliminary assessment of the CCA technology under vibration conditions does not constitute credit for the qualification testing of the CCA when it is integrated into the end-user equipment.

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Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C204a
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Optional
Power Input	16.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system.
Voltage Spike	17.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Induced-Signal Susceptibility	19.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory for the conducted susceptibility of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type certification programme.
Emission of Radio Frequency Energy	21.0	Mandatory for the conducted emission of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C204a
		part of the end-user ETSO application or as part of a type-certification programme.
Lightning-Induced Transient Susceptibility	22.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Mandatory for all areas that are subject to human contact during the operation of the CCA.
Fire, Flammability	26.0	Mandatory

3.1.2.2 — Environmental Test Procedures for End User

The end user of this ETSO article will be required to complete the environmental qualification testing after integration of the ETSO-2C204a CCA. In order to allow the end user to properly test the functionality of the SBAS CCA functional sensor in environmental conditions, the applicant for the 'SBAS CCA functional sensor' shall provide the detailed functional test procedures to evaluate the required performance of the SBAS CCA functional sensor in compliance with RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a:

— major failure condition for a loss of function and malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data;

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— major failure condition for a loss of function of approach localiser performance without vertical guidance (LP), and approach localiser performance with vertical guidance (LPV) position data; and

— hazardous failure condition for a malfunction of approach (LP and LPV) position data that results in misleading information.

3.2.2 — Additional Specific

If the SBAS CCA functional sensor can only satisfy the requirements of RTCA DO-229E when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation.

This requirement shall be included in the installation manual as a limitation.

The applicant shall have all the data necessary to evaluate the geostationary (GEO) satellite bias as defined in RTCA DO-229E, Section 2.1.4.1.5, available for review by EASA.

If the SBAS CCA functional sensor uses barometric-aiding to enhance the availability of FDE, then the equipment shall meet the requirements in RTCA DO-229E, Appendix G.

The applicant shall provide to the end user the detailed functional test procedures of the SBAS CCA functional sensor for the end user to complete the environmental testing.

Limitations:

The following specific limitations shall be documented in the installation manual and in the DDP of the SBAS CCA functional sensor:

— 'The manufacturer of the end-use equipment, who installs the <insert equipment model> SBAS CCA functional sensor, is required to perform the testing described in ETSO-C145e<latest revision> Appendix 1 with the SBAS CCA functional sensor installed in the end-use equipment.'

— 'The manufacturer of end-use equipment is required to complete full environmental qualification at the end-use equipment level.'

4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

The SBAS CCA functional sensor must be permanently and legibly marked with the operational equipment class (e.g. Class 2), as defined in Section 1.4.2 of RTCA document DO-229E. The functional equipment class (e.g. Beta) defined in Section 1.4.1 of RTCA document DO-229E is not required to be marked.

It is sufficient to declare the proper functional equipment class in the declaration of design and performance (DDP).

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

ADDITION TO RTCA DO-229E

This Appendix describes the modifications and additions to RTCA DO-229E that are required for compliance with this ETSO.
This Appendix adds a new Section 1.8.3, on cybersecurity and GPS spoofing mitigation, to RTCA DO-229E, and corrects a long-standing mistake in the Section 2.4 environmental requirements tables. The new section provides information for cybersecurity and GPS spoofing mitigation to make RTCA DO-229E consistent with the new RTCA MOPS template and RTCA DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, dated July 2017.

1.8.3 Cybersecurity and GPS Spoofing Mitigation.

This section contains information to address intentional interference with the GPS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive the operation of a receiver when they are processed. Spoofing may be unintentional, such as effects from the signals of a GPS repeater, or may be intentional and even malicious. There are two classes of spoofing:

— Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of the time of arrival or the frequency of arrival, or their rates of change;

— Data spoofing introduces incorrect digital data to the target receiver for its use in the processing of signals and the calculation of positioning, navigation and timing (PNT).

Either class of spoofing can cause a range of effects: from incorrect outputs of PNT to receiver malfunctions. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or improperly installed GNSS re-radiators act like spoofers. Re-radiators, replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate the processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognise and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GPS equipment can be found in the U.S. Department of Homeland Security document 'Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure'[14] and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003, 28 July 2016.

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 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered to be vulnerable only to RF signals and OEM and/or aircraft operator controlled processes for maintenance and update. In some cases, aircraft

[14] https://ics-cert.us-ert.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_(GPS)_Equipment_Used_by_Critical_Infrastructure_S508C.pdf

GNSS receivers may be field-loadable by approved personnel, requiring physical access and a physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as means for aircraft or equipment manufacturers to update the software of installed avionics, 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 'authorised 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 of 'non-trusted' connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit the input of externally supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerabilities through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important for manufacturers to 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 the MOPS, it is recommended that manufacturers should consider 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, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering, although navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer outsources the development of software code, are 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 connection through which the installation can potentially introduce aircraft information security vulnerabilities. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerabilities could propagate to existing downstream systems. Therefore, manufacturers are recommended to reference their equipment aircraft information security review and mitigation strategies in the installation manual of the equipment so that the applicant can consider them in meeting the regulatory requirements of the installation.

Table 2-14 through Table 2-20

The tables incorrectly reference and label RTCA/DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding '2.1.1.7 Acquisition Time' and '2.1.1.9 Reacquisition Time'. Change the table references as follows:
The MOPS initial acquisition time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (DO-160E Sections 16.5.2 and 16.6.2) and the satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (DO-160E Sections 16.5.1 and 16.6.1).

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APPENDIX 2

Reserved.

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APPENDIX 3

This Appendix describes the EASA modifications to RTCA document DO-229E, Section 2.

In Section 2.1.1.2, after the first sentence, add the following:

‘The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II of IS-GPS-200D, “Navstar GPS Space Segment/Navigation User Interfaces”, December 2004, provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising the coarse/acquisition (C/A) code.’

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and that no CNAV data, which is defined in Appendix III of IS-GPS-200D, is used, for which the SBAS does not provide integrity.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: CIRCUIT CARD ASSEMBLY (CCA) FUNCTIONAL CLASS DELTA EQUIPMENT USING THE SATELLITE-BASED AUGMENTATION SYSTEM (SBAS) FOR NAVIGATION APPLICATIONS

1 — Applicability

This ETSO provides the requirements which circuit card assembly (CCA) functional Class Delta-4 equipment using the satellite-based augmentation system (SBAS) for navigation applications, that are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

ETSO-2C205a is intended as a means for manufacturers of end-use equipment to rationalise their ETSO-C146e application for a Class Delta-4 sensor by using an ETSO Delta-4 CCA for partial certification credit. ETSO-2C205a is only intended for navigation applications; it is not intended for non-navigation applications.

The standards in this ETSO apply to equipment that is intended to accept a desired flight path and provide deviation commands that are keyed to that path. Pilots and autopilots will use these deviations to guide the aircraft.

An ETSO-2C205a article has a limitation that requires the end-use equipment manufacturer to repeat selected detailed functional tests in the end-use equipment and complete the environmental qualification tests in RTCA DO-229E (see paragraphs 3.2.2.1 and 3.2.2 below).

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are those provided for functional Class Delta-4 equipment in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2, as modified by Appendices 1 and 3 of this ETSO standard. Class Delta-4 equipment is defined in DO-229E, Section 1.4.

3.1.2 — Environmental Testing and Test Procedures

3.1.2.1 — Environmental Testing

For the applicable environmental standards, see CS-ETSO, Subpart A, paragraph 2.1.

Nevertheless, not all types of environmental test are required for this ETSO standard, as the ETSO article for this ETSO standard is a CCA that will be later integrated into an ETSO equipment. Therefore, a minimal set of the environmental test conditions of EUROCAE ED-14/RTCA DO-160 has been defined (refer to Table 1) in order to verify the performance of the ETSOA article under this minimal set of conditions. The required performance under a particular environmental test is defined in the related test section in RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

This minimal set is defined in Table 1 below. The chosen test category, associated with the selectable parameters in the test conditions per EUROCAE ED-14/RTCA DO-160, should be documented in the installation manual as limitations for the installation.

The test sections that are identified as optional are not required for an ETSO-2C205a application. Nevertheless, the ETSO CCA article can be subjected to these test conditions on the applicant's voluntary basis. When optional sections are not tested, they shall be marked with X in the environmental testing summary.

Table 1 — Environmental Qualification Testing minimum set for ETSO-2C205a

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C205a
Temperature	4.5	Mandatory If the performance of the module under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended installation context. For example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), the temperature of the environment of the CCA (inside an equipment) may be much higher or lower than the equipment level condition expressed in the aforementioned Section 4.0. Therefore, the applicant may qualify their CCA functional sensor based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA is guaranteed.
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory As for Section 4.5, if the performance of the CCA under environmental conditions is dependent on the end-user

Environmental Test	**EUROCAE ED-14/RTCA DO-160 Section**	**Requirement for ETSO-2C205a**
		equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended CCA installation context. As for Section 4.5, for example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), in which the temperature of the environment of the CCA (inside an equipment) may be much higher or lower than the equipment level condition as expressed in Section 4.0 of EUROCAE ED-14/RTCA DO-160, the applicant can qualify their CCA based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA functional sensor is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	Optional
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Optional Note: The CCA technology should be assessed for further vibration qualification (EUROCAE ED-14/RTCA DO-160). This preliminary assessment could consider the technology diversity of the components of the CCA, as well as the integration density and number of layers of the circuit card. The assessment could be confirmed by tests conducted on a circuit card that is representative of the CCA technology used in the article under certification. This preliminary assessment of the CCA technology under vibration conditions does not constitute credit for the qualification testing of the CCA when it is integrated into the end-user equipment.
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Optional
Power Input	16.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system.
Voltage Spike	17.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the

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Environmental Test	**EUROCAE ED-14/RTCA DO-160 Section**	**Requirement for ETSO-2C205a**
		integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Induced-Signal Susceptibility	19.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory for the conducted susceptibility of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Emission of Radio Frequency Energy	21.0	Mandatory for the conducted emission of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning-Induced Transient Susceptibility	22.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Mandatory for all areas that are subject to human contact during the operation of the CCA.
Fire, Flammability	26.0	Mandatory

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3.1.2.2 — Environmental Test Procedures for End User

The end user of this ETSO article will be required to verify its performance after integration, and complete the environmental qualification testing after integration of the ETSO-2C205a CCA. In order to allow the end user to properly test the functionality of the CCA functional Class Delta equipment in environmental conditions, the applicant for the 'functional Class Delta ETSO article' shall provide the detailed functional test procedures to evaluate the required performance of the functional Class Delta equipment in compliance with RTCA document DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.4.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4

A failure of the function defined in paragraph 3.1.1 of this ETSO is a:

— major failure condition for a loss of function and malfunction of en route, terminal, approach lateral navigation (LNAV), and approach LNAV/vertical navigation (VNAV) position data;

— major failure condition for a loss of function of approach localiser performance without vertical guidance (LP), and approach localiser performance with vertical guidance (LPV) position data; and

— hazardous failure condition for a malfunction of approach (LP and LPV) position data that results in misleading information.

3.2.2 — Additional Specific

If the CCA functional Class Delta equipment can satisfy the requirements of RTCA DO-229E only when used with a particular antenna, the use of that antenna (by part number) shall be a requirement on the installation.
This requirement shall be included in the installation manual as a limitation.

The applicant shall have all the data necessary to evaluate the geostationary (GEO) satellite bias as defined in RTCA DO-229E, Section 2.1.4.1.5, available for review by EASA.

If the functional Class Delta equipment uses barometric-aiding to enhance the availability of FDE, then the equipment shall meet the requirements in RTCA DO-229E, Appendix G.

The applicant shall provide to the end user the detailed functional test procedures of the functional Class Delta equipment for the end user to complete the environmental testing.

Limitations:

The following specific limitations shall be documented in the IM and in the DDP of the CCA functional Class Delta equipment :

— 'The manufacturer of the end-use equipment, using the <insert equipment model> Class Delta CCA, is required to perform the testing described in ETSO-C146e<latest revision> Appendix 1 with the Class Delta CCA installed in the end-use equipment.'

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— ‘the manufacturer of end-use equipment is required to complete full environmental qualification at the end-use equipment level.’

4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

The functional Class Delta equipment must be permanently and legibly marked with the operational equipment class (e.g. Class 4) as defined in Section 1.4.2 of RTCA document DO-229E. A marking of Class 4 indicates compliance with the Delta-4 requirements. The functional equipment class (e.g. Delta) defined in Section 1.4.1 of RTCA document DO-229E is not required to be marked.
It is sufficient to declare the proper functional equipment class in the declaration of design and performance (DDP).

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

ADDITION TO RTCA DO-229E

This Appendix describes the modifications and additions to RTCA DO-229E that are required for compliance with this TSO.

This Appendix adds a new Section 1.8.3, on cybersecurity and GPS spoofing mitigation, to RTCA DO-229E, and corrects a long-standing mistake in the Section 2.4 environmental requirement tables. The new section provides information for cybersecurity and GPS spoofing mitigation to make RTCA DO-229E consistent with the new RTCA MOPS template and RTCA DO-253D, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, dated July 2017.

1.8.3 Cybersecurity and GPS Spoofing Mitigation.

This section contains information to address intentional interference with the GPS. Spoofing is caused by RF waveforms that mimic true signals in some ways, but deny, degrade, disrupt, or deceive the operation of a receiver when they are processed. Spoofing may be unintentional, such as effects from the signals of a GPS repeater, or may be intentional and even malicious. There are two classes of spoofing:

— Measurement spoofing introduces RF waveforms that cause the target receiver to produce incorrect measurements of the time of arrival or the frequency of arrival, or their rates of change;

— Data spoofing introduces incorrect digital data to the target receiver for its use in the processing of signals and the calculation of positioning, navigation and timing (PNT).

Either class of spoofing can cause a range of effects: from incorrect outputs of PNT to receiver malfunctions. The onset of effects can be instantaneous or delayed, and the effects can continue even after the spoofing has ended. Improperly used or improperly installed GNSS re-radiators act like spoofers. Re-radiators, replay and GNSS emulator devices can present misleading information to GNSS equipment and/or could cause lasting effects.

Equipment manufacturers should implement measures to mitigate the processing of erroneous data. Cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data checks can be implemented in the antenna, receiver, and/or through integration with other systems at the aircraft level. Data validity checks to recognise and reject measurement and data spoofing should be implemented in the receiver. Additional guidance and best practices related to GPS equipment can be found in the U.S. Department of Homeland Security document 'Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure'[15] and GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION: INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision H, IRN-IS-200H-003, 28 July 2016.

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 1970s and even longer for RF systems, and the advent of internet connectivity has substantially increased those risks. Typically, access to navigation receivers has been controlled such that they are considered to be vulnerable only to RF signals and OEM and/or aircraft operator controlled processes for maintenance and update. In some cases, aircraft GNSS receivers may be field-loadable by approved personnel, requiring physical access and a physical interface to the ground receivers. However, it is expected that not all aircraft in the future will rely on such physical isolation for the security of avionics. Internet and Wi-Fi connectivity have become popular as a means for aircraft or equipment

[15] https://ics-cert.us-cert.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_(GPS)_Equipment_Used_by_Critical_Infrastructure_S508C.pdf

manufacturers to update the software of installed avionics, 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 'authorised 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 of 'non-trusted' connectivity such as the internet, Wi-Fi, or manufacturer-supplied equipment interfaces which permit the input of externally supplied data into aircraft systems. A manufacturer may expose aircraft information vulnerabilities through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important for manufacturers to 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 the MOPS, manufacturers are recommended to consider 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, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering, although navigation avionics are typically located in an avionics bay inaccessible to passengers. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer outsources the development of software code, are 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 connection through which the installation can potentially introduce aircraft information security vulnerabilities. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerabilities could propagate to existing downstream systems. Therefore, manufacturers are recommended to reference their equipment aircraft information security review and mitigation strategies in the installation manual of the equipment so that the applicant can consider them in meeting the regulatory requirements of the installation.

Table 2-14 through Table 2-20

The tables incorrectly reference and label RTCA DO-160 Sections 16.5.1.2 and 16.6.1.2 regarding '2.1.1.7 Acquisition Time' and '2.1.1.9 Reacquisition Time'. Change the table references as follows:
The MOPS Initial Acquisition Time requirement (2.1.1.7) applies to both AC and DC equipment under abnormal operating conditions (DO-160E Sections 16.5.2 and 16.6.2), and the satellite reacquisition time requirement (2.1.1.9) applies to both AC and DC equipment under normal operating conditions (DO-160E Sections 16.5.1 and 16.6.1).

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APPENDIX 2

Reserved.

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APPENDIX 3

This Appendix describes the EASA modifications to RTCA document DO-229E, Section 2.

In Section 2.1.1.2, after the first sentence, add the following:

‘The demodulation of data from the GPS signals shall be restricted to the necessary subset of the data defined in Appendix II of IS-GPS-200D, “Navstar GPS Space Segment/Navigation User Interfaces”, December 2004, provided on RF link L1. The pseudo-ranging shall be performed on RF link L1 utilising the coarse/acquisition (C/A) code.’

This is to ensure that only the L1 NAV data, for which the SBAS provides corrections and integrity, is used, and that no CNAV data, which is defined in Appendix III of IS-GPS-200D, is used, for which the SBAS does not provide integrity.

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Date: XX.XX.20XX

European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: CIRCUIT CARD ASSEMBLY (CCA) FUNCTIONAL SENSORS USING AIRCRAFT-BASED AUGMENTATION FOR NAVIGATION AND NON-NAVIGATION POSITION/VELOCITY/TIME (PVT) OUTPUT

1 — Applicability

This ETSO provides the requirements which circuit card assembly (CCA) functional sensors using aircraft-based augmentation for navigation and non-navigation position/velocity/time (PVT) output, that are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

ETSO-2C206 is intended as a means for manufacturers of end-use equipment that incorporates a GPS CCA to rationalise their ETSO-C196b application for a GPS PVT sensor by using an ETSO-authorised GNSS CCA for partial certification credit.

An ETSO-2C206 article has a limitation that requires the end-use equipment manufacturer to repeat selected detailed functional tests in the end-use equipment and complete the environmental qualification tests in RTCA DO-316 (see paragraphs 3.1.2.2 and 3.2.2 below).

This ETSO standard applies to equipment that is intended to provide PVT information for a navigation management unit application that outputs deviation commands keyed to a desired flight path, or a non-navigation application (such as automatic dependent surveillance — broadcast (ADS-B)). In navigation applications, pilots or autopilots will use the deviations output by the navigation management unit to guide the aircraft. In non-navigation applications, the PVT outputs will provide the necessary capability for the end-use equipment.

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are those provided for functional sensors in RTCA document DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft-Based Augmentation System Airborne Equipment, dated 14 April 2009, Section 2.

3.1.2 — Environmental Testing and Test Procedures

3.1.2.1 — Environmental Testing

For the applicable environmental standards, see CS-ETSO, Subpart A, paragraph 2.1, for the applicable environmental standard.

Nevertheless, not all types of environmental test are required for this ETSO standard, as the ETSO article for this ETSO standard is a CCA that will be later integrated into an ETSO equipment. Therefore, a minimal set of the environmental test conditions of EUROCAE ED-14/RTCA DO-160 has been defined (refer to Table 1) in order to verify the performance of the ETSOA article under this minimal set of conditions. The required performance under a particular environmental test is defined in the related test section in RTCA document DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, dated 14 April 2009, Section 2.2.

This minimal set is defined in Table 1 below. The chosen test category, associated wih the selectable parameters in the test conditions per EUROCAE ED-14/RTCA DO-160 should be documented in the installation manual as limitations for the installation.

The test sections that are identified as optional are not required for an ETSO-2C206 application. Nevertheless, the ETSO CCA article can be subjected to these test conditions on the applicant's voluntary basis. When optional sections are not tested, they shall be marked with X in the environmental testing summary.

Table 1 — Environmental Qualification Testing minimum set for ETSO-2C206

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C206
Temperature	4.5	Mandatory If the performance of the module under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended installation context. For example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), the temperature of the environment of the CCA (inside an equipment) may be much higher or lower than the equipment level condition expressed in the aforementioned Section 4.0. Therefore, the applicant may qualify their CCA functional sensor based on

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Environmental Test	**EUROCAE ED-14/RTCA DO-160 Section**	**Requirement for ETSO-2C206**
		a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA is guaranteed.
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory As for Section 4.5, if the performance of the CCA under environmental conditions is dependent on the end-user equipment, it is the responsibility of the applicant to adapt the EUROCAE ED-14/RTCA DO-160 high and low temperature values and temperature variation cycles to the intended CCA installation context. As for Section 4.5, for example, in the case of temperature testing (Section 4.0 of EUROCAE ED-14/RTCA DO-160), where the temperature of the environment of the CCA (inside an equipment) may be much higher or lower than the equipment level condition as expressed in Section 4.0 of EUROCAE ED-14/RTCA DO-160, the applicant can qualify their CCA based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the correct operation of the CCA functional sensor is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	Optional
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Optional Note: The CCA technology should be assessed for further vibration qualification (ED-14/DO-160). This preliminary assessment could consider the technology diversity of the components of the CCA, as well as the integration density and number of layers of the circuit card. The assessment could be confirmed by tests conducted on a circuit card that is representative of the CCA technology used in the article under certification. This preliminary assessment of the CCA technology under vibration conditions does not constitute credit for the qualification testing of the CCA when it is integrated into the end-user equipment.
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C206
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Optional
Power Input	16.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system.
Voltage Spike	17.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Audio Frequency Conducted Susceptibility — Power Input	18.0	Mandatory for CCA interfaces that are directly connected to the aircraft power distribution system. Note: CCA interfaces that are not directly connected to the aircraft power distribution system will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Induced-Signal Susceptibility	19.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Radio Frequency Susceptibility (radiated and conducted)	20.0	Mandatory for the conducted susceptibility of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Emission of Radio Frequency Energy	21.0	Mandatory for the conducted emission of CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as part of the end-user ETSO application or as part of a type-certification programme.
Lightning-Induced Transient Susceptibility	22.0	Mandatory for CCA interfaces that are directly connected to the aircraft wiring. Note: CCA interfaces that are not directly connected to the aircraft wiring will be tested after the integration phase as

Environmental Test	EUROCAE ED-14/RTCA DO-160 Section	Requirement for ETSO-2C206
		part of the end-user ETSO application or as part of a type-certification programme.
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electrostatic Discharge (ESD)	25.0	Mandatory for all areas that are subject to human contact during the operation of the CCA.
Fire, Flammability	26.0	Mandatory

3.1.2.2 — Environmental Test Procedures for End User

The end user of this ETSO article will be required to complete the environmental qualification testing after integration of the ETSO-2C206 CCA. In order to allow the end user to properly test the functionality of the CCA functional sensor in environmental conditions, the applicant for a 'CCA functional sensor' shall provide the detailed functional test procedures to evaluate the required performance of the CCA functional sensor in compliance with RTCA document DO-316, Minimum Operational Performance Standards for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment, dated 15 December 2016, Section 2.2.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the function defined in paragraph 3.1.1 of this ETSO is a:

— major failure condition for a malfunction of oceanic/remote, en route, terminal navigation and lateral navigation (LNAV) approaches;

— minor failure condition for a loss of navigation in oceanic/remote, en route, terminal navigation and lateral navigation (LNAV) approaches.

3.2.2 — Additional Specific

Barometric-aiding fault detection and exclusion (FDE)

If the CCA functional sensor uses barometric-aiding to enhance the availability of FDE, then the equipment shall meet the requirements in RTCA DO-316, Appendix G.

The applicant shall provide to the end user the detailed functional test procedures of the CCA functional sensor for the end user to complete the environmental testing.

Limitations:

The following specific limitations shall be documented in the installation manual and in the DDP of

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the CCA functional sensor:

— ‘The manufacturer of the end-use equipment, using the <insert equipment model> CCA functional sensor, is required to perform the testing described in ETSO-C196<latest revision> Appendix 1 with the CCA functional sensor installed in the end-use equipment.’

— ‘The manufacturer of end-use equipment is required to complete full environmental qualification at the end-use equipment level.’

4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AIRCRAFT HALOCARBON CLEAN AGENT ~~HAND-HELD~~HANDHELD FIRE EXTINGUISHER

1 — Applicability

This ETSO provides the requirements which an aircraft halocarbon clean agent ~~hand-held~~handheld fire extinguisher that is designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The ~~A~~applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable ~~S~~standards are those ~~set forth~~provided in ~~the Society of Automotive Engineers (~~SAE~~)~~ International's Aerospace Standard AS6271, ~~'~~Halocarbon Clean Agent Hand-Held Fire Extinguisher~~'~~, issued in January 2013, as modified by ~~Appendix~~ Appendices 1 and 2 ~~to~~ of this ETSO.

3.1.2 — Environmental Standard

Refer to the environmental qualification requirements specified in ANSI/UL 2129.

3.1.3 — ~~Computer~~ Software

None.

3.1.4 — Airborne Electronic Hardware ~~Qualification~~

None.

3.2 — Specific

3.2.1 — Failure Condition Classification

A ~~F~~failure of the function defined in paragraph 3.1.1 of this ETSO has been determined to be a minor failure condition.

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4 — Marking

4.1 — General

~~Marking as detailed in~~ See CS-ETSO, Subpart A, paragraph 1.2.4.2.

4.2 — Specific

The fire extinguisher type, as specified in paragraph 3.1 of AS6271, shall be marked on the article.

In addition, the fire extinguisher rating, as specified in ANSI/UL 711, shall be marked on the article.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

HALOCARBON CLEAN AGENT ~~HAND-HELD~~HANDHELD FIRE EXTINGUISHER

This Appendix prescribes the minimum performance standards (MPSs) for aircraft handheld fire extinguishers. The applicable standard is SAE AS6271 'Halocarbon Clean Agent Hand-Held Fire Extinguisher', issued in January 2013. EASA ~~did~~ has revised it as follows:

1 . On page 4, replace paragraph 3.2 with the following:

'Halocarbon clean agents shall be registered according to REACH[16] for use in a fire extinguisher to be sold in the European Union (EU). REACH is the EU Regulation on chemicals and their safe use. REACH applies to substances manufactured or imported into the EU in quantities of 1 ton or more per year (see 2.1.7).'

2 . On page 5, replace paragraph 4.1.1 with the following:

'The fire extinguisher/mounting bracket assembly shall be shown to withstand without any failures the highest ultimate inertia force/load, applied to all on-axis (X, Y, Z) orientations, specified in the Certification Specifications (CS) applicable to the specific aircraft type or types on which the fire extinguisher is suitable to be installed. The ultimate inertia forces/loads shall be increased, if necessary, to meet the aircraft manufacturer's specifications for flight and ground loads accordingly. A fitting factor of 1.33 as specified in C2X.561 shall be included to address wear and tear through frequent removal of the fire extinguisher from its mounting bracket. In addition, the manufacturer shall provide an Interface Control Drawing (ICD) specifying for the fire extinguisher/mounting bracket assembly:

— the ultimate inertia force/loads shown during qualification,

— the mounting orientations (X, Y, Z) for installation,

— the interface loads and the specified means of attachment for installation,

— the Certification Specification(s) (e.g. CS 25.561) including the amendment for which the assembly is demonstrated to be compliant.'

3. On ~~P~~page 5, add a note to paragraph 5.2.2:

'Note: If the proposed agent was already proven to pass the seat/toxicity test of the MPS in combination with another fire extinguisher, that test would not need to be repeated for the proposed fire extinguisher/agent combination.'

[16] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

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APPENDIX 2

HALOCARBON CLEAN AGENT ~~HAND-HELD~~HANDHELD FIRE EXTINGUISHER

This Appendix prescribes the minimum performance standards (MPSs) for aircraft handheld fire extinguishers. As referred to in SAE AS6271, the applicable standard is ANSI/UL 2129 'Halocarbon Clean Agent Hand-Held Fire Extinguisher', issued in February 2005. EASA ~~did~~ has revised it as follows:

1 . On ~~P~~page 9, replace paragraph 6.8 with the following:

'An extinguisher shall operate as intended at temperatures from - 40 ~~°C~~ to 49 °C as required per UL 2129. Ground survival temperature of the unit shall be – 54 ~~°C~~ up to 85 °C (refer to EUROCAE ED-14/RTCA DO-160 ~~release~~ revisions defined in CS-ETSO, Subpart A, paragraph 2.1, ground survival temperature).'

2 . On ~~P~~page 12, replace the first phrase of paragraph 12.4 with the following:

'The maximum indicated gauge pressure shall be between 150 and 250 %~~per cent~~ of the indicated charging pressure specified by the manufacturer (at either 20 ~~°C~~ or ~~at~~ 21 °C).'

3 . On ~~P~~page 12, replace paragraph 12.5 with the following:

'The mark used to indicate the charging pressure at the charging temperature (at either 20 ~~°C~~ or ~~at~~ 21 °C) as specified by the manufacturer shall be a minimum of 0.6-mm wide and not more than 1.0-mm wide.'

4 . On ~~P~~page 12, disregard paragraphs 12.6 and 12.7.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AIRBORNE SYSTEMS FOR VIDEO/AUDIO SURVEILLANCE OF CABIN AND CARGO AREAS

1 — Applicability

This ETSO provides the requirements which airborne systems to be installed on aircraft for the surveillance of cabin and cargo areas using video (and audio) detector means that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are provided in Appendix 1.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

Equipment that is part of a video surveillance system (VSS) shall be tested in accordance with Appendix 1, Chapter 4, of this ETSO.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

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4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

AIRBORNE SYSTEMS FOR VIDEO/AUDIO SURVEILLANCE OF CABIN AND CARGO AREAS

1. GENERAL

PURPOSE AND SCOPE

This minimum operational performance specification defines the minimum performance that is expected from an airborne system to be installed on aircraft for the surveillance of cabin and cargo areas of an aircraft. The performance of specific equipment may be enhanced or superior to this specification, depending on the intended application and configuration.

Chapter 1 describes typical equipment applications and operational objectives, and is the basis for the performance criteria specified in Chapter 2 and Chapter 3. The definitions that are essential to a proper understanding of this document are also provided in Chapter 1.

Chapter 2 contains general design requirements.

Chapter 3 contains the minimum performance specification for the equipment, defining the performance under standard operating conditions.

Chapter 4 prescribes the environmental test conditions which provide a laboratory means of determining the performance characteristics of the equipment under conditions that are representative of those which may be encountered in actual operations.

Chapter 5 specifies the performance of the equipment, and gives guidance for the installation.

APPLICATION

Compliance with this minimum operational performance specification by manufacturers, installers and users is strongly recommended as a means of ensuring that the equipment will satisfactorily and safely perform its intended functions under the conditions that are normally encountered in routine aircraft operations.

This specification does not cover non-aeronautical aspects. It is the responsibility of the manufacturer as well as the operator to obtain the necessary approvals from the responsible authorities and bodies, if applicable.

DESCRIPTION OF SYSTEM

The video surveillance system (VSS) consists of electronic on-board equipment and is, by itself, not required for any phase of flight by any aviation rule, although it is used for required functions. It is normally not connected to, nor does it interact with, any aircraft system, except the intercom, electrical power and mechanical mounting. However, in special cases, it may be useful to establish additional interfaces with other systems. Examples are communication management systems for the transmission of data such as video, audio data, etc. It might be useful to use further detectors for further data, e.g. temperature detectors, etc.

The main functions of the system might be:

— cabin video (and audio) monitoring,
— cockpit door video (and audio) surveillance,
— cargo video (and audio) surveillance,
— 'direct view' applications as per CS 25.785.

The VSS may allow cabin/cockpit crew and security staff on board the aircraft to assess the criticality of exceptional cabin events by monitoring the affected cabin and cargo areas of the aircraft. Video and audio data from the cameras and microphones should be recordable for archiving and later analysis by the e.g. airline operations centre. In addition, the data streams might be made available at an existing ground service panel, and could be used by armed forces to observe the situation in the cabin from outside the aircraft. Further, the surveillance of the cargo area might be useful, for instance concerning luggage or cargo theft, aircraft damage control, etc.

SYSTEM ARCHITECTURE AND COMPONENTS

This paragraph describes the architecture of the system and its components. The following block diagram shows an example of the basic system architecture:

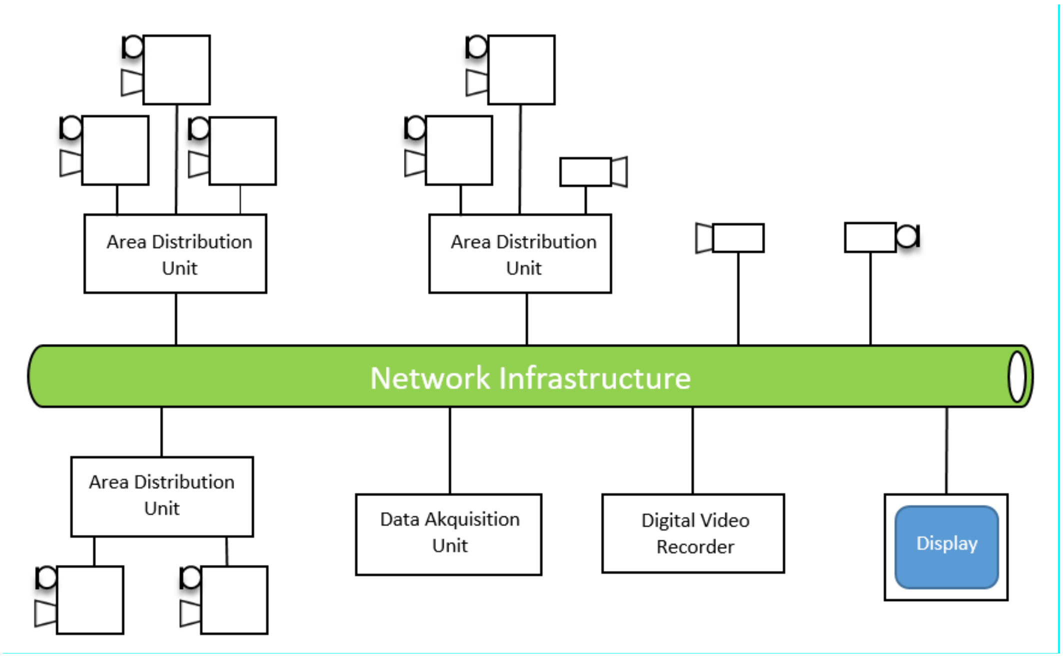

Figure 1 — VSS Basic System Architecture

The elements should be considered as parts of an overall concept, which provides for easy modular adaptions. All the elements can be connected by network infrastructure. However, not all the elements are required, and further items could be added, depending on the use cases.

A VSS may consist of:

— cabin cameras (CAMs),
— cargo cameras (CCAMs),
— flight deck cameras (FDCAMs),
— area distribution units (ADUs),
— data acquisition units (DAUs),
— attendant control panels (ACPs),
— digital video recorders (DVRs),
— detectors (optional, e.g. separate microphones).

Cameras shall have an infrared (IR) means of illumination to provide their function under conditions of poor illumination, if needed. The cameras might have variants with different lenses and mounting directions to adapt to the mounting position and the situation of their integration. The cargo and flight deck cameras shall have a dedicated panel/housing for cargo or flight deck area use.

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For the end-to-end functional chain, considering the mounting position and the distance to the observed object, all the system performance parameters such as the resolution of the image, colour space, frame rate and the optical system, etc., shall be sufficient to:

a) uniquely identify the identity of a person;
b) determine their visible state of health and well-being;
c) determine their position.

The system shall be compliant with the cabin attendant direct view requirements of CS 25.785, if this use case is foreseen.

The data acquisition unit (DAU) shall host the configuration data of the system and shall be responsible for managing the configuration of the system. It shall establish the communication interfaces between the elements of the system, and those between the VSS and the aircraft systems, if applicable. Smaller system configurations may operate without a DAU if the functions of a DAU are implemented by other elements of the VSS.

The ADUs shall collect data streams and shall provide power supplies for the cameras. The ADUs shall be able to be connected to each other in a daisy-chain configuration.

A ground service panel might be connected to the system to provide a data link.

The DVR shall be capable of recording all data streams (video, audio, further data) from all connected cameras (respectively from other detectors) to exchangeable data storage media, e.g. solid-state drives (SSDs).
Aircraft data for control of the system and e.g. watermarking of the video streams might be obtained via an integrated interface (e.g. ARINC 429) and shall be distributed system-wide by e.g. the DVR or the DAU.

The ACPs shall allow the system to be operated via the HMI on a touchscreen. The ACPs shall be able to display live video streams from the cameras and shall provide playback of recorded streams from the DVR.

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2. GENERAL DESIGN REQUIREMENTS

AIRWORTHINESS

The equipment shall not, under either normal or failure conditions, impair the airworthiness of the aircraft in which it is installed.

OPERATION OF CONTROLS

None of the possible positions, combinations and sequences of the controls that are intended for use during flight shall result in a condition whose presence or continuation would be detrimental to the continued safe operation of the aircraft.

Operating the system shall not significantly affect the workload of the aircrew.

DESIGN CONSIDERATIONS

The controls and indicators intended for use by the flight crew shall be of a design that is suitable for the intended cockpit environment/philosophy (e.g. size, readability, illumination).

If VSS equipment is integrated within a required aircraft system, the VSS equipment shall not adversely affect the safety of the aircraft or its occupants, or the proper functioning of required equipment or systems under all foreseeable conditions.

EFFECTS OF TESTS

Unless otherwise provided, the design of the equipment shall be such that, subsequent to the application of the specific tests, no condition exists which would be detrimental to the continued safe operation of the aircraft.

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AIRCRAFT EQUIPMENT INFORMATION VULNERABILITIES

If the equipment interfaces with aircraft busses and has connectivity to non-governmental services (e.g. Wi-Fi, the internet, etc.), the manufacturer may expose aircraft information vulnerabilities (such as cybersecurity risks) through the design of the equipment, or the equipment may become vulnerable as a result of being connected to a common interface. Therefore, it is important for manufacturers to consider aircraft information security risk mitigation strategies in the design of their equipment, particularly when the equipment is responsible for an interface between the aircraft and aircraft-external systems.

It is recommended that manufacturers consider 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, for equipment such as in an in-flight entertainment system in the cabin, a manufacturer could consider connectors that require special tools to remove them to prevent passenger tampering. And finally, but just as important, manufacturers should consider supply chain risk management; for example, if a manufacturer outsources the development of software code, are 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 connection through which the installation can potentially introduce aircraft information security vulnerabilities. This requires the applicant to address not only the information security vulnerabilities and mitigation techniques for the new installation, but to also consider how vulnerabilities could propagate to existing downstream systems. Therefore, it is recommended that manufacturers reference their equipment aircraft information security review and mitigation strategies in the installation manual of the equipment so that the applicant can consider them in meeting the regulatory requirements of the installation.

If stored data streams of the VSS (video, audio, etc.) are to be used for judicial purposes, these stored data streams must be legally admissible. This means that the data must be marked by the VSS as authentic (e.g. by watermarking) and must be permanently protected against manipulation.

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3. MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD CONDITIONS

GENERAL

The VSS must meet the basic requirement that it must not interfere with other on-board systems.
It must be ensured that the equipment can neither become a source of danger in itself, nor threaten the proper functioning of any essential system or service.

SYSTEM PARAMETERS

If appropriate, the manufacturer shall define details to show compliance with the 'GENERAL' subpart of this document.

A set of technical parameters showing that the system performs its intended functions shall be declared by the manufacturer. This set of data should include the quality, availability and reliability of the information channel and all the requirements for such equipment. However, provided that it is agreed by EASA, a demonstration of compliance is only necessary for a very basic requirement such as 'a live video stream should be displayed'. However, the extent of the demonstration of compliance depends on the use case of the VSS.

If the system interfaces with other on-board equipment, compliance with the interface-related requirements for that equipment has to be shown in order to exclude adverse effects on connected systems and the aircraft itself.

A means shall be provided to disconnect the equipment from the power bus or from other systems (if applicable) (i.e. a master switch) for the case of unexpected interference, fire, smoke or other hazards.

Note: Compliance with this requirement can be achieved by the design of the equipment itself, or by measures described in the installation manual.

CLASSES OF EQUIPMENT

Not applicable.

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4. MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS

INTRODUCTION

The environmental tests and performance requirements described in this chapter provide a laboratory means of determining the performance characteristics of the equipment under conditions that are representative of those which may be encountered in actual operations.
The VSS needs to comply with environmental tests so far as it is necessary to ensure that the equipment cannot become a source of danger under environmental conditions.

Some of the tests contained in this chapter are identified with the phrase 'if required'. They do not have to be performed unless the manufacturer wishes to qualify the equipment for these additional environmental conditions, or if they are requested by EASA.
Unless otherwise specified, the test procedures that are applicable to a determination of the performance of the equipment under environmental test conditions are specified below.

EQUIPMENT PERFORMANCE COMPLIANCE

The performance requirements as defined in Chapter 3 are not required to be tested under all of the conditions specified in CS-ETSO, Subpart A, paragraph 2.1.
If the equipment is exposed to a high temperature and/or pressure as well as a power input and a voltage spike test, it shall be ensured that there is no risk of fire, smoke or similar hazards being induced by the equipment.

During all the shock and vibration tests, the equipment shall remain in its mounting, and no part of the equipment or its mounting shall become detached and free of the shock test table.

Direct lightning tests of any equipment that is to be mounted outside the aircraft are only intended to ensure that a lightning strike is blocked by the outside of the equipment itself, and that the lightning cannot affect other installations, or the aircraft itself.

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PERFORMANCE TESTS

The following environmental requirements shall apply:

EUROCAE ED-14/ RTCA-DO160 Test	**Section**	**CAT**	**applicable**
Temperature and Altitude	4.0	A1 / Z	+
Temperature Variation	5.0	B	–
Humidity	6.0	C	–
Operational Shocks and Crash Safety	7.0	B	+
Vibration	8.0	S	+
Explosion Proofness	9.0	–	–
Waterproofness	10.0	Y	–
Fluids Susceptibility	11.0	F	–
Sand and Dust	12.0	D	–
Fungus Resistance	13.0	F	–
Salt Spray	14.0	–	–
Magnetic Effect	15.0	A	+
Power Input	16.0	*	+
Voltage Spike	17.0	A	+
Audio Frequency Conducted Susceptibility	18.0	–	–
Induced Signal Susceptibility	19.0	–	–
Radio Frequency Susceptibility	20.0	–	–
Emission of Radio Frequency Energy	21.0	M	+
Lightning-Induced Transient Susceptibility	22.0	AZXXLX	–
Lightning Direct Effects	23.0	–	–
Icing	24.0	–	–
Electrostatic Discharge	25.0	no test CAT	+
Fire, Flammability	26.0	*	+

***+** mandatory test*
***–** if required*
** not here definable due to unknown equipment design and installation location in aircraft*

The tests marked with 'if required' may become mandatory for specific technical reasons. The aforementioned test CAT shall be treated as the minimum performance. This shall be agreed with EASA.

Note: The table above is based on ED-14G/RTCA DO-160G. If the test conditions or test levels are re-evaluated, CS-ETSO requires compliance with ED-14G/RTCA DO-160G or later revisions as endorsed by CS-ETSO paragraph 2.1.

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5. INSTALLED EQUIPMENT PERFORMANCE

The material contained in the following paragraphs is intended as guidance material only, and it does not have any direct significance in the type certification of the equipment concerned. The aircraft installation must comply with the applicable airworthiness requirements, and it needs to be agreed by EASA.

EQUIPMENT INSTALLATION

Special care should be taken in selecting the locations in which VSS articles are installed in relation to other aircraft systems. A non-interference demonstration is required. Aircraft lightning zones and the necessary system lightning protection have to be determined. The interface with the on-board intercom or other systems shall be installed in such a manner that a malfunction of the communication system does not cause conditions which prevent the safe continuation of the flight. The equipment shall be installed in accordance with the manufacturer's installation instructions.

If the VSS equipment contains a memory retention device which employs a rechargeable lithium battery, the flammability risk must be addressed. Manufacturers of installed VSS equipment that employs a rechargeable lithium battery must ensure that the lithium battery meets the airworthiness standards that are appropriate for the size and the intended function of the battery.

OPERATING RESTRICTIONS

All the operating restrictions which are defined, e.g. by any rule of an authority, should be enforced by technical provisions and procedures that are stated in the installation manual , as well as in the operation manual.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: AUTOMATIC DEPLOYABLE FLIGHT RECORDER (ADFR) SYSTEMS

1 — Applicability

This ETSO provides the requirements which automatic deployable flight recorder (AFDR) systems that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are those provided in EUROCAE document ED-112A, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, Section 3, as modified per Appendix 1 of this ETSO.

The ADFR system shall also be approved in accordance with the latest revision of the ETSO that is applicable to the supported function:

ETSO-C123()	Cockpit Voice Recorder Systems
ETSO-C124()	Flight Data Recorder Systems
ETSO-C176()	Aircraft Cockpit Image Recorder Systems
ETSO-C177()	Data Link Recorder Equipment

The emergency locator transmitter fitted to the ADFR shall be approved in accordance with ETSO-C126c, Type ELT(AD) Class 0 or 1, with capabilities C (Crash resistance), H1 (121.5MHz homing) and be of any generation (capability T.001 or T.018).

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1, and EUROCAE ED-112A.

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3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

A failure of the ADFR to deploy when required is classified as a minor failure condition.

An unintended deployment of the ADFR is classified as a major failure condition.

Note: The classification of the unintended deployment of the ADFR is driven by the risk to the people on the ground. The unintended deployment of the ADFR may also damage the aircraft. Assessing this impact when installing the article on an aircraft may result in a more stringent classification.

4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

4.2.1 — Lettering identification

The equipment shall comply with the identification requirement in EUROCAE ED-112A, Section 3-1, paragraph 3-1.8.3 as modified by Appendix 1 of this ETSO.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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APPENDIX 1

Mps For Automatic Deployable Flight Recorder (Adfr) Systems

The applicable standard is EUROCAE ED-112a, MOPS for Crash Protected Airborne Recorder Systems, dated September 2013, and shall be modified as per Table 1 below.

Table 1 — Modification of EUROCAE ED-112A for ADFR systems

Location	Initial ED-112A text	Amending text
3-1.1	This section details the additional requirements and exceptions that are specific to deployable recorders. The requirements specified in this section shall be met in addition to the requirements of Sections 1 and 2, together with Sections 4 and 5 as applicable, and the appropriate recorder specific parts. A deployable recorder is a recording medium housed in a crash-protected memory module that is automatically deployed (released) from the aircraft at the start of an accident sequence. Its characteristics have the objective of enabling it to land at low speeds clear of the main aircraft wreckage, or, in the event of an over-water accident, its flotation characteristics enable it to float on water. Since the recorder is no longer with the aircraft it should be equipped with a means to locate it. This type of recorder is attached to the exterior of the airframe, and under normal conditions, functions in the same manner as a fixed recorder. The Recorder Memory Unit, Beacon Transmitters, Antennas, Battery Pack and the survival packaging for these units are all an integral part of the Automatic Deployable Package. The deployable Package incorporates flight characteristics that enable it to deploy and rapidly establish a flight trajectory that clears the airframe.	This section details the additional requirements and exceptions that are specific to deployable recorders. The requirements specified in this section shall be met in addition to the requirements of Sections 1 and 2, together with the requirements of Sections 4 and 5 as applicable, and the appropriate recorder-specific parts. A deployable recorder is a recording medium housed in a crash-protected memory module that is automatically deployed (released) from the aircraft at the start of an accident sequence. Its characteristics have the objective of enabling it to land at low speeds clear of the main aircraft wreckage or, in the event of an over-water accident, its flotation characteristics enable it to float on water. An ELT is embedded in the deployable recorder to permit the location of the point of the end of flight, and to locate the recorder. This type of recorder is attached to the exterior of the airframe, and under normal conditions, it functions in the same manner as a fixed recorder. The recorder memory unit, beacon transmitters, antennas, battery pack and the survival packaging for these units are all integral parts of the automatic deployable package. The deployable package incorporates flight characteristics that enable it to deploy and rapidly establish a flight trajectory that clears the airframe.
3-1.2		Ignore 3-1.2
3-1.3	This section defines the minimum specification to be met for Deployable Recorder Systems. It is applicable to any crash-protected recorder that is designed to be deployed, its ancillary equipment and its installation in civil aircraft.	This section defines the minimum specification to be met for automatic deployable flight recorder systems. It is applicable to any crash-protected recorder that is designed to be deployed, and to its ancillary equipment.
3-1.4	3-1.4 APPLICATION	Replace by the following paragraph:

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Location	**Initial ED-112A text**	**Amending text**
	Compliance with this section will ensure that deployable systems will perform their function under the conditions encountered in aircraft operations.	3-1.4 DEFINITIONS The following definitions are provided for the terms that are used in Section 3. ADFR — Automatic deployable flight recorder ADFR system — The system composed of: — the automatic deployable package; and — the system components installed in the aircraft and that support the deployment (deployment mechanism, sensors except those that detect the deformation of the aircraft, etc.) and the recording. Automatic deployable package — The part of the system that is deployed, including the crash-protected memory module, the ELT, its antenna and battery, contained in a floatable aerofoil. Immersion depth — The maximum depth of immersion in salt water at which the automatic deployable package has been tested.
3-1.5.1	In addition to the safety requirements specified in paragraph 2-1.3.1, the following requirements shall apply to all deployable recorders: a. The exterior of the equipment shall have no sharp edges or projections that could damage inflatable survivable equipment or injure persons. b. The overall quantitative probability (per flight hour) of the failure event 'non-commanded deployment' shall be < 10^{-7}. This probability objective addresses such hardware and software components, which contribute directly to the deployment event.	In addition to the safety requirements specified in Section 2-1.3.1, the exterior of the automatic deployable package shall have no sharp edges or projections that could damage inflatable survivable equipment or injure persons.
3-1.5.2	In addition to the certification documents specified in paragraph 2-1.3.4, the following shall be provided. a. Instructions shall be provided for safely removing deployable recorders from the aircraft for maintenance purposes.	In addition to the certification documents specified in Section 2-1.3.4, the following shall be provided: a. The transmission frequency and modulation characteristics of the radio location beacon. b. Installation instructions that contain: 1. the tested impact speed;

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Location	Initial ED-112A text	Amending text
	b. The transmission frequency and modulation characteristics of the radio location beacon.	2. the deployment time as defined in 3-1.7.f; 3. the immersion depth at which the hydrostatic sensor triggers the deployment; 4. the immersion depth that the automatic deployable package can withstand before deployment as tested in 3-3.2.8; 5. the maximum ice thickness that can be permitted before de-icing action is necessary, as determined during the icing test in Table 2 of this Appendix; 6. the recommended recorder orientation on the fuselage to ensure the performance of the deployment when installed; 7. instructions shall be provided for safely removing deployable recorders from the aircraft for maintenance purposes; 8. the kinetic energy of the automatic deployable package once deployed from a fixed position; 9. installation constraints. Because of the reduced levels of qualification of the memory unit and of the ELT, the ADFR system installation manual shall state that the installer must verify that: a. the automatic deployable package is installed at the aft of the aircraft, so that it may not be crushed or penetrated by aircraft parts when deployed; b. the impact speed of the automatic deployable package is less than the one used for the impact shock test (Section 3-3.2.1); c. the automatic deployable package lands away from the crash site locations where fire may exceed the characteristics used during the high and low temperature fire tests (Sections 3-3.2.4 and 3-3.2.5); d. the automatic deployable package does not collide with the aircraft.
3-1.6	Refer to ED-112A	Unchanged
3-1.6.1	A visual method to alert the cockpit crew when the deployable recorder is no longer captive to the aircraft shall be provided. The cockpit crew shall have an unobstructed view of the visual indicator when in the normal seated position. The brilliance of any indicator may be adjustable to levels suitable for data	The ADFR system shall provide a means to inform the flight crew that the recorder is no longer captive to the aircraft.

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Location	**Initial ED-112A text**	**Amending text**
	interpretation under all cockpit ambient light conditions ranging from total darkness to reflected sunlight.	
3-1.7.a	Refer to ED-112A	Unchanged
3-1.7.b	Refer to ED-112A	Unchanged
3-1.7.c	Refer to ED-112A	Unchanged
3-1.7.d.	Refer to ED-112A	Ignore 3.1.7.d.
3-1.7.e.	Refer to ED-112A	Ignore 3.1.7.e.
3-1.7.f	Refer to ED-112A	Unchanged
3-1.7.g	g. In order to minimise potential safety hazards, the deployment mechanism may be locked while the aircraft is on the ground. There shall be no means for manual deployment.	g. The ADFR system shall provide a means to lock the deployment mechanism while the aircraft is on the ground.
3-1.8.h		h. There shall be no means for manual deployment.
3-1.8.i		i. the impact point of the automatic deployable package shall be within 20 metres of the deployment mechanism, and its speed shall never exceed 14 m/swhen deployed from a fixed position in any direction over a horizontal plane.
3.1.7.	The design characteristics of a deployable recorder should result in the recorder landing clear of the aircraft wreckage. The unit shall incorporate flight characteristics that enable it to rapidly establish a flight trajectory that clears the airframe. The unit shall not be given sufficient initial momentum on deployment such that its release could endanger ground support personnel or the aircraft itself.	The equipment manufacturer shall provide sufficient information to the installer so that the installer can verify on representative accident trajectories: — that the impact speed of the automatic deployable package is less than the one used for the impact shock test (Section 3-3.2.1); — that the automatic deployable package lands away from the crash site locations where fire may exceed the characteristics used during the high and low temperature fire tests (Sections 3-3.2.4 and 3-3.2.5); — that the automatic deployable package does not collide with the aircraft. The unit shall not be given so much initial momentum on deployment that its release could endanger ground support personnel.
3-1.7.1	Refer to ED-112A	Ignore 3-1.7.1
3-1.7.2	Sensor(s) shall be installed to activate deployment of the recorder at a depth of 3 m or more.	The ADFR system shall deploy the automatic deployable package when it detects an immersion by measuring the water pressure. A pressure equivalent to a water depth between 1.5 and 5 m (between 5 and 16.4 ft — between 2.1 and 7.1 PSI relative pressure or between 16.9 and 21.9 PSI absolute pressure) is recommended for the switching threshold of a hydrostatic pressure switch. ADFR systems shall be designed such that immersion shall not prevent the deployment of the automatic deployable package, or the activation of the ELT and,

Location	Initial ED-112A text	Amending text
		once floating, it shall not affect the transmission performance of the ELT. Automatic deployment shall still take place up to 15 minutes after the loss of external electrical power. All the component electronics, power sources, mechanisms and interconnecting cables that are needed to ensure that the ADFR system activates and deploys shall be identified in the installation manual , as well as any caution notes to ensure successful deployment and activation.
3-1.8.1	Refer to ED-112A	Unchanged
3-1.8.2	All deployable recorders shall be equipped with a Class 1 dual frequency 406 MHz and 121.5 MHz radio location beacon compliant with the requirements of ED-62A instead of the underwater locator beacon and its attachment as specified in paragraph 2-1.16.4.	The automatic deployable package shall be equipped with an ELT that is approved in accordance with ETSO-C126c, type ELT(AD) Class 0 or 1 with capabilities C (crash resistance), H1 (121.5 MHz homing) and be of any generation (capability T.001 or T.018) instead of the underwater locator beacon and its attachment as specified in Section 2-1.16.4.
3-1.8.3	Refer to ED-112A	Add the following text: The ADFR shall bear the labels specified in Appendix 2 of this ETSO.
3-1.8.4	Refer to ED-112A	Unchanged
3-2.1	CHAPTER 2-3 defines the environmental tests to be performed on the recorder system. Deployable recorders shall satisfy the functional requirements as detailed in Chapter 4 of the applicable function specific Part(s).	Table 2 of this Appendix defines the environmental tests to be performed on the ADFR system. During each test, an unintended deployment of the ADFR shall be considered to indicate that the test has been failed. Unless Table 2 of this Appendix specifies that the deployment shall be performed during the tests, the successful deployment shall be verified after submission of the equipment to each test. The ADFR system shall satisfy the functional requirements as detailed in Chapter 4 of the applicable function-specific part(s).
3-3.1	Refer to ED-112A	Unchanged
3-3.2.1	The integrity of the crash-protected recording medium contents and the proper operation of the Radio Location Beacon are to be validated when subjected to the following impact shock test. a. Subject the deployable recorder package, to an impact shock applied to the most probable landing attitude in the most damage vulnerable direction. The shock shall be such a level as to simulate a landing velocity of 46.33 m/s (152 ft/s)	The integrity of the contents of the crash-protected recording medium, the proper operation of the radio location beacon and the seaworthiness of the automatic deployable package are to be validated when subjected to the following impact shock test. a. Subject the automatic deployable package to an impact shock that is applied to the most probable landing attitude in the most damage-vulnerable direction. The shock shall be such a level as to simulate a landing velocity of 46.33 m/s (152 ft/s) onto a hard surface such as rock, concrete or steel. The manufacturer may choose a higher impact speed

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Location	**Initial ED-112A text**	**Amending text**
	onto a hard surface such as rock, concrete or steel. NOTE: The definitions of 'landing attitude' and 'most damage-vulnerable direction' should not be limited to the three primary axes of the recorder. b. The deployable recorder containing the protected memory module shall impact or be impacted by a hard surface (50 mm thick steel plate of dimensions greater that the overall dimensions of the recorder) at a minimum impact velocity of 46.33 m/s (152 ft/s). Figure 3-3.1 illustrates an acceptable impact shock test set-up for deployable recorders. Figure 3-3.2 illustrates an acceptable method and set-up for retrieval of the deployable after impact. The mass of the impact plate shall be greater than 10 times the mass of the deployable recorder and experience no yield when subjected to the impact. c. Apart from the test sequence specified in paragraph 3-1.8 a iii, electronic components external to the crash-protected memory may be removed and replaced with representative mass models prior to commencing the impact shock test. For test sequence iii, the radio location beacon shall be installed and the test carried out on the complete recorder.	and declare it in the installation manual and the declaration of design and performance (DDP). NOTE: The definitions of 'landing attitude' and 'most damage-vulnerable direction' should not be limited to the three primary axes of the recorder. b. The deployable recorder that contains the protected memory module shall impact or be impacted by a hard surface (a 50-mm-thick steel plate of dimensions greater than the overall dimensions of the recorder) at a minimum impact velocity of 46.33 m/s (152 ft/s) (or higher as declared by the manufacturer). Figure 3-3.1 illustrates an acceptable impact shock test set-up for the automatic deployable package. Figure 3-3.2 illustrates an acceptable method and set-up for the retrieval of the deployable after impact. The mass of the impact plate shall be greater than 10 times the mass of the deployable recorder and shall not yield when it is subjected to the impact. c. Apart from the test sequence specified in paragraph 3-1.8.a.iii, electronic components that are external to the crash-protected memory may be removed and replaced with representative mass models prior to commencing the impact shock test. For test sequence iii, the radio location beacon shall be installed and the test carried out on the complete automatic deployable package.
3-3.2.2 (except note)	Refer to ED-112A	Unchanged
3-3.2.2 (note)	*NOTE: This test methodology is the same as the penetration test specified for Emergency Locator Transmitters (ELTs) in ED-62A.*	*NOTE: This test methodology is the same as that for the impact test specified for emergency locator transmitters (ELTs) in ED-62B Section 4.5.10. Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the ED-62B impact test described in Section 4.5.10.*
3-3.2.3	Refer to ED-112A	Add the following note to ED-112A Section 3-3.2.3: *NOTE: Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the static crush test, as described in ED-62B Section 4.5.12.*
3-3.2.4	Refer to ED-112A	Add the following note to ED-112A Section 3-3.2.4: *NOTE: Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the ED-62B Section 4.5.14 fire test.*
3-3.2.5	Refer to ED-112A	Add the following note to ED-112A Section 3-3.2.5:

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Location	**Initial ED-112A text**	**Amending text**
		NOTE: Per ETSO-C126c, the ELT(AD)s fitted to the ADFR are required to pass the ED-62B Section 4.5.14 fire test.
3-3.2.6	Refer to ED-112A	Unchanged
3-3.2.7	Refer to ED-112A	Unchanged
3-3.2.8	The deployable recorder shall be buoyant and, when floating in fresh water or salt water, shall be self-righting and sufficiently stable to maintain the antenna substantially in its normal operating position and to transmit on its 406 MHz and 121.5 MHz frequencies. Transmission of the ELT frequencies shall be demonstrated by testing in fresh and then salt water and confirming the reception of the 406 MHz Alert frequency via COSPAS SARSAT Satellite, and the 121.5 MHz homing frequency via a SAR Homing receiver. This test shall be performed in water conditions that are representative of an open sea state 7 (equivalent to Beaufort Scale force 10).	The automatic deployable package shall be buoyant and, when floating in fresh water or salt water, shall be self-righting and sufficiently stable to maintain the antenna substantially in its normal operating position, and to transmit on its 406-MHz and 121.5-MHz frequencies. The automatic deployable package shall be immersed at the immersion depth for 5 minutes and shall then return to the surface when released. Transmission on the ELT frequencies shall then be demonstrated by conducting testing in fresh water and confirming the reception of the 406-MHz alert frequency via the COSPAS SARSAT Satellite. The 121.5-MHz homing transmission shall be tested in the conditions described in ED-62B Section 5.5.6.
3-3.2.9 a.	Unless it can be shown that the recording medium can withstand the conditions associated with deep sea immersion and that it is unlikely to be damaged as a consequence of collapse of any protective armour, immerse the recorder in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m (20 000 feet) for a period of 30 days.	Ignore 3-3.2.9.a.
3-3.2.9 b.	Unless it can be shown that the recording medium and the identification required by paragraph 2-1.16.3 are resistant to the corrosive effects of sea water, immerse the recorder in sea water at a depth of 3 m and nominal temperature of + 25°C for a period of 30 days.	Unless it can be shown that the recording medium and the identification required by Section 2-1.16.3 are resistant to the corrosive effects of seawater, immerse the recorder in seawater at a depth of 3 m and a nominal temperature of at least + 25.0 °C for a period of 90 days.
3-3.2.10		Add a section: **Water sensor test** This test may be performed on an additional individual ADFR system that is not part of the test sequence. The ELT shall be activated and the system deprived of external power before the test for the duration defined in Section 3-1.7.2, as modified by this Appendix. For an ADFR system that is fitted with a water-detection sensor, submerge it in fresh water at a

Location	**Initial ED-112A text**	**Amending text**
		speed of not less than 1 m per minute. Verify that the ADFR deploys when the water sensor is submerged. For an ADFR system that is fitted with a pressure sensor, submerge it in fresh water at a speed of not less than 1 m per minute. Verify that the ADFR deploys when the water sensor is at a depth of between 1.5 and 5 m. Perform an aliveness test of the ELT as defined in EUROCAE ED-62B Section 4.3.1.

Table 2 — Environmental test for ADFR systems

Test	**EUROCAE ED-14G/ RTCA DO-160G Section**	**Minimum category/Remarks**
Temperature	4.0	Category to be defined by the manufacturer. Deployment shall be tested at the short-time low and high operating temperatures.
Altitude	4.0	Category to be defined by the manufacturer.
Temperature Variations	5.0	A, S1 or S2
Humidity	6.0	C for the components and parts of the ADFR system that are exposed to the outside air, A for the rest of the system. Deployment shall be tested at the end of exposure period, without draining off any condensed moisture.
Operational Shock	7.0	Category to be defined by the manufacturer.
Crash Safety Shock	7.0	Category to be defined by the manufacturer.
Vibration	8.0	R, U or U2 and H or Z A deployment shall be performed during the test, at the most unfavourable vibration condition (e.g. the resonance frequency).
Explosion Proofness	9.0	As required.
Waterproofness	10.0	S for the components and parts of the ADFR system that are exposed to the outside air, Y for the rest of the system including for the water sensor.
Fluids Susceptibility	11.0	F, with at least fuel, hydraulic fluids, lubricating oils, de-icing fluids and fire extinguishants.
Sand and Dust	12.0	S
Fungus Resistance	13.0	F
Salt Spray	14.0	T
Magnetic Effect	15.0	Category to be defined by the manufacturer.
Power Input	16.0	Category to be defined by the manufacturer. A deployment shall be performed under the most unfavourable testing conditions. The unit under test may encompass only the installed components of the ADFR system.

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Test	**EUROCAE ED-14G/ RTCA DO-160G Section**	**Minimum category/Remarks**
Voltage Spike	17.0	Category to be defined by the manufacturer. The unit under test may encompass only the installed components of the ADFR system.
AF Conducted Susceptibility	18.0	Category to be defined by the manufacturer. A deployment shall be performed during the test under the most unfavourable testing conditions. The unit under test may encompass only the installed components of the ADFR system.
Induced Signal Susceptibility	19.0	Category to be defined by the manufacturer. A deployment shall be performed during the test under the most unfavourable testing condition. The unit under test may encompass only the installed components of the ADFR system.
RF Susceptibility	20.0	Category to be defined by the manufacturer. A deployment shall be performed during the test under the most unfavourable testing conditions.
RF Emission	21.0	Category to be defined by the manufacturer.
Lightning-Induced Transient Susceptibility	22.0	Category to be defined by the manufacturer.
Lightning Direct Effects	23.0	Category to be defined by the manufacturer. The recorder is required to successfully deploy after a direct impact. No unintended deployment shall occur, and no part shall detach.
Icing	24.0	The test shall be performed for Categories B and C. For Category B, 2 cycles are required. The deployment of the recorder shall be tested at the end of first cycle and at the end of the low-temperature phase for the second cycle. For Category C, the deployment shall be tested after the required ice thickness (which shall not be less than 5 mm) is met and the temperature is stabilised at its lowest value as required by the ED-14G/DO-160G test.
Electrostatic Discharge	25.0	A
Fire	26.0	C + ED-112A Sections 3-3.2.4 and 3-3.2.5.

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APPENDIX 2

DANGER LABELS FOR THE AUTOMATIC DEPLOYABLE FLIGHT RECORDER (ADFR) SYSTEM

If the automatic deployable package (ADP) is designed to be installed with one side exposed to the exterior of the aircraft, that side of the ADP shall bear an external danger label.

This external danger label is intended to provide a visual warning to maintenance and servicing crews, as well as to rescue or other personnel at the scene of an accident or incident in the event that the ADFR has not deployed. The ADFR system may include devices such as rocket motors, mortars, explosive projectiles, springs or other stored-energy devices, and additional marking may be required at the installation level to address this.

The external danger label (see the examples in Figure 1):

a) shall be of an 8-cm minimum triangular form with the word 'DANGER';

b) may contain an explanatory box printed next to the indication in a). The explanatory box may describe the type of deployment device and provide contact information for rescue personnel to seek help from the manufacturer of the deployment mechanism;

c) shall be printed with a red border with white (or reverse type) letters and shall employ reflective background material for enhanced visibility in low-light or obscured conditions.

Figure 1 — Examples of external danger labels

In addition to the above external danger label, any ADFR system device that stores energy in excess of 50 Joules (e.g. a rocket motor) should bear a device danger label to warn rescue personnel in the event that this device becomes separated from the aircraft due to high G forces on impact.

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This device label shall:

a) be of a 5-cm minimum triangular form with the word 'DANGER';

b) have contact information as well as graphic images;

c) be printed with a red border with white (or reverse type) letters with a descriptive graphic element.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: RUNWAY OVERRUN AWARENESS AND ALERTING SYSTEM

1 — Applicability

This ETSO provides the requirements which runway overrun awareness and alerting systems that are designed and manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are those provided in EUROCAE ED-250, Minimum Operational Performance Standards for a Runway Overrun Awareness and Alerting System, dated December 2017.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

See CS-ETSO, Subpart A, paragraph 2.2.

3.1.4 — Airborne Electronic Hardware

See CS-ETSO, Subpart A, paragraph 2.3.

3.2 — Specific

3.2.1 — Failure Condition Classification

See CS-ETSO, Subpart A, paragraph 2.4.

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4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

None.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

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European Union Aviation Safety Agency

European Technical Standard Order (ETSO)

Subject: EMERGENCY BREATHING SYSTEM (EBS)

1 — Applicability

This ETSO provides the requirements which emergency breathing systems (EBSs), for operations to or from helidecks that are located in hostile sea areas, that are designed and manufactured on or after the date of this ETSO, must meet in order to be identified with the applicable ETSO marking.

2 — Procedures

2.1 — General

The applicable procedures are detailed in CS-ETSO, Subpart A.

2.2 — Specific

None.

3 — Technical Conditions

3.1 — Basic

3.1.1 — Minimum Performance Standard

The applicable standards are those provided in AeroSpace and Defence Industries Association of Europe — Standardization (ASD-STAN) document EN4856:2018, dated December 2018.

3.1.2 — Environmental Standard

See CS-ETSO, Subpart A, paragraph 2.1.

3.1.3 — Software

None.

3.1.4 — Airborne Electronic Hardware

None.

3.2 — Specific

3.2.1 — Failure Condition Classification

None.

4 — Marking

4.1 — General

See CS-ETSO, Subpart A, paragraph 1.2.

4.2 — Specific

The specific marking requirements are detailed in ASD-STAN document EN4856:2018.

5 — Availability of Referenced Documents

See CS-ETSO, Subpart A, paragraph 3.

4. Impact assessment (IA)

No impact analysis has been conducted in line with Article 3(5) of EASA MB Decision No 18-2015, as this NPA has been prepared in the framework of a regular update of CS-ETSO.

5. Proposed actions to support implementation

EASA has created a specific link within the EASA internet page[17] in order to simplify the identification and the download of the current ETSO articles.

For consultation purposes, EASA has also created a specific webpage[18] that lists all (current and historic) ETSOs.

No additional actions are foreseen to support the implementation of new and amended ETSO articles.

[17] https://www.easa.europa.eu/easa-and-you/aircraft-products/etso-authorisations/list-of-current-etso

[18] https://www.easa.europa.eu/easa-and-you/aircraft-products/etso-authorisations/list-of-all-etso

6. References

6.1. Affected regulations

N/A

6.2. Affected decisions

Decision No. 2003/10/RM of the Executive Director of the Agency of 24 October 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for European Technical Standard Orders ('CS-ETSO')

6.3. Other reference documents

None