CS-ETSO AMENDMENT 2 CHANGE INFORMATION

The Agency publishes amendments to Certification Specifications-European Technical Standard Orders (CS-ETSO) as consolidated text for each constituent European Technical Standard Order (ETSO) individually.

Consequently, except for the revision indication letter and revised issue date in the header of the ETSO, the consolidated text of each individual ETSO does not allow readers to see the detailed changes introduced by the amendment. To allow readers to also see these detailed changes this document has been created. The same format as for publication of Notices of Proposed Amendments has been used to show the changes:

1. text not affected by the amendment remains the same: unchanged
2. deleted text is shown with a strike through: ~~deleted~~
3. new text is highlighted with grey shading: new
4. ....
   Indicates that remaining text is unchanged in front of or following the reflected amendment.
   ....

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-~~3~~ 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.
From the marking options in Part 21 Section A Subpart Q § 21A.807(a)(2), the 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 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), 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, AS AMENDED BY ~~JAA~~ EASA

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1.3 System Function and Overview.

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e. Class A TAWS equipment must….

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NOTE: Class A equipment will be entitled to a ETSO-C92c authorization approval for the purpose of complying with the mandatory GPWS requirements in ~~CS-OPS 1.666~~ JAR-OPS 1.665/ EU-OPS 1.665, until such time that those rules are superseded by TAWS rules.

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3.3 Class A Requirements for GPWS Alerting.

….

e. Sweep Tones „Whoop-Whoop“. If a two tone sweep….

….

NOTE: Class A equipment will be entitled to a ETSO-C92c authorization approval for the purpose of complying with the mandatory GPWS requirements in ~~CS-OPS 1.665~~ JAR-OPS 1.665/ EU-OPS 1.665 until such time that those rules are superseded by TAWS rules.

….

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 ETSO except for aircraft operated under ~~CS-OPS 1~~ JAR-OPS 1/ EU-OPS 1. Operations under ~~CS-OPS 1~~ JAR-OPS 1/ EU-OPS 1 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.

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Appendices 2 and 3 are unchanged.

APPENDIX 4. FEDERAL AVIATION ADMINISTRATION MINIMUM PERFORMANCE STANDARD (MPS) FOR A TERRAIN AWARENESS AND WARNING SYSTEM FOR CLASS C, AS AMENDED BY EASA

1.0 INTRODUCTION.

1.1 This appendix describes modifications to this ETSO for TAWS Class C equipment.

1.2 This appendix contains only modifications to existing requirements in this ETSO. It is intended that Class C meet all Class B requirements that are not modified or addressed here. The paragraph numbers below relate directly to the paragraphs in appendices **1** and **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 as prescribed in paragraph 4.2 of this ETSO, so that it can be uniquely distinguished from the Class A and B TAWS equipment.

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 required obstacle clearance (ROC), inside traffic area, distance to nearest runway threshold is increasing, and aeroplane is below 1,000 feet.
Cruise – anytime the aeroplane is outside the airport traffic control area.
Landing – inside traffic area and distance to nearest runway threshold is decreasing, and aeroplane is below 1,000 feet.

1.2 Altitude Accuracy. 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 labelled 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.

Modifications to Appendix 3, Test Conditions.

NOTE 1: Paragraph 1.1 of the ETSO 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 ETSO is changed to specify altitude levels, test speeds and pull-ups more appropriate for small aircraft:

1.2 Cruise Descent Requirements. A terrain alert must be provided in time so as to assure that the aeroplane 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 aeroplane. 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 aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

NOTE 2: Cruise operations are considered to exist beyond the airport control area until inside the destination airport control area for VFR operations. Distances may extend to 10 NM from the airport (takeoff and landing) for IFR operations. Use of the nearest runway logic is permissible provided suitable logic is incorporated to ensure that the transitions to the terminal logic will typically occur only when the aeroplane is in terminal airspace.

NOTE 3: The values shown in column E may be reduced by 50 feet (to permit a 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 aeroplane

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 aeroplane operations.

TABLE A

ENROUTE DESCENT ALERTING CRITERIA

Alerting for Premature Descent during Cruise					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 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

ETSO Note: Paragraph 1.3 in the ETSO is changed to specify altitude levels, test speeds and pull-ups more appropriate to small aircraft:

1.3 Cruise Level Flight Requirement. During level flight operations (vertical speed is ± 200 feet per minute), a terrain alert should be posted when the aeroplane is within 250 feet of the terrain and is predicted to be equal to or less than 200 feet within the prescribed test criteria. See Table B for Test Criteria.

NOTE 1: The actual values for the aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

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 aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

NOTE 2: The values shown in Column F are appropriate for an aeroplane without an Autopilot or Flight Director function, and are based upon 10 percent of the vertical velocity that is appropriate to manual flight and small general aviation aeroplane 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.