ETSO-C151a
Date : 24.10.03

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 appendices 1-3.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2. In addition:

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 misleading information (MI), 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). 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). 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 1and 3.

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 - <u>Marking</u>

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.

APPENDIX 1. FEDERAL AVIATION ADMINISTRATION MINIMUM PERFORMANCE STANDARD (MPS) FOR A TERRAIN AWARENESS AND WARNING SYSTEM, AS AMENDED BY JAA

1.0 Introduction.

1.1 Purpose. This standard provides the MPS for a Terrain Awareness and Warning System (TAWS).

1.2 Scope. This appendix sets forth the standard for two Classes of TAWS equipment, Class A and Class B.

1.3 System Function and Overview. The system shall 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 ETSO approved systems include the following :

a. A Forward Looking Terrain Avoidance (FLTA) function. The FLTA function looks ahead of the aeroplane along and below the aeroplane's lateral and vertical flight path and provides suitable alerts if a potential CFIT threat exists.

b. A Premature Descent Alert (PDA) function. The PDA function of the TAWS uses the aeroplane's current position and flight path information as determined from a suitable navigation source and airport database to determine if the aeroplane is hazardously below the normal (typically 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 DO-161A, Minimum Performance Standards - Airborne Ground Proximity Warning Equipment, dated May 27, 1976, and Section 3.3 of this appendix. Deviations from 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 aeroplane descends to 500 feet above the terrain or nearest runway elevation.

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 , until such time that those rules are superseded by TAWS rules.

f. Class B equipment must provide indications of imminent contact with the ground during the following aeroplane 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 aeroplane 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 shall at least meet the same qualification testing and software verification and validation requirements as provided under this ETSO. Additional information such as „human-made“ obstacles may be added as long as they do not adversely alter the terrain functions.

1.5 Other Technologies. Although this ETSO envisions a TAWS based on the use of an onboard terrain and airport data base, other technologies such as the use of radar are not excluded. Other concepts and technologies may be approved under this ETSO using IR 21A.610, 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 aeroplane, 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 Misleading Information (MI). An incorrect depiction of the terrain threat relative to the aeroplane 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 aeroplane’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 aeroplane and its projected flight path. Class A and Class B Equipment will be required to look ahead of the aeroplane, 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 aeroplane’s flight path, and a specified look down distance based upon the aeroplane’s vertical flight path. This search volume should vary as a function of phase 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 shall provide suitable alerts when the aeroplane is currently above the terrain in the aeroplane’s projected flight path but the projected amount of terrain clearance is considered unsafe for the particular phase of flight. The required obstacle (terrain) clearance (ROC) as specified in TERPS and the Aeronautical Information Manual (AIM) 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 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 aeroplane is projected to be within 100 feet vertically of terrain. However, Class A and Class B equipment should not alert if the aeroplane is projected to be more than 400 feet above the terrain.

NOTE 2: As an alternate to the stepped down reduction from the terminal to approach phase 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 shall provide suitable alerts when the aeroplane is currently below the elevation of a terrain cell along the aeroplane's lateral projected flight path and, based upon the vertical projected flight path, the equipment predicts that the terrain clearance will be less than the value given in the RTC column of Table 3.1. See appendix 3 for test conditions that must be conducted (Table G).

3.1.3 FLTA Turning Flight. Class A and Class B equipment shall provide suitable alerts for the functions specified in 3.1.1 and 3.1.2 above when the aeroplane is in turning flight.

3.2 Class A and Class B Equipment Safety Agency for Detection and Alerting for Premature Descents Along the Final Approach Segment. Class A and Class B equipment shall provide a suitable alert when it determines that the aeroplane is significantly below the normal approach flight path to a runway. Approximately one third of all CFIT accidents occur during the final approach phase of flight, when the aeroplane is properly configured for landing and descending at a normal rate. For a variety of reasons which include poor visibility, night time operations, loss of situational awareness, operating below minimums without adequate visual references and deviations from the published approach procedures, many aeroplanes have crashed into the ground short of the runway. A means to detect and alert the flight crew to this condition is an essential safety requirement of this ETSO. 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 ETSO 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. Aeroplanes routinely operate at traffic pattern altitudes of 800 feet above field/runway elevation for traffic pattern operations within 5NM of the airport.

c. Aeroplanes 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. Aeroplanes routinely operate in the visual segment of a circling approach within 2 NM of the airport/runway of intended landing with 300 feet of obstacle clearance. Operations at circling minimums 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 shall provide the GPWS functions listed below in accordance with ETSO-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 ETSO C92c equipment functions, except for power supply failure, input sensor failure, or failure of other common portions of the equipment, shall not cause a loss of the FLTA, PDA, or Terrain Display.

The functions described in ETSO-C92c and the referenced document 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 shall 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 shall be provided during non precision approaches per ETSO-C92c 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 ETSO-C10b, Altimeter, Pressure Actuated, Sensitive Type, or later revisions) and/or altimeter altitude (accuracy specified in ETSO-2C87 (Low range radio altimeters) - for air carrier aircraft, or later revisions) to meet the warning requirements described in RTCA Document No. DO-161A. In addition, ETSO-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 Document No. 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 ETSO-C92c authorization approval for the purpose of complying with the mandatory GPWS requirements in CS-OPS 1.665 until such time that those rules are superseded 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 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 shall 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 DO-161A. The alerting is identical to the alerting envelope in 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 aeroplane 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 aeroplane 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 shall 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 shall be designed to interface with a Terrain Display, either color or monochromatic. Class A equipment for TAWS shall be capable of providing the following terrain related information to a display system.

a. The terrain shall be depicted relative to the aeroplane’s position such that the pilot may estimate the relative bearing to the terrain of interest.

b. The terrain shall be depicted relative to the aeroplane’s position such that the pilot may estimate the distance to the terrain of interest.

c. The terrain depicted shall be oriented to either the heading or track of the aeroplane. In addition, a North-up orientation may be added as a selectable format.

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

e. Terrain that generates alerts shall 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 shall be capable of driving a terrain display function in the event the installer wants to include the terrain display function.

> NOTE: This ETSO 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 shall identify the reason for the alert such as „too low terrain“ and „Glideslope,“ or other acceptable annunciation.

4.4 The system shall remove the visual and aural alert once the situation has been resolved.

4.5 The system shall be capable of accepting and processing aeroplane performance related data or aeroplane dynamic data and providing the capability to update aural and visual alerts at least once per second.

4.6 The aural and visual outputs as defined in Table 4-1 shall 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 aeroplanes.

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

4.9 As a minimum the TAWS shall 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

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	**<u>Visual Alert</u>** Amber text message that is obvious, concise, and must be consistent with the Aural message. **<u>Aural Alert</u>** „Don't Sink" and „Too Low-Terrain"	**<u>Visual Alert</u>** None Required. **<u>Aural Alert</u>** None Required.
Ground Proximity Envelope 1 (Not in Landing Configuration) Class A	**<u>Visual Alert</u>** Amber text message that is obvious, concise, and must be consistent with the Aural message. **<u>Aural Alert</u>** „Too Low Terrain" and „Too Low Gear"	**<u>Visual Alert</u>** None Required. **<u>Aural Alert</u>** None Required.
Ground Proximity Envelope 2 Insufficient Terrain Clearance (Landing and Go-around configuration) Class A	**<u>Visual Alert</u>** Amber text message that is obvious, concise, and must be consistent with the Aural message. **<u>Aural Alert</u>** „Too Low Terrain" and „Too Low Flaps"	**<u>Visual Alert</u>** None Required. **<u>Aural Alert</u>** None Required
Ground Proximity Envelope 3 Insufficient Terrain Clearance (Take-off configuration) Class A	**<u>Visual Alert</u>** Amber text message that is obvious, concise, and must be consistent with the Aural message. **<u>Aural Alert</u>** „Too Low Terrain"	**<u>Visual Alert</u>** None Required. **<u>Aural Alert</u>** None Required
Ground Proximity Excessive Glide Slope Deviation Class A	**<u>Visual Alert</u>** Amber text message that is obvious, concise, and must be consistent with the Aural message. **<u>Aural Alert</u>** „Glide Slope"	**<u>Visual Alert</u>** None Required. **<u>Aural Alert</u>** None Required
Ground Proximity Voice Call Out (See Note 1) Class A & Class B	**<u>Visual Alert</u>** None Required **<u>Aural Alert</u>** „Five Hundred"	**<u>Visual Alert</u>** None Required. **<u>Aural Alert</u>** 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 shall 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 multiply 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 Airborne Collision Avoidance System (ACAS). Table 4 – 2 includes an alert prioritization scheme. If the PWS, RWS and/or ACAS functions are provided within the TAWS, Table 4 - 2 also applies. The Agency 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 ACAS, RWS, PWS. If prioritization with those functions is provided, the prioritization scheme shall be in accordance with the Table 4 - 2. The Agency will consider alert prioritization schemes other than the one included in Table 4 – 2.

c. Class B Equipment. Class B equipment shall establish an internal priority alerting system (scheme) for each of the functions. The priority scheme shall 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.

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]	ACAS RA ("*Climb*", "*Descend*", etc.)	W	Continuous
Mode 6 [a]	ACAS 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 aeroplane horizontal aeroplane 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 aeroplane horizontal aeroplane 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 aeroplanes. 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 Aeroplane Horizontal Position Determination for Source Data.

5.1 Class A equipment. Class A equipment that uses the on-board aeroplane navigation system for horizontal position information for the TAWS and that meets ETSO-C115b or follow AC90-45A for approved RNAV systems, ETSO-C129a for GPS, TSO-C145 for WAAS, or that follow 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 ETSO except for aircraft operated under CS-OPS-1. Operations under CS-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.

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 ETSO-C129a/ ED-72A, 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 shall be provided for the expected areas of operation, airports and routes to be flown.

6.2 Development and Methodology. The manufacturer shall 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 shall 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 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 shall be capable of accepting updated terrain and airport information.

7.0 Class A and Class B Failure Indication. Class A and Class B equipment shall include a failure monitor function that provides reliable indications of equipment condition during operation. It shall monitor the equipment itself, input power, input signals, and aural and visual outputs. A means shall 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 shall have a self-test function to verify system operation and integrity. It shall monitor the equipment itself, input power, input signals, and aural and visual outputs. Failure of the system to successfully pass the self-test shall 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 shall 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 shall 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 paragraph 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 aeroplane is more than 15 NM from the nearest airport or whenever the conditions for Terminal, Approach and Departure Phases are not met.

10.2 Terminal Phase. The Terminal Phase exists when the aeroplane is 15 NM or less from the nearest runway while the range to the nearest runway threshold is decreasing and the aeroplane is at or 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 aeroplane is on the ground upon initial power-up. If, for example, the equipment can determine that the aeroplane is „on the ground“ by using some logic such as ground speed less than 35 knots and altitude within +/- 75 feet of field elevation or nearest runway elevation and „airborne“ by using some logic such as ground speed greater than 50 knots and altitude 100 feet greater than field elevation, then the equipment can reliably determine that it is in the „Departure Phase.“ Other parameters to consider are climb state, and distance from departure runway. Once the aeroplane reaches 1500 feet above the departure runway, the Departure Phase is ended.

11.0 <u>Class A and Class B Summary Requirements.</u>
(Reserved)

TABLE 11-1

(RESERVED)

APPENDIX 2. STANDARDS APPLICABLE TO ENVIRONMENTAL TEST PROCEDURES

RESERVED FOR MODIFICATIONS OF OR ADDITIONAL REQUIREMENTS BEYOND THE TEST PROCEDURES CONTAINED IN EUROCAE/RTCA DOCUMENT ED-14D/DO-160D.

APPENDIX 3. TEST CONDITIONS

1.0 Forward looking Terrain Avoidance - Reduced Required Terrain Clearance (RRTC) Test Conditions. This condition exists, when the aeroplane is currently above the terrain but the combination of current altitude, height above terrain, and projected flight path indicates that there is a significant reduction in the 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 shall be provided in time so as to assure that the aeroplane can level off (L/O) with a minimum of 500 feet altitude clearance over the terrain/obstacle when descending toward the terrain/obstacle at any speed within the operational flight envelope of the aeroplane. The test conditions assume a descent along a flight path 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 aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted and the minimum terrain clearance altitude must be recorded.

NOTE 2: Enroute operations are considered to exist beyond 15 NM from the departure runway until 15 NM from the destination airport. Use of the nearest runway logic is permissible provided suitable logic is incorporated to ensure that the transitions to the terminal logic will typically occur only when the aeroplane is in terminal airspace.

NOTE 3: The values shown in column E may be reduced by 100 feet (to permit a 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 CS-25 certificated aeroplanes (Large Aeroplanes). The values are based upon 20 percent of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts based upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation aeroplane operations.

TABLE A

Enroute Descent Alerting Criteria					
A	B	C	D	E	F
VERT SPEED (FPM)	ALT LOST WITH 3 SEC PILOT DELAY	ALT REQ'D TO L/O WITH 0.25G	TOTAL ALT LOST DUE TO RECOVERY MANEUVER	MINIMUM TAWS WARNING ALERT HEIGHT (ABOVE TERRAIN)	MAXIMUM 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 aeroplane is within 700 feet of the terrain and is predicted to be equal to or less than 700 feet within the prescribed alerting time or distance. See Table B for Test Criteria.

NOTE 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

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

NOTE 2: For Class B Equipment Considerations. The values shown in Column F are appropriate for Autopilot or Flight Director operations with an Altitude Capture function typical of many CS-25 certificated aeroplanes (Large Aeroplanes). The values are based upon 20 percent of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation aeroplane 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 aeroplane 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 aeroplane altitude, distance and time from the terrain cell when caution and warning alerts are posted must be recorded.

TABLE D

Terminal Area Level Flight Alerting Criteria			
GROUND SPEED (KT)	HEIGHT OF TERRAIN CELL (MSL)	TEST RUN ALTITUDE (MSL)	ALERT CRITERIA:
150	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 shall be provided in time to assure that the aeroplane 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 aeroplane.

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

NOTE 2: For Class B equipment Considerations. The values shown in Column F are appropriate for Autopilot or Flight Director operations with an Altitude Capture function typical of many CS-25 certificated aeroplanes (Large Aeroplanes). The values are based upon 20 percent of the aeroplanes vertical velocity. If TAWS is installed on an aeroplane without such an Autopilot or Flight Director function, consideration should be given to computing the alerts based upon 10 percent of the vertical velocity which is more appropriate to manual flight and small general aviation aeroplane operations.

TABLE E

Final 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 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 aeroplane is within 150 feet of the terrain and is predicted to be within less than 150 feet within the prescribed alerting time or distance. See Table F for test criteria.

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

NOTE 2: Based upon a one second pilot delay and a 0.25 g incremental pull to constant 6.0 degree climb gradient, compute and record the aeroplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the aeroplane position and time (after the alert), when the alert envelope is cleared.

2.1 Test Criteria. For each of the test cases below, a positive clearance of the terrain cell of interest is required.

2.2 Additional Test Criteria. Repeat each of the test cases below with the altitude error (-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 ETSO 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 paragraphs 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 4000FPM. 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 2000FPM. 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 1000FPM. 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 shall be shown, by analysis, simulation or flight testing, that the system will not produce nuisance alerts when the aeroplane is conducting normal flight operations in accordance with published instrument approach procedure. This assumes the normal range in variation of input parameters.

5.1 Test Cases. As a minimum, the following cases (1 –9) shall 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) shall be simulated. For all listed VOR, VOR/DME and Localizer based approaches, from the FAF to the MAP the aeroplane will descend at 1000 FPM until reaching either MDA (run #1) or MDA-50 feet (run #2). The aeroplane 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, CN	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 aeroplane altitude at the terrain cell, the positive (or negative) clearance altitude, and the aeroplane position and time (after the alert), when the alert envelope is cleared.

> NOTE: The terrain cell of interest is the one associated with the accident and not necessarily the terrain cell that caused the warning.

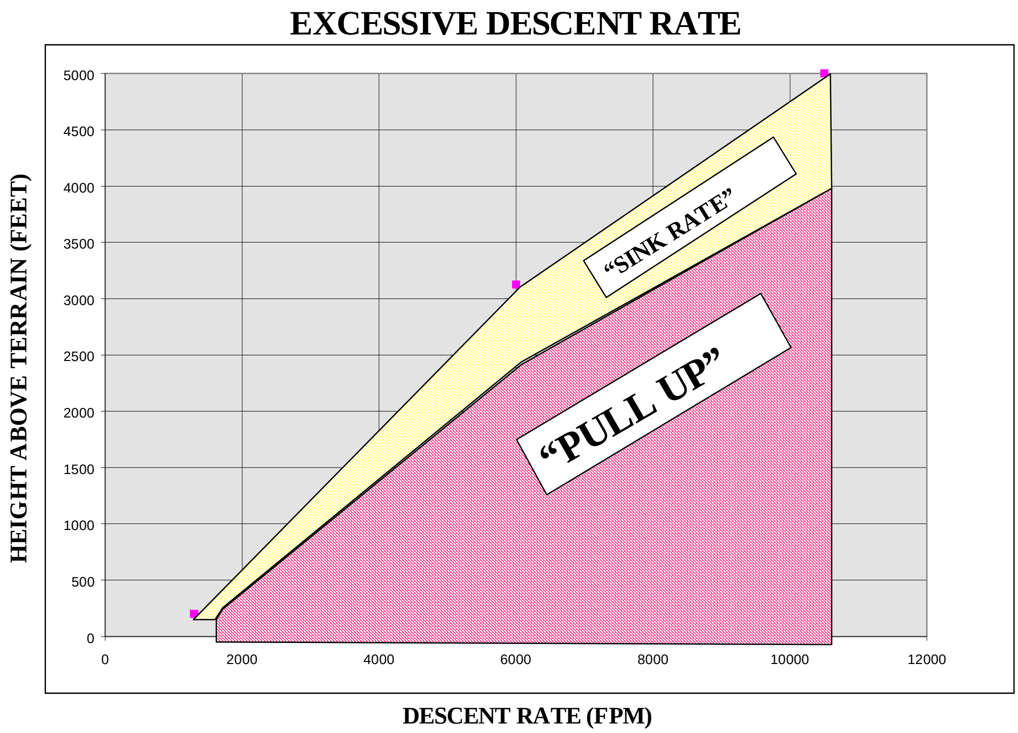
6.3 Test Criteria. In each of the test cases below, it shall be necessary to demonstrate that the aeroplane profile clears the terrain cell of interest.

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 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 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 shall be provided.

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