Deviation request #96 for an ETSO approval for CS-ETSO applicable to Airborne VHF Omni-directional Ranging (VOR) Equipment (ETSO-2C40c) 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 12-2007[1] 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 2C40c#3 VHF Omni-directional Ranging (VOR) Equipment

Deviate from ED-22B § 3.9b Emission of Radio Frequency Energy in the 960-1215 MHz range from not to exceed -90 dBm to not to exceed -74 dBm.

Requirement:

ED-22B § 3.9 (b) (DO-196 § 2.2.14 b) specifies that:

When the receiver is terminated in a resistive load of 50 ohms, the level of any spurious emission into the load shall not exceed -57 dBm over the frequency range of 10 kHz to 10 GHz except on the following frequency ranges:

74	–	76 MHz:	-64 dBm
108	–	138 MHz:	-64 dBm
329	–	335 MHz:	-64 dBm
960	–	1215 MHz:	-90 dBm

Industry:

The MOPS requirement for radio emissions in the 960-1215 MHz frequency range from a VOR receiver through its antenna port is intended to provide sufficient margin for safe operation of on-board radio receivers that operate in this frequency band, including ATC Transponder, TCAS/ADS-B In and DME. The emissions limit allows for worst case aircraft installations where the VOR antenna is in very close proximity to the ATC Transponder, TCAS/ADS-B In or DME antennas and where the VOR antenna has resonant frequencies that allow it to radiate significant energy in the 960-1215 MHz frequency range.

The table below compares the minimum attenuation allowed by the ED-22B/DO-196 MOPS between the VOR emitter and the ATC Transponder, TCAS/ADS-B In and DME antennas to not degrade the sensitivity of those receivers by more than 0.5 dB (line G)

[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

with the minimum attenuation required when the VOR equipment emissions level in the 960-1215 MHz range is -74 dBm (line I).

		ATC Transponder	TCAS/ ADS-B In	DME
Receiving System Operating Frequency (MHz)		1030	1090	960-1215
Receiving System Sensitivity level @ antenna (dBm)	(A)	-77[1]	-84[2]	-91[3]
Signal-to-Noise ratio required to detect desired signal (dB)	(B)	13[4]	13[4]	11[5]
Receiving system noise level referenced @ antenna[6] (dBm)	(C=A-B)	-90	-97	-102
Safety Margin (dB)	(D)	10	10	10
Maximum tolerable interference level @ antenna (dBm)	(E=C-D)	-100	-107	-112
Maximum Emission Level allowed by DO-196 MOPS (dBm)	(F)	-90	-90	-90
Minimum attenuation between VOR emitter and receiver (dB)	(G=F-E)	10	17	22
Emission Level per by deviation request (dBm)	(H)	-74	-74	-74
Minimum required attenuation between VOR emitter and other L-BAND receiving systems input @ antenna[7] (dB)	(I=H-E)	26	33	38
Required Attenuation specified in Installation Manual (dB)	(J)	40	40	40
Additional Safety Margin (dB)	(K=J-I)	14	7	2

Note 1: This is the smaller of the 1030 MHz transponder receiver minimum triggering levels (MTL) specified in DO-181D § 2.2.2.4 for better than 90% reply ratios to ATCRBS and Mode S interrogations. The received signal level is specified at the antenna end of the coaxial cable between the transponder and the antenna per § 2.2.1 and assumes an antenna with gain not less than the gain of a vertically polarized quarter wave monopole minus 3 dB over 90% of a coverage volume from 0 to 360° in azimuth and 5 to 30° in elevation when placed at the center of a flat circular ground plane with 1.2 m diameter as specified in DO-181D §2.2.15.4. The nominal gain of the MOPS reference antenna is taken to be 0 dBi

Note 2: This is the smaller of the 1090 MHz receiver minimum triggering levels (MTL) specified in DO-185B § 2.2.4.4.1 for better than 90% decoding ratios to received replies to TCAS interrogations and MTL specified in DO-260B §2.2.4.3.1.1 for better than 90% successful ADS-B message reception. The signal level is specified at the antenna end of the coaxial cable between the 1090 MHz receiver and the antenna per DO-185B § 2.2.1 and DO-260B § 2.2.1. The smaller MTL applies to ADB-B reception which assumes an antenna gain not less than the gain of a vertically polarized quarter wave monopole minus 1 dB over 90% of a coverage volume from 0 to 360° in azimuth and -15° to +20° in elevation when placed at the center of a 1.2m diameter of ground plane which can be flat or cylindrical as specified in DO-260B §2.2.13.2. The nominal gain of the MOPS reference antenna is taken to be 0 dBi

Note 3: This is the smaller of the minimum DME reply input signal level that results in acquisition of the correct range and tracking 80% of the time (lock-on sensitivity) specified in DO-189 §2.2.8 and ARINC Characteristic 709A §4.15, the latter of which is applicable to equipment installed on Air Transport aircraft. Both documents specify the signal level at the receiver input. Therefore the level given in the table at the antenna end of the coaxial cable assumes a worst case installation with maximum 3 dB of cable loss and +2dBi peak antenna gain. The antenna is assumed to be also a quarter wave monopole minus 3 dB with coverage identical to the Transponder antenna since the DME and Transponder antennas have typically the same characteristics.

Note 4: The required SNR is derived from the Mode S interrogation signal characteristics specified in DO-181D § 2.1.11, the ADS-B signal characteristics specified in DO-260B § 2.2.3.1, and the theory for the detection of a train of

pulses in the presence of broadband noise with white Gaussian statistics (e.g. “Detection, Estimation and Modulation Theory”, Vol 1 by Harry L. Van Trees). The SNR quoted in the table allows for a 1 dB implementation margin.

Note 5: The required SNR is derived from the DME reply signal characteristics specified in ICAO Annex 10 § 3.5.4 and the theory for the detection of a train of pulses in the presence of broadband noise with white Gaussian statistics (e.g. “Detection, Estimation and Modulation Theory”, Vol 1 by Harry L. Van Trees). The SNR quoted in the table allows for a 1 dB implementation margin.

Note 6: The receiving system noise power level reference at the antenna in dBm is equal to the receiver noise power level referenced at the input to the receiver in dBm plus the cable and connector losses in dB.

Note 7: The input to the victim receiving systems is defined to be at the antenna end of the coaxial cable between the antenna and the victim receiver because the receiver sensitivity for these systems is also defined at the antenna end of the coaxial cable. Receiving equipment will be designed to have lower sensitivity taking into account worst case installation losses. If installed in aircraft with lower installation losses than the worst case installation, the sensitivity of the system will exceed the MOPS requirements but in no case will it be worse than the MOPS compliant worst case installation.

Equivalent level of Safety:

This deviation results in an installation limitation that requires the combined isolation (i.e. attenuation) resulting from installed VOR cable plus connector losses minus VOR antenna gain in the 960-1215 MHz frequency range plus attenuation due to the spacing between the VOR antenna and ATC Transponder, TCAS and DME antennas, minus the antenna gain of the victim receiving system at low elevation angles be greater than 40 dB. Note that the required isolation does not include the coaxial and connector cable losses of the victim receiving system because these are already accounted for in the receiver sensitivity specified in the MOPS for these systems (see Notes in above table). This would guarantee that the maximum interfering VOR emission level measured at the output port of the ATC Transponder, TCAS and DME antennas is less than -114 dBm. This limitation will be noted in the VOR equipment maintenance/installation manual.

This deviation provides an equivalent of safety for DME, ATC Transponder and TCAS equipment installed on aircraft that provide 40 dB or more of isolation between the VOR radios and the antennas of these L-band systems.

EASA:

The proposed deviation provides an equivalent level of safety as the receivers sharing the same frequency band do not receive a level of spurious emission which would affect their operation. This isolation is not provided by ED-22B level of spurious emission itself, but by the 40 dB installation attenuation required in the installation manual.

EASA also considered in its assessment that the VOR receiver is meeting ED-14E requirements for emission of Radio Frequency Energy Section 21 Category M and that spurious emissions of the other equipment sharing the same frequency band (namely Transponders, Airborne Collision Avoidance System (ACAS) and Distance Measuring Equipment (DME)) are allowed to be in the same range as the considered VOR equipment (-70 dBm).

Indeed,

- For ACAS equipment, ED-143 §2.2.3.2: unwanted output power :

  When the TCAS II interrogator is in the inactive state, the RF power at 1030 ±3 MHz at the terminals of the antenna shall not exceed -70 dBm. The inactive state is defined to include the entire period between ATCRBS and/or Mode S interrogations less 10 microsecond transition periods, if necessary, preceding and following the extremes of the interrogation transmission.

  Note: This power restriction is necessary to ensure that TCAS II does not prevent the on-board Mode S transponder from meeting its sensitivity and interference rejection requirements. It assumes that the isolation between the TCAS II antenna and the Transponder antenna exceeds 20 dB.

- For transponders ED-73E §3.3.4 Residual Power Output:

  When the transponder transmitter is in the inactive state, the RF output power at 1090 ±3 MHz, at the terminals of the antenna shall not exceed -50 dBm, except in transponders intended for use with ACAS where it shall not exceed -70 dBm

- For 1090 MHz Extended Squitter for ADS-B/TIS-B ED-102A §2.2.2.2.11 Unwanted Output Power:

  When the ADS-B transmitter is in the inactive state, the RF output power at 1090 ±3.0 MHz at the terminals of the antenna shall not exceed -70 dBm.

  Notes:

  (...)

  2. This unwanted power requirement is necessary to insure that the ADS-B transmitter does not prevent closely located 1090 MHz receiver equipment from meeting its requirements. It assumes that the isolation between the ADS-B transmitter antenna and the 1090 MHz receiver equipment antenna exceeds 20 dB. The resultant interference level at the 1090 MHz receiver equipment antenna should then be below -90 dBm.

- For DME ED-54 §3.18 Emission of Spurious CW R.F. energy

  a) The emission of spurious CW RF energy from the equipment on any frequency within the range 960 to 1215 MHz shall not exceed -47 dBm and shall not exceed -57 dBm on 1030 ± 3MHz and 1090 ± 3MHz.

  b) DME's intended for installation with TCAS equipment shall meet the requirement of a) above except that the emissions on 1030 ± 5MHz and 1090 ± 5 MHz shall not exceed -67dBm.

  c) For dual DME installations, the CW emission of each DME shall be such as not to produce a C.W. signal level at the input of the other DME greater than -99dBm. With an isolation of 20 dB between the two DME antennas and a feeder loss of 2dB per equipment the maximum allowable emission level would be -75dBm (-99 dBm + 4dB + 20 dB).

§7.2.1.4 Isolation between antennae (when applicable)

Note: Typical figures for the isolation between antennas are between 20 dB (which normally requires wired suppression) and 40dB.

From the extracts above, it can also be seen that a 40 dB isolation can reasonably be achieved. As a further example, a 2.5 m distance between antennas can typically provide a 40 dB isolation at the considered wavelength.

The deviation results in a limitation in the installation manual that the installation shall provide 40 dB or more of isolation between the VOR radios and the antennas of these L-band systems.

Therefore, EASA accepts the deviation.