NOTICE OF PROPOSED AMENDMENT (NPA) No 14-2005
DRAFT DECISION OF THE EXECUTIVE DIRECTOR,

AMENDING
DECISION NO 2003/10/RM OF THE EXECUTIVE DIRECTOR,

of 24 October 2003, on

Certification Specifications, Including Airworthiness Codes And Acceptable Means Of Compliance, For European Technical Standard Orders (CS-ETSO)

Miscellaneous ETSO.

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A Explanatory Note

I. General

1. The purpose of this Notice of Proposed Amendment (NPA) is to envisage amending Decision N° 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). This NPA introduces a number of new European Technical Standard Orders (ETSO).
   The scope of this rulemaking activity is outlined in ToR CS-ETSO.004 and is described in more detail below.

2. The Agency is directly involved in the rule-shaping process. It assists the Commission in its executive tasks by preparing draft regulations, and amendments thereof, for the implementation of the Basic Regulation[1] which are adopted as "Opinions" (Article 14.1). The Agency also adopts Certification Specifications, including Airworthiness Codes and Acceptable Means of Compliance and Guidance Material to be used in the certification process (Article 14.2(a) and (b)).

3. This rulemaking activity is included in the Agency's rulemaking programme for 2005. It implements the rulemaking task ETSO.004 Miscellaneous ETSO.
   The rulemaking task ETSO.004 has been divided in to two NPAs to accommodate for the difference in timeframe for consultation. One NPA will deal with changes to CS-ETSO already presented under the JAA NPA TSO-10 and for which a six weeks consultation period was agreed with the Agency's consultative bodies (SSCC and AGNA). The other NPA, this one, deals with amendments not published before and for which therefore a consultation period of three month is necessary.

4. The text of this NPA is based on the Draft JAA NPA TSO-11 which was developed by the Joint Aviation Authorities (JAA). This JAA Draft NPA was reviewed by the Equipment Steering Group (EqStG) but not published for consultation. It was adapted to the EASA regulatory context by the Agency. It is now submitted for consultation of all interested parties in accordance with Article 43 of the Basic Regulation and Articles 5(3) of the EASA rulemaking procedure[2].

[1] Regulation (EC) No 1592/2002. OJ L 240, 7.9.2002, p.1.
[2] Decision of the Management Board concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material ("rulemaking procedure"), EASA MB/7/03, 27.6.2003.

II. Consultation

5. To achieve optimal consultation, the Agency is publishing the draft decision on its internet site.
Comments on this proposal may be forwarded *(preferably by e-mail)*, using the attached comment form, to:

By e-mail: **NPA@easa.eu.int**

By Fax: **+49(221) 89990 5508**

By correspondence: Process Support Unit
Rulemaking Directorate
EASA
Ref: NPA 08-2005
Postfach 10 12 53
D-50452 Köln
Germany

Comments should be received by the Agency **before 20-12-2005**. If received after this deadline they might not be treated. Comments may not be considered if the form provided for this purpose is not used.

III. Comment response document

6. All comments received will be responded to and incorporated in a Comment Response Document (CRD). This may contain a list of all persons and/or organisations that have provided comments. The CRD will be widely available ultimately before the Agency adopts its final decision.

IV. Content of the draft decision

7. This NPA proposes the introduction or amendment of the following ETSOs:

7.1 Existing ETSOs amended by this NPA.

ETSO-C145a: Airborne Navigation Sensors using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)

Update of existing ETSO-C145 further to Federal Aviation Administration (FAA) Technical Standard Orders (TSO) TSO-C145a dated 19 September 2002

ETSO-C146a: Stand-Alone Airborne Navigation Equipment using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)

Update of existing ETSO-C146 further to FAA TSO-C146a dated 19 September 2002.

In the frame of the WAAS system development the Minimum Operational Performance Standards (MOPS) issued by the Radio Technical Commission for Aeronautics (RTCA) document DO-229 has been updated to revision C. The update includes message type 28 information, modification of the satellite tracking constrains, changes to the equipment classifications and the accommodating document realignment, interference environment revisions in Appendix C, and new GPS/Inertial requirements in Appendix R. The FAA has adapted their TSO-C145 and -C146 and modified some requirements to reflect changes in the Navstar GPS Space segment definitions, to adapt signal latency requirements, to freeze alert limits to a defined value and not store them in a database.

ETSO-C151b: Terrain Awareness and Warning System (TAWS)

Update of existing ETSO-C151a further to FAA TSO-C151b dated 17 December 2002.

The new version of this ETSO has a number of editorial changes. Some technical requirements are formulated more precise. However, the main difference is the addition of Appendix 4 in the new version. It defines a new Class C for TAWS to be installed in General Aviation aeroplanes in which such an installation are not mandated.
For this purpose, it modifies the definitions and requirements given in Appendix 1 for Class B equipment transferred to the ETSO format.

7.2 Existing ETSO modified in INDEX 2 by this NPA.

ETSO-2C123b: Cockpit Voice Recorder Systems
Update and transfer of existing ETSO-C123a Subpart B index 1 into ETSO-2C123b in Subpart B index 2, with a revised reference to European Organisation for Civil Aviation Equipment (Eurocae) ED-112 dated March 2003 instead of „ED-56A dated December 1993 (Amd 1. 1997) ".

ETSO-2C124b: Flight Data Recorder Systems
Update and transfer of existing ETSO-C124a Subpart B index 1 into ETSO-2C124b in Subpart B index 2, with a revised reference to Eurocae ED-112 dated March 2003 instead of „ED-56A dated December 1993 (Amd 1. 1997) ".

7.3 New ETSOs introduced in INDEX 2 by this NPA.

ETSO-2C510: Crash Protected Airborne Recorder Systems - Image Recorder
New ETSO with reference to Eurocae ED-112 dated March 2003.

ETSO-2C511: Crash Protected Airborne Recorder Systems - CNS/ATM Recorder
New ETSO with reference to Eurocae ED-112 dated March 2003.

Note: ED-112 deals with crash protected recorders and is structured in sections for four functionalities: cockpit voice recorder systems, flight data recorder systems, image recorder systems, and CNS/ATM (data link) recorder systems. A differentiation between fixed installed and removable equipment is also done. For the first two of the ED-112 functionalities there are already ETSOs in place. It was decided to update them and to add two separate ETSOs for the other ED-112 functionalities.

ETSO-2C507: Inflight Icing Detection System
New ETSO with reference to Eurocae ED-103 dated July 2001.

ETSO-2C508: Ground Icing Detection System
New ETSO with reference to Eurocae ED-104A dated June 2003.

ETSO-2C509: Light Aviation Secondary Surveillance Transponders (LAST)
New ETSO with reference to Eurocae ED-115 dated August 2002.

7.4 **Changes to (INDEX 1 AND INDEX 2)**

Both INDEX 1 and INDEX 2 in CS-ETSO will have to be amended in accordance with the described changes as reflected in the following table.

INDEX 1

ETSO	Subject Title	
ETSO-C123a	Cockpit Voice Recorder Systems	Deleted see INDEX 2
ETSO-C124a	Flight Data Recorder Systems	Deleted see INDEX 2
ETSO-C145a	**Airborne Navigation Sensors using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)**	Update of ETSO-C145
ETSO-C146a	**Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)**	Update of ETSO-C146
ETSO-C151b	**Terrain Awareness and Warning System (TAWS)**	Update of ETSO-C151a

INDEX 2

ETSO	Subject Title	
ETSO-2C123b	**Cockpit Voice Recorder Systems**	Update of ETSO-C123a
ETSO-2C124b	**Flight Data Recorder Systems**	Update of ETSO-C124a
ETSO-2C507	**Inflight Icing Detection System**	New ETSO
ETSO-2C508	**Ground Icing Detection System**	New ETSO
ETSO-2C509	**Light Aviation Secondary Surveillance Transponders (LAST)**	New ETSO
ETSO-2C510	**Crash Protected Airborne Recorder Systems - Image Recorder**	New ETSO
ETSO-2C511	**Crash Protected Airborne Recorder Systems - CNS/ATM Recorder**	New ETSO

V. Regulatory Impact Assessment

8. The proposals contained in this NPA are intended to achieve a common international standard with regard to the approval of equipment.
Harmonisation of CS-ETSO and FAR-TSO would yield cost savings by minimising any duplication of certification and maintenance activities.

B. DRAFT DECISION

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

1. ~~Text to be deleted is shown with a line through it.~~
2. New text to be inserted is highlighted with grey shading.
3. New paragraph or parts are not highlighted with grey shading, but are accompanied by the following box text:

Insert new paragraph / part *(Include N° and title)*, ore replace existing paragraph/ part

4. ….
   in front of or following the reflected amendment indicates that remaining text is unchanged
   ....

I Draft Decision CS-ETSO

SUBPART B
INDEX 1

….

~~ETSO-C123a~~	~~Cockpit Voice Recorders Systems~~
~~ETSO-C124a~~	~~Flight Recorder~~

....

....

ETSO-C145a	Airborne Navigation Sensors using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C146a	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)

....

ETSO-C151a~~a~~b	Terrain Awareness and Warning System (TAWS)

....

SUBPART B
INDEX 2

....

ETSO-2C123b	Cockpit Voice Recorder Systems
ETSO-2C124b	Flight Data Recorder Systems

....

ETSO-2C507	Inflight Icing Detection System
ETSO-2C508	Ground Icing Detection System
ETSO-2C509	Light Aviation Secondary Surveillance Transponders (LAST)
ETSO-2C510	Crash Protected Airborne Recorder Systems - Image Recorder
ETSO-2C511	Crash Protected Airborne Recorder Systems - CNS/ATM Recorder

....

CS-ETSO INDEX 1

Replace the following amended ETSO

ETSO-C145a

Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: AIRBORNE NAVIGATION SENSORS USING THE GLOBAL POSITIONING SYSTEM (GPS) AUGMENTED BY THE WIDE AREA AUGMENTATION SYSTEM (WAAS)

1 - Applicability

This ETSO gives the requirements that new models of airborne navigation sensors using the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS) that are manufactured on or after the date of this ETSO must meet in order to be identified with 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. These deviations will be used by the pilot or autopilot to guide the aircraft. These standards do not address integration issues with other avionics, such as the potential for the sensor to inadvertently command an autopilot hard over. These standards also do not address the use of position information for other applications such as automatic dependent surveillance.

2 - Procedures

2.1 - General

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

Airborne navigation sensors using GPS augmented by WAAS that are to be so identified must meet the minimum performance standards for Class Beta equipment set forth in Section 2 of RTCA/DO-229~~A~~C, "Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment", dated ~~June 8, 1998~~ November 28, 2001, as amended and supplemented by Appendix 1 of this ETSO. Class Beta equipment is defined in ~~Section 1 of RTCA/DO-229A~~ Section 1.4 of RTCA/DO-229 C.

If the equipment uses barometric-aiding to enhance the availability of Fault Detection and Exclusion (FDE), it must meet the requirements in Appendix G of RTCA/DO-229C.

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.

3.2 - Failure Condition Classification

Failure of the function defined in paragraph 1 of this ETSO has been determined to be:
- a major failure condition for loss of function and malfunction of en route, terminal, or non precision approach navigation data;
- a major failure condition for loss of function of precision approach navigation data;
- and a hazardous failure condition for the malfunction of precision approach navigation data.

The applicant must develop the system to at least the design assurance level commensurate with this hazard classification.

3.3. - Functional qualifications

The required performance shall be demonstrated under the test conditions specified in RTCA/DO-229~~A~~C, Section 2.5. The use of test procedures other than those specified in Sections 2.5.2 through 2.5.9 of RTCA/DO-229~~A~~C constitutes a deviation to this ETSO.

4 - Marking

4.1 – General

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

4.2 - Specific

In addition, the following requirements apply to all separate components of equipment that are manufactured under this ETSO:
- The operational equipment class as defined in Section 1.4.2 of RTCA/DO-229~~A~~C (e.g., Class 2),
- When applicable, identification that the article is an incomplete system or that the article accomplishes additional functions beyond that described in paragraph 1 of this ETSO.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

Insert new APPENDIX 1 to ETSO-C145a

APPENDIX 1.

MINIMUM PERFORMANCE STANDARD FOR AIRBORNE NAVIGATION SENSORS USING GPS/WAAS

This appendix prescribes the MPS for airborne navigation sensors using GPS/WAAS, modified by the Agency in this ETSO. The applicable standard is RTCA/DO-229C, "Minimum Operational Performance Standards for GPS WAAS Airborne Equipment", November 18, 2001, with errata dated August 16, 2002, and is modified as follows:

1. Page 32, paragraph 2.1.1.5.5 (GPS UNHEALTHY Designation).
Replace first sub-bullet with:

- 6 bit health word in subframe 1: all cases where MSB="1" ~~except when other bits are "11101", indicating that the satellite will be out of service but is not at this time~~ (ref. 20.3.3.3.1.4 and 20.3.3.5.1.3 of ICD-GPS-200C, "Navstar GPS Space Segment / Navigation User Interfaces," April 2000);

2. Page 38, paragraph 2.1.1.13.1 (Protection Level).
Change latency requirement to 2 seconds as follows:

Class Beta equipment shall output the Horizontal Protection Level (HPL_{WAAS} or HPL_{FD} as described in Sections 2.1.2.2.2, 2.1.3.2.2, 2.1.4.2.2, and 2.1.5.2.2). Class Gamma and Delta equipment intended to support an external ADS-B function shall output HPL. The latency of the WAAS-based protection levels shall not exceed ~~4.8~~ 2 seconds, from the arrival at the antenna port of the last bit of a message which affects the horizontal protection level. The GPS/WAAS equipment shall indicate if the HPL cannot be calculated (insufficient number of WAAS HEALTHY satellites and fault detection is not available).

3. Page 55, paragraph 2.1.4.12.1 (Protection Level).
Change latency requirement to 1 second as follows:

Class Beta-2 equipment shall output WAAS-based protection levels (HPL_{WAAS} and VPL_{WAAS}) once per second. The latency of the output of the WAAS-based protection levels shall not exceed ~~0.7~~ 1 second, from the arrival at the antenna port of the last bit of a message, which affects the horizontal or vertical protection levels to output of the last bit of a message containing the protection levels. The GPS/WAAS equipment shall indicate if the HPL_{WAAS} and VPL_{WAAS} cannot be calculated (insufficient number of WAAS HEALTHY satellites). Note that when the HPL_{WAAS} and VPL_{WAAS} cannot be calculated, LNAV/VNAV is not available.

4. Page 56, paragraph 2.1.4.12.2 (Navigation Alert).
Change latency requirement for insufficient WAAS HEALTHY satellites to 1 second as follows:

Class Beta-2 equipment shall provide an indication or output of the loss of navigation capability within one second of the onset of any of the following conditions:

a) The absence of power (loss of function is an acceptable indicator);

b) Probable equipment malfunction or failure (must consider all malfunctions and failures that could affect the navigation function and are more probable than 10^{-5});

c) The presence of a condition where fault detection detects a position failure; or

d) when no valid WAAS message has been received for 4 seconds or more (this indicates a probable communications link problem or WAAS signal blockage).

Class Beta-2 equipment shall also provide an indication or output of the loss of navigation capability within ~~0.6~~1 second of the onset of any of the following conditions:

e) there are fewer than 4 WAAS HEALTHY satellites (e.g., onset of condition is: (1) when satellite is blocked; (2) when the last bit of a WAAS message indicating "Don't Use" arrives at the antenna port).

The alert shall be returned to its normal state immediately upon termination of the responsible condition

ETSO-C146a
Date : X.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: STAND-ALONE AIRBORNE NAVIGATION EQUIPMENT USING THE GLOBAL POSITIONING SYSTEM (GPS) AUGMENTED BY THE WIDE AREA AUGMENTATION SYSTEM (WAAS)

1 - Applicability

This ETSO gives the requirements that new models of stand-alone airborne navigation equipment using the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS) that are manufactured on or after the date of this ETSO must meet in order to be identified with 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.~~accept a desired flight path and provide deviation commands referenced to that path. These deviations will be used by the pilot or autopilot to guide the aircraft. These standards do not address integration issues with other avionics, such as the potential for the ~~sensor to~~ system inadvertently to command an autopilot hard over. These standards also do not address the use of position information for other applications, such as automatic dependent surveillance.

2 - Procedures

2.1 - General

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

Airborne navigation sensors using GPS augmented by WAAS that are to be so identified must meet the minimum performance standards for Class Gamma or Class Delta equipment set forth in Section 2 of RTCA/DO-229~~B~~C, "Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment", dated ~~October 5, 1999~~ November 28, 2001, as amended and supplemented by Appendix 1 of this ETSO. Class Gamma and Class Delta equipment are defined in Section 1.4 of RTCA/DO-229~~B~~C.

If the equipment uses barometric-aiding to enhance the availability of Fault Detection and Exclusion (FDE), it must meet the requirements in Appendix G of RTCA/DO-229C.

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.

3.2 - Failure Condition Classification

Failure of the function defined in paragraph 1 of this ETSO has been determined to be:

- a major failure condition for loss of function and malfunction of en route, terminal, or nonprecision approach navigation data;
- a major failure condition for loss of function of precision approach navigation data;
- and a hazardous failure condition for the malfunction of precision approach navigation data.

The applicant must develop the system to at least the design assurance level commensurate with this hazard classification.

3.3. - Functional qualifications

The required performance shall be demonstrated under the test conditions specified in RTCA/DO-229~~B~~C, Section 2.5. The use of test procedures other than those specified in Sections 2.5.2 through 2.5.9 of RTCA/DO-229~~B~~C constitutes a deviation to this ETSO.

4 - Marking

4.1 – General

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

4.2 - Specific

In addition, the following requirements apply to all separate components of equipment that are manufactured under this ETSO:

- The operational equipment class as defined in Section 1.4.2 of RTCA/DO-229~~B~~C (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/DO-229~~ B~~C (e.g. Gamma, Delta) is not required to be marked.
- When applicable, identification that the article is an incomplete system or that the article accomplishes additional functions beyond that described in paragraph 1 of this ETSO.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

Insert new APPENDIX 1 to ETSO-C146a

APPENDIX 1.

MINIMUM PERFORMANCE STANDARD FOR AIRBORNE NAVIGATION SENSORS USING GPS/WAAS

This appendix prescribes the MPS for airborne navigation sensors using GPS/WAAS, modified by the Agency in this ETSO. The applicable standard is RTCA/DO-229C, "Minimum Operational Performance Standards for GPS WAAS Airborne Equipment", November 18, 2001, with errata dated August 16, 2002, and is modified as follows:

1. Page 32, paragraph 2.1.1.5.5 (GPS UNHEALTHY Designation).
Replace first sub-bullet with:

- 6 bit health word in subframe 1: all cases where MSB="1" ~~except when other bits are "11101", indicating that the satellite will be out of service but is not at this time~~ (ref. 20.3.3.3.1.4 and 20.3.3.5.1.3 of ICD-GPS-200C, "Navstar GPS Space Segment / Navigation User Interfaces," April 2000);

2. Page 38, paragraph 2.1.1.13.1 (Protection Level).
Change latency requirement to 2 seconds as follows:

Class Beta equipment shall output the Horizontal Protection Level (HPL_{WAAS} or HPL_{FD} as described in Sections 2.1.2.2.2, 2.1.3.2.2, 2.1.4.2.2, and 2.1.5.2.2). Class Gamma and Delta equipment intended to support an external ADS-B function shall output HPL. The latency of the WAAS-based protection levels shall not exceed ~~4.8~~ 2 seconds, from the arrival at the antenna port of the last bit of a message which affects the horizontal protection level. The GPS/WAAS equipment shall indicate if the HPL cannot be calculated (insufficient number of WAAS HEALTHY satellites and fault detection is not available).

3. Page 55, paragraph 2.1.4.12.1 (Protection Level).
Change latency requirement to 1 second as follows:

Class Beta-2 equipment shall output WAAS-based protection levels (HPL_{WAAS} and VPL_{WAAS}) once per second. The latency of the output of the WAAS-based protection levels shall not exceed ~~0.7~~ 1 second, from the arrival at the antenna port of the last bit of a message, which affects the horizontal or vertical protection levels to output of the last bit of a message containing the protection levels. The GPS/WAAS equipment shall indicate if the HPL_{WAAS} and VPL_{WAAS} cannot be calculated (insufficient number of WAAS HEALTHY satellites). Note that when the HPL_{WAAS} and VPL_{WAAS} cannot be calculated, LNAV/VNAV is not available.

4. Page 56, paragraph 2.1.4.12.2 (Navigation Alert).
Change latency requirement for insufficient WAAS HEALTHY satellites to 1 second as follows:

Class Beta-2 equipment shall provide an indication or output of the loss of navigation capability within one second of the onset of any of the following conditions:

a) The absence of power (loss of function is an acceptable indicator);

b) Probable equipment malfunction or failure (must consider all malfunctions and failures that could affect the navigation function and are more probable than 10^{-5});

c) The presence of a condition where fault detection detects a position failure; or

d) when no valid WAAS message has been received for 4 seconds or more (this indicates a probable communications link problem or WAAS signal blockage).

Class Beta-2 equipment shall also provide an indication or output of the loss of navigation capability within ~~0.6~~ 1 second of the onset of any of the following conditions:

e) there are fewer than 4 WAAS HEALTHY satellites (e.g., onset of condition is: (1) when satellite is blocked; (2) when the last bit of a WAAS message indicating "Don't Use" arrives at the antenna port).

The alert shall be returned to its normal state immediately upon termination of the responsible condition

5. Pages 111-112, paragraph 2.2.4.6.1 (Alert Limits).
Define HAL and VAL for LNAV/VNAV as follows:

Prior to sequencing the FAWP, the HAL shall be 0.3 NM. There is no VAL.

After sequencing the FAWP, the alert limits shall be as follows:

a) LNAV/VNAV: HAL = 556 m, VAL = 50 m. ~~HAL and VAL as stored in the database for each LNAV/VNAV per Section 2.2.4.5.1.~~

The equipment shall not provide the flight crew a means of changing the alert limit.

As described in Section 2.2.4.7.4, the equipment must provide an advisory of the level of service available. Once that advisory is provided, the level of service shall not change unless the missed approach is initiated or the pilot changes the desired level of service. The equipment shall use the alert limits for the monitoring described in Sections 2.2.4.6.2 and 2.2.4.6.3.

6. Page 119, paragraph 2.2.5.5.1 (Content).
Insert a reference to the data defined in Appendix D (which includes the HAL and VAL as described in item 7 of this appendix), and delete redundant requirement for VAL to be stored in the database as follows:

In addition to the requirements of paragraph 2.2.1.5.2, the equipment shall store the GLS and APV-II procedures in the area(s) in which IFR operation is intended, including the data defined in Appendix D (Table D-1). For each procedure, the equipment shall also identify the types of approach with vertical guidance that are published (i.e., GLS, APV-II, and/or LNAV/VNAV), and the naming convention associated with the types of approach (e.g., “GLS”, “LNAV/VNAV”).

The complete sequence of waypoints, in the correct order for each approach, must be retrievable as a procedure (so that selecting the procedure by name results in loading the appropriate waypoints and legs into the flight plan).

Waypoints utilized as a final approach waypoint (FAWP) and LTP/FTP in a GLS and APV-II procedure shall be uniquely identified as such to provide proper approach mode operation.

~~In addition to the above requirements, the equipment shall store the VAL for each GLS and APV-II approach.~~

7. Page D-5, Appendix D, section D.3.2, Table D-1.
Insert the HAL and VAL into the table before the CRC, as follows:

Table D-1 Final Approach Segment (FAS)

Data content	***Bits used***	***Range of values***	***Resolution***
Operation type	4	0 to 15	1
SBAS provider ID	4	0 to 15	1
Airport ID	32	-	-
Runway number (Note 1)	6	0 to 36	1
Runway letter	2	-	-
Approach performance designator	3	0 to 7	1
Route indicator	5	-	-
Reference path data selector	8	0 to 48	1
Reference path identifier	32	-	-
LTP/FTP latitude	32	± 90.0 °	0.0005 arcsec
LTP/FTP longitude	32	± 180.0 °	0.0005 arcsec
LTP/FTP height	16	-512.0 to 6041.5 m	0.1 m
∆FPAP latitude	24	± 1.0 °	0.0005 arcsec
∆FPAP longitude	24	± 1.0 °	0.0005 arcsec
Approach threshold crossing height (TCH) (note 1)	15	0 to 1638.4 m (0 to 3276.8 ft)	0.05 m (0.1 ft)
Approach TCH units selector	1	-	-
Glidepath angle (GPA)	16	0 to 90.0 °	0.01°
Course width at threshold (Note 1)	8	80.0 to 143.75 m	0.25 m
∆Length offset	8	0 to 2032 m	8 m
Horizontal Alert Limit (HAL)	8	0 to 50.8 m	0.2 m
Vertical Alert Limit (VAL) (Note 2)	8	0 to 50.8 m	0.2 m
Final approach segment CRC	32	-	-

Note 1: When the runway number is set to 00, then the course width field is ignored and the course width is 38 meters.

Note 2: A VAL of 0 indicates that the vertical deviations should not be used (i.e., a lateral-only approach).

ETSO-C151b
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)

1 - Applicability

This ETSO gives the requirements which Terrain awareness and Warning System (TAWS) equipment that is 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

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

Standards set forth in this paragraph and the attached Federal Aviation Administration Technical Standard Order "TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)" appendices 1 through 4.

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. Software implementing the functions defined in this ETSO must be developed to Level C as defined in ED-12B/DO-178B. Monitoring software required by appendix 1 of this ETSO must be developed to Level C. Software in the TAWS other than the software implementing the function and monitoring requirements defined in the ETSO, such as maintenance software, should be developed to Level C also unless the applicant can demonstrate that the ETSO functional software and monitoring software is protected from failure of the other software by means such as developed to the highest level commensurate with its functionality and its most severe failure condition categories as determined by a system safety assessment.

3.2 - Specific

3.2.1 - Failure Condition Classification

A minimum level of reliability and integrity must be built into the TAWS computer for warning functions. Therefore, the presentation of hazardously misleading information (HMI), as defined in paragraph 2.8 of appendix 1, on the terrain display, or the unannunciated loss of the terrain warning functions as a result of TAWS

Computer failure ~~should be shown to be improbable (i.e. <10-5 per flight hour)~~ is considered a major failure condition.

A false terrain warning as a result of a TAWS computer failure ~~should also be shown to be improbable (i.e. <10-5 per flight hour)~~ is also considered a major failure condition. False sensor inputs (erroneous altitude, terrain data, airport data, etc) to the TAWS computer need not be considered for compliance to these failure condition classifications.

3.2.2 - Functional Qualifications

The required performance shall be demonstrated under the test conditions specified in Appendixes 1 ~~and 3~~ through 4.

3.2.3 - Fire Protection

All material used shall be self-extinguishing except for small parts (such as knobs, fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire.

4 - Marking

4.1 - General

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

4.2 - Specific

~~None~~.

a. At least one major component must be permanently and legibly marked with all of the information listed in Part 21 Section A Subpart Q § 21A.807(a).In addition to this information the applicable Class A, B or C must be permanently and legibly marked. In Part 21 Section A Subpart Q § 21A.807(a)(2), the option name, type and part number must be used in lieu of the optional model number; and in Part 21 Section A Subpart Q § 21A.807(a)(3), the option date of manufacture must be used in lieu of the serial number.

b. In addition to the requirements of Part 21 Section A Subpart Q § 21A.807(a) ~~14 CFR § 21.607(d)~~, each separate component that is easily removable (without hand tools), each interchangeable element, and each separate sub-assembly of the article that the manufacturer determines may be interchangeable must be permanently and legibly marked with at least the name of the manufacturer, manufacturer's sub-assembly part number, and ETSO number.

c. If the component includes a digital computer, the part number must include hardware and software identification, or a separate part number may be utilized for hardware and software. Either approach must include a means for showing the modification status. Note that similar software versions, which have been approved to different software levels, must be differentiated by part number.None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

APPENDIX 1. FEDERAL AVIATION ADMINISTRATION MINIMUM PERFORMANCE STANDARD (MPS) 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 equipment is required for certain 14 CFR part 121 operators and certain 14 CFR part 135 operators. Class B equipment is required for certain 14 CFR part 135 operators and certain 14 CFR part 91 operators. See Table 11-1 and the appropriate operating rules for specific details.

1.3 System Function and Overview. The system must provide the flight crew with sufficient information and alerting to detect a potentially hazardous terrain situation that would permit the flight crew to take effective action to prevent a controlled flight into terrain (CFIT) event. The basic TAWS functions for all TSO approved systems include the following:

a. A Forward Looking Terrain Avoidance (FLTA) function. The FLTA function looks ahead of the airplane along and below the airplane'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 airplane's current position and flight path information as determined from a suitable navigation source and airport database to determine if the airplane is hazardously below the normal (typically 3 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 to be 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 RTCA/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 minimized while an equivalent level of safety for the following conditions is provided.

(1) Excessive Rates of Descent
(2) Excessive Closure Rate to Terrain.
(3) Negative Climb Rate or Altitude Loss After Take-off
(4) Flight Into Terrain When Not in Landing Configuration
(5) Excessive Downward Deviation From an ILS Glideslope.

(6) Voice callout "Five Hundred" when the airplane descends to 500 feet above the terrain or nearest runway elevation

NOTE: Class A equipment will be entitled to a TSO-C92c authorization approval for the purpose of complying with the mandatory GPWS requirements in 14 CFR §§ 121.360 and 135.153, until such time that those rules are superceded by TAWS rules.

f. Class B equipment must provide indications of imminent contact with the ground during the following airplane operations as defined in section 3.4 of this appendix.

(1) Excessive Rates of Descent
(2) Negative Climb Rate or Altitude Loss After Takeoff
(3) A voice callout "Five Hundred" when the airplane descends to 500 feet above the nearest runway elevation.

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 and software verification and validation requirements as provided under this TSO. 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 TSO envisions a TAWS based on the use of an onboard terrain and airport database, other technologies such as the use of radar are not excluded. Other concepts and technologies may be approved under this TSO using 14 CFR § 21.609, Approval for Deviation.

2.0 DEFINITIONS.

2.1 Alert. A visual, aural, or tactile stimulus presented to attract attention and convey information regarding system status or condition.

2.2 Aural Alert. A discrete sound, tone, or verbal statement used to annunciate a condition, situation, or event.

2.3 Caution Alert. An alert requiring immediate crew awareness. Subsequent corrective action will normally be necessary.

2.4 Controlled Flight Into Terrain (CFIT). An accident or incident in which an airplane, under the full control of the pilot, is flown into terrain, obstacles, or water.

2.5 Failure. The inability of the equipment or any sub-part of that equipment to perform within previously specified limits.

2.6 False Alert. An inappropriate alert that occurs as a result of a failure within the TAWS or when the design alerting thresholds of the TAWS are not exceeded.

2.7 Hazard. A hazard is a state or set of conditions that together with other conditions in the environment could lead to an accident.

2.8 Hazardously Misleading Information (HMI). An incorrect depiction of the terrain threat relative to the airplane during an alert condition (excluding source data).

2.9 Nuisance Alert. An inappropriate alert, occurring during normal safe procedures, that occurs as a result of a design performance limitation of TAWS.

2.10 Search Volume. A volume of airspace around the airplane's current and projected path that is used to define a TAWS alert condition.

2.11 Visual Alert. The use of projected or displayed information to present a condition, situation, or event.

2.12 Warning Alert. An alert for a detected terrain threat that requires immediate crew action.

3.0 REQUIRED TAWS FUNCTIONS.

3.1 Class A and Class B Requirements for Forward Looking Terrain Avoidance (FLTA). The majority of CFIT accidents have occurred because the flight crews did not have adequate situational information regarding the terrain in the vicinity of the airplane and its projected flight path. Class A and Class B Equipment will be required to look ahead of the airplane, within their 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 airplane's flight path, and a specified look down distance based upon the airplane's vertical flight path. This search volume should vary as a function of phase of flight, distance from runway, and the required obstacle clearance (ROC) in order to perform its intended function and to minimize 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 Handbook 8260.3B and ICAO PANOPS 8168, volume 2, to prevent nuisance alerts.

3.1.1 Reduced Required Terrain Clearance (RTC). Class A and Class B equipment must provide suitable alerts when the airplane is currently above the terrain in the airplane'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) have been used to define the minimum requirements for obstacle/terrain clearance (RTC) appropriate to the FLTA function. These requirements are specified in Table **3.1**. The FLTA function must be tested to verify the alerting algorithms to meet the test conditions specified in appendix 3, Tables A, B, C, D, E, and F.

TABLE 3.1

TAWS REQUIRED TERRAIN CLEARANCE (RTC) BY PHASE OF FLIGHT

Phase of Flight	TERPS (ROC)	TAWS (RTC) Level Flight	TAWS (RTC) Descending
Enroute	1000 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/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 airplane is projected to be within 100 feet vertically of terrain. However, Class A and Class B equipment should not alert if the airplane 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 in Table **3.1**, a linear reduction of the RTC as the aircraft comes closer to the nearest runway is allowed, providing the requirements of Table **3.1** 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 minimize nuisance alerts. Below a certain altitude or distance from the runway threshold, logic may be incorporated to inhibit the FLTA function. Typical operations below Minimum Descent Altitude (MDA), Decision Height (DH), or the Visual Descent Point (VDP) should not generate nuisance alerts.

NOTE 4: The specified 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 airplane is currently below the elevation of a terrain cell along the airplane'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**. See appendix **3** 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 3.1.1 and 3.1.2 above when the airplane 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 airplane 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 airplane 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 airplanes have crashed into the ground short of the runway. A means to detect and alert the flight crew to this condition is an essential safety requirement of this TSO. There are numerous ways to accomplish the overall objectives of this requirement. Alerting criteria may be based upon height above runway elevation and distance to the runway. It may be based upon height above terrain and distance to runway or other suitable means. This TSO will not define the surfaces for which alerting is required. It will specify some general requirements for alerting and some cases when alerting is inappropriate. See appendix 3 Table H for test requirements.

a. The PDA function should be available for all types of instrument approaches. This includes both straight-in approaches and circling approaches. This includes approaches that are not aligned within 30 degrees of the runway heading.

b. The TAWS equipment should not generate PDA alerts for normal VFR operations in the airport area. Airplanes routinely operate at traffic pattern altitudes of 800 feet above field/runway elevation for traffic pattern operations within 5 NM of the airport.

c. Airplanes routinely operate in VFR conditions at 1000 feet AGL within 10-15 NM of the nearest airport and these operations should not generate alerts.

d. Airplanes 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 should not cause PDA alerts or FLTA alerts.

3.3 Class A Requirements for GPWS Alerting. In addition to the TAWS Forward Looking Terrain Avoidance and PDA functions, the equipment must provide the GPWS functions listed below in accordance with TSO-C92c. Some GPWS alerting thresholds may be adjusted or modified to be more compatible with the FLTA alerting functions and to minimize GPWS nuisance alerts. However, it is essential to retain the independent protective features provided by both the GPWS and FLTA functions. In each case, all the following situations must be covered. The failure of the TSO-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.

The functions described in TSO-C92c and the referenced document RTCA/DO-161A include:

(1) Excessive Rates of Descent
(2) Excessive Closure Rate to Terrain
(3) Negative Climb Rate or Altitude Loss After Take-Off
(4) Flight Into Terrain When Not in Landing Configuration
(5) Excessive Downward Deviation From an ILS Glideslope

a. Flap Alerting Inhibition. A separate guarded control may be provided to inhibit GPWS alerts based on flaps being other than the landing configuration.

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. Voice Callouts. Voice callouts of altitude above the terrain must be provided during nonprecision approaches per TSO-C92, but are recommended for all approaches. These advisories are normally, but are not limited to 500 feet above the terrain or the height above the nearest runway threshold elevation.

d. Barometric Altitude Rate. Class A and Class B equipment may compute Barometric Altitude Rate using an Instantaneous Vertical Speed Indicator (IVSI) or an inertial smoothed vertical speed indicator. An alternative means, with demonstrated equal or better accuracy, may be used in lieu of barometric altitude rate (accuracy specified in TSO-C10b, Altimeter, Pressure

Actuated, Sensitive Type, or later revisions) and/or altimeter altitude (accuracy specified in TSO-C67, Airborne Radar Altimeter Equipment - for air carrier aircraft, or later revisions) to meet the warning requirements described in RTCA/DO-161A. In addition, TSO-C106 for Air Data Computers may be used as an alternative means of compliance with this provision.

e. 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.

> **NOTE:** Class A equipment will be entitled to a TSO-C92c authorization approval for the purpose of complying with the mandatory GPWS requirements in 14 CFR §§ 121.360 and 135.153 until such time that those rules are superceded by TAWS rules.

3.4 Class B Requirements for GPWS Alerting

a. Class B equipment must provide alerts for excessive descent rates. The alerting envelope of RTCA/DO-161A has been modified to accommodate a larger envelope for both caution and warning alerts. Height above Terrain may be determined by using the Terrain Data Base elevation and subtracting it from QNH barometric altitude (or equivalent). In addition, since the envelopes are not limited by a radio altitude measurement to a maximum of 2500 feet AGL, the

envelopes are expanded to include higher vertical speeds. The equipment must meet either the requirements set forth in appendix **3**, section 7.0 or that specified in 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 is identical to the alerting envelope in RTCA/DO-161A except that Height above Terrain is based upon Height above Runway threshold elevation instead of radio altitude.

c. Class B equipment must provide a voice callout "Five Hundred" during descents for landing. This feature is primarily intended to provide situational awareness to the flight crew when the airplane is being operated properly per normal procedures. During a normal approach, it is useful to provide the flight crew with a 500-foot voice callout referenced to the runway threshold elevation for the runway of intended landing. This feature also has an important CFIT protection function. In the event the airplane is operated unintentionally close to terrain when not in the airport area or the area for which PDA protection is provided, a 500-foot voice callout referenced to Height above Terrain will alert the flight crew to a hazardous condition.

The equipment must meet the requirements specified in appendix **3**, section 9.0.

> **NOTE 1:** Class B equipment will not require a radio altimeter. Height above Terrain may be determined by subtracting the elevation of the current position terrain cell from the current barometric altitude (or equivalent).
>
> **NOTE 2:** Class B equipment should compute the voice callout for five hundred feet based upon barometric height above runway elevation. The nearest runway elevation may be used for this purpose.

3.5 Class A Equipment Requirements for a Terrain Display. Class A equipment must be designed to interface with a Terrain Display, either color or monochromatic. Class A equipment for TAWS must be capable of providing the following terrain related information to a display system.

a. The terrain must be depicted relative to the airplane's position such that the pilot may estimate the relative bearing to the terrain of interest.

b. The terrain must be depicted relative to the airplane'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 track of the airplane. In addition, a North-up orientation may be added as a selectable format.

d. Variations in terrain elevation depicted relative to the airplane's elevation (above and below) must be visually distinct. Terrain that is more than 2000 feet below the airplane's elevation need not be depicted.

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.

NOTE: This TSO does not include requirements for the display system/hardware.

4.0 AURAL AND VISUAL ALERTS.

4.1 The TAWS is required to provide aural alerts and visual alerts for each of the functions described in section 3.0 of this appendix.

4.2 The required aural and visual alerts must initiate from the TAWS system simultaneously, except when suppression of aural alerts are necessary to protect pilots from nuisance aural alerting.

4.3 Each aural alert must identify the reason for the alert such as “too low terrain” and “Glideslope,” or other 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 airplane performance related data or airplane 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.

4.7 The aural and visual alerts should be selectable to accommodate operational commonality among fleets of airplanes.

4.8 The visual display of alerting information must be immediately and continuously displayed until the situation is no longer valid.

4.9 As 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.

TABLE 4 – 1

STANDARD SET OF VISUAL AND AURAL ALERTS		
Alert Condition	**Caution**	**Warning**
Reduced Required Terrain Clearance Class A & Class B	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the Aural message. **Aural Alert** 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 Alert** Minimum Selectable Voice Alerts: "Terrain, Terrain; Pull-Up, Pull- up" **and** "Terrain Ahead, Pull- up; Terrain Ahead, Pull-Up"
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 Alert** 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 Alert** 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 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) 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"
Ground Proximity Excessive Closure Rate (Landing Configuration) 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** None Required. **Aural Alert** "Pull-Up" – for gear up None Required – for gear down

FAA Standard associated with ETSO–C151b

TABLE 4 – 1 (Continued)

STANDARD SET OF VISUAL AND AURAL ALERTS		
Alert Condition	**Caution**	**Warning**
Ground Proximity Altitude Loss after Take-off Class A & Class B	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the Aural message. **Aural Alert** "Don't Sink" and "Too Low-Terrain"	**Visual Alert** None Required. **Aural Alert** None Required.
Ground Proximity Envelope 1 (Not in Landing Configuration) Class A	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the Aural message. **Aural Alert** "Too Low Terrain" and "Too Low Gear"	**Visual Alert** None Required. **Aural Alert** None Required.
Ground Proximity Envelope 2 Insufficient Terrain Clearance (Landing and Go-around configuration) Class A	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the Aural message. **Aural Alert** "Too Low Terrain" and "Too Low Flaps"	**Visual Alert** None Required. **Aural Alert** None Required
Ground Proximity Envelope 3 Insufficient Terrain Clearance (Take-off configuration) 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
Ground Proximity Excessive Glide Slope Deviation Class A	**Visual Alert** Amber text message that is obvious, concise, and must be consistent with the Aural message. **Aural Alert** "Glide Slope"	**Visual Alert** None Required. **Aural Alert** None Required
Ground Proximity Voice Call Out (See Note 1) Class A & Class B	**Visual Alert** None Required **Aural Alert** "Five Hundred"	**Visual Alert** None Required. **Aural Alert** None Required

NOTE 1: The aural alert for Ground Proximity Voice Call Out 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 colored annunciator lamps meet the alerting color requirements.

4.10 Prioritization

a. Class A Equipment. Class A Equipment must have an interactive capability with other external alerting systems so an alerting priority can be automatically executed for the purpose of not causing 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 Windshear (PWS), Reactive Windshear (RWS), and possibly in the future Traffic Collision Avoidance System (TCAS). Table **4-2** includes an alert prioritization scheme. If the PWS, RWS and/or TCAS functions are provided within the TAWS, Table **4-2** also applies. The FAA will consider alert prioritization schemes other than the one included in Table **4-2**.

b. Class B Equipment. Class B Equipment does not require prioritization with external systems such as TCAS, RWS, and PWS. If prioritization with those functions is provided, the prioritization scheme must be in accordance with the Table **4-2**.

c. Class B Equipment. Class B equipment must establish an internal priority alerting system (scheme) for each of the functions. The priority scheme must ensure that more critical alerts override the presentation of any alert of lesser priority. Table **4-3** is the internal priority scheme of the system. Class B equipment need only consider the TAWS functions required for Class B equipment.

FAA Standard associated with ETSO–C151b

Table 4-2

ALERT PRIORITIZATION SCHEME			
Priority	Description	Alert Level [b]	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	C	3 s period
20	PWS Caution	C	
21	Approaching Minimums	I	
22	Bank Angle	C	
23	Reactive Windshear Caution	C	
Mode 6 [a]	TCAS RA ("*Climb*", "*Descend*", etc.)	W	continuous
Mode 6 [a]	TCAS TA ("*Traffic, Traffic*")	C	Continuous

NOTE 1: These alerts can occur simultaneously with TAWS voice callout alerts.

NOTE 2: W = Warning, C = Caution, A = Advisory, I = Informational

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 Callouts "500"
6.	Sink Rate
7.	Don't Sink (Mode 3)

4.11 During ILS 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.

NOTE 1: Non-GPS RNAV/FMC Systems that are used for the TAWS airplane horizontal airplane information may be "Localizer Updated" to remove cross track errors. In addition, the alerting envelope may be modified to account for the higher accuracy and closer obstacles associated with ILS conditions.

NOTE 2: GPS-based Systems that are used for the TAWS airplane horizontal airplane position information should be able to meet the minimum criteria found in appendix **1**, section 5.0.

NOTE 3: The level off initiation height of 20 percent 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 level off (altitude capture) algorithms whereas the technique of using 10 percent of the existing vertical speed as a level off initiation point is usually considered as a minimum appropriate only to manual operations of smaller general aviation airplanes. With high rates of descent, experienced pilots often use a manual technique of reducing the vertical speed by one half when reaching 1000 feet above/below the level off altitude. This technique will significantly reduce the likelihood of nuisance alerts. In the event that use of the 20 percent of vertical speed as a minimum standard for nuisance free operations is shown not to be compatible with the installed autopilot or flight director level off (altitude capture) algorithms, consideration should be given to setting the alert logic closer to the 10 percent vertical speed criteria to minimize nuisance alerts.

5.0 AIRPLANE HORIZONTAL POSITION DETERMINATION FOR SOURCE DATA.

5.1 Class A equipment. Class A equipment that uses the on-board airplane navigation system for horizontal position information for the TAWS and that meets TSO-C115 or follows AC90-45A for approved RNAV systems, TSO-C129a for GPS, TSO-C145 for WAAS, or that follows the recommendations in AC 20-130a or AC-138 are considered acceptable. See note below.

5.2 Class B equipment. Class B equipment will be required to interface with an approved GPS for horizontal position information as specified in 5.1. See note below.

> **NOTE:** Experience with these systems to date and analysis support that, as position accuracy decreases, a larger area must be considered for alerts in order for the system to perform its intended function. As the area of consideration is expanded and position accuracy is decreased the system tends to become more prone to nuisance alerts. In order to keep the system nuisance free, the TAWS must be inhibited or its operation degraded to accommodate certain types of operations. Therefore designers should be aware that at the present time only systems that use position information which provides GPS accuracy will be considered to meet this TSO except for aircraft operated under 14 CFR part 121. Operations under 14 CFR part 121 provide factors that compensate for the decreased accuracy. These factors include type of operation, route structure analysis, flight crew training, route proving requirements, continued surveillance, and extensive operations into a limited number of airports.

5.3 Internal GPS Navigator Function. Class A and Class B equipment that use a GPS internal to the TAWS for horizontal position information and are capable of detecting a positional error that exceeds the appropriate alarm limit for the existing phase of flight in accordance with TSO - C129a/RTCA/DO-208, or equivalent are considered acceptable. When this alarm limit is activated, the GPS computed position is considered unsuitable for the TAWS function, and an indication should be provided to the flight crew that the TAWS functions that require GPS for operation are no longer available.

6.0 CLASS A AND CLASS B REQUIREMENTS FOR A TERRAIN AND AIRPORT DATABASE.

6.1 Minimum Geographical Considerations. As a minimum, terrain and airport information must be provided for the expected areas of operation, airports and routes to be flown.

6.2 Development and Methodology. The manufacturer must present the development and methodology used to validate and verify the terrain and airport information. RTCA/DO-200A/EUROCAE ED 76, Standards for Processing Aeronautical Data, should be used as a guideline.

6.3 Resolution. Terrain and airport information must be of the accuracy and resolution suitable for the system to perform its intended function. Terrain data should be gridded at 30 arc seconds with 100 foot resolution within 30 nautical miles of all airports with runway lengths of 3500 feet or greater and whenever necessary (particularly in mountainous environments) 15 arc seconds with 100 foot resolution (or even 6 arc seconds) within 6 nautical miles 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 3500 feet whether public or private. Small airplane owners and operators, and small non-schedule part 135 operators probably will be the largest market for Class B equipment. Such operators frequently use airports of less than 3500 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 Updates and Continued Airworthiness. The system must be capable of accepting updated terrain and airport information.

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 must be provided to inform the flight crew whenever the system has failed or can no longer perform the intended function.

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 A TERRAIN AWARENESS INHIBIT FOR THE FLTA FUNCTION, THE PREMATURE DESCENT ALERT FUNCTION AND TERRAIN DISPLAY.

9.1 Manual Inhibit. Class A equipment must have the capability, via a control switch to the flight crew, to inhibit only the FLTA function, the Premature Descent Alert function, and Terrain Display. This is required in the event of a navigational system failure or other failures that would adversely affect FLTA, the Premature Descent Alert function or the Terrain Display. The basic TAWS required functions must remain active when the inhibit function is utilized.

9.2 Automatic Inhibit. The capability of automatically inhibiting Class A functions within TAWS equipment is acceptable utilizing the conditions described in section 7.0. If auto inhibit capability is provided, the "inhibit status" must be annunciated to the flight crew.

10.0 PHASE OF FLIGHT DEFINITIONS. The TAWS equipment search volumes and alerting thresholds should vary as necessary to be compatible with TERPS and other operational considerations. For that 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 will comply with the test criteria specified in appendix **3**.

10.1 Enroute Phase. The Enroute Phase exists anytime the airplane 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 airplane is 15 NM or less from the nearest runway while the range to the nearest runway threshold is decreasing and the airplane is at or below (lower than) a straight line drawn between the two points specified in Table **10-1** relative to the nearest runway.

TABLE 10-1

HEIGHT ABOVE RUNWAY VERSUS DISTANCE TO RUNWAY

Distance to Runway	Height above Runway
15 NM	3500 Feet
5 NM	1900 Feet

10.3 Approach Phase. Distance to nearest runway threshold is equal to, or less than 5 NM; and height above the nearest runway threshold location and elevation is equal to, or less than 1900 feet; and 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 airplane is on the ground upon initial power-up. If, for example, the equipment can determine that the airplane 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 airplane reaches 1500 feet above the departure runway, the Departure Phase is ended.

FAA Standard associated with ETSO–C151b

11.0 CLASS A AND CLASS B SUMMARY REQUIREMENTS. A Summary Table of Requirements is provided in Table **11-1**. This is provided only as convenience and general information. Official, regulatory requirements are contained in the Federal Aviation Regulations.

TABLE 11-1

CLASS A AND B SUMMARY REQUIREMENTS								
TAWS CLASS	OPERATING RULE	PAX SEATS (MIN)	FLTA	PDA	GPWS DO-161A	FMS/RNAV OR GPS	TERRAIN DISPLAY MANDATORY	TERRAIN/ AIRPORT DATABASE
A	121	See Note	YES	YES	1-6	FMS OR GPS	YES	YES
A	135	>9	YES	YES	1-6	GPS	YES	YES
B	135	6-9	YES	YES	1,3,6	GPS	NO	YES
B	91	= or >6	YES	YES	1,3,6	GPS	NO	YES

NOTE: There is no seat threshold for 14 CFR part 121. All 14 CFR part 121 airplanes affected by the TAWS rules must install TAWS regardless of number of seats.

APPENDIX 2. STANDARDS APPLICABLE TO ENVIRONMENTAL TEST PROCEDURES

RESERVED FOR MODIFICATIONS OF OR ADDITIONAL REQUIREMENTS BEYOND THE TEST PROCEDURES CONTAINED IN RTCA DOCUMENT No. (RTCA/DO)-160D.

APPENDIX 3. TEST CONDITIONS

1.0 FORWARD LOOKING TERRAIN AVOIDANCE - REDUCED REQUIRED TERRAIN CLEARANCE (RTC) TEST CONDITIONS. This condition exists, when the airplane 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 Required Terrain Clearance (RTC).

1.1 Phase of Flight Definitions. For the following test conditions, refer to appendix 1, paragraph 10.0 for an expanded discussion on the definitions of the phases of flight.

1.2 Enroute Descent Requirement. A terrain alert must be provided in time so as to assure that the airplane 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 airplane. The test conditions assume a descent along a flight path that has terrain that is 1000 feet below the expected level off altitude. If the pilot initiates the level off at the proper altitude, no TAWS alert would be expected. However, if the pilot is distracted or otherwise delays the level off, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

a. See 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 3, section 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 1.2:

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:	1000, 2000, 4000, and 6000 fpm

Assumed Pilot Task for Column F: Level off at 1000 feet above the terrain per TERPS Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the airplane 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 15nm 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 airplane is

in terminal airspace.

NOTE 3: The values shown in column E may be reduced by 100 feet (to permit a level off 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 14 CFR part 25 certificated airplanes (Large Airplanes). The values are based upon 20 percent of the airplanes vertical velocity. If TAWS is installed on an airplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts based upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation airplane 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 CAUTION ALERT HEIGHT (ABOVE TERRAIN)
1000	50	17	67	567	1200
2000	100	69	169	669	1400
4000	200	278	478	978	1800

1.3 Enroute Level Flight Requirement. During level flight operations (vertical speed is +/- 500 feet per minute), a terrain alert should be posted when the airplane 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 1: The actual values for the airplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

TABLE B

Enroute Level Flight Alerting Criteria			
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA
200	5000	6000	NO ALERT
250	5000	5800	NO ALERT
300	5000	5800	NO ALERT
200	5000	5700 (+0/-100)	MUST ALERT
250	5000	5700 (+0/-100)	MUST ALERT
300	5000	5700 (+0/-100)	MUST ALERT
400	5000	5700 (+0/-100)	MUST ALERT
500	5000	5700 (+0/-100)	MUST ALERT

1.4 Terminal Area (Intermediate Segment) Descent Requirement. A terrain alert must be provided in time so as to assure that the airplane can level off (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 airplane. The test conditions assume a descent along a flight path that has terrain that is 500 feet below the expected level off altitude. If the pilot initiates the level off at the proper altitude, no TAWS alert would be expected. However, if the pilot is distracted or otherwise delays the level off, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

a. See 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 3, section 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 1.4:

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:	1000, 2000, and 3000 fpm

Assumed Pilot Task for Column F: Level off at 500 feet above the terrain per TERPS Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the airplane 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 14 CFR part 25 certificated airplanes (Large Airplanes). The values are based upon 20 percent of the airplanes vertical velocity. If TAWS is installed on an airplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation airplane operations.

TABLE C

Terminal Descent Area Alerting Criteria					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 1 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)
1000	17	17	34	334	700
2000	33	69	102	402	900
3000	50	156	206	506	1100

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 airplane is less than 350 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 1: The actual values for the airplane 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	1000	1500	NO ALERT
200	1000	1500	NO ALERT
250	1000	1500	NO ALERT
100	1000	1350	MUST ALERT
150	1000	1350	MUST ALERT
200	1000	1350	MUST ALERT
250	1000	1350	MUST ALERT

1.6 Final Approach Segment Descent Requirement. A terrain alert must be provided in time to assure that the airplane can level off (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 airplane.

a. See 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 **3**, section 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:	0.25 g's
Minimum Allowed Terrain Clearance:	100 feet AGL
Descent rates:	500, 750, 1000, and 1500 fpm

Assumed Pilot Task for Column F: Level off at 250 feet above the terrain per TERPS Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the airplane 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 14 CFR part 25 certificated airplanes (Large Airplanes). The values are based upon 20 percent of the airplanes vertical velocity. If TAWS is installed on an airplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts based upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation airplane operations.

TABLE E

A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 1 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)
500	8	4	12	112	350
750	12	10	22	122	400
1000	17	18	35	135	450
1500	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 airplane 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 1: The actual values for the airplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

TABLE F

Final Approach Level Flight Alerting Criteria:				
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	DISTANCE TERRAIN FROM RWY (NM)	TEST RUN ALTI-TUDE (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 airplane 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 0.25 g incremental pull to constant 6.0 degree climb gradient, compute and record the airplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the airplane 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 (-100 feet or -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	10000	30	9000	MUST ALERT
250	10000	30	9000	MUST ALERT
300	10000	30	9000	MUST ALERT
400	10000	30	8000	MUST ALERT
500	10000	30	8000	MUST ALERT
150	2000	10	1500	MUST ALERT
200	2000	10	1500	MUST ALERT
250	2000	10	1500	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 PREMATURE DESCENT ALERT TEST CONDITIONS. The purpose of this test is to verify that the pilot will be alerted to a "low altitude condition" at an altitude that is defined by the specific design PDA Alert surface. This TSO will not define specific pass/fail criteria since, as stated in paragraph 3.2 of appendix **1**, it does not define the surfaces for which alerting is required. The applicant must provide its proposed pass/fail criteria along with the proposed recovery procedures for the specific alerting criteria proposed by the applicant. In developing its test plan, the applicant should refer to paragraph 3.2 of appendix **1** that contain some general requirements for alerting and some cases when alerting is inappropriate. The applicant also may want to consider the recovery procedures specified in sections 1.2, 1.4, and 1.6 of paragraph 1 of appendix **3**. The following test conditions must be conducted to evaluate PDA performance.

3.1 Test Conditions for 3.0 Premature Descent Alerts.
Descent rates: 750, 1500, 2000, 3000 FPM
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.

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	1500	15		
120	750	15		
140	1500	15		
160	750	15		
200	1500	15		
250	2000	15		
80	750	12		
100	1500	12		
120	750	12		
140	1500	12		
160	750	12		
80	750	4		
100	1500	4		
120	750	4		
140	1500	4		
80	750	2		
100	1500	2		
120	750	2		
140	1500	2		

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 4000 FPM. It must be possible to descend at 4000 FPM in the enroute airspace and level off 1000 feet above the terrain using a normal level off procedure (leading the level off by 20 percent of the vertical speed) without a caution or warning alert. See Table **A.**

4.2 2000 FPM. It must be possible to descend at 2000 FPM in the Terminal area and level off 500 feet above the terrain using the normal level off procedure described in 4.1 above, without a caution or warning alert. See Table **C**.

4.3 1000 FPM. It must be possible to descend at 1000 FPM in the Final Approach Segment and level off at the Minimum Descent Altitude (MDA) using the normal level off procedure described in 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 airplane is conducting normal flight operations in accordance with published instrument approach procedure. This assumes the normal range in variation of input parameters.

5.1 Test Cases. As a minimum, the following cases (1-9) must be tested twice; one set of runs will be conducted with no lateral or vertical errors while another set of runs will be conducted with both lateral and vertical Flight Technical Errors (FTE). A lateral FTE of 0.3 NM and a vertical FTE of -100 feet (aircraft is closer to terrain) up to the FAF and a lateral FTE of 0.3 NM and a vertical FTE of -50 feet from the FAF to the Missed Approach Point (MAP) must be simulated. For all listed VOR, VOR/DME and Localizer based approaches, from the FAF to the MAP the airplane will descend at 1000 FPM until reaching either MDA (run #1) or MDA-50 feet (run #2). The airplane will then level off and fly level until reaching the MAP. Localizer updating of lateral position errors (if provided) may be simulated.

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 Operations Assessment Division, DTS-43, Volpe National Transportation Systems Center, Cambridge, Massachusetts or at the FAA web page at the following address: http://www.faa.gov/avr/air/airhome.htm or http://www.faa.gov and then select "Regulation and Certification", select "Aircraft Certification".

6.1 Test Report. The test report should include as many of the following parameters use to recreate the events. They are (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 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 airplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the airplane 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. In each of the test cases below, it must be necessary to demonstrate that the airplane profile clears the terrain cell of interest.

TABLE J

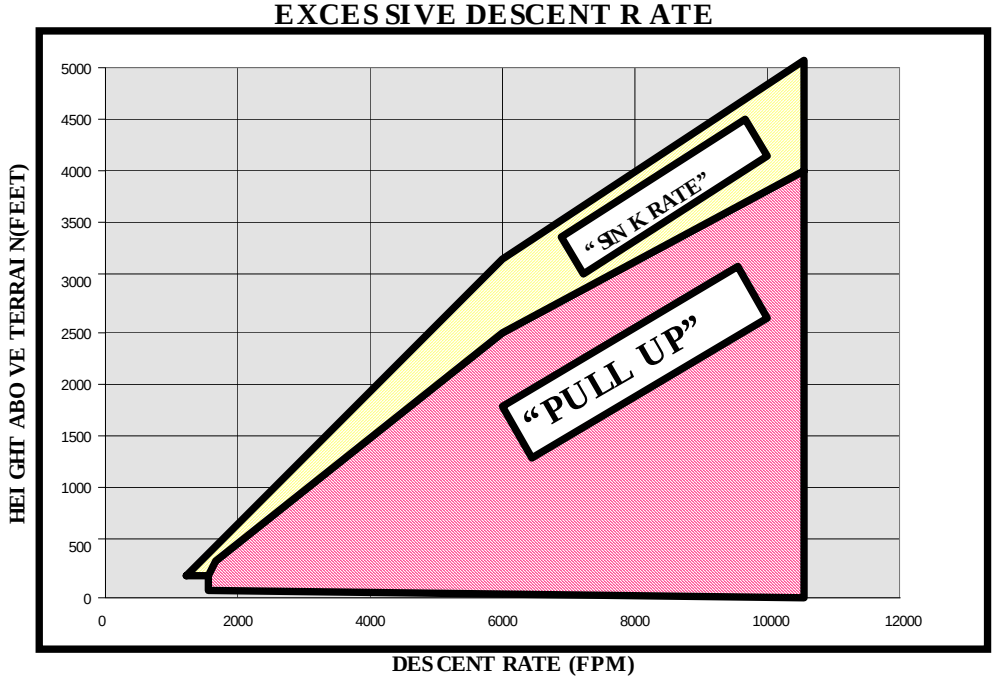
Known Accident Cases			
LOCATION	IATA CODE	DATE	AIRCRAFT REGISTRATION NUMBER
La Paz, Bolivia		1/1/85	N819EA
Flat Rock, NC		8/23/85	N600CM
Windsor, MA		12/10/86	N65TD
Eagle, CO		3/27/87	N31SK
Tegucigalpa, Honduras		10/21/89	N88705
Halawa Point, HI		10/28/89	N707PV
San Diego, CA		3/16/91	N831LC
Rome, GA		12/11/91	N25BR
Gabriels, NY		1/3/92	N55000
Alamogordo, NM		6/24/92	N108SC
E. Granby, CT		11/12/95	N566AA
Buga, Columbia		12/20/95	N651AA
Nimitz Hill, Guam		8/6/97	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. Instead of using Height of Terrain as determined by a radio altimeter, determine "Height above Terrain" as determined by subtracting the Terrain Elevation (from the Terrain Data Base) from the current QNH barometric altitude (or equivalent). The curve represents the minimum heights at which alerting must occur.

NOTE: Class B equipment may be designed to meet the requirements of RTCA/DO-161A for Excessive Descent Rate in lieu of the requirements of 7.0

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 (or equivalent) and runway elevation in lieu of radio altimeter inputs.

9.0 CLASS B EQUIPMENT TEST REQUIREMENTS FOR THE ALTITUDE CALLOUTS. Instead of using Height of Terrain as determined by a radio altimeter, determine Height above runway as determined by subtracting the Runway Elevation (from the Airport Data Base) from the current barometric altitude (or equivalent). When the Height above Terrain value first reaches 500 feet, a single voice alert ("Five Hundred ") or equivalent must be provided.



APPENDIX 4. FEDERAL AVIATION ADMINISTRATION 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 TSO for General Aviation (GA) category of aircraft not required to have TAWS equipment installed. Class C equipment is intended for small GA airplanes that are not required to install Class B equipment.

1.2 This appendix contains only modifications to existing requirements in this TSO. 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 **3**.

2.0 CLASS C.

Class C TAWS equipment must meet all the requirements of a Class B TAWS with the small aircraft 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 B TAWS required by 14 CFR parts 91, 135, and 121.

Modifications to Appendix 1.

Minimum performance Standards, MPS

1.1 Phase of Flight Definitions. For appendix **4**, 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 airplane is below 1,000 feet.
Cruise – anytime the airplane is outside the airport traffic control area.
Landing – inside traffic area and distance to nearest runway threshold is decreasing, and airplane is below 1,000 feet.

1.2 Altitude Accuracy. 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. If the TAWS includes a terrain display output, this reference altitude value used for the TAWS alerts should also be output for display. Since the altitude value is necessarily based upon GPS derived MSL altitude, which is required for horizontal position in all class B & C TAWS, the displayed value must be labeled MSL/G or MSL-G, or other obvious acronym that relates to the pilot that altitude is GPS derived MSL altitude.

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 Altered Table **3.1** applies to small aircraft flying visually, and the TERPS criteria need not apply to TAWS. Thus, ROC numbers more appropriate to low level visual flight have been chosen.

Alternate Table 3.1 is shown below.

TABLE 3.1

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

TABLE 4 – 1

STANDARD SET OF VISUAL AND AURAL ALERTS		
Alert Condition	**Caution**	**Warning**
Terrain Awareness Reduced Required Terrain Clearance	**Visual Alert** Amber text message that is obvious, concise, and must be 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 must be consistent with the Aural message. **Aural Alert** Minimum Selectable Voice Alert: "Terrain; Terrain"
Terrain Awareness Imminent Impact with Terrain	**Visual Alert** Amber text message that is obvious, concise, and must be 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 must be 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 Take-off	**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 Call Out (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 Call Out 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 colored enunciator lamps meet the alerting color requirements. Audio alerts are still required regardless of terrain display visual alerts.

FAA Standard associated with ETSO–C151b

Modifications to Appendix 3, Test Conditions.

NOTE 1: Paragraph 1.1 of the TSO is not applicable; for small aircraft only three phases of flight are considered, take-off, cruise, and final approach to landing

NOTE 2: Paragraph 1.2 of the TSO 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 so as to assure that the airplane can level off (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 airplane. The test conditions assume a descent along a flight path that has terrain that is 500 feet below the expected level off altitude. If the pilot initiates the level off at the proper altitude, no TAWS alert would be expected. However, if the pilot is distracted or otherwise delays the level off, a TAWS alert is required to permit the pilot to recover to level flight in a safe manner.

a. See 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 **3**, section 4.0

b. For each of the Descent rates specified below, recovery to level flight at or above 200 feet terrain clearance is required.

c. Test Conditions for 1.2:

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, 1000, and 2000 fpm

Assumed Pilot Task for Column F: Level off at 500 feet above the terrain per Appendix 4 Table 3–1 Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the airplane 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 airplane is in terminal airspace.

NOTE 3: The values shown in column E may be reduced by 50 feet (to permit a level off to occur at 150 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: The values shown in Column F are appropriate for an airplane without an Autopilot or Flight Director function, and are based upon 10-15 percent of the vertical velocity, which is appropriate to manual flight and small general aviation airplane 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 3 SEC 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
1000	50	4	54	254	600
2000	100	17	117	317	800

TSO Note: Paragraph 1.3 in the TSO 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 airplane 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 1: The actual values for the airplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

TABLE B

Level Cruise Flight Alerting Criteria			
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA
100	5000	5340 (+0/-50)	NO ALERT
150	5000	5340 (+0/-50)	NO ALERT
200	5000	5340 (+0/-50)	NO ALERT
100	5000	5240 (+0/-50)	MUST ALERT
150	5000	5240 (+0/-50)	MUST ALERT
200	5000	5240 (+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. See 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 **3**, section 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 1000 fpm

Assumed Pilot Task for Column F: Level off at 250 feet above the terrain per Appendix 4, Table 3–1 Required Obstacle Clearance (ROC).

NOTE 1: The actual values for the airplane 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 airplane without an Autopilot or Flight Director function, and are based upon 10 percent of the vertical velocity that is appropriate to manual flight and small general aviation airplane operations.

TABLE E

Approach Descent Alerting Criteria					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 1 SEC 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	8	1	9	109	300
750	12	2	14	114	325
1000	17	4	21	121	350

1.7 Landing Flight Requirement. Applies as written.

2.0 through 2.2. FORWARD LOOKING TERRAIN AVOIDANCE IMMINENT IMPACT 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 in Note 2.

3.0 and 3.1 PREMATURE DESCENT ALERT TEST CONDITIONS. Apply as written.

4.0 NUISANCE ALERT TEST CONDITIONS - GENERAL. Apply as written.

4.1 4000 FPM. Not applicable.

4.2 2000 FPM. It must be possible to descend at 2000 FPM and level off 500 feet above the terrain using a normal level off procedure (leading the level off by 10 percent of the vertical speed), without a caution or warning alert.

4.3 1000 FPM. It must be possible to descend at 1000 FPM in the Final Approach Segment and level off at 250 feet using the normal level off 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 are to be determined by the applicant using actual NTSB 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 **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.

9.0 CLASS C EQUIPMENT TEST REQUIREMENTS FOR THE ALTITUDE CALLOUTS. Apply Class B as written.

CS-ETSO INDEX 2

Replace the following amended ETSO
ETSO-2C123b
ETSO-2C124b
Insert the following new ETSO:
ETSO-2C510
ETSO-2C511
ETSO-2C507
ETSO-2C508
ETSO-2C509

ETSO-2C123b
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: COCKPIT VOICE RECORDER SYSTEMS

1 - Applicability

This ETSO gives the requirements that new models of the Cockpit Voice Recorder functional elements of crash protected airborne recorder systems that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

2 - Procedures

2.1 - General

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

~~Standards set forth in EUROCAE document ED-56A chapter 2, 3, 4, 5, and 6, dated October 1993,~~
~~with amendment 1 dated 25 November 1997, as amended and supplemented by this ETSO.~~

Standards set forth in Sections 1 to 5 and Part I of EUROCAE document ED-112 dated March 2003.

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.

3.2 - Specific

None.

4 – Marking

4.1 - General

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

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

ETSO-2C124b
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: FLIGHT DATA RECORDER SYSTEMS

1 - Applicability

This ETSO gives the requirements that new models of the Flight Data Recorder functional elements of crash protected airborne recorder systems that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

2 - Procedures

2.1 - General

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

~~Standards set forth in EUROCAE document ED-55 dated May 1990 with amendment 1 dated 23~~
~~September 1998, as amended and supplemented by this ETSO.~~

Standards set forth in Sections 1 to 5 and Part II of EUROCAE document ED-112 dated March 2003.

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.

3.2 - Specific

None.

4 - Marking

4.1 - General

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

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

ETSO-2C510
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: CRASH PROTECTED AIRBORNE RECORDER SYSTEMS – IMAGE RECORDER

1 - Applicability

This ETSO gives the requirements that new models of the Image Recorder functional elements of crash protected airborne recorder systems that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

2 - Procedures

2.1 - General

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

Standards set forth in Sections 1 to 5 and Part III of EUROCAE document ED-112 dated March 2003.

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.

3.2 - Specific

None.

4 - Marking

4.1 - General

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

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

ETSO-2C511
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: CRASH PROTECTED AIRBORNE RECORDER SYSTEMS – CNS/ATM RECORDER

1 - Applicability

This ETSO gives the requirements that new models of the CNS/ATM (Communication Navigation Surveillance / Air Traffic Management) Recorder functional elements of crash protected airborne recorder systems that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

2 - Procedures

2.1 - General

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

Standards set forth in Sections 1 to 5 and Part IV of EUROCAE document ED-112 dated March 2003.

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.

3.2 - Specific

None.

4 - Marking

4.1 - General

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

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

ETSO-2C507
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: INFLIGHT ICING DETECTION SYSTEMS

1 - Applicability

This ETSO gives the requirements that new models of inflight icing detection systems that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

2 - Procedures

2.1 - General

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

Standards set forth in EUROCAE document ED-103 dated July 2001.

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.

3.2 - Specific

None.

4 - Marking

4.1 - General

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

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

ETSO-2C508
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: GROUND ICE DETECTION SYSTEMS

1 - Applicability

This ETSO gives the requirements that new models of ground ice detection systems that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking.

2 - Procedures

2.1 - General

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

Standards set forth in EUROCAE document ED-104A dated June 2003.

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.

3.2 - Specific

None.

4 - Marking

4.1 - General

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

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

ETSO-2C509
Date : XX.XX.XX

European Aviation Safety Agency

European Technical Standard Order

Subject: LIGHT AVIATION SECONDARY SURVEILLANCE TRANSPONDER (LAST)

1 - Applicability

This ETSO gives the requirements which light aviation secondary surveillance transponders (LAST) that are manufactured on or after the date of this ETSO must meet in order to be identified with applicable ETSO marking. The use of those transponders is restricted to cruising speed up to 324 km/h, altitude up to 4572 m and non diversity operation.

2 - Procedures

2.1 - General

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

Standard given in EUROCAE ED-115: „Minimum Performance Specification for Light Aviation Secondary Surveillance Transponders".
The following functionalities, capabilities, variants and options specified in ED-115 are not applicable for an ETSO authorised LAST:

1.1	Note 2 (low power, non ICAO compliant)	
1.4.2.1	Transponder Functionality:	a) Level 1 Surveillance only
2.11.1	LAST Capabilities:	a) Lc0 Mode A/C only transponder
2.11.2	LAST Variants:	a) V1 (Self-contained removable LAST)

Paragraph 1.2 of ED-115 is not a requirement (guidance 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.

3.2 - Specific

None.

4 - Marking

4.1 - General

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

4.2- Specific

Additional requirements for labeling are given in EUROCAE ED-115 paragraph 1.4.2.2.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.