



Deviations request #94 for an ETSO approval for CS-ETSO applicable to Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II (ETSO- C119c) Consultation Paper

1. Introductory note

The hereby presented deviation requests shall be subject to public consultation, in accordance with EASA Management Board Decision No 7-2004 as amended by EASA Management Board Decision No 12-2007¹ products certification procedure dated 11th September 2007, Article 3 (2.) of which states:

"2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency."

2. ETSO-C119c#21 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II , Variable suppression time

Deviation:

Deviate from EUROCAE ED-143 2.2.3.12 to use a variable suppression time T, which is given by $T = \text{MAX} (35, T_{\text{max}} * 10^{(ATN / 20)})$, where T_{max} is 75 microseconds for top antenna transmissions, T_{max} is 95 microseconds for bottom antenna transmissions, and ATN is the power transmitted (in dB) relative to the maximum power out.

Requirement:

EUROCAE ED-143 2.2.3.12

The TCAS equipment shall issue a 70 ± 1 microsecond suppression pulse to other on-board aircraft equipment beginning at each interrogation transmitted from the top-mounted antenna. The TCAS II equipment shall issue a 90 ± 1 microsecond suppression pulse to other equipment for each interrogation from the bottom antenna.

Industry:

The EUROCAE ED-143 Volume I, 2.2.3.12 requirement has been modified based upon field experience with DO-185 versions of the applicant TCASs.

The suppression time is varied based on interrogation power to reduce the amount of time that own transponder is suppressed from transmitting. Having a fixed suppression time for all interrogations causes excessive, unnecessary own transponder off-time during low power interrogations. This deviation reduces own aircraft channel loading induced by the on-board TCAS.

Additionally, this deviation request is very similar to the previously approved ETSO-C119c, deviation #10. In general, this deviation is closer to the ED-143 requirement because the reduction in suppression time is less than a system with the previously

¹ Cf. EASA Web: <http://easa.europa.eu/management-board/docs/management-board-meetings/2007/04/MB%20Decision%2012-2007%20amending%20the%20certification%20procedure.pdf>
ETSO.DevP.94.v11

approved deviation #10. The table below highlights the differences in this proposed deviation and the previously approved deviation (#10).

Parameter		ETSO-C119c Deviation 10	This Deviation	ED-143
Maximum Suppression Time (nanoseconds)	Top Ant	70	75	70
	Bot Ant	90	95	90
Minimum Suppression Time (nanoseconds)	Top Ant	30	35	70
	Bot Ant			90

In order to illustrate that the proposed deviation is more compliant than the previously approved deviation, an estimate of the suppression time for an unrealistically high traffic density scenario is given. The total suppression time for a system compliant with this deviation is approximately 6500 microseconds vs. 6120 for a system compliant with the previously approved deviation. The load limiting or interference limiting algorithms of equation #1 and equation #3 of ED-143, section 2.2.3.6.1 would prevent the total suppression time from ever reaching this value.

The requirement provides an Equivalent Level of Safety (ELOS) with respect to the EUROCAE ED-143 requirement, since the TCAS B will lessen the impact to the on-board transponder, allowing for lower transponder utilization than the requirements prescribed by the EUROCAE ED-143 requirements. Lower on-board transponder utilization provides other TCAS equipped aircraft and ground stations better interrogation response from the transponder. Suppression characteristics to other L-Band equipment (Transponder, DME, TACAN, IFF, etc.) are unaffected by the use of variable TCAS suppression times.

EASA:

We accept the deviation , as it is very similar to ETSO-C119c#10 with a slightly larger minimal suppression time, and a slightly different Tmax.

3. ETSO-C119c#22 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, modified whisper-shout interrogation sequences and power levels

Deviation:

Deviate from EUROCAE ED-143 2.2.4.5.4.1.2, by amplifying the whisper-shout (step 2) interrogations by 1dB, and by raising the MTL of whisper-shout interrogations by 1 db, for those transmissions which are attenuated by more than 3 dB.

Description of change:

Transmitter Power

Field experience indicates that additional forward direction uplink path margin is desirable in that it improves the probability of long range ATCRBS intruders receiving TCAS interrogations. The TCAS B system uses a dual receiver path method of reducing internal receiver bias and errors. The system is designed so that it must receive at least one reply from two different whisper-shout steps (each step's replies are received on the alternate receiver path from the previous step) in order to establish a track. This alternating of receiver paths allows the bias in one path to be offset by the bias in the other path. In order to improve the probability that the longest range ATCRBS targets will receive at least two whisper-shout interrogations, transmitter power was increased by one dB for high resolution Top Forward interrogation step 2.

The 1 dB of additional power represents 18 watts of additional total radiated power. This additional power will not present an additional load in areas where traffic density is high because equations 1 and 3 of ED-143, section 2.2.3.6.1 require that all TCAS limit TCAS channel loading caused by TCAS interrogations. This limit becomes more stringent in the presence of more TCAS. In areas of low density where longer range performance is beneficial, the additional power will be transmitted. In areas of high density the additional interrogation will be eliminated.

Additionally, as specified in ED 143, 2.2.4.5.4 “Alternative whisper-shout sequences that are either more or less capable than those specified above may be implemented, so long as the combination of the whisper-shout resolution and the azimuth directionality, result in degarbling performance that equals or exceeds the minimum requirement to satisfy the system requirements of 2.2.2.”.

MTL

The MTL, for all steps whose power is attenuated by more than 3 dB, has been chosen to be 1 dB less sensitive than that given in EUROCAE ED-143. This has been proven in the applicant’s TCAS to reduce FRUIT (Free Replies Unsolicited In Time), and therefore false tracks, while maintaining the required true track rate. A 1 dB change in the MTL is not a major deviation, since at the reduced-power whisper-shout steps, the TCAS-to-transponder link establishes the range, not the transponder-to-TCAS link. The change in MTL has no impact on channel loading.

ELOS

The modified whisper-shout sequences have been defined to provide an ELOS to the EUROCAE ED-143 requirements, which maximize the ability of acquiring and maintaining tracks on ATCRBS-equipped aircraft, while minimizing the potential for false tracks. The defined whisper-shout sequences also maintain the required range of ATCRBS tracking, while continuing to conform to the EUROCAE ED-143 required Interference Limiting requirements.

Additionally, TCASs of the applicant with the deviation implemented have more than 18 years of active service history in a wide variety of aircraft throughout various locations around world, with no significant service difficulties related to its installed or operational environment. Flight evaluations have been conducted throughout the TCAS system’s life cycle and robustness testing simulating high FRUIT environments has been conducted to demonstrate acceptable performance in dense airspace.

EASA:

The deviations are granted, as they are basically ETSO-C119c#11 with slightly reduced power levels.

4. ETSO-C119c#23 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, receive antenna as first interrogation antenna

Deviation:

When the landing gear is not extended, deviate from EUROCAE ED-143 2.2.4.6.2.2.2 by using the antenna through which the squitter was received for the first two acquisition interrogations. If these two acquisition interrogations to the target fail to elicit valid replies, the next two acquisition interrogations to that target shall be transmitted using the other antenna.

Requirement:

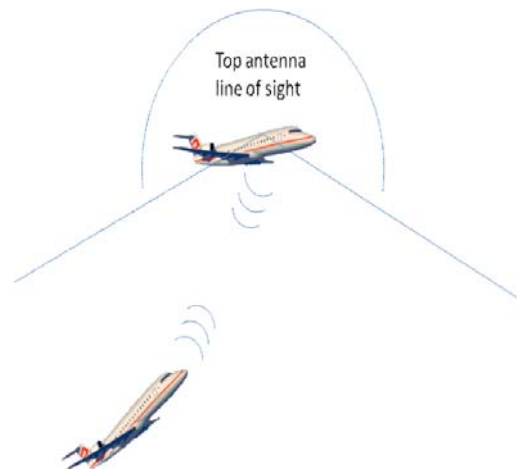
EUROCAE ED-143: 2.2.4.6.2.2.2

The first acquisition interrogation shall be transmitted using the top antenna. If two acquisition interrogations to a target fail to elicit valid replies, the next two acquisition interrogations to that target shall be transmitted using the bottom antenna.

Industry:

Flight evaluations have demonstrated that there is equal-to or better reply reception when using the directional antenna on which the squitter was received for the initial acquisition interrogations. Using the same antenna from which the initial squitter was received (when the bottom antenna is directional) provides a higher probability of successful reply reception, rather than defaulting to the top antenna. In this way, the line of sight would not change significantly between squitter reception and interrogation. The MOPS (Minimum Operational Performance Standard) intended to use the (top) directional antenna and not the (bottom) omni-directional antenna. When using a bottom directional antenna, it affords the same tracking (line of sight) benefits as a top directional antenna. Refer to the following figure.

As can be seen in the example to the right, intruder aircraft that are below own TCAS II aircraft are not always in line-of-sight of the top antenna. The intruder aircraft's squitter would be received on the bottom directional antenna, so the most expeditious means of acquiring the intruder is to interrogate out the same directional antenna on which the squitter was received (in this case the bottom), as an interrogation from the top directional antenna would not solicit a reply. Thus a better than Equivalent Level Of Safety is achieved, as an intruder aircraft, such as the one described, would be acquired one second earlier by using the bottom directional antenna for the initial acquisition interrogation.



In addition, channel loading related to TCAS Mode S interrogations is limited by equation #1 specified in ED-143 2.2.3.6.1, irrespective of the interrogation antenna being used. Furthermore, interrogating on the antenna from which the squitter was received, increases the likelihood that the interrogation will be successful, without requiring retry interrogations, which again, helps limit the impact to channel loading.

An ELOS for the second sentence of this deviation is provided, as switching antennas for the second set of interrogations is consistent with the intent of the EUROCAE ED-143 requirement. The presence of a bottom monopole antenna or a bottom omni-directional antenna (bottom directional antenna when the landing gear is extended) is handled as a special case. Since the top directional antenna was used for the first two interrogations, (even though the squitter may have been received on the bottom antenna), switching to the bottom antenna is still consistent with the intent of the MOPS by using the alternate antenna, when the first two interrogation attempts are unsuccessful.

Additionally, TCASs of the applicant with the deviation implemented have in excess of 18 years of active service history in a wide variety of aircraft throughout various locations around world with no significant service difficulties related to its installed or operational environment.

EASA:

The deviation is granted.

5. ETSO-C119c#24 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, modified antenna sequence in case of tracking failure

Deviation:

If two successive tracking interrogations fail to elicit valid replies from a target, deviate from EUROCAE ED-143 2.2.4.6.2.2.3, by using the same antenna for the next tracking interrogation, and then using the other antenna (to the previously used antenna) for each successive tracking interrogation.

Requirement:

EUROCAE ED-143 2.2.4.6.2.2.3

If two successive tracking interrogations fail to elicit valid replies from a target, the next two interrogations to that target shall be transmitted using the other antenna.

Industry:

The following table depicts the Mode S Interrogation scheduling of the TCAS B System, as described above:

Table 6-1 - Mode-S Interrogation Retry

TCAS Processing Cycle	Antenna Sequence if first antenna is bottom antenna	Antenna Sequence if first antenna is top antenna
1	Bottom	Top
	Bottom	Top
2	Bottom	Top
	Top	Bottom
3	Bottom	Top
	Top	Bottom
4	Bottom	Top
	Top	Bottom
5	Bottom	Top
	Top	Bottom
6	Bottom	Top
	Top	Bottom

As in the previous two deviations, an ELOS is achieved by using modified line-of-sight interrogation/reply techniques to maintain track on intruder aircraft. The line of sight would not change significantly between the previous reply and the next interrogation when using a dual directional antenna scheme.

Additionally, flight evaluations have confirmed that the above scheme provides equal-to or better reply reception after missing a reply or replies.

TCASs of the applicant with the deviation implemented have in excess of 18 years of active service history in a wide variety of aircraft throughout various locations around world with no significant service difficulties related to its installed or operational environment.

Again, channel loading related to TCAS Mode S interrogations is limited by equation #1 specified in ED-143 2.2.3.6.1., irrespective of the interrogation antenna being used.

EASA:

EASA accepts this deviation

6. ETSO-C119c#25 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, additional interrogation for bearing estimate,

Deviation:

Deviate from EUROCAE ED-143 2.2.4.6.2.2.3 to allow an additional interrogation before 5 seconds to re-interrogate if an additional interrogation is needed to improve the bearing estimate for the intruder aircraft.

Requirement:

An intruder with a TAU value greater than 60 seconds shall be interrogated at a rate of no more than once every five surveillance update intervals if:

- a. the tracked barometric altitude of own aircraft is less than 18,000 ft, and
- b. the tracked altitude of the intruder aircraft is less than 18,000 ft.

A hysteresis of +/- 500 ft shall be applied to the above 18,000-ft altitude boundary in order to prevent rapid oscillations between two different interrogation rates.

Note: The above statement is not intended to prohibit re-interrogation(s). If a tracking interrogation fails to elicit a valid reply from a target being updated at a 5-second rate, additional interrogations are transmitted as specified below, i.e., surveillance should not wait five seconds to re-interrogate.

Industry:

The TCAS B can interrogate and receive replies from two received positions (within the 5 second update time-frame) in order to derive a more accurate bearing through averaging. Since the intruding aircraft are typically being interrogated once every 5 seconds, it is imperative to present as accurate a bearing as possible to the pilot/flight crew. The TCAS B System maintains an ELOS by adhering to the EUROCAE ED-143 Interference Limiting requirements while providing improved bearing accuracy of targets beyond the 60 second TAU threshold.

Once again, channel loading related to TCAS Mode S interrogations is limited by equation #1 specified in ED-143, 2.2.3.6.1. The additional interrogations required to enhance the bearing accuracy adds a small amount to the power budget of Equation #1. Should the equation #1 budget be exceeded, the system will adhere to the interference limiting procedures specified in ED-143, 2.2.3.6.2, which includes reducing transmit power incrementally. The additional power budget used for bearing measurement is more than offset by the efficient system interrogation design. Specifically, the TCAS B system only performs directional interrogations, instead of omni-directional interrogations, as well as restricting the number of Mode S interrogations (to a single Mode S target) to 12 instead of 16, over six successful surveillance intervals, as permitted by ED-143.

EASA:

EASA accepts this deviation.

7. ETSO-C119c#26 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, strappable audio tone before voice message

Deviation:

Deviate from EUROCAE ED-143 2.2.6.3.1.1 to allow an audio tone, as a strappable configuration item, before the voice message is presented.

Requirement:

EUROCAE ED-143 2.2.6.3.1.1

Aural alerts shall be presented by voice announcements only.

Industry:

Some existing customers already have this feature (which was allowed by EUROCAE RTCA/DO-185). When upgrading the DO-185 TCAS to the DO-185A TCAS and then to EUROCAE ED-143/DO-185B TCAS, it is not desirable to lose this feature. This is one additional means of alerting the pilot/flight crew of an advisory. An ELOS is achieved as the EUROCAE ED-143/DO-185B specified aural alerts (voice messages) continue to be presented immediately following the Audio Tone. As the default configuration is Voice, any existing installation using the audio tone option was approved by the governing certification authority and maintaining this configuration would not impact the safety aspects. The installation aspects for the optional audio tone enable are defined in the TCAS Installation Manual. This will be addressed in the applicable limitations sections of the DDP and Installation Manual.

EASA:

EASA accepts this deviation.

8. ETSO-C119c#27 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, reduced wording for aural annunciation)

Deviation:

Deviate from EUROCAE ED-143 2.2.6.3.4 to alert additional traffic alerts during a traffic alert by the aural annunciation "TRAFFIC" instead of the aural annunciation "TRAFFIC-TRAFFIC" which is only used when there is no other traffic alert.

Requirement:

EUROCAE ED-143 2.2.6.3.4

When a TA is initially issued, the aural annunciation "TRAFFIC-TRAFFIC" shall be spoken once.

Industry:

The aural annunciation of subsequent TA's, while the initial TA is on-going, does not need to be spoken in the same manner as the initial TA. The pilot/flight crew is already in a heightened state of TCAS alertness, as was intended by the initial "Traffic, Traffic" callout. The single "Traffic" aural annunciation is an indication to the Pilot/Flight Crew that subsequent traffic has been encountered and is being monitored, in addition to the first (initially issued) TA which is still being monitored. Thus, an equivalent Level of Safety is maintained as the Pilot/Flight Crew is already monitoring the TCAS traffic display(s) and would still see any additional TA's, (with or without an additional aural annunciation). During flight evaluations, a single 'TRAFFIC' aural annunciation was deemed to be acceptable and sufficient for crew awareness. (See additional supporting history below.)

History supporting single “Traffic” aural annunciation:

- Lab testing and early flight evaluations identified the need to reduce the amount of cockpit audio (alerts) in high density traffic areas.
- The TA aural alerting scheme was implemented as an inherent part of the initial Systems Requirements dating back to Jan. 1994.
- TSO flight evaluations were conducted in conjunction with STC flight testing in September 1994 with FAA Flight Test Pilots participation. Review of the flight test report identifies 18 flights totaling approx. 40 hrs of flight time were conducted to cover 28 different TCAS encounter scenarios including TCAS-Mode S, TCAS-Mode C and TCAS-TCAS coordinated encounters, 4 of which were multi-aircraft scenarios. The report stated *“The TCAS II aural messages are acceptable in volume and intelligibility during high and low cockpit noise levels, with and without headsets.”*
- The TCAS, which has the same deviation, has had in excess of 18 years of active service history in a wide variety of aircraft throughout various locations around world with no Service Related Difficulties or reported issues related to the single “TRAFFIC” callout for subsequent Traffic Advisories.
- The operational aspects of the aural “TRAFFIC” annunciation and the “TRAFFIC, TRAFFIC” aural annunciation are defined in the TCAS Pilot’s Guide.

Training and Limitations:

- All deviations are clearly identified in the Installation Manual (IM) and the DDP.
- Single Traffic Advisory aural alert is annotated in the TCAS Pilot’s Guide(s).
- No change for existing operators upgrading from (MOPS Changes) 6.04A/7.0 to 7.1, or for new follow-on installations (previously certified aircraft models).
- Installation limitations will be identified in the TCAS IM & DDP to address installations in new aircraft types, with emphasis on training requirements for operators of mixed fleets.
- For operators with mixed fleets having different TCAS II systems with different TA aural alerts, the TA Aural callouts will have to be addressed in the AFMS for all TCAS II systems.

EASA:

EASA accepts this deviation, provided that in the training material for the crews the matter of single traffic aural alerts and the matter of single traffic aural alerts versus the standard behaviour in mixed fleets where some aircraft have the standard behaviour and others have the deviation behaviour are adequately addressed.

9. ETSO-C119c#28 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, inclusion of aircraft on the ground

Deviation:

Deviate from EUROCAE ED-143 2.2.4.8.1, 2.2.4.6.2.1.2, 2.2.4.6.2.2.1, 2.2.3.10.2.1, 2.2.4.6.2.2.2 and 2.2.4.6.2.2.3 by allowing a configuration option to provide information for aircraft that are determined to be on the ground to the CAS logic; to make available to the collision avoidance logic Mode C intruder reports that are identified as having been formed by replies from aircraft that are on the ground; to interrogate for purposes of tracking Mode S targets that are established and determined to be on the ground and own aircraft is less than or equal to 2000 ft. AGL at a rate not to exceed once every five surveillance update intervals; and to acquire and establish tracks on Mode S targets determined to be on the ground, if own aircraft is at or below 2000 ft. AGL.

Requirement:

EUROCAE ED-143 2.2.4.8.1

Information shall not be provided to the CAS logic for aircraft that are determined to be on the ground as specified in [MOPS subparagraph] 2.2.4.6.1.3.

EUROCAE ED-143 2.2.4.6.2.1.2

Mode C target reports that are identified as having been formed by replies from aircraft that are on the ground ([MOPS subparagraph] 2.2.4.6.1.3) shall be used to initiate tracks but shall not be made available to the CAS logic.

EUROCAE ED-143 2.2.4.6.2.2.1

The equipment shall not interrogate an aircraft for acquisition in the following two cases: (1) the aircraft's CA field indicates that the aircraft is currently on the ground and the aircraft does not have an operational TCAS II, or (2) the aircraft's CA field indicates that the aircraft is currently on the ground, the aircraft has an operational TCAS II, but own TCAS is above 2000 feet AGL.

EUROCAE ED-143 2.2.3.10.2.1

TCAS shall make use of the CA field information from DO-181A or later transponders to prevent interrogations to aircraft that are on the ground that do not have an operational TCAS II.

Additionally, TCAS II shall examine the Vertical Status field, VS, in the DF=0 transmissions from the aircraft in order to minimize interrogations and prevent tracking of aircraft on the ground.

EUROCAE ED-143 2.2.4.6.2.2.2

Mode S aircraft that are determined to be on the ground according to the VS field shall be monitored either passively with DF=0 or DF=4 replies or by actively interrogating once every five surveillance update intervals as long as the aircraft remains on the ground and continues to transmit squitters. Monitored information shall not be made available to the CAS logic.

EUROCAE ED-143 2.2.4.6.2.2.3

The TCAS II equipment shall also delete the established track on a Mode S transponder-equipped aircraft following five consecutive replies in which the VS field indicated the aircraft to be on the ground.

Industry:

The current TCAS system has had the ability to be configured to display aircraft that are determined to be on the ground. Several Applicant TCAS customers/operators have been using this feature over the years and have expressed a desire to maintain the ability to continue to display aircraft that are determined to be on the ground when upgrading to the new TCAS System. Surveillance data for on-ground intruders is passed to the CAS Logic via the Intruder Surveillance Buffer in the same manner as airborne aircraft. The on-ground intruders are marked as having a "5-second" track update rate, which prevents the majority of the CAS Logic from operating for the on-ground aircraft. The on-ground aircraft will be displayed as "Other Traffic" (open diamonds). An ELOS is maintained as the display of on-ground intruders does not affect the Collision Avoidance capabilities of the TCAS system, nor does it violate the Interference Limiting requirements of EUROCAE ED-143/DO-185B. Existing installations enabling the display of on-ground intruders were approved by the governing certification authority and maintaining this configuration would not impact the safety aspects. If a new installation was being certified, enabling display of on-ground intruders would have to be assessed by the certifying authority.. The installation and operational aspects for enabling the display of on-ground intruders is defined in the TCAS Installation Manual and TCAS Pilot's Guide.

On-ground aircraft are required by ED-143/DO-185B to be monitored either passively or by actively interrogating at a 5 second update rate. The TCAS system actively interrogates the on-ground aircraft at a 5 second update rate for the purposes of tracking. This 5 second tracking interrogation rate for on-ground aircraft is equivalent to the requirement for monitoring on-ground aircraft, thus no additional RF spectrum interference is caused.

EASA:

EASA accepts this deviation.

10.ETSO-C119c#29 Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II, reduction of number of advisory inhibit discretes

Deviation:

Deviate from EUROCAE ED-143 2.2.7.3.5 to have the monitor of the TCAS only be capable to receive 2 advisory inhibit discretes from the aircraft instead of 4.

Requirement:

EUROCAE ED-143 2.2.7.3.5

The Monitor shall be capable of receiving the following data from the aircraft discretes:

- RA/TA discretes
- 4 advisory inhibit discretes

Industry:

An ELOS is maintained as two (2) discrete inputs are adequate for inhibiting the TCAS from GPWS and Windshear. (Note: Not all aircraft with TCAS will have Windshear equipment installed and in some cases could have Windshear integrated with the GPWS/EGPWS, where in most cases, one (1) discrete input is adequate). The installation and operational aspects of the 2 advisory inhibit discretes are defined in the TCAS Installation Manual and TCAS Pilot's Guide. Additionally, there have been numerous aircraft installations certified using this hardware configuration without any service related difficulties.

EASA:

EASA accepts this deviation, but this will result in an installation limitation to installations which require only 2 advisory inhibit discretes.