ETSO-C60b
Date : 24.10.03

European Aviation Safety Agency

European Technical Standard Order

Subject: AIRBORNE AREA NAVIGATION EQUIPMENT USING LORAN C INPUTS

1 - Applicability

This ETSO gives the requirements which airborne area navigation equipment using Loran C inputs 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 - Basic

3.1.1 - Minimum Performance Standard

Standards set forth in Radio Technical Commission for Aeronautics (RTCA) Document DO-194 "Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Loran C Inputs," dated November 17, 1986 as amended and supplemented by this ETSO in particular as specified in appendix 1.

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3 - Computer Software

See CS-ETSO Subpart A paragraph 2.2

3.2 - Specific

None.

4 - Marking

4.1 - General

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

4.2 - Specific

None.

5 - Availability of Referenced Document

See CS-ETSO Subpart A paragraph 3.

APPENDIX 1

(i) Waypoint Storage. Add the following requirement to paragraph 2.2.1.6 of RTCA DO-194 :
If the equipment has an approach mode it shall store the complete sequence of waypoints for a selected approach. The sequence of waypoints shall consist of at least the following:
initial approach fix
final approach fix
missed approach point
missed approach holding point
The receiver must be designed in such a manner that waypoint coordinate data entry will not be possible when the approach mode has been selected. Waypoint coordinates, GRI, triad and TD correction factors may be included in the equipment data base or manually input as specified in paragraphs 2.2.1.5 and 2.2.1.13.

(ii) Holding Pattern Manoeuvring. Add the following requirement to the RTCA/DO-194:
The equipment shall provide the capability to proceed to a selected waypoint and hold on a specified inbound course to the waypoint with repeated crossing of the selected waypoint.

(iii) Failure/Status Indications. Add the following requirement to paragraph 2.2.1.10 of RTCA/DO-194:
In the approach mode, the lack of adequate navigation signals or sources shall be annunciated by means of a flag displayed on the primary navigation display. In other modes, an appropriately located annunciator may be used to satisfy this requirement.
In lieu of the loss of signal and cycle slip requirements specified paragraphs 2.2.1.10(b)(2) and (3) of RTCA/DO-194, substitute the following requirements:

(2) Loss of signal - The equipment shall detect loss of signal within 30 seconds for en route and terminal and 10 seconds for approach.

(3) Cycle slip - The equipment shall detect or correct a cycle slip within 10 minutes with a 90% probability after occurrence for en route and terminal mode operation, and shall present an alarm or correct a cycle slip within 10 seconds in the approach mode. In addition if the equipment encounters a cycle slip for a station and is switched to approach mode using that station for navigation, the equipment shall, within 10 seconds, present an alarm or have that station back in proper track.

(iv) Table 2-lB, 2D RNAV Loran C equipment Accuracy Requirements and Total System Error Evaluation. In lieu of the oceanic accuracy requirements specified in Table 2-lB of RTCA/DO-194, substitute the following requirement:

Error Type	Oceanic	
	XTK	ATK
Equipment (nmi)	12.6	12.6
FTE (nmi)	2.0	N/A
Total (nmi)	12.8	12.6

(v) Envelope-to-Cycle Discrepancy (ECD) In lieu of paragraph 2.2.3.2 of RTCA/DO-194, substitute the following requirement:
The equipment shall be able to properly acquire and track signals with an ECD of 0 to -2.4 microseconds at signal-to-noise ratios from -6 to-16 dB, and an ECD of -2.4 to +3.5 microseconds at signal-to-noise ratios above -6 dB.

(vi) Table 2-6. Loran Signal Test Conditions. In lieu of Table 2-6 of RTCA/DO-194, substitute the following requirement:

TABLE 2-6 LORAN SIGNAL TEST CONDITIONS

Test	Test	GRI	Groundwave Noise									CRI			CWI	
			Sm	Sx	Sy	Sn	Taw*	Saw*	ECDm	ECDx	ECDy	Scr	F1	S1	F2	S2
1	Dyn. Range	4990 ____	110	30	30	30			+3.5	0	-2.4					
2	ECD		40	40	40	46			0	0	0					
3			40	40	40	46			0	-2.4	0					
4			40	40	40	56			0	-2.4	-2.4					
••5	Skywave		40	40	40	56	35	46	0	0	0					
6			40	40	40	56	37.5	50	0	0	0					
7			40	40	40	56	40	50	0	0	0					
8			40	40	40	56	42.5	55	0	0	0					
9		btwn 7980 and 9990	40	40	40	56	45	60	0	0	0					
10			40	40	40	56	50	60	0	0	0					
11			40	40	40	56	55	65	0	0	0					
12			40	40	40	56	35	46	-2.4	-2.4	-2.4					
13			40	40	40	56	37.5	50	-2.4	-2.4	-2.4					
14			40	40	40	56	40	50	-2.4	-2.4	-2.4					
15			40	40	40	56	42.5	55	-2.4	-2.4	-2.4					
16			40	40	40	56	45	60	-2.4	-2.4	-2.4					
17			40	40	40	56	50	60	-2.4	-2.4	-2.4					
18			40	40	40	56	55	65	-2.4	-2.4	-2.4					
19	CWI		60	60	60	60			0	0	0		88.0	80	76.3	80
20			60	60	60	60			0	0	0		119.85	80	124	80
21			60	60	60	60			0	0	0		76.3	80	134	80
22			50	50	50	50			0	0	0		48.5	110	214	110
23		_____	80	50	50	50			+1.5	-2.4	-2.4					
24	CRI 3/	7980	110	50	0	40			0	-2.4	-2.4	110				
25	4/	7930	40	40	40	40			0	0	0	40				
26	ECD	4990	30	110	30	30			-2.4	+3.5	0					

Definitions:

Sm, Sx, Sy Signal strength in dB microvolts per meter of the Master, X and Y stations
Sn Signal strength of atmospheric noise in dB microvolts per meter (see paragraph (a)(1)(vii) of TSO C60b)
Taw Skywave delay with respect to groundwave
Saw Signal strength of skywave in dB microvolts per meter
Scr Cross-rate signal strength in dB microvolts per meter 3/
F1 Frequency of the i-th CW interferer
S1 Signal strength of the i-th CW interferer in dB microvolts per meter

* Skywave and signal strength are for secondary signals only, zero for master.
** For cases 5 thru 18, the skywave delay is from the ground wave cycle zero crossing to the skywave cycle zero crossing and the skywave ECD is equal to 0.

3/ Cross-rate GRI = 9960 master
4/ Cross-rate GRI = 7970 master and four secondaries

NOTES FOR TABLE 2-6:

(1) dB microvolts per meter equals dB above 1 microvolt per meter.
(2) The interference frequencies contained in Table 2-6 are based upon the existing environment at the time of publication. It is recognized that this environment could change over time, including the possible need for more than four notch filters. The manufacturer may select different/additional interference test frequencies (using the criteria of paragraph 2.2.3.3) if it is shown that the sequences specified in Table 2-6 are inappropriate.

(vii) 2D Failure Indication. Add the following requirements to paragraph 2.5.2.6 of RTCA/DO-194: Demonstrate that the equipment displays appropriate warning annunciations whenever accuracy or other status indication (blink, cycle slip, low SNR, loss of signal, etc.) requirements applicable to the selected mode of operation cannot be assured. Test conditions applicable to the particular equipment being evaluated, including limiting SNR and station geometry considerations, shall be established by the equipment manufacturer to verify proper operation. Should the equipment manufacturer establish an operating SNR lower than -16 dB, the noise signal level (Sn) of Table 2-6, test cases 4 thru 18, shall be increased to obtain the selected lower SNR level for all tests using these cases.

(viii) Acquisition Under Combined Conditions. In lieu of paragraph 2.5.2.7 of RTCA/DO-194, substitute the following requirement:
The capabilities identified in paragraphs 2.2.3.1 through 2.2.3.5 shall be demonstrated by subjecting the equipment to the following test.
Establish each of the conditions of Table 2-6 for a simulated chain of a master and two secondaries. For each of these conditions have the equipment acquire the signal 10 times. For Tests Nos. 5 thru 23, acquisition on the proper cycle shall be achieved within 450 seconds in 9 out of 10 trials and within 600 seconds in 10 out of 10 trials. For Test Nos. 1 thru 4 and 24 thru 26, acquisition on the proper cycle shall be achieved in 10 of 10 trials within 450 seconds.
Proper acquisition may be determined by observing TD values or Lat/Long output displayed by the equipment, and is considered successful if the signal is correctly acquired within the specified time period. Acquisition on the incorrect cycle is considered a failure.
If the equipment uses previous position data as an aid in acquisition, at least 50% of the acquisition tests shall be accomplished without the benefit of this data.

(ix) Cycle Slip. In lieu of paragraph 2.5.2.12 of RTCA/DO-194, substitute the following requirement:
Establish the conditions of Table 2-6, test cases 4 thru 23, with the en route mode selected and simulated chain of a master and two secondaries. Raise the noise level 20 dB for 10 seconds and during this same interval also change one of the TDs by ± 10 microseconds. Observe that within 10 minutes there is an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 5 times and -10 microseconds 5 times for each test case for a total of 200 trials. The test must be successful (result in an alarm or correction of the error) in at least 9 of 10 trials for each test case with no more than 5 failures overall.
Establish the conditions of Table 2-6 test cases 4, 5, 17 and 23 with the enroute mode selected and a simulated chain of a master and two secondaries. Turn off one secondary signal for 10 seconds and during the same interval change that secondary TD by ±10 microseconds. Observe that within 10 minutes there is either an alarm or that the 10 microseconds tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 5 times and -10 microseconds 5 times for each test case, for a total of 40 trials. The test must be successful (result in an alarm or correction of the error) in at least 39 of the 40 trials.
Set up the equipment as indicated in Figure 2-3, accelerate one secondary station signal while maintaining a known reference. Set the following conditions:

GRI = 7980
TD_1 = 28 417 microseconds
TD_2 = 11 128 microseconds
SNR = The lower of -14 dB or 2 dB above any lower operating SNR established by the equipment manufacturer

Using the signal test conditions of Table 2-6 test case 4, with Sn adjusted to establish the required SNR, accelerate TD_2 at 0.0567 microsecond/second/second or more until TD_2 = 11.133 microseconds then decelerate at the same rate until TD_2 = 11,138 microseconds. After zero velocity is reached wait 10 minutes. Observe that the signal is being tracked on the proper cycle or that there is an alarm. Repeat this procedure with TD_2 values decreasing to 11,118 microseconds using the same method. Repeat this test a sufficient number of times to establish its success (result in an alarm or correction of the error) 90% of the time with a 95% confidence level. A 95% confidence level can be achieved by conducting 30 trials (each 10 microsecond TD variation constitutes a trial) with zero failures, 48 trials with 1 failure, 63 trials with 2 failures etc.
If the equipment has an approach mode:
Establish the conditions of Table 2-6 test cases 1, 2 and 23 with a simulated chain of a master and two secondaries. Raise the noise level 35 dB for 10 seconds and during this interval also change one of the TDs by ± 10 microseconds. Wait five minutes. Switch to approach mode. Observe that within 10 seconds there is either an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 10 times and -10 microseconds 10 times for each test case for a total of 60 trials. All trials must be successful.
Establish the conditions of Table 2-6 test cases 1 and 2 with a simulated chain of a master and two secondaries. Turn off one secondary signal for 10 seconds and during the same interval change that secondary TD by ± 10 microseconds. Wait 5 minutes. Switch to approach mode. Observe that within 10 seconds there is either an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 10 times and -10 microseconds 10 times for each test case, for a total of 40 trials. All trials must be successful
Establish the conditions of Table 2-6, test cases 1, 2 and 23 with the approach mode selected and simulated chain of a master and two secondaries. Raise the noise level 35 dB for 10 seconds and during this interval also change one of the TDs by + 10 microseconds. Observe that within 10 seconds there is either an alarm or that the 10 microsecond tracking error has been corrected. The TD change shall be accomplished by altering the TD + 10 microseconds 10 times and -10 microseconds 10 times for each test case for a total of 60 trials. All trials must be successful.

(x) Atmospheric Noises Model. In demonstrating compliance with this TSO, the following model may be used to simulate atmospheric noise. The applicant may select a different model provided adequate substantiation is submitted to establish validity of the selected model.
Atmospheric noise is basically composed of two components, one a very weak component which has a Gaussian distribution. This first component may be simulated as follows: Simulated random noise (Gaussian) will be considered to have a uniform power spectral density prior to filtering. After filtering by a single resonator L-C filter having a center frequency of 100 kHz and a 3 dB bandwidth of 30 kHz, the noise level is the voltage generated across a 50-ohm resistive load measured on a true rms voltmeter; this noise level is defined as the rms noise level, denoted by X. This component is taken as 15.85% of the total noise power. The remaining 84.15% of the noise power is composed of the second component. This second component is simulated by pulses of 100 kHz, 30 microseconds wide, the rms value of which is A times X. The average number of pulses per second (P) is nominally 50 and lies in the range 40-60. The pulses (tone bursts) are randomly distributed (Poisson) in time. The linear addition of these two components is the simulated atmospheric noise with level N.

(1) N^2 = total noise power = $X^2 + (30 \times 10^{-6})PA^2X^2$

(2) Since $(30 \times 10^{-6})\ PA^2 = \frac{84.15}{15.85} = 5.309$

Using P = 50 pps and solving (2)
for A gives A = 59.5

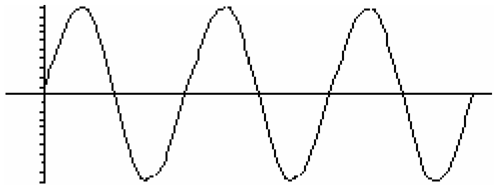
N^2 = total noise power
X = rms value of Gaussian noise
A = relative amplitude of l00 kHz pulse
P = number of pulses per second

Signal strength in dB microvolts per meter referenced in Table 2-6 and elsewhere shall be converted to voltages at the space coupling node of Figure 2-1 by multiplying by the effective electrical height (in meters) of the simulated antenna. Atmospheric noise in dB microvolts per meter, Sn, is converted to voltage by the expression

$$\text{Sn (voltage)} = 10^{\left[\frac{\text{Sn(dB) x effective antenna height (meters)}}{20}\right]}$$

Set this value equal to the total noise power, N^2, in the atmospheric noise model and solve equation (1) for X. The result is the desired rms value of Gaussian noise measured across the 50-ohm resistive load.

$$\sqrt{2AX}$$



30 µs

100 kHz Tone Burst