GOVERNMENT NOTICE NO. 61 published on 31/1/2026

THE CIVIL AVIATION ACT,
(CAP. 80)

REGULATIONS

(Made under regulation 5)

THE CIVIL AVIATION (RADIO NAVIGATION AIDS) (AMENDMENT) REGULATIONS, 2026

Citation

GN No. 68 of 2017

1. These Regulations may be cited as the Civil Aviation (Radio Navigation Aids) (Amendment) Regulations, 2026 and shall be read as one with the Civil Aviation (Radio Navigation Aids) Regulations, 2017, hereinafter referred to as the "principal Regulations".

Amendment of regulation 2

2. The principal Regulations are amended in regulation 2 by adding in their appropriate alphabetical order the following definitions:

""Advanced Receiver Autonomous Integrity Monitoring (ARAIM)" means a function contained in ABAS which uses an ISD;

"Integrity Support Data (ISD)" means a set of parameters that characterize the signal-in-space (SIS) integrity performance for each specific core satellite constellation and ARAIM service type;

"Integrity Support Message (ISM)" means a dedicated core satellite constellation broadcast navigation message that contains ISD parameters which may improve ARAIM performance compared to the default ISD values;

"Integrity Support Message Generator (ISMG)" means a module which determines the values of an ISD parameters transmitted in the ISM for

ARAIM in a given core satellite constellation.”.

Deletion and substitution of Schedule

3. The principal Regulations are amended by deleting the Schedule and substituting for it the following:

“

SCHEDULE

(Made under regulations 23, 24, 28, 31, 32, 34, 35, 41 and 42)

1.0 SPECIFICATION FOR PRECISION APPROACH RADAR SYSTEM
1.1 The precision approach radar element (PAR)

1.1.1 Coverage
1.1.1.1 The PAR shall be capable of detecting and indicating the position of an aircraft of 15 m^2 echoing area or larger, which is within a space bounded by a 20-degree azimuth sector and a 7-degree elevation sector, to a distance of at least 16.7 km (9 NM) from its respective antenna.
1.1.1.2 For guidance in determining the significance of the echoing areas of aircraft, the following shall included:
a) private flyer (single-engined): 5 to 10 m2;
b) small twin-engined aircraft: from 15 m2;
c) medium twin-engined aircraft: from 25 m2;
d) four-engined aircraft: from 50 to 100 m2.

1.1.2 *Sitting*
1.1.2.1 The PAR shall be sited and adjusted so that it gives complete coverage of a sector with its apex at a point 150 m (500 ft) from the touchdown in the direction of the stop end of the runway and extending plus or minus 5 degrees about the runway centre line in azimuth and from minus 1 degree to plus 6 degrees in elevation.

1.1.3 *Accuracy*
1.1.3.1 ***Azimuth accuracy*** - *Azimuth* information shall be displayed in such a manner that left-right deviation from the on-course line shall be easily observable. The maximum permissible error with respect to the deviation from the on-course line shall be either 0.6 per cent of the distance from the PAR antenna plus 10 per cent of the deviation from the on-course line or 9 m (30 ft), whichever is greater. The equipment shall be so sited that the error at the touchdown shall not exceed 9 m (30 ft). The equipment shall be so aligned and adjusted that the displayed error at the touchdown shall be a minimum and shall not exceed 0.3 per cent of the distance from the PAR antenna or 4.5 m (15 ft), whichever is greater. It shall be possible to resolve the positions of two aircraft which are at 1.2 degrees in azimuth

of one another.

1.1.3.2 ***Elevation accuracy*** - *Elevation* information shall be displayed in such a manner that up-down deviation from the descent path for which the equipment is set shall be easily observable. The maximum permissible error with respect to the deviation from the on-course line shall be 0.4 per cent of the distance from the PAR antenna plus 10 per cent of the actual linear displacement from the chosen descent path or 6 m (20 ft), whichever is greater. The equipment shall be so sited that the error at the touchdown shall not exceed 6 m (20 ft). The equipment shall be so aligned and adjusted that the displayed error at the touchdown shall be a minimum and shall not exceed 0.2 per cent of the distance from the PAR antenna or 3 m (10 ft), whichever is greater. It shall be possible to resolve the positions of two aircraft that are at 0.6 degree in elevation of one another.

1.1.3.3 ***Distance accuracy*** - *The* error in indication of the distance from the touchdown shall not exceed 30 m (100 ft) plus 3 per cent of the distance from the touchdown. It shall be possible to resolve the positions of two aircraft which are at 120 m (400 ft) of one another on the same azimuth.

1.1.4 Information shall be made available to permit the position of the controlled aircraft to be established with respect to other aircraft and obstructions. Indications shall also permit appreciation of ground speed and rate of departure from or approach to the desired flight path.

1.1.5 Information shall be completely renewed at least once every second.

1.2 The surveillance radar element (SRE)

1.2.1 *Coverage*

1.2.1.1 The SRE shall be capable of detecting aircraft of 15 m2 echoing area and larger, which are in line of sight of the antenna within a volume described as follows: The rotation through 360 degrees about the antenna of a vertical plane surface bounded by a line at an angle of 1.5 degrees above the horizontal plane of the antenna, extending from the antenna to 37 km (20 NM); by a vertical line at 37 km (20 NM) from the intersection with the 1.5-degree line up to 2 400 m (8 000 ft) above the level of the antenna; by a horizontal line at 2 400 m (8 000 ft) from 37 km (20 NM) back towards the antenna to the intersection with a line from the antenna at 20 degrees above the horizontal plane of the antenna, and by a 20-degree line from the intersection with the 2 400 m (8 000 ft) line to the antenna.

1.2.1.2 Efforts shall be made in development to increase the coverage on an aircraft of 15 m^2 echoing area to at least the volume obtained by amending 3.2.4.2.1 with the following substitutions:

- for 1.5 degrees, read 0.5 degree;
- for 37 km (20 NM), read 46.3 km (25 NM);
- for 2 400 m (8 000 ft), read 3 000 m (10 000 ft);
- for20 degrees, read 30 degrees.

1.2.2 *Accuracy*

1.2.2.1 *Azimuth accuracy.* The indication of position in azimuth shall be within plus or minus 2 degrees of the true position. It shall be possible to resolve the positions of two aircraft which are at 4 degrees of azimuth of one another.

1.2.2.2 *Distance accuracy.* The error in distance indication shall not exceed 5 per cent of true distance or 150 m (500 ft), whichever is the greater. It shall be possible to resolve the positions of two aircraft that are separated by a distance of 1 per cent of the true distance from the point of observation or 230 m (750 ft), whichever is the greater.

1.2.2.2.1 The error in distance indication shall not exceed 3 per cent of the true distance or 150 m (500 ft), whichever is the greater.

1.2.3 The equipment shall be capable of completely renewing the information concerning the distance and azimuth of any aircraft within the coverage of the equipment at least once every 4 seconds.

1.2.4 Efforts shall be made to reduce, as far as possible, the disturbance caused by ground echoes or echoes from clouds and precipitation.

2.0 Specification for ILS

2.0.1 Basic requirements

2.0.2. The ILS shall comprise the following basic components:

a) VHF localizer equipment, associated monitor system, remote control and indicator equipment;

b) UHF glide path equipment, associated monitor system, remote control and indicator equipment;

c) an appropriate means to enable glide path verification checks.

Note.— The Procedures for Air Navigation Services — Aircraft Operations *(PANS-OPS)*
(Doc 8168) provide guidance on the conduct of glide path verification checks.

2.0.3 **Recommendation.—** Distance to threshold information to enable glide path verification checks should be provided by either VHF marker beacons or distance measuring equipment (DME), together with associated monitor systems and remote control and indicator equipment.

2.0.4 If one or more VHF marker beacons are used to provide distance to threshold information, the equipment shall conform to the specifications in 3.1.7. If DME is used in lieu of marker beacons, the equipment shall conform to the specifications in 3.1.7.6.5.

Note.— Guidance material relative to the use of DME and/or other standard radio navigation aids as an alternative to the marker beacon is contained in Attachment C, 2.11.

2.0.5 Facility Performance Categories I, II and III — ILS shall provide indications at designated remote control points of the operational status of all ILS ground system components, as follows:

a) for all Facility Performance Category II and Category III ILS, the air traffic services unit involved in the control of aircraft on the final approach shall be one of the designated remote control points and shall receive information on the operational status of the ILS, with a delay commensurate with the requirements of the operational environment;

b) for a Facility Performance Category I ILS, if that ILS provides an essential radio navigation service, the air traffic services unit involved in the control of aircraft on the final approach shall be one of the designated remote control points and shall receive information on the operational status of the ILS, with a delay commensurate with the requirements of the operational environment.

Note.— The indications required by this Standard are intended as a tool to support air traffic management functions, and the applicable timeliness requirements are sized accordingly (consistently with 2.3.1).

2.0.6 The ILS shall be constructed and adjusted so that, at a specified distance from the threshold, similar instrumental indications in the aircraft represent similar displacements from the course line or ILS glide path as appropriate, irrespective of the particular ground installation in use.

2.0.7The localizer and glide path components specified in 3.1.2.1 a) and b) which form part of a Facility Performance Category I — ILS shall comply at least with the Standards in 3.1.3 and 3.1.5 respectively, excepting those in which application to Facility Performance Category II — ILS is prescribed.

2.0.8 The localizer and glide path components specified in 3.1.2.1 a) and b) which form part of a Facility Performance Category II — ILS shall comply with the Standards applicable to these components in a Facility Performance Category I — ILS, as supplemented or amended by the Standards in 3.1.3 and 3.1.5 in which application to Facility Performance Category II — ILS is prescribed.

2.0.9 The localizer and glide path components and other ancillary equipment specified in 3.1.2.1.3, which form part of a Facility Performance Category III — ILS, shall otherwise comply with the Standards applicable to these components in Facility Performance Categories I and II — ILS, except as supplemented by the Standards in 3.1.3 and 3.1.5 in which application to Facility Performance Category III — ILS is prescribed.

2.0.10 To ensure an adequate level of safety, the ILS shall be so designed and maintained that the probability of operation within the performance requirements specified is of a high value, consistent with the category of operational performance concerned.

2.0.11 For Facility Performance Category II and III localizers and glide paths, the level of integrity and continuity of service shall be at least Level 3, as defined in 3.1.3.12.4 (localizer) and 3.1.5.8.4 (glide path).

Note.— The specifications for Facility Performance Categories II and III — ILS are intended to achieve the highest degree of system integrity, reliability and stability of operation under the most adverse environmental conditions to be encountered.

Guidance material to achieve this objective is given in 2.8 of Attachment C.

2.0.12 At those locations where two separate ILS facilities serve opposite ends of a single runway, and operationally harmful interference would be present if both facilities were transmitting, an interlock shall ensure that only the localizer serving the approach direction in use shall radiate.

Note 1.— While a low height overflight of a transmitting localizer may generate interference within airborne ILS receivers, this interference may only be considered as operationally harmful when it occurs in specific conditions, e.g. without visual cues of the runway, or when the autopilot is engaged. Additional guidance material is contained in 2.1.8 and 2.13 of Attachment C.

Note 2.— Interference may also be caused by transmissions from other localizers *not serving the opposite end of the same runway (i.e. crossing, parallel or adjacent runways). In such cases, use of interlock to prevent the interference can also be considered.*

Note 3.— An interlock can be provided through hardware, software or an equivalent procedural means.

2.0.13 At locations where ILS facilities serving opposite ends of the same runway or different runways at the same airport use the same paired frequencies, an interlock shall ensure that only one facility shall radiate at a time. When switching from one ILS facility to another, radiation from both shall be suppressed for not less than 20 seconds.

Note.— Additional guidance material on the operation of localizers on the same frequency channel is contained in Volume V, Chapter 4.

2.0.14 At those locations where an ILS facility and a GBAS facility serve opposite approach directions to the same runway, when the approach direction in use is not the direction served by the ILS, the localizer shall not radiate when GBAS low visibility operations that require GAST D are being conducted, except where it can be demonstrated that the localizer signal supports compliance with the requirements in Appendix B, 3.6.8.2.2.5 and 3.6.8.2.2.6 defining the desired to undesired signal ratios and the maximum adjacent channel power tolerable by the GBAS VDB receiver.

Note.— If the localizer is radiating there is a possibility of interference to the GBAS VDB signals in the region where the aircraft overflies the localizer. A means to ensure that the localizer does not radiate can be provided through either hardware or software interlock or a procedural mitigation. Additional guidance material is contained in Attachment C, 2.1.8.1 and Attachment D, 7.2.3.3.

2.1 Specifications for VHF localizer and associated monitor

Introduction: The specifications in this section cover ILS localizers providing either positive guidance information over 360 degrees of azimuth, or providing such guidance only within a specified portion of the front coverage (see 3.1.3.7.4). Where ILS localizers providing positive guidance information in a limited sector are installed, information from some suitably located navigation aid, together with appropriate procedures, will generally be required to ensure that any misleading guidance information outside the sector is not operationally significant.

2.2 General

2.2.1 The radiation from the localizer antenna system shall produce a composite field pattern which is amplitude modulated by a 90 Hz and a 150 Hz tone. The radiation field pattern shall produce a course sector with one tone predominating on one side of the course and with the other tone predominating on the opposite side.

2.2.2 When an observer faces the localizer from the approach end of a runway, the depth of modulation of the radio frequency carrier due to the 150 Hz tone shall predominate on the observer's right hand and that due to the 90 Hz tone shall predominate on the observer's left hand.

2.2.3 All horizontal angles employed in specifying the localizer field patterns shall originate from the centre of the localizer antenna system which provides the signals used in the front course sector

2.3 Radio frequency

2.3.1 The localizer shall operate in the band 108 MHz to 111.975 MHz. Where a single radio frequency carrier is used, the frequency tolerance shall not exceed plus or minus 0.005 per cent. Where two radio frequency carriers are used, the frequency tolerance shall not exceed 0.002 per cent and the nominal band occupied by the carriers shall be symmetrical about the assigned frequency. With all tolerances applied, the frequency separation between the carriers shall not be less than 5 kHz nor more than 14 kHz.

2.3.2 The emission from the localizer shall be horizontally polarized. The vertically polarized component of the radiation on the course line shall not exceed that which corresponds to a DDM error of 0.016 when an aircraft is positioned on the course line and is in a roll attitude of 20 degrees from the horizontal.

2.3.2.1 For Facility Performance Category II localizers, the vertically polarized component of the radiation on the course line shall not exceed that which corresponds to a DDM error of 0.008 when an aircraft is positioned on the course line and is in a roll attitude of 20 degrees from the horizontal.

2.3.2.2 For Facility Performance Category III localizers, the vertically polarized component of the radiation within a sector bounded by 0.02 DDM either side of the course line shall not exceed that which corresponds to a DDM error of 0.005 when an aircraft is in a roll attitude of 20 degrees from the horizontal.

2.3.3 For Facility Performance Category III localizers, signals emanating from the transmitter shall contain no components which result in an apparent course line fluctuation of more than 0.005 DDM peak to peak in the frequency band 0.01 Hz to 10 Hz.

2.4 Coverage

2.4.1 The localizer shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation within the localizer and glide path coverage sectors. The localizer coverage sector shall extend from the centre of the localizer antenna system to distances of:

- 46.3 km (25 NM) within plus or minus 10 degrees from the front course line;

- 31.5 km (17 NM) between 10 degrees and 35 degrees from the front course line;
- 18.5 km (10 NM) outside of plus or minus 35 degrees if coverage is provided;

except that, where topographical features dictate or operational requirements permit, the limits may be reduced to 33.3 km (18 NM) within the plus or minus 10-degree sector and 18.5 km (10 NM) within the remainder of the coverage when alternative

navigational facilities provide satisfactory coverage within the intermediate approach area. The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2 000 ft) above the elevation of the threshold, or 300 m (1 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher. Such signals shall be receivable, to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7 degrees above the horizontal.

2.4.2 In all parts of the coverage volume specified in 2.3.1 other than as specified in 2.3.2.1, 2.3.2.2 and 2.3.2.3, the field strength shall be not less than 40 microvolts per metre (minus 114 dBW/m2). This minimum field strength shall be required to permit satisfactory operational usage of ILS localizer facilities.

2.4.2.1 For Facility Performance Category I localizers, the minimum field strength on the ILS glide path and within the localizer course sector from a distance of 18.5 km (10 NM) to a height of 60 m (200 ft) above the horizontal plane containing the threshold shall be not less than 90 µv per metre (minus 107 dBW/m2).

2.4.2.2 For Facility Performance Category II localizers, the minimum field strength on the ILS glide path and within the localizer course sector shall be not less than 100 µv per metre (minus 106 dBW/m2) at a distance of 18.5 km (10 NM) increasing to not less than 200 µv per metre (minus 100 dBW/m2) at a height of 15 m (50 ft) above the horizontal plane containing the threshold.

2.4.2.3 For Facility Performance Category III localizers, the minimum field strength on the ILS glide path and within the localizer course sector shall be not less than 100 µv permetre (minus 106 dBW/m2) at a distance of 18.5 km (10 NM), increasing to not less than 200 µv per metre (minus 100 dBW/m2) at 6 m (20 ft) above the horizontal plane containing the threshold. From this point to a further point 4 m (12 ft) above the runway centre line, and 300 m (1 000 ft) from the threshold in the direction of the localizer, and thereafter at a height of 4 m (12 ft) along the length of the runway in the direction of the localizer, the field strength shall be not less than 100 µv per metre (minus 106 dBW/m2).

2.4.3 When coverage is achieved by a localizer using two radio frequency carriers, one carrier providing a radiation field pattern in the front course sector and the other providing a radiation field pattern outside that sector, the ratio of the two carrier signal strengths in space within the front course sector to the coverage limits specified at 2.3.1 shall not be less than 10 dB.

2.4.4 For Facility Performance Category III localizers, the ratio of the two carrier signal strengths in space within the front course sector shall not be less than 16 dB.

2.5 Course structure For Facility Performance Category I localizers, bends in the course line shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "A"	0.031
ILS Point "A" to ILS Point "B"	0.031 at ILS Point "A" decreasing at a linear rate to 0.015 at ILS Point "B"
ILS Point "B" to ILS Point "C"	0.015

2.5.1 For Facility Performance Categories II and III localizers, bends in the course line shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "A"	0.031
ILS Point "A" to ILS Point "B"	0.031 at ILS Point "A" decreasing at a linear rate to 0.005 at ILS Point "B"
ILS Point "B" to the ILS reference datum	0.005
and, for Category III only:	
ILS reference datum to ILS Point "D"	0.005
ILS Point "D" to ILS Point "E"	0.005 at ILS Point "D" increasing at a linear rate to 0.010 at ILS Point "E"

2.6 Carrier modulation

2.6.1 The nominal depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tones shall be 20 per cent along the course line.

2.6.2 The depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tones shall be within the limits of 18 and 22 per cent.

2.6.3 The following tolerances shall be applied to the frequencies of the modulating tones:

a) the modulating tones shall be 90 Hz and 150 Hz within plus or minus 2.5 per cent;

b) the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1.5 per cent for Facility Performance Category II installations;

c) the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1 per cent for Facility Performance Category III installations;

d) the total harmonic content of the 90 Hz tone shall not exceed 10 per cent; additionally, for Facility Performance Category III localizers, the second harmonic of the 90 Hz tone shall not exceed 5 per cent;

e) the total harmonic content of the 150 Hz tone shall not exceed 10 per cent.

2.6.3.1 For Facility Performance Category I ILS, the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1.5 per cent.

2.6.3.2 For Facility Performance Category III localizers, the depth of amplitude modulation of the radio frequency carrier at the power supply frequency or its harmonics, or by other unwanted components, shall not exceed 0.5 per cent. Harmonics of the supply, or other unwanted noise components that may inter-modulate with the 90 Hz and 150 Hz navigation tones or their harmonics to produce fluctuations in the course line, shall not exceed 0.05 per cent modulation depth of the radio frequency carrier.

2.6.3.3 The modulation tones shall be phase-locked so that within the half course sector, the demodulated 90 Hz and 150 Hz wave forms pass through zero in the same direction within:

a) for Facility Performance Categories I and II localizers: 20 degrees; and

b) for Facility Performance Category III localizers: 10 degrees, of phase relative to the 150 Hz component, every half cycle of the combined 90 Hz and 150 Hz wave form.

2.6.3.4 With two-frequency localizer systems, 2.5.3.3 shall apply to each carrier. In addition, the 90 Hz modulating tone of one carrier shall be phase-locked to the 90 Hz modulating tone of the other carrier so that the demodulated wave forms pass through zero in the same direction within:

a) for Categories I and II localizers: 20 degrees; and

b) for Category III localizers: 10 degrees, of phase relative to 90 Hz. Similarly, the 150 Hz tones of the two carriers shall be phase-locked so that the demodulated wave forms pass through zero in the same direction within:
1) for Categories I and II localizers: 20 degrees; and

2) for Category III localizers: 10 degrees, of phase relative to 150 Hz.

2.6.3.5 Alternative two-frequency localizer systems that employ audio phasing different from the normal in-phase conditions described in 2.5.3.4 shall be permitted. In this alternative system, the 90 Hz to 90 Hz phasing and the 150 Hz to 150 Hz phasing shall be adjusted to their nominal values to within limits equivalent to those stated in 2.5.3.4

2.6.3.6 The sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones shall not exceed 60 per cent or be less than 30 per cent within the required coverage.

2.6.3.6.1 For equipment first installed after 1 January 2000, the sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones shall not exceed 60 per cent or be less than 30 per cent within the required coverage.

2.6.3.7 When utilizing a localizer for radiotelephone communications, the sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones shall not exceed 65 per cent within 10 degrees of the course line and shall not exceed 78 per cent at any other point around the localizer.

2.7 Course alignment accuracy

2.7.1 The mean course line shall be adjusted and maintained within limits equivalent to the following displacements from the runway centre line at the ILS reference datum:

a) for Facility Performance Category I localizers: plus or minus 10.5 m (35 ft), or the linear equivalent of 0.015 DDM, whichever is less;
b) for Facility Performance Category II localizers: plus or minus 7.5 m (25 ft);

c) for Facility Performance Category III localizers: plus or minus 3 m (10 ft).

2.7.2 For Facility Performance Category II localizers, the mean course line shall be adjusted and maintained within limits equivalent to plus or minus 4.5 m (15 ft) displacement from runway centre line at the ILS reference datum.

2.8 Displacement sensitivity

2.8.1 The nominal displacement sensitivity within the half course sector shall be the equivalent of 0.00145 DDM/m (0.00044 DDM/ft) at the ILS reference datum except that for Category I localizers, where the specified nominal displacement sensitivity cannot be met, the displacement sensitivity shall be adjusted as near as possible to that value. For Facility Performance Category I localizers on runway codes 1 and 2, the nominal displacement sensitivity shall be achieved at the ILS Point "B". The maxim um course sector angle shall not exceed six degrees.

2.8.2 The lateral displacement sensitivity shall be adjusted and maintained within the limits of plus or minus:

a) 17 per cent of the nominal value for Facility Performance Categories I and II;
b) 10 per cent of the nominal value for Facility Performance Category III.

2.8.3 For Facility Performance Category II ILS, displacement sensitivity shall be adjusted and maintained within the limits of plus or minus 10 per cent.

2.8.4 The increase of DDM shall be substantially linear with respect to angular displacement from the front course line (where DDM is zero) up to an angle on either side of the front course line where the DDM is 0.180. From that angle to plus or minus 10 degrees, the DDM shall not be less than 0.180. From plus or minus 10 degrees to plus or minus 35 degrees, the DDM shall not be less than 0.155. Where coverage is required outside of the plus or minus 35 degrees sector, the DDM in the area of the coverage, except in the back course sector, shall not be less than 0.155.

2.9 Voice

2.9.1 Facility Performance Categories I and II localizers may provide a ground-to- air radiotelephone communication channel to be operated simultaneously with the navigation and identification signals, provided that such operation shall not interfere in any way with the basic localizer function.

2.9.2 Category III localizers shall not provide such a channel, except where extreme care has been taken in the design and operation of the facility to ensure that there is no possibility of interference with the navigational guidance.

2.9.3 If the channel is provided, it shall conform with the following Standards:

2.9.3.1 The channel shall be on the same radio frequency carrier or carriers as used for the localizer function, and the radiation shall be horizontally polarized. Where two carriers are modulated with speech, the relative phases of the modulations on the two carriers shall be such as to avoid the occurrence of nulls within the coverage of the localizer.

2.9.4 The peak modulation depth of the carrier or carriers due to the radiotelephone communications shall not exceed 50 per cent but shall be adjusted so that:

a) the ratio of peak modulation depth due to the radiotelephone communications to that due to the identification signal is approximately 9:1;

b) the sum of modulation components due to use of the radiotelephone channel, navigation signals and identification signals shall not exceed 95 per cent.

2.9.4.1 The audio frequency characteristics of the radiotelephone channel shall be flat to within 3 dB relative to the level at 1 000 Hz over the range 300 Hz to 3 000 Hz.

2.10 Identification

2.10.1 The localizer shall provide for the simultaneous transmission of an identification signal, specific to the runway and approach direction, on the same radio frequency carrier or carriers as used for the localizer function. The transmission of the identification signal shall not interfere in any way with the basic localizer function.

2.10.2 The identification signal shall be produced by Class A2A modulation of the radio frequency carrier or carriers using a modulation tone of 1 020 Hz within plus or minus 50 Hz. The depth of modulation shall be between the limits of 5 and 15 per cent except that, where a radiotelephone communication channel is provided, the depth of modulation shall be adjusted so that the ratio of peak modulation depth due to radiotelephone communications to that due to the identification signal modulation is approximately 9:1 (see 2.8.3.2). The emissions carrying the identification signal shall be horizontally polarized. Where two carriers are modulated with identification signals, the relative phase of the modulations shall be such as to avoid the occurrence of nulls within the coverage of the localizer.

2.10.3 The identification signal shall employ the International Morse Code and consist of two or three letters. It may be preceded by the International Morse signal of the letter "I", followed by a short pause where it is necessary to distinguish Code the ILS facility from other navigational facilities in the immediate area.

2.10.4 The identification signal shall be transmitted by dots and dashes at a speed corresponding to approximately seven words per minute, and shall be repeated at approximately equal intervals, not less than six times per minute, at all times during which the localizer is available for operational use. When the transmissions of the localizer are not available for operational use, as, for example, after removal of navigation components, or during maintenance or test transmissions, the identification signal shall be suppressed. The dots shall have a duration of 0.1 second to 0.160 second. The dash duration shall be typically three times the duration of a dot. The interval between dots and/or dashes shall be equal to that of one dot plus or minus 10 per cent. The interval between letters shall not be less than the duration of three dots.

2.11 Sitting

2.11.1 For Facility Performance Categories II and III, the localizer antenna system shall be located on the extension on the centre line of the runway at the stop end, and the equipment shall be adjusted so that the course lines will be in a vertical plane containing the centre line of the runway served. The antenna height and location shall be consistent with safe obstruction clearance practices.

2.11.2 For Facility Performance Category I, the localizer antenna system shall be located and adjusted as in 2.10.1, unless site constraints dictate that the antenna be offset from the centre line of the runway.

2.11.2.1 The offset localizer system shall be located and adjusted in accordance with the offset ILS provisions of the ICAO *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS) (Doc 8168), Volume II, and the localizer standards shall be referenced to the associated fictitious threshold point.

2.12 Monitoring

2.12.1 The automatic monitor system shall provide a warning to the designated control points and cause one of the following to occur, within the period specified in 2.11.3.1, if any of the conditions stated in 2.11.2 persist:

a) radiation to cease; and

b) removal of the navigation and identification components from the carrier.

2.12.2 The conditions requiring initiation of monitor action shall be the following:

a) for Facility Performance Category I localizers, a shift of the mean course line from the runway centre line equivalent to more than 10.5 m (35 ft), or the linear equivalent to 0.015 DDM, whichever is less, at the ILS reference datum;

b) for Facility Performance Category II localizers, a shift of the mean course line from the runway centre line equivalent to more than 7.5 m (25 ft) at the ILS reference datum;

c) for Facility Performance Category III localizers, a shift of the mean course line from the runway centre line equivalent to more than 6 m (20 ft) at the ILS reference datum;

d) in the case of localizers in which the basic functions are provided by the use of a single-frequency system, a reduction of power output to a level such that any of the requirements of 2.3, 2.4 or 2.5 are no longer satisfied, or to a level that is less than 50 per cent of the normal level (whichever occurs first);

e) in the case of localizers in which the basic functions are provided by the use of a two-frequency system, a reduction of power output for either carrier to less than 80 per cent of normal, except that a greater reduction to between 80 per cent and 50 per cent of normal may be permitted, provided the localizer continues to meet the requirements of 2.3, 2.4 and 2.5;

f) change of displacement sensitivity to a value differing by more than 17 per cent from the nominal value for the localizer facility.

2.12.2.1 In the case of localizers in which the basic functions are provided by the use of a two-frequency system, the conditions requiring initiation of monitor action shall include the case when the DDM in the required coverage beyond plus or minus 10 degrees from the front course line, except in the back course sector, decreases below 0.155.

2.12.2.2 The total period of radiation, including period(s) of zero radiation, outside the performance limits specified in a), b), c), d), e) and f) of 2.11.2 shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the localizer.
2.12.2.2.1 The total period referred to under 2.11.3 shall not exceed under any circumstances: 10 seconds for Category I localizers; 5 seconds for Category II localizers; 2 seconds for Category III localizers.

2.12.2.2.2 , The total period under 2.11.2.2.1 shall be reduced so as not to exceed two seconds for Category II localizers and one second for Category III localizers.

2.12.2.3 Design and operation of the monitor system shall be consistent with the requirement that navigation guidance and identification will be removed and a warning provided at the designated remote control points in the event of failure of the monitor system itself.

2.13 Integrity and continuity of service requirements

2.13.1 The probability of not radiating false guidance signals shall not be less than 1
– 0.5 × 10–9 in any one landing for Facility Performance Categories II and III localizers.

2.13.2 The probability of not radiating false guidance signals shall not be less than 1
– 1.0 × 10–7 in any one landing for Facility Performance Category I localizers.

2.14 The probability of not losing the radiated guidance signal shall be greater than:
a) 1 – 2 × 10–6 in any period of 15 seconds for Facility Performance Category II localizers or localizers intended to be used for Category III A operations (equivalent to 2 000 hours mean time between outages); and b) 1 – 2 × 10–6 in any period of 30 seconds for Facility Performance Category III localizers intended to be used for the full range of Category III operations (equivalent to 4 000 hours mean time between outages).

2.14.1 The probability of not losing the radiated guidance signal shall exceed 1 – 4 ×
10–6 in any period of 15 seconds for Facility Performance Category I localizers (equivalent to 1 000 hours mean time between outages).

2.15 Interference immunity performance for ILS localizer receiving systems

2.15.1 The ILS localizer receiving system shall provide adequate immunity to interference from two-signal, third order inter modulation products caused by VHF FM broadcast signals having levels in accordance with the following:

$$2N_1 + N_2 + 72 \leq 0$$

for VHF FM sound broadcasting signals in the range 107.7 – 108.0 MHz

and

$$2N_1 + N_2 + 3\left(24 - 20\log\frac{\Delta f}{0.4}\right) \leq 0$$

for VHF FM sound broadcasting signals below 107.7 MHz, where the frequencies of the two VHF FM sound broadcasting signals produce, within the receiver, a two-signal, third-order inter modulation product on the desired ILS localizer frequency. *N*1 and *N*2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the ILS localizer receiver input. Neither level shall exceed the desensitization criteria set forth = 108.1 – f1, where f1 is the frequency of N1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

2.13.3 The ILS localizer receiving system shall not be desensitized in the presence of VHF FM broadcast signals having levels in accordance with the following table:

Maximum level of unwanted Frequency signal at receiver input

Frequency (MHz)	*Maximum level of unwanted signal at receiver input (dBm)*
88-102	+15
104	+10
106	+5
107.9	–10

3.0 UHF glide path equipment and associated monitor

3.1 *General*

3.1.1 The radiation from the UHF glide path antenna system shall produce a composite field pattern which is amplitude modulated by a 90 Hz and a 150 Hz tone. The pattern shall be arranged to provide a straight line descent path in the vertical plane containing the centre line of the runway, with the 150 Hz tone

equal to 1.75 θ

predominating below the path and the 90 Hz tone predominating above the path to at least an angle

3.1.2 The ILS glide path angle shall be 3 degrees. ILS glide path angles in excess of 3 degrees shall not be used except where alternative means of satisfying obstruction clearance requirements are impracticable.

3.1.2.1 The glide path angle shall be adjusted and maintained within:

ILS glide paths;

a) 0.075 θ from θ for Facility Performance Categories I and II —

b) 0.04 θ from θ for Facility Performance Category III —

ILS glide paths.

3.1.3 The downward extended straight portion of the ILS glide path shall pass through the ILS reference datum at a height ensuring safe guidance over obstructions and also safe and efficient use of the runway served.

3.1.4 The height of the ILS reference datum for Facility Performance Categories II and III ILS shall be 15 m (50 ft). A tolerance of plus 3 m (10 ft) is permitted.

3.1.5 The height of the ILS reference datum for Facility Performance Category I ILS shall be 15 m (50 ft). A tolerance of plus 3 m (10 ft) is permitted. —

3.1.6 The height of the ILS reference datum for Facility Performance Category I ILS used on short precision approach runway codes 1 and 2 shall be 12 m (40 ft). A tolerance of plus 6 m (20 ft) is permitted.

3.2 Radio frequency

3.2.1 The glide path equipment shall operate in the band 328.6 MHz to 335.4 MHz. Where a single radio frequency carrier is used, the frequency tolerance shall not exceed

0.005 per cent. Where two carrier glide path systems are used, the frequency tolerance shall not exceed 0.002 per cent and the nominal band occupied by the carriers shall be symmetrical about the assigned frequency. With all tolerances applied, the frequency separation between the carriers shall not be less than 4 kHz nor more than 32 kHz.

3.2.2 The emission from the glide path equipment shall be horizontally polarized.

3.2.3 For Facility Performance Category III ILS glide path equipment, signals emanating from the transmitter shall contain no components which result in apparent glide path fluctuations of more than 0.02 DDM peak to peak in the frequency band

0.01 Hz to 10 Hz.

3.3 Coverage

3.3.1 The glide path equipment shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation in sectors of 8 degrees in azimuth on each side of the centre line of the ILS glide path, to a distance of at least18.5 km (10 NM) up

to 1.75 θ and down to 0.45 θ above the horizontal or to such lower angle, down to 0.30 θ, as required to safeguard the promulgated glide path intercept procedure.

3.3.2 In order to provide the coverage for glide path performance specified in 3.3.1, the minimum field strength within this coverage sector shall be 400 microvolts per metre(minus 95 dBW/m2). For Facility Performance Category I glide paths, this field strength shall be provided down to a height of 30 m (100 ft) above the horizontal plane containing the threshold. For Facility Performance Categories II and III glide paths, this field strength shall be provided down to a height of 15 m (50 ft) above the horizontal plane containing the threshold.

3.4 ***ILS glide path structure***

3.4.1 For Facility Performance Category I ILS glide paths, bends in the glide path shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "C"	0.035

3.4.2 For Facility Performance Categories II — and III ILS glide paths, bends in the glide path shall not have amplitudes which exceed the following:

Zone	*Amplitude (DDM) (95% probability)*
Outer limit of coverage to ILS Point "A"	0.035
ILS Point "A" to ILS Point "B"	0.035 at ILS Point "A" decreasing at a linear rate to 0.023 at ILS Point "B"
ILS Point "B" to the ILS reference datum	0.023

3.5 Carrier modulation

3.5.1 The nominal depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tones shall be 40 per cent along the ILS glide path. The depth of modulation shall not deviate outside the limits of 37.5 per cent to 42.5 per cent.

3.5.2 The following tolerances shall be applied to the frequencies of the modulating tones:

a) the modulating tones shall be 90 Hz and 150 Hz within 2.5 per cent for Facility

Performance Category I ILS;

b) the modulating tones shall be 90 Hz and 150 Hz within 1.5 per cent for Facility Performance Category II ILS;

c) the modulating tones shall be 90 Hz and 150 Hz within 1 per cent for Facility Performance Category III ILS;
d) the total harmonic content of the 90 Hz tone shall not exceed 10 per cent: additionally, for Facility Performance
Category III equipment, the second harmonic of the 90 Hz tone shall not exceed 5 per cent;

e) the total harmonic content of the 150 Hz tone shall not exceed 10 per cent.

3.5.2.1 For Facility Performance Category I ILS, the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1.5 per cent.

3.5.2.2 For Facility Performance Category III glide path equipment, the depth of amplitude modulation of the radio frequency carrier at the power supply frequency or harmonics, or at other noise frequencies, shall not exceed 1 per cent.

3.5.3 The modulation shall be phase-locked so that within the ILS half glide path sector, the demodulated 90 Hz and 150 Hz wave forms pass through zero in the same direction within:
a) for Facility Performance Categories I and II ILS glide paths: 20 degrees;
b) for Facility Performance Category III ILS glide paths: 10 degrees, of phase relative to the 150 Hz component, every half cycle of the combined 90 Hz and 150 Hz wave form.

3.5.3.1 With two-frequency glide path systems, 3.5.3 shall apply to each carrier. In addition, the 90 Hz modulating tone of one carrier shall be phase-locked to the 90 Hz modulating tone of the other carrier so that the demodulated wave forms pass through zero in the same direction within:

a) for Categories I and II ILS glide paths: 20 degrees;

b) for Category III ILS glide paths: 10 degrees, of phase relative to 90 Hz. Similarly, the 150 Hz tones of the two carriers shall be phase-locked so that the demodulated wave forms pass through zero in the same direction, within:
1) for Categories I and II ILS glide paths: 20 degrees;
2) for Category III— ILS glide paths: 10 degrees, of phase relative to 150 Hz.
3.5.3.2 Alternative two-frequency glide path systems that employ audio phasing different from the normal in-phase condition described in 3.5.3.1 shall be permitted. In these alternative systems, the 90 Hz to 90 Hz phasing and the 150 Hz to 150 Hz phasing shall be adjusted to their nominal values to within limits equivalent to those stated in 3.5.3.1

3.5.4 Undesired frequency and phase modulation on ILS glide path radio frequency carriers that can affect the displayed DDM values in glide path receivers shall be minimized to the extent practical.

3.6 *Displacement sensitivity*

3.6.1 For Facility Performance Category I ILS glide paths, the nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at angular
above and below the glide path between 0.07 θ and 0.14 θ.
displacements

3.6.2 For Facility Performance Category I ILS glide paths, the nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at an angular displacement below the glide path of 0.12 θ with a tolerance of plus or minus 0.02 θ.

The upper and lower sectors shall be as symmetrical as practicable within the limits specified in 3.6.1.

3.6.3 For Facility Performance Category II ILS glide paths, the angular displacement sensitivity shall be as symmetrical as practicable. The nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at an angular displacement of:

3.6.4 For Facility Performance Category III ILS glide paths, the nominal

a) 0.12 θ below path with a tolerance of plus or minus 0.02 θ;

b) 0.12 θ above path with a tolerance of plus 0.02 θ and minus 0.05 θ

angular displacement sensitivity shall correspond to a DDM of 0.0875 at angular displacements —

above and below the glide path of 0.12 θ with a tolerance of plus or minus 0.02 θ.

3.6.5 The DDM below the ILS glide path shall increase smoothly for decreasing angle until a value of 0.22 DDM is reached. This value shall be achieved at an angle

not less than 0.30 θ above the horizontal. However, if it is achieved at an angle above 0.45 θ, the DDM value shall not be less than 0.22 at least down to 0.45 θ or to such lower angle, down to 0.30 θ, as required to safeguard the promulgated glide path intercept procedure.

3.6.6 For Facility Performance Category I ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 25 per cent of the nominal value selected.

3.6.7 For Facility Performance Category II ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 20 per cent of the nominal value selected.

3.6.8 For Facility Performance Category III ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 15 per cent of the nominal value selected.

3.7 ***Monitoring***

3.7.1 The automatic monitor system shall provide a warning to the designated control points and cause radiation to cease within the periods specified in 3.7.3.1 if any of the following conditions persist:

a) shift of the mean ILS glide path angle equivalent to more than minus 0.075 θ to plus 0.10 θ from θ;

b) in the case of ILS glide paths in which the basic functions are provided by the use of a single-frequency system, a reduction of power output to less than 50 per cent of normal, provided the glide path continues to meet the requirements of 3.3, 3.4 and 3.5;

c) in the case of ILS glide paths in which the basic functions are provided by the use of two-frequency systems, a reduction of power output for either carrier to less than 80 per cent of normal, except that a greater reduction to between 80 per cent and 50 per cent of normal may be permitted, provided the glide path continues to meet the requirements of 3.3, 3.4 and 3.5;

d) for Facility Performance Category I ILS glide paths, a change of the angle between the glide path and the line below the glide path (150 Hz predominating) at which a DDM of 0.0875 is realized by more than the greater of:
i) Plus or minus 0.0375 θ; or
ii) An angle equivalent to a change of displacement sensitivity to a value differing by 25 per cent from the nominal value;
e) for Facility Performance Categories II and III ILS glide paths, a change of displacement sensitivity to a value differing by more than 25 per cent from the nominal value;
f) lowering of the line beneath the ILS glide path at which a DDM of 0.0875 is to less than 0.7475 θ from horizontal;
realized
g) a reduction of DDM to less than 0.175 within the specified coverage below the glide path sector.

3.7.2 Monitoring of the ILS glide path characteristics to smaller tolerances shall be arranged in those cases where operational penalties would otherwise exist.

3.7.3 The total period of radiation, including period(s) of zero radiation, outside the performance limits specified in 3.7.1 shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the ILS glide path.
3.7.3.1 The total period referred to under 3.7.3 shall not exceed under any circumstances:
6 seconds for Category I ILS glide paths;
2 seconds for Categories II and III ILS glide paths.
3.7.3.2 The total period specified under 3.7.3.1 for Categories II and III ILS glide paths shall not exceed 1 second. —

3.7.4 Design and operation of the monitor system shall be consistent with the requirement that radiation shall cease and a warning shall be provided at the designated remote control points in the event of failure of the monitor system itself.

3.8 *Integrity and continuity of service requirements*

3.8.1 The probability of not radiating false guidance signals shall not be less than 1
0.5 × 10 9 in any one landing for Facility Performance Categories II and III glide paths.

3.8.2 The probability of not radiating false guidance signals shall not be less than 1
1.0 × 10 7 in any one landing for Facility Performance Category I glide paths.

3.8.3 The probability of not losing the radiated guidance signal shall be greater than
1 2 × 10 6 in any period of 15 seconds for Facility Performance Categories II and III glide paths (equivalent to 2 000 hours mean time between outages).

of not losing the radiated guidance signal shall exceed 1

5 seconds for Facility Performance Category I glide
) hours mean time between outages).

lide path frequency pairing
ie runway localizer and glide path transmitter frequencies
system shall be taken from the following list:

Localizer (MHz)	*Glide path (MHz)*
108.1	334.7
108.15	334.55
108.3	334.1
108.35	333.95
108.5	329.9
108.55	329.75
108.7	330.5
108.75	330.35
108.9	329.3
108.95	329.15
109.1	331.4
109.15	331.25
109.3	332.0
109.35	331.85
109.5	332.6
109.55	332.45
109.7	333.2
109.75	333.05
109.9	333.8
109.95	333.65
110.1	334.4
110.15	334.25
110.3	335.0
110.35	334.85
110.5	329.6
110.55	329.45
110.7	330.2
110.75	330.05
110.9	330.8
110.95	330.65
111.1	331.7
111.15	331.55
111.3	332.3
111.35	332.15
111.5	332.9
111.55	332.75
111.7	333.5
111.75	333.35
111.9	331.1
111.95	330.95

4.0 VHF marker beacons

4.1 *General*

a) There shall be two marker beacons in each installation except where, in the opinion of the Competent Authority, a single marker beacon is considered to be sufficient.. A third marker beacon may be added whenever, in the opinion of the Competent Authority, an additional beacon is required because of operational procedures at a particular site.

b) The marker beacons shall conform to the requirements prescribed in 4.0. When the installation comprises only two marker beacons, the requirements applicable to the middle marker and to the outer marker shall be complied with. When the installation comprises only one marker beacon, the requirements applicable to either the middle or the outer marker shall be complied with. If marker beacons are replaced by DME, the requirements of 4.6.5 shall apply.

c) The marker beacons shall produce radiation patterns to indicate predetermined distance from the threshold along the ILS glide path.

4.1.1 When a marker beacon is used in conjunction with the back course of a localizer, it shall conform with the marker beacon characteristics specified in 4.0.

4.1.2 Identification signals of marker beacons used in conjunction with the back course of a localizer shall be clearly distinguishable from the inner, middle and outer marker beacon identifications, as prescribed in 4.5.1.

4.2 *Radio frequency*

4.2.1 The marker beacons shall operate at 75 MHz with a frequency tolerance of plus or minus 0.005 per cent and shall utilize horizontal polarization.

4.3 *Coverage*

4.3.1 The marker beacon system shall be adjusted to provide coverage over the following distances, measured on the ILS glide path and localizer course line:

a) *inner marker:* 150 m plus or minus 50 m (500 ft plus or minus 160 ft);
b) *middle marker:* 300 m plus or minus 100 m (1 000 ft plus or minus 325 ft);
c) *outer marker:* 600 m plus or minus 200 m (2 000 ft plus or minus 650 ft).

4.3.2 The field strength at the limits of coverage specified in 4.3.1 shall be 1.5 millivolts per metre(minus 82 dBW/m2). In addition, the field strength within the coverage area shall rise to at least 3.0 millivolts per metre(minus 76 dBW/m2).

4.4 *Modulation*

4.4.1 The modulation frequencies shall be as follows:

a) *inner marker:* 3 000 Hz;
b) *middle marker:* 1 300 Hz;
c) *outer marker:* 400 Hz.

The frequency tolerance of the above frequencies shall be plus or minus 2.5 per cent, and the total harmonic content of each of the frequencies shall not exceed 15 per cent.

4.4.2 The depth of modulation of the markers shall be 95 per cent plus or minus 4 per cent.

4.5 *Identification*

4.5.1 The carrier energy shall not be interrupted. The audio frequency modulation shall be keyed as follows:

a) *inner marker:* 6 dots per second continuously;

b) *middle marker:* a continuous series of alternate dots and dashes, the dashes keyed at the rate of 2 dashes per second, and the dots at the rate of 6 dots per second;
c) *outer marker:* 2 dashes per second continuously. These keying rates shall be maintained to within plus or minus 15 per cent.

4.6 *Siting*
4.6.1 The inner marker shall be located so as to indicate in low visibility conditions the imminence of arrival at the runway threshold.

4.6.1.1 If the radiation pattern is vertical, the inner marker shall be located between 75 m (250 ft) and 450 m (1 500 ft) from the threshold and at not more than 30 m (100 ft) from the extended centre line of the runway.

4.6.1.2 If the radiation pattern is other than vertical, the equipment shall be located so as to produce a field within the course sector and ILS glide path sector that is substantially similar to that produced by an antenna radiating a vertical pattern and located as prescribed in 3.1.7.6.1.1.

4.6.2 The middle marker shall be located so as to indicate the imminence, in low visibility conditions, of visual approach guidance.

4.6.2.1 If the radiation pattern is vertical, the middle marker shall be located 1 050 m (3 500 ft) plus or minus 150 m (500 ft), from the landing threshold at the approach end of the runway and at not more than 75 m (250 ft) from the extended centre line of the runway.
4.6.2.2 If the radiation pattern is other than vertical, the equipment shall be located so as to produce a field within the course sector and ILS glide path sector that is substantially similar to that produced by an antenna radiating a vertical pattern and located as prescribed in 4.6.2.1.

4.6.3 The outer marker shall be located so as to provide height, distance and equipment functioning checks to aircraft on intermediate and final approach.
4.6.3.1 The outer marker shall be located 7.2 km (3.9 NM) from the threshold except that, where for topographical or operational reasons this distance is not practicable, the outer marker may be located between 6.5 and 11.1 km (3.5 and 6 NM) from the threshold.

4.6.4 If the radiation pattern is vertical, the outer marker shall be not more than 75 m (250 ft) from the extended centre line of the runway. If the radiation pattern is other than vertical, the equipment shall be located so as to produce a field within the course sector and ILS glide path sector that is substantially similar to that produced by an antenna radiating a vertical pattern.
4.6.5 The positions of marker beacons, or where applicable, the equivalent distance(s) indicated by the DME when used as an alternative to part or all of the marker beacon component of the ILS, shall be published in accordance with the

provisions of the Air Navigation (Aeronautical Information Services) Regulations.

4.6.5.1 3. When so used, the DME shall provide distance information operationally equivalent to that furnished by marker beacon(s).

4.6.5.2 When used as an alternative for the middle marker, the DME shall be frequency paired with the ILS localizer and sited so as to minimize the error in distance information.

4.6.5.3 The DME in 4.6.5 shall conform to the specification in 7.0.

4.7 *Monitoring*

4.7.1 Suitable equipment shall provide signals for the operation of an automatic monitor. The monitor shall transmit a warning to a control point if either of the following conditions arise:
a) failure of the modulation or keying;
b) reduction of power output to less than 50 per cent of normal.
4.7.2 For each marker beacon, suitable monitoring equipment shall be provided which will indicate at the appropriate location a decrease of the modulation depth below 50 per cent.

4.8 Integrity and continuity of service for an ILS ground equipment

4.8.1 *Introduction*
4.8.1.1 This material is intended to provide clarification of the integrity and continuity of service objectives of ILS localizer and glide path ground equipment and to provide guidance on engineering design and system characteristics of this equipment. Integrity is needed to ensure that an aircraft on approach will have a low probability of receiving false guidance; continuity of service is needed to ensure that an aircraft in the final stages of approach will have a low probability of being deprived of a guidance signal. Integrity and continuity of service are both key safety factors during the critical phase of approach and landing. The integrity and continuity of service must of necessity be known from an operational viewpoint in order to decide the operational application which an ILS could support.

4.8.1.2 It is generally accepted, irrespective of the operational objective, that the average rate of a fatal accident during landing, due to failures or shortcomings in the whole system, comprising the ground equipment, the aircraft and the pilot, should not exceed 1 × 10–7. This criterion is frequently referred to as the global risk factor.

4.8.1.3 In the case of Category I operations, responsibility for assuring that the above objective is not exceeded is vested more or less completely in the pilot. In Category III operations, the same objective is required but must now be inherent in the whole system. In this context it is of the utmost importance to endeavour to

conditions appropriate to the manufacturers' achieve the highest level of integrity and continuity of service of the ground equipment.

4.8.1.4 The requirements for integrity and high continuity of service require highly reliable systems to minimize the probability of failure which may affect any characteristic of the total signal-in-space. It is suggested that Kenya endeavours to achieve reliability with as large a margin as is technically and economically reasonable. Reliability of equipment is governed by basic construction and operating environment. Equipment design should employ the most suitable engineering techniques, materials and components, and rigorous inspection should be applied in manufacture. Equipment should be operated in environmental design criteria.

4.8.2 ***Achievement and retention of integrity service levels***

4.8.2.1 An integrity failure can occur if radiation of a signal which is outside specified tolerances is either unrecognized by the monitoring equipment or the control circuits fail to remove the faulty signal. Such a failure might constitute a hazard if it results in a gross error.

4.8.2.2 Clearly not all integrity failures are hazardous in all phases of the approach. For example, during the critical stages of the approach, undetected failures producing gross errors in course width or course line shifts are of special significance whereas an undetected change of modulation depth, or loss of localizer and glide slope clearance and localizer identification would not necessarily produce a hazardous situation. The criterion in assessing which failure modes are relevant must however include all those deleterious fault conditions which are not unquestionably obvious to the automatic flight system or pilot.

4.8.2.3 The highest order of protection is required against the risk of undetected failures in the monitoring and associated control system. This would be achieved by careful design to reduce the probability of such occurrences to a low level and provide fail-safe operations compliant with 2.11.2.3 and 3.7.4, and by carrying out maintenance checks on the monitor system performance at intervals which are determined by a design analysis.

4.8.2.4 A design analysis can be used to calculate the level of integrity of the system in any one landing. The following formula applies to certain types of ILS and provides an example of the determination of system integrity, *I*, from a calculation of the probability of transmission of undetected erroneous radiation, *P*.

(1) $I = 1 - P$

$P = \frac{T_1 T_2}{\alpha_1 \alpha_2 M_1 M_2}$ when $T_1 < T_2$

where

I = integrity

P = the probability of a concurrent failure in transmitter and monitor systems resulting in erroneous undetected radiation

M_1 = transmitter mean time between failures (MTBF)

M_2 = MTBF of the monitoring and associated control system

$\frac{1}{\alpha_1}$ = ratio of the rate of failure in the transmitter resulting in the radiation of an erroneous signal to the rate of all transmitter failures

$\frac{1}{\alpha_2}$ = ratio of the rate of failure in the monitoring and associated control system resulting in inability to detect an erroneous signal to the rate of all monitoring and associated control system failures

T_1 = period of time (in hours) between transmitter checks

T_2 = period of time (in hours) between checks on the monitoring and associated control system

When $T_1 \geq T_2$ the monitor system check may also be considered a transmitter check. In this case, therefore $T_1 = T_2$ and the formula would be:

(2) $P = \frac{T_2^2}{\alpha_1 \alpha_2 M_1 M_2}$

4.8.2.5 Since the probability of occurrence of an unsafe failure within the monitoring or control equipment is extremely remote, to establish the required integrity level with a high degree of confidence would necessitate an evaluation period many times that needed to establish the equipment MTBF. Such a protracted period is unacceptable and therefore the required integrity level can only be predicted by rigorous design analysis of the equipment.

4.8.2.6 Protection of the integrity of the signal-in-space against degradation which can arise from extraneous radio interference falling within the ILS frequency band or from re-radiation of ILS signals must also be considered. With regard to radio interference it may be necessary to confirm periodically that the level of interference does not constitute a hazard.

4.8.2.7 In general, monitoring equipment design is based on the principle of continuously monitoring the radiated signals-in-space at specific points within the coverage volume to ensure their compliance with the Standards specified at 2.11 and
3.7. Although such monitoring provides to some extent an indication that the signal-in- space at all other points in the coverage volume is similarly within tolerance, this is largely inferred. It is essential therefore to carry out rigorous flight and ground inspections at periodic intervals to ensure the integrity of the signal-in-space throughout the coverage volume.

4.8.3 *Achievement and retention of continuity of service levels*
4.8.3.1 A design analysis should be used to predict the MTBF and continuity of service of the ILS equipment. Before assignment of a level of continuity of service and introduction into Category II or III service, however, the mean time between outages (MTBO) of the ILS should be confirmed by evaluation in an operational environment. In this evaluation, an outage is defined as any unanticipated cessation of signal-in- space. This evaluation takes into account the impact of operational factors, i.e. airport environment, inclement weather conditions, power availability, quality and frequency of maintenance. MTBO is related to MTBF, but is not equivalent, as some equipment failures, such as a failure of a transmitter resulting in the immediate transfer to a standby transmitter may not necessarily result in an outage. For continuity of service Level 2, 3 or 4, the evaluation period should be sufficient to determine achievement of the required level with a high degree of confidence. One method to demonstrate that continuity standards are met is the sequential test method. If this method is used, the following considerations apply:
a) the minimum acceptable confidence level is 60 per cent. To achieve the confidence level of 60 per cent, the evaluation period has to be longer than the required MTBO hours. Typically, these minimal evaluation periods for new and subsequent installations are for Level 2, 1 600 operating hours, for Level 3, 3 200 hours and for Level 4, 6 400 hours. To assess the seasonal influence of the environment, a minimal evaluation period of one year is typically required for a new type of installation in a particular environment. It may be possible to reduce this period in cases where the operating environment is well controlled and similar to other proven installations. Where several identical systems are being operated under similar conditions, it may be possible to base the assessment on the cumulative operating hours of all the systems; this will result in a reduced evaluation period. Once a higher confidence level is obtained for a type of installation, subsequent installation of the same type of equipment under similar operational and environmental conditions may follow shorter evaluation periods;

b) during the evaluation period, it should be decided for each outage if it is caused by a design failure or if it is caused by a failure of a component due to its normal failure rate. Design failures are, for instance, operating components beyond their specification (overheating, over current, overvoltage, etc. conditions). These design failures should be dealt with such that the operating condition is brought back to the normal operating condition of the component or that the component is replaced with a part suitable for the operating conditions. If the design failure is treated in this way, the evaluation may continue and this outage is not counted, assuming that there is a high probability that this design failure will not occur again. The same applies to outages due to any causes which can be mitigated by permanent changes to the operating conditions.

4.8.3.2 An assigned continuity of service level should not be subject to frequent change. A suitable method to assess the behaviour of a particular installation is to keep the records and calculate the average MTBO over the last five to eight failures of the equipment. This weighs the MTBO for continuity of service purposes to be more relevant to the next approach, rather than computing MTBO over the lifetime of the equipment. If continuity of service deteriorates, the assigned designation should be reduced until improvements in performance can be effected.

4.8.4 The following configuration is an example of a redundant equipment arrangement that is likely to meet the objectives for integrity and continuity of service Levels 3 and 4. The localizer and glide path facilities each consist of two continuously operating transmitters, one connected to the antenna and the standby connected to a dummy load. With these transmitters is associated a monitor system performing the following functions:

a) confirming proper operation within the specified limits of the main transmitter and antenna system by means of majority voting among redundant monitors;

b) confirming operation of the standby equipment.

4.8.4.1 Whenever the monitor system rejects one of the equipment the facility continuity of service level will be reduced because the probability of cessation of signal consequent on failure of other equipment will be increased. This change of performance must be automatically indicated at remote locations.

4.8.4.2 An identical monitoring arrangement to the localizer is used for the glide path facility.

4.8.4.3 To reduce mutual interference between the main and standby transmitters any stray radiation from the latter is at least 50 dB below the carrier level of the main transmitter measured at the antenna system.

4.8.4.4 In the above example, the equipment would include provision to facilitate monitoring system checks at intervals specified by the manufacturer, consequent to the design analysis, to ensure attainment of the required integrity level. Such checks, which can be manual or automatic, provide the means to verify correct operation of the monitoring system including the control circuitry and changeover switching system. The advantage of adopting an automatic monitor integrity test is that no interruption to the operational service provided by the localizer or glide path is necessary. It is important when using this technique to ensure that the total duration of the check cycle is short enough not to exceed the total period specified in 2.11.2.3 or 3.7.4 Interruption of facility operation due to primary power failures is avoided by the provision of suitable standby supplies, such as batteries or “no break” generators. Under these conditions, the facility should be capable of continuing in operation over the period when an aircraft may be in the critical stages of the approach. Therefore the standby supply should have adequate capacity to sustain service for at least two minutes.

4.8.4.5 Warnings of failures of critical parts of the system, such as the failure of the primary power supply, must be given at the designated control points.
4.8.4.6 In order to reduce failure of equipment that may be operating near its monitor tolerance limits, it is useful for the monitor system to include provision to generate a pre-alarm warning signal to the designated control point when the monitored parameters reach a limit equal to a value in the order of 75 per cent of the monitor alarm limit.
4.8.4.7 An equipment arrangement similar to that at 4.8.4, but with no transmitter redundancy, would normally be expected to achieve the objectives for continuity of service Level 2.

4.8.5 Guidance relating to localizer far field monitors is given below.
4.8.5.1 Far field monitors are provided to monitor course alignment but may also be used to monitor course sensitivity. A far field monitor operates independently from integral and near field monitors. Its primary purpose is to protect against the risk of erroneous setting-up of the localizer, or faults in the near field or integral monitors. In addition, the far field monitor system will enhance the ability of the combined monitor system to respond to the effects of physical modification of the radiating elements or variations in the ground reflection characteristics. Moreover, multipath effects and runway area disturbances not seen by near field and integral monitors, and some occurrences of radio interferences may be substantially monitored by using a far field monitoring system built around a suitable receiver(s), installed under the approach path.

4.8.5.2 A far field monitor is generally considered essential for Category III operations, while for Category II it is generally considered to be desirable. Also for Category I installations, a far field monitor has proved to be a valuable tool to supplement the conventional monitor system.

4.8.5.3 The signal received by the far field monitor will suffer short-term interference effects caused by aircraft movements on or in the vicinity of the runway and experience have shown that it is not practical to use the far field monitor as an executive monitor. When used as a passive monitor, means must be adopted to minimize such temporary interference effects and to reduce the occurrence of nuisance downgrade indications;

some methods of achieving this are covered in 4.8.5.4. The response of the far field monitor to interference effects offers the possibility of indicating to the air traffic control point when temporary disturbance of the localizer signal is present. However, experience has shown that disturbances due to aircraft movements may be present along the runway, including the touchdown zone, and not always be observed at the far field monitor. It must not be assumed, therefore, that a far field monitor can provide comprehensive surveillance of aircraft movements on the runway.

4.8.5.3.1 Additional possible applications of the far field monitor are as follows:

a) it can be a useful maintenance aid to verify course and/or course deviation sensitivity in lieu of a portable far field monitor;
b) it may be used to provide a continuous recording of far field signal performance showing the quality of the far field signal and the extent of signal disturbance.

4.8.5.4 Possible methods of reducing the occurrence of nuisance downgrade indications include:

a) incorporation of a time delay within the system adjustable from 30 to 240 seconds;
b) the use of a validation technique to ensure that only indications not affected by transitory disturbances are transmitted to the control system;
c) use of low pass filtering.

4.8.5.5 A typical far field monitor consists of an antenna, VHF receiver and associated monitoring units which provide indications of DDM, modulation sum, and RF signal level. The receiving antenna is usually of a directional type to minimize unwanted interference and should be at the greatest height compatible with obstacle clearance limits. For course line monitoring, the antenna is usually positioned along the extended runway centre line. Where it is desired to also monitor displacement sensitivity, an additional receiver and monitor are installed with antenna suitably positioned to one side of the extended runway centre line. Some systems utilize a number of spatially separated antennas.

5.0 Specification for VHF Omni directional Range (VOR)

5.1 General

5.1.1 The VOR shall be constructed and adjusted so that similar instrumental indications in aircraft represent equal clockwise angular deviations (bearings), degree for degree from magnetic North as measured from the location of the VOR.

5.1.2 The VOR shall radiate a radio frequency carrier with which is associated two separate 30 Hz modulations. One of these modulations shall be such that its phase is independent of the azimuth of the point of observation (reference phase). The other modulation (variable phase) shall be such that its phase at the point of observation

differs from that of the reference phase by an angle equal to the bearing of the point of observation with respect to the VOR.

5.1.3 The reference and variable phase modulations shall be in phase along the reference magnetic meridian through the station.

5.2 Radio frequency

5.2.1 The VOR shall operate in the band 111.975 MHz to 117.975 MHz except that frequencies in the band 108 MHz to 111.975 MHz may be used when, in accordance with the provisions of Civil Aviation (Aeronautical Radio Frequency Spectrum Utilization) Regulations, the use of such frequencies is acceptable. The highest assignable frequency shall be 117.950 MHz. The channel separation shall be in increments of 50 kHz referred to the highest assignable frequency. In areas where 100 kHz channel spacing is in general use, the frequency tolerance of the radio frequency carrier shall be plus or minus 0.005 per cent.

5.2.2 The frequency tolerance of the radio frequency carrier of all new installations implemented after 23 May 1974 in areas where 50 kHz channel spacing is in use shall be plus or minus 0.002 per cent.

5.2.3 In areas where new VOR installations are implemented and are assigned frequencies spaced at 50 kHz from existing VORs in the same area, priority shall be given to ensuring that the frequency tolerance of the radio frequency carrier of the existing VORs is reduced to plus or minus 0.002 per cent.

5.3 Polarization and pattern accuracy

5.3.1 The emission from the VOR shall be horizontally polarized. The vertically polarized component of the radiation shall be as small as possible.

5.3.2 The ground station contribution to the error in the bearing information conveyed by the horizontally polarized radiation from the VOR for all elevation angles between 0 and 40 degrees, measured from the centre of the VOR antenna system, shall be within plus or minus 2 degrees.

5.4 Coverage

5.4.1 The VOR shall provide signals such as to permit satisfactory operation of a typical aircraft installation at the levels and distances required for operational reasons, and up to an elevation angle of 40 degrees.

5.4.2 The field strength or power density in space of VOR signals required to permit satisfactory operation of a typical aircraft installation at the minimum service level at the maximum specified service radius shall be 90 microvolts per metre or minus 107 dBW/m2.

5.5 Modulations of navigation signals

5.5.1 The radio frequency carrier as observed at any point in space shall be amplitude modulated by two signals as follows:

a) a subcarrier of 9 960 Hz of constant amplitude, frequency modulated at 30 Hz:

1) for the conventional VOR, the 30 Hz component of this FM subcarrier is fixed without respect to azimuth and is termed the "reference phase" and shall have a deviation ratio of 16 plus or minus 1 (i.e. 15 to 17);

2) for the Doppler VOR, the phase of the 30 Hz component varies with azimuth and is termed the "variable phase" and shall have a deviation ratio of 16 plus or minus 1 (i.e 15 to 17) when observed at any angle of elevation up to 5 degrees, with a minimum deviation ratio of 11 when observed at any angle of elevation above 5 degrees and up to 40 degrees;

b) a 30 Hz amplitude modulation component:

1) for the conventional VOR, this component results from a rotating field pattern, the phase of which varies with azimuth, and is termed the "variable phase";

2) for the Doppler VOR, this component, of constant phase with relation to azimuth and constant amplitude, is radiated omni-directionally and is termed the "reference phase"

5.5.2 The nominal depth of modulation of the radio frequency carrier due to the 30 Hz signal or the subcarrier of 9 960 Hz shall be within the limits of 28 per cent and 32 per cent.

5.5.3 The depth of modulation of the radio frequency carrier due to the 30 Hz signal, as observed at any angle of elevation up to 5 degrees, shall be within the limits of 25 to 35 per cent. The depth of modulation of the radio frequency carrier due to the 9 960 Hz signal, as observed at any angle of elevation up to 5 degrees, shall be within the limits of 20 to 55 per cent on facilities without voice modulation, and within the limits of 20 to 35 per cent on facilities with voice modulation.

5.5.4 The variable and reference phase modulation frequencies shall be 30 Hz within plus or minus 1 per cent.

5.5.5 The subcarrier modulation mid-frequency shall be 9 960 Hz within plus or minus 1 per cent.

5.5.6
a) For the conventional VOR, the percentage of amplitude modulation of the 9 960 Hz subcarrier shall not exceed 5 percent.
b) For the Doppler VOR, the percentage of amplitude modulation of the 9 960 Hz subcarrier shall not exceed 40 percent when measured at a point at least 300 m (1 000 ft) from the VOR.
5.5.7 Where 50 kHz VOR channel spacing is implemented, the sideband level of the harmonics of the 9 960 Hz component in the radiated signal shall not exceed the following levels referred to the level of the 9 960 Hz sideband:

Subcarrier	*Level*
9 960 Hz	0 dB reference
2nd harmonic	–30 dB
3rd harmonic	–50 dB
4th harmonic and above	–60 dB

5.6 Voice and identification
5.6.1 If the VOR provides a simultaneous communication channel ground-to-air, it shall be on the same radio frequency carrier as used for the navigational function. The radiation on this channel shall be horizontally polarized.

5.6.2 The peak modulation depth of the carrier on the communication channel shall not be greater than 30 per cent.
5.6.3 The audio frequency characteristics of the speech channel shall be within 3 dB relative to the level at 1 000 Hz over the range 300 Hz to 3 000 Hz.
5.6.4 The VOR shall provide for the simultaneous transmission of a signal of identification on the same radio frequency carrier as that used for the navigational function. The identification signal radiation shall be horizontally polarized.
5.6.5 The identification signal shall employ the International Morse Code and consist of two or three letters. It shall be sent at a speed corresponding to approximately 7 words per minute. The signal shall be repeated at least once every 30 seconds and the modulation tone shall be 1 020 Hz within plus or minus 50 Hz.
5.6.5.1 The identification signal shall be transmitted at least three times each 30 seconds, spaced equally within that time period. One of these identification signals will take the form of a voice identification.
5.6.6 The depth to which the radio frequency carrier is modulated by the code identification signal shall be close to, but not in excess of 10 per cent except that,

where a communication channel is not provided, it shall be permissible to increase the modulation by the code identification signal to a value not exceeding 20 per cent.

5.6.6.1 If the VOR provides a simultaneous communication channel ground-to-air, the modulation depth of the code identification signal shall be 5 plus or minus 1 per cent in order to provide a satisfactory voice quality.

5.6.7 The transmission of speech shall not interfere in any way with the basic navigational function. When speech is being radiated, the code identification shall not be suppressed.

5.6.8 The VOR receiving function shall permit positive identification of the wanted signal under the signal conditions encountered within the specified coverage limits, and with the modulation parameters specified at 5.6.5, 5.6.6 and 5.6.7.

5.7 Monitoring

5.7.1 Suitable equipment located in the radiation field shall provide signals for the operation of an automatic monitor. The monitor shall transmit a warning to a control point, and either remove the identification and navigation components from the carrier or cause radiation to cease if any one or a combination of the following deviations from established conditions arises:

a) a change in excess of 1 degree at the monitor site of the bearing information transmitted by the VOR;

b) a reduction of 15 per cent in the modulation components of the radio frequency signals voltage level at the monitor of either the subcarrier, or 30 Hz amplitude modulation signals, or both.

5.7.2 Failure of the monitor itself shall transmit a warning to a control point and either:

a) remove the identification and navigation components from the carrier; or

b) cause radiation to cease.

5.8 Interference immunity performance for VOR receiving systems

5.8.1 The VOR receiving system shall provide adequate immunity to interference from two signal, third-order inter-modulation products caused by VHF FM broadcast signals having levels in accordance with the following:

$$2N_1 + N_2 + 72 \leq 0$$

for VHF FM sound broadcasting signals in the range 107.7 – 108.0 MHz

and

$$2N_1 + N_2 + 3\left(24 - 20 \log \frac{\Delta f}{0.4}\right) \leq 0$$

for VHF FM sound broadcasting signals below 107.7 MHz,
where the frequencies of the two VHF FM sound broadcasting signals produce, within the receiver, a two signal, third-order inter modulation product on the desired VOR frequency.
N1 and N2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the VOR receiver input. Neither level shall exceed the desensitization criteria set forth in 5.8.2.
Δf = 108.1 – f1, where f1 is the frequency of N1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

5.8.2 The VOR receiving system shall not be desensitized in the presence of VHF FM broadcast signals having levels in accordance with the following table:

Frequency (MHz)	*Maximum level of unwanted signal at receiver input (dBm)*
88-102	+15
104	+10
106	+ 5
107.9	–10

6.0 Specification for non-directional radio beacon (NDB)

6.1 Coverage
6.1.1 The minimum value of field strength in the rated coverage of an NDB shall be 70°microvolts per metre.

6.1.2 All notifications or promulgations of NDBs shall be based upon the average radius of the rated coverage.

6.1.3 Where the rated coverage of an NDB is materially different in various operationally significant sectors, its classification shall be expressed in terms of the average radius of rated coverage and the angular limits of each sector as follows:

Radius of coverage of sector/angular limits of sector expressed as magnetic bearing clockwise from the beacon. Where it is desirable to classify an NDB in such a manner, the number of sectors shall be kept to a minimum and preferably shall not exceed two.

6.2 Limitations in radiated power
The power radiated from an NDB shall not exceed by more than 2 dB that necessary to achieve its agreed rated coverage, except that this power may be increased if coordinated regionally or if no harmful interference to other facilities will result.

6.3 Radio frequencies
6.3.1 The radio frequencies assigned to NDBs shall be selected from those available in that portion of the spectrum between 190 kHz and 1 750 kHz.
6.3.2 The frequency tolerance applicable to NDBs shall be 0.01 per cent except that, for NDBs of antenna power above 200 W using frequencies of 1 606.5 kHz and above, the tolerance shall be 0.005 per cent.

6.3.3 Where two locators are used as supplements to an ILS, the frequency separation between the carriers of the two shall be not less than 15 kHz to ensure correct operation of the radio compass, and preferably not more than 25 kHz in order to permit a quick tuning shift in cases where an aircraft has only one radio compass.
6.3.4 Where locators associated with ILS facilities serving opposite ends of a single runway are assigned a common frequency, provision shall be made to ensure that the facility not in operational use cannot radiate.

6.4 Identification
6.4.1 Each NDB shall be individually identified by a two- or three-letter International Morse Code group transmitted at a rate corresponding to approximately 7 words per minute.
6.4.2 The complete identification shall be transmitted at least once every 30 seconds, except where the beacon identification is effected by on/off keying of the carrier. In this latter case, the identification shall be at approximately 1-minute intervals, except that a shorter interval may be used at particular NDB stations where this is found to be operationally desirable.

6.4.2.1 Except for those cases where the beacon identification is effected by on/off keying of the carrier, the identification signal shall be transmitted at least three times each 30 seconds, spaced equally within that time period.

6.4.3 For NDBs with an average radius of rated coverage of 92.7 km (50 NM) or less that are primarily approach and holding aids in the vicinity of an aerodrome, the identification shall be transmitted at least three times each 30 seconds, spaced equally within that time period.
6.4.4 The frequency of the modulating tone used for identification shall be 1 020 Hz plus or minus 50 Hz or 400 Hz plus or minus 25 Hz.

6.5 Characteristics of emissions

6.5.1 Except as provided in 3.4.6.1.1, all NDBs shall radiate an uninterrupted carrier and be identified by on/off keying of an amplitude modulating tone (NON/A2A).
6.5.1.1 NDBs other than those wholly or partly serving as holding, approach and landing aids, or those having an average radius of rated coverage of less than 92.7 km (50 NM), may be identified by on/off keying of the unmodulated carrier (NON/A1A) if they are in areas of high beacon density and/or where the required rated coverage is not practicable of achievement because of:

a) radio interference from radio stations;

b) high atmospheric noise;

c) local conditions
.
6.5.2 For each NDB identified by on/off keying of an audio modulating tone, the depth of modulation shall be maintained as near to 95 per cent as practicable.

6.5.3 For each NDB identified by on/off keying of an audio modulating tone, the characteristics of emission during identification shall be such as to ensure satisfactory identification at the limit of its rated coverage.
6.5.4 The carrier power of an NDB with NON/A2A emissions shall not fall when the identity signal is being radiated except that, in the case of an NDB having an average radius of rated coverage exceeding 92.7 km (50 NM), a fall of not more than
1.5 dB will be accepted.
6.5.5 Unwanted audio frequency modulations shall total less than 5 per cent of the amplitude of the carrier.

6.5.6 The bandwidth of emissions and the level of spurious emissions shall be kept at the lowest value that the state of technique and the nature of the service permit.

6.6 Siting of locators

6.6.1 Where locators are used as a supplement to the ILS, they shall be located at the sites of the outer and middle marker beacons. Where only one locator is used as a supplement to the ILS, preference shall be given to location at the site of the outer marker beacon. Where locators are employed as an aid to final approach in the absence of an ILS, equivalent locations to those applying when an ILS is installed shall be selected, taking into account the relevant obstacle clearance provisions of the PANS- OPS (Doc 8168)

6.6.2 Where locators are installed at both the middle and outer marker positions, they shall be located, where practicable, on the same side of the extended centre line of the runway in order to provide a track between the locators which will be more nearly parallel to the centre line of the runway.

6.7 Monitoring

6.7.1 For each NDB, suitable means shall be provided to enable detection of any of the following conditions at an appropriate location:

a) a decrease in radiated carrier power of more than 50 per cent below that required for the rated coverage;

b) failure to transmit the identification signal;

c) malfunctioning or failure of the means of monitoring itself.

6.7.2 When an NDB is operated from a power source having a frequency which is close to airborne ADF equipment switching frequencies, and where the design of the NDB is such that the power supply frequency is likely to appear as a modulation product on the emission, the means of monitoring shall be capable of detecting such power supply modulation on the carrier in excess of 5 per cent.

6.7.3 During the hours of service of a locator, the means of monitoring shall provide for a continuous check on the functioning of the locator as prescribed in 6.7.1 a), b) and c).

6.7.4 During the hours of service of an NDB other than a locator, the means of monitoring shall provide for a continuous check on the functioning of the NDB as prescribed in 6.7.1 a), b) and c).

7.0 Specification for UHF distance measuring equipment (DME)

7.1 General

7.1.1 The DME system shall provide for continuous and accurate indication in the cockpit of the slant range distance of an equipped aircraft from an equipped ground reference point.

7.1.2 The system shall comprise two basic components, one fitted in the aircraft, the other installed on the ground. The aircraft component shall be referred to as the interrogator and the ground component as the transponder.

7.1.3 In operation, interrogators shall interrogate transponders which shall, in turn, transmit to the interrogator replies synchronized with the interrogations, thus providing means for accurate measurement of distance.

7.1.4 DME/P shall have two operating modes, IA and FA.

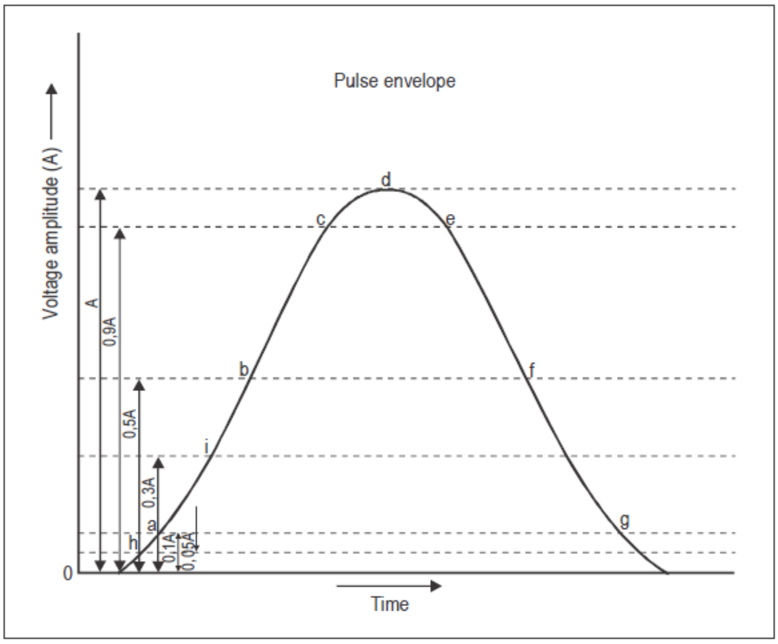

Figure 7-1

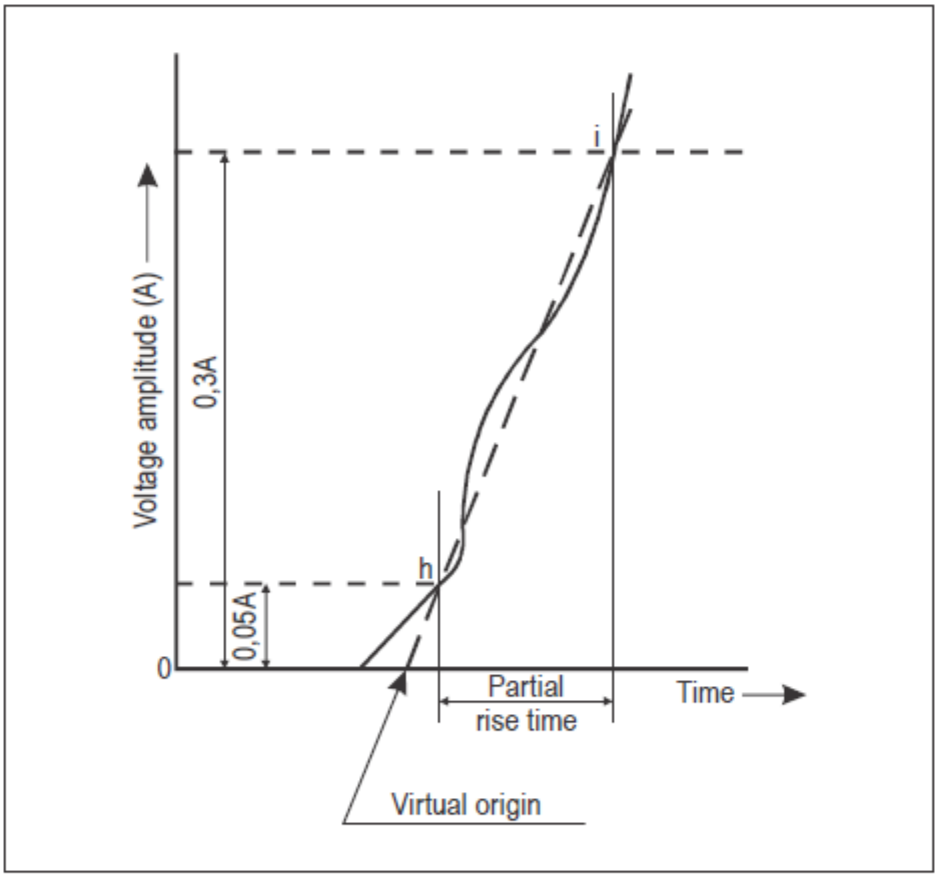

Figure 7-2

7.1.5 When a DME is associated with an ILS, MLS or VOR for the purpose of constituting a single facility, they shall:
a) be operated on a standard frequency pairing in accordance with 7.2.3.4;
b) be collocated within the limits prescribed for associated facilities in 7.1.6; and
c) comply with the identification provisions of 7.2.6.4

7.1.6 ***Collocation limits for a DME facility associated with an ILS, MLS or VOR facility***
7.1.6.1 Associated VOR and DME facilities shall be collocated in accordance with the following:

a) for those facilities used in terminal areas for approach purposes or other procedures where the highest position fixing accuracy of system capability is required, the separation of the VOR and DME antennas does not exceed 80 m (260 ft);

b) for purposes other than those indicated in a), the separation of the VOR and

DME antennas does not exceed 600 m (2 000 ft).

7.1.6.2 Use of DME and/or other standard radio navigation aids as an alternative to ILS marker beacons

7.1.6.2.1 When DME is used as an alternative to ILS marker beacons, the DME should be located on the airport so that the zero range indication will be a point near the runway. If the DME associated with ILS uses a zero range offset, this facility has to be excluded from RNAV solutions

7.1.6.2.1.1 In order to reduce the triangulation error, the DME should be sited to ensure a small angle (e.g. less than 20degrees) between the approach path and the direction to the DME at the points where the distance information is required.

7.1.6.3.1.2 The use of DME as an alternative to the middle marker beacon assumes a DME system accuracy of 0.37 km(0.2 NM) or better and a resolution of the airborne indication such as to allow this accuracy to be attained.

7.1.6.3.1.3 While it is not specifically required that DME be frequency paired with the localizer when it is used as an alternative for the outer marker, frequency pairing is preferred wherever DME is used with ILS to simplify pilot operation and to enable aircraft with two ILS receivers to use both receivers on the ILS channel

7.1.6.3.1.4 When the DME is frequency paired with the localizer, the DME transponder identification should be obtained by the ‘associated’ signal from the frequency-paired localizer

7.1.6.2.2 In some locations, the Competent Authority may authorize the use of other means to provide fixes, such as NDB, VOR or GNSS. This may be useful in particular in locations where aircraft user equipage with DME is low, or if the DME is out of service.

7.1.7 The Standards in 7.2, 7.3 and 7.4 denoted by ‡ shall apply only to DME equipment first installed after 1 January 1989.

7.2 System characteristics

7.2.1 *Performance*

7.2.1.1 . The system shall provide a means of measurement of slant range distance from an aircraft to a selected transponder to the limit of coverage prescribed by the operational requirements for the selected transponder.

7.2.1.2 *Coverage*

7.2.1.2.1 The DME/N shall provide signals such as to permit satisfactory operation of a typical aircraft installation at the levels and distances required for operational reasons, and up to an elevation angle at least 40 degrees.

Note. — Guidance to support performance-based navigation as described in the Performance-based Navigation (PBN) Manual (Doc 9613)

7.2.1.2.1 When associated with a VOR, DME/N coverage shall be at least that of the VOR to the extent practicable.

7.2.1.2.2 When associated with an ILS, DME/N coverage shall be at least that of the ILS localizer coverage sector within plus or minus 10 degrees.
7.2.1.2.3 DME/P coverage or DME/N coverage when associated with an MLS shall be at least that provided by the MLS azimuth angle guidance coverage sectors.

7.2.1.3 *Accuracy*
7.2.1.3.1 *System accuracy.* The accuracy standards specified in 7.2.1.4, 7.3.5 and 7.4.5 shall be met on a 95 per cent probability basis.
7.2.1.4 *DME/P accuracy*
7.2.1.4.1 *Error components.* The path following error (PFE) shall be comprised of those frequency components of the DME/P error at the output of the interrogator which lie below 1.5 rad/s. The control motion noise (CMN) shall be comprised of those frequency components of the DME/P error at the output of the interrogator which lie between 0.5 rad/s and 10 rad/s.

7.2.1.4.2 Errors on the extended runway centre line shall not exceed the values given in Table B at the end of this chapter.

7.2.1.4.3 In the approach sector, away from the extended runway centre line, the allowable PFE for both standard 1 and standard 2 shall be permitted to increase linearly with angle up to plus or minus 40 degrees MLS azimuth angle where the permitted error is 1.5 times that on the extended runway centre line at the same distance. The allowable CMN shall not increase with angle. There shall be no degradation of either PFE or CMN with elevation angle.
7.2.2 *Radio frequencies and polarization.* The system shall operate with vertical polarization in the frequency band 960 MHz to 1 215 MHz. The interrogation and reply frequencies shall be assigned with 1MHz spacing between channels.

7.2.3 *Channelling*
7.2.3.1 DME operating channels shall be formed by pairing interrogation and reply frequencies and by pulse coding on the paired frequencies.

7.2.3.2 *Pulse coding.* DME/P channels shall have two different interrogation pulse codes as shown in the table in 7.3.4.1. One shall be used in the initial approach (IA) mode; the other shall be used in the final approach (FA) mode.

7.2.3.3 DME operating channels shall be chosen from Table A (located at the end of this schedule), of 352 channels in which the channel numbers, frequencies, and pulse codes are assigned.
7.2.3.4 *Channel pairing.* When a DME transponder is intended to operate in association with a single VHF navigation facility in the 108 MHz to 117.95 MHz frequency band and/or an MLS angle facility in the 5 031.0 MHz to 5 090.7 MHz frequency band, the DME operating channel shall be paired with the VHF channel and/or MLS angle frequency as given in Table A.

7.2.4 ***Interrogation Pulse repetition frequency.***

7.2.4.1 *DME/N.* The interrogator average pulse repetition frequency (PRF) shall not exceed 30 pairs of pulses per second, based on the assumption that at least 95 per cent of the time is occupied for tracking.

7.2.4.2 *DME/N.* If it is desired to decrease the time of search, the PRF may be increased during search but shall not exceed 150 pairs of pulses per second.

7.2.4.3 DME/N. After 15 000 pairs of pulses have been transmitted without acquiring indication of distance, the PRF shall not exceed 60 pairs of pulses per second thereafter, until a change in operating channel is made or successful search is completed.

7.2.4.4 *DME/N.*When, after a time period of 30 seconds, tracking has not been established, the pulse pair repetition frequency shall not exceed 30 pulse pairs per second thereafter.
7.2.4.5 *DME/P.* The interrogator pulse repetition frequency shall not exceed the following number of pulse pairs per second:

a) Search 40
b) aircraft on the ground 5
c) initial approach mode track 16
d) final approach mode track 40

7.2.5 ***Aircraft handling capacity of the system***
7.2.5.1 The aircraft handling capacity of transponders in an area shall be adequate for the peak traffic of the area or 100 aircraft, whichever is the lesser.

7.2.5.2 Where the peak traffic in an area exceeds 100 aircraft, the transponder shall be capable of handling that peak traffic.
7.2.6 *Transponder identification*

7.2.6.1 All transponders shall transmit an identification signal in one of the following forms as required by 7.2.6.5:

a) an "independent" identification consisting of coded (International Morse Code) identity pulses which can be used with all transponders;
b) an "associated" signal which can be used for transponders specifically associated with a VHF navigation or an MLS angle guidance facility which itself transmits an identification signal.

7.2.6.2 Both systems of identification shall use signals, which shall consist of the transmission for an appropriate period of a series of paired pulses transmitted at a
repetition rate of 1 350 pulse pairs per second, and shall temporarily replace all reply pulses that would normally occur at that time except as in 3.5.3.6.2.2. These pulses shall have similar characteristics to the other pulses of the reply signals.

7.2.6.2.1 *DME/N.* Reply pulses shall be transmitted between key down times.

7.2.6.2.2 *DME/N.*If it is desired to preserve a constant duty cycle, an equalizing pair of pulses, having the same characteristics as the identification pulse pairs, shall be transmitted 100 microseconds plus or minus 10 microseconds after each identity pair.

7.2.6.2.3 *DME/P.* Reply pulses shall be transmitted between key down times.

7.2.6.2.4 For the DME/P transponder, reply pulse pairs to valid FA mode interrogations shall also be transmitted during key down times and have priority over identification pulse pairs.

7.2.6.2.5 The DME/P transponder shall not employ the equalizing pair of pulses of 7.2.6.2.2.

7.2.6.3 The characteristics of the “independent” identification signal shall be as follows:

a) the identity signal shall consist of the transmission of the beacon code in the form of dots and dashes (International Morse Code) of identity pulses at least once every 40 seconds, at a rate of at least 6 words per minute; and

b) the identification code characteristic and letter rate for the DME transponder shall conform to the following to ensure that the maximum total key down time does not exceed 5 seconds per identification code group. The dots shall be a time duration of 0.1 second to 0.160 second. The dashes shall be typically 3 times the duration of the dots.

The duration between dots and/or dashes shall be equal to that of one dot plus or minus 10 per cent. The time duration between letters or numerals shall not be less than three dots. The total period for transmission of an identification code group shall not exceed 10 seconds.

7.2.6.4 The characteristics of the “associated” signal shall be as follows:

a) when associated with a VHF or an MLS angle facility, the identification shall be transmitted in the form of dots and dashes (International Morse Code) as in 7.2.6.3 and shall be synchronized with the VHF facility identification code;

b) each 40-second interval shall be divided into four or more equal periods, with the transponder identification transmitted during one period only and the associated VHF and MLS angle facility identification, where these are provided, transmitted during the remaining periods;

c) for a DME transponder associated with an MLS, the identification shall be the last three letters of the MLS angle facility identification.

7.2.6.5 *Identification implementation*

7.2.6.5.1 The “independent” identification code shall be employed wherever a transponder is not specifically associated with a VHF navigational facility or an MLS facility.

7.2.6.5.2 Wherever a transponder is specifically associated with a VHF navigational facility or an MLS facility, identification shall be provided by the “associated” code.

7.2.6.5.3 When voice communications are being radiated on an associated VHF navigational facility, an "associated signal" from the transponder shall not be suppressed.

7.2.7 *DME/P mode transition*

7.2.7.1 The DME/P interrogator for standard 1 accuracy shall change from IA mode track to FA mode track at 13 km (7 NM) from the transponder when approaching the transponder, or any other situation when within 13 km (7 NM)
7.2.7.2 For standard 1 accuracy, the transition from IA mode to FA mode track operation may be initiated within 14.8 m (8 NM) from the transponder. Outside 14.8 km (8 NM), the interrogator shall not interrogate in the FA mode.

7.2.8 *System efficiency.* The DME/P system accuracy of 3.5.3.1.4 shall be achieved with a system efficiency of 50 per cent or more.

7.3 Detailed technical characteristics of transponder and associated monitor
7.3.1 *Transmitter*

7.3.1.1 *Frequency of operation.* The transponder shall transmit on the reply frequency appropriate to the assigned DME channel (see 7.2.3).
7.3.1.2 *Frequency stability.* The radio frequency of operation shall not vary more than plus or minus 0.002 per cent from the assigned frequency.

7.3.1.3 *Pulse shape and spectrum.* The following shall apply to all radiated pulses:
a) *Pulse rise time.*

1) *DME/N.* Pulse rise time shall not exceed 3 microseconds.
2) *DME/P.* Pulse rise time shall not exceed 1.6 microseconds. For the FA mode, the pulse shall have a partial rise time of 0.25 plus or minus 0.05 microsecond. With respect to the FA mode and accuracy standard 1, the slope of the pulse in the partial rise time shall not vary by more than plus or minus 20 per cent. For accuracy standard 2, the slope shall not vary by more than plus or minus 10 per cent.

b) Pulse duration shall be 3.5 microseconds plus or minus 0.5 microsecond.
c) Pulse decay time shall nominally be 2.5 microseconds but shall not exceed 3.5 microseconds.

d) The instantaneous amplitude of the pulse shall not, at any instant between the point of the leading edge which is 95 per cent of maximum amplitude and the point of the trailing edge which is 95 per cent of the maximum amplitude, fall below a value which is 95 per cent of the maximum voltage amplitude of the pulse.

e) For DME/N and DME/P: the spectrum of the pulse modulated signal shall be such that during the pulse the EIRP contained in a 0.5 MHz band centred on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case shall not exceed 200 mW, and the EIRP contained in a 0.5 MHz band centred on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2 mW. The EIRP contained within any 0.5 MHz band shall decrease monotonically as the band centre frequency moves away from the nominal channel frequency.

f) To ensure proper operation of the thresholding techniques, the instantaneous magnitude of any pulse turn-on transients which occur in time prior to the virtual origin shall be less than one per cent of the pulse peak amplitude. Initiation of the turn-on process shall not commence sooner than 1 microsecond prior to the virtual origin.

7.3.1.4 *Pulse spacing*

7.3.1.4.1 The spacing of the constituent pulses of transmitted pulse pairs shall be as given in the table in 3.5.4.4.1.

7.3.1.4.2 *DME/N.* The tolerance on the pulse spacing shall be plus or minus 0.25 microsecond.

7.3.1.4.3 *DME/N.* The tolerance on the DME/N pulse spacing shall be plus or minus
0.10 microsecond.

7.3.1.4.4 *DME/P.* The tolerance on the pulse spacing shall be plus or minus 0.10 microsecond.

7.3.1.4.5 The pulse spacings shall be measured between the half voltage points on the leading edges of the pulses.

7.3.1.5 *Peak power output*

7.3.1.5.1 *DME/N.* The peak EIRP shall not be less than that required to ensure a peak pulse power density of approximately minus 83 dBW/m2 at the maximum specified service range and level.

7.3.1.5.2 *DME/N.* The peak equivalent isotropically radiated power shall not be less than that required to ensure a peak pulse power density of minus 89 dBW/m2 under all operational weather conditions at any point within coverage specified in 7.2.1.2.

7.3.1.5.3 *DME/P.* The peak equivalent isotropically radiated power shall not be less than that required to ensure the following peak pulse power densities under all operational weather conditions:

a) minus 89 dBW/m2 at any point within the coverage specified in 7.2.1.2 at ranges greater than 13 km (7 NM) from the transponder antenna;

b) minus 75 dBW/m2 at any point within the coverage specified in 7.2.1.2 at ranges less than 13 km (7 NM) from the transponder antenna;

c) minus 70 dBW/m2 at the MLS approach reference datum;

d) minus 79 dBW/m2 at 2.5 m (8 ft) above the runway surface, at the MLS datum point, or at the farthest point on the runway centre line which is in line of sight of the DME transponder antenna.

7.3.1.5.4 The peak power of the constituent pulses of any pair of pulses shall not differ by more than 1 dB.

7.3.1.5.5 The reply capability of the transmitter shall be such that the transponder should be capable of continuous operation at a transmission rate of 2 700 plus or minus 90 pulse pairs per second (if 100 aircraft are to be served).

7.3.1.5.6 The transmitter shall operate at a transmission rate, including randomly distributed pulse pairs and distance reply pulse pairs, of not less than 700 pulse pairs per second except during identity. The minimum transmission rate shall be as close as practicable to 700 pulse pairs per second. For DME/P, in no case shall it exceed 1 200 pulse pairs per second.

7.3.1.6 *Spurious radiation.* During intervals between transmission of individual pulses, the spurious power received and measured in a receiver having the same characteristics as a transponder receiver, but tuned to any DME interrogation or reply frequency, shall be more than 50 dB below the peak pulse power received and measured in the same receiver tuned to the reply frequency in use during the

transmission of the required pulses. This provision refers to all spurious transmissions, including modulator and electrical interference.
7.3.1.6.1 *DME/N.* The spurious power level specified in 3.5.4.1.6 shall be more than 80 dB below the peak pulse power level.

7.3.1.6.2 *DME/P.* The spurious power level specified in 3.5.4.1.6 shall be more than 80 dB below the peak pulse power level.
7.3.1.6.3 *Out-of-band spurious radiation.* At all frequencies from 10 to 1 800 MHz, but excluding the band of frequencies from 960 to 1 215 MHz, the spurious output of the DME transponder transmitter shall not exceed minus 40 dBm in any one kHz of receiver bandwidth.
7.3.1.6.4 The equivalent isotropically radiated power of any CW harmonic of the carrier frequency on any DME operating channel shall not exceed minus 10 dBm.

7.3.2 *Receiver*
7.3.2.1 *Frequency of operation.* The receiver centre frequency shall be the interrogation frequency appropriate to the assigned DME operating channel (see 7.2.3).

7.3.2.2 *Frequency stability.* The centre frequency of the receiver shall not vary more than plus or minus 0.002 percent from the assigned frequency.
7.3.2.3 *Transponder sensitivity*

7.3.2.3.1 In the absence of all interrogation pulse pairs, with the exception of those necessary to perform the sensitivity measurement, interrogation pulse pairs with the correct spacing and nominal frequency shall trigger the transponder if the peak power density at the transponder antenna is at least:

a) minus 103 dBW/m2 for DME/N with coverage range greater than 56 km (30 NM);

b) minus 93 dBW/m2 for DME/N with coverage range not greater than 56 km (30

NM);
c) minus 86 dBW/m2 for DME/P IA mode;

d) minus 75 dBW/m2 for DME/P FA mode.
7.3.2.3.2 The minimum power densities specified in 7.3.2.3.1 shall cause the transponder to reply with an efficiency of at least:

a) 70 per cent for DME/N;
b) 70 per cent for DME/P IA mode;
c) 80 per cent for DME/P FA mode.

7.3.2.3.3 *DME/N dynamic range.* The performance of the transponder shall be maintained when the power density of the interrogation signal at the transponder antenna has any value between the minimum specified in 7.3.2.3.1 up to a maximum of minus 22 dBW/m2 when installed with ILS or MLS and minus 35 dBW/m2 when installed for other applications.

7.3.2.3.4 *DME/P dynamic range.* The performance of the transponder shall be maintained when the power density of the interrogation signal at the transponder antenna has any value between the minimum specified in 7.3.2.3.1 up to a maximum of minus 22 dBW/m2.

7.3.2.3.5 The transponder sensitivity level shall not vary by more than 1 dB for transponder loadings between 0 and 90 per cent of its maximum transmission rate.
7.3.2.3.6 *DME/N.*When the spacing of an interrogator pulse pair varies from the nominal value by up to plus or minus 1 microsecond, the receiver sensitivity shall not be reduced by more than 1 dB.
7.3.2.3.7 *DME/P.* When the spacing of an interrogator pulse pair varies from the nominal value by up to plus or minus 1 microsecond, the receiver sensitivity shall not be reduced by more than 1 dB.

7.3.2.4 *Load limiting*
7.3.2.4.1 *DME/N.* When transponder loading exceeds 90 per cent of the maximum transmission rate, the receiver sensitivity shall be automatically reduced in order to limit the transponder replies, so as to ensure that the maximum permissible transmission rate is not exceeded. (The available range of sensitivity reduction shall be at least 50 dB.)

7.3.2.4.2 *DME/P.* To prevent transponder overloading the transponder shall automatically limit its replies, so as to ensure that the maximum transmission rate is not exceeded. If the receiver sensitivity reduction is implemented to meet this requirement, it shall be applied to the IA mode only and shall not affect the FA mode.

7.3.2.5 *Noise.* When the receiver is interrogated at the power densities specified in
7.3.2.3.1 to produce a transmission rate equal to 90 per cent of the maximum, the noise generated pulse pairs shall not exceed 5 per cent of the maximum transmission rate.

7.3.2.6 *Bandwidth*
7.3.2.6.1 The minimum permissible bandwidth of the receiver shall be such that the transponder sensitivity level shall not deteriorate by more than 3 dB when the total receiver drift is added to an incoming interrogation frequency drift of plus or minus 100 kHz.
7.3.2.6.2 *DME/N.* The receiver bandwidth shall be sufficient to allow compliance with
3.5.3.1.3 when the input signals are those specified in 7.4.1.3
7.3.2.6.3 *DME/P — IA mode.* The receiver bandwidth shall be sufficient to allow compliance with 3.5.3.1.3 when the input signals are those specified in 7.4.1.3 The 12 dB bandwidth shall not exceed 2 MHz and the 60 dB bandwidth shall not exceed 10 MHz.

7.3.2.6.4 *DME/P* **—** *FA mode.* The receiver bandwidth shall be sufficient to allow compliance with 7.4.1.3when the input signals are those specified in 7.4.1.3. The 12 dB bandwidth shall not exceed 6 MHz and the 60 dB bandwidth shall not exceed 20 MHz.

7.3.2.6.5 Signals greater than 900 kHz removed from the desired channel nominal frequency and having power densities up to the values specified in 7.3.2.3.3 for DME/N and 7.3.2.3.4 for DME/P shall not trigger the transponder. Signals arriving at the intermediate frequency shall be suppressed at least 80 dB. All other spurious response or signals within the 960 MHz to 1 215 MHz band and image frequencies shall be suppressed at least 75 dB.
7.3.2.7 *Recovery time.* Within 8 microseconds of the reception of a signal between 0 dB and 60 dB above minimum sensitivity level, the minimum sensitivity level of the transponder to a desired signal shall be within 3 dB of the value obtained in the absence of signals. This requirement shall be met with echo suppression circuits, if any, rendered inoperative. The 8 microseconds are to be measured between the half voltage points on the leading edges of the two signals, both of which conform in shape, with the specifications in 7.4.1.3.

7.3.2.8 *Spurious radiations.* Radiation from any part of the receiver or allied circuits shall meet the requirements stated in 7.3.1.6.

7.3.2.9 *CW and echo suppression*
CW and echo suppression shall be adequate for the sites at which the transponders will be used.

7.3.2.10 *Protection against interference*
Protection against interference outside the DME frequency band shall be adequate for the sites at which the transponders will be used.

7.3.3 *Decoding*
7.3.3.1 The transponder shall include a decoding circuit such that the transponder can be triggered only by pairs of received pulses having pulse duration and pulse spacings appropriate to interrogator signals as described in 7.4.1.3 and 7.4.1.4.
7.3.3.2 The decoding circuit performance shall not be affected by signals arriving

before, between, or after, the constituent pulses of a pair of the correct spacing.
7.3.3.3 *DME/N — Decoder rejection.* An interrogation pulse pair with a spacing of plus or minus 2 microseconds, or more, from the nominal value and with any signal level up to the value specified in 7.3.2.3.3 shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.

7.3.3.4 *DME/P — Decoder rejection.* An interrogation pulse pair with a spacing of plus or minus 2 microseconds, or more, from the nominal value and with any signal level up to the value specified in 7.3.2.3.4 shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.

7.3.4 *Time delay*
7.3.4.1 When a DME is associated only with a VHF facility, the time delay shall be the interval from the half voltage point on the leading edge of the second constituent pulse of the interrogation pair and the half voltage point on the leading edge of the second constituent pulse of the reply transmission. This delay shall be consistent with the following table, when it is desired that aircraft interrogators are to indicate distance from the transponder site.

Table 7-1: Time delay

		Pulse pair spacing (μs)		*Time delay (μs)*	
Channel suffix	*Operating mode*	*Interrogation*	*Reply*	*1st pulse timing*	*2nd pulse timing*
X	DME/N	12	12	50	50
	DME/P IA M	12	12	50	–
	DME/P FA M	18	12	56	–
Y	DME/N	36	30	56	50
	DME/P IA M	36	30	56	–
	DME/P FA M	42	30	62	–
W	DME/N	–	–	–	–
	DME/P IA M	24	24	50	–
	DME/P FA M	30	24	56	–
Z	DME/N	–	–	–	–
	DME/P IA M	21	15	56	–
	DME/P FA M	27	15	62	–

a) W and X are multiplexed on the same frequency.
b) Z and Y are multiplexed on the same frequency.

7.3.4.2 When a DME is associated with an MLS angle facility, the time delay shall be the interval from the half voltage point on the leading edge of the first constituent pulse of the interrogation pair and the half voltage point on the leading edge of the first constituent pulse of the reply transmission. This delay shall be 50 microseconds for mode X channels and 56 microseconds for mode Y channels, when it is desired that aircraft interrogators are to indicate distance from the transponder site.

7.3.4.2.1 For DME/P transponders, no time delay adjustment shall be permitted.

7.3.4.3 For the DME/N the transponder time delay shall be capable of being set to an appropriate value between the nominal value of the time delay minus 15 microseconds and the nominal value of the time delay, to permit aircraft interrogators to indicate zero distance at a specific point remote from the transponder site.

7.3.4.3.1 *DME/N.* The time delay shall be the interval from the half voltage point on the leading edge of the first constituent pulse of the interrogation pair and the half voltage point on the leading edge of the first constituent pulse of the reply transmission.

7.3.4.3.2 *DME/P — IA mode.* The time delay shall be the interval from the half voltage point on the leading edge of the first constituent pulse of the interrogation pulse pair to the half voltage point on the leading edge of the first constituent pulse of the reply pulse pair.

7.3.4.3.3 *DME/P — FA mode.* The time delay shall be the interval from the virtual origin of the first constituent pulse of the interrogation pulse pair to the virtual origin of the first constituent pulse of the reply pulse pair. The time of arrival measurement points shall be within the partial rise time of the first constituent pulse of the pulse pair in each case.

7.3.4.4 *DME/N.* Transponders shall be sited as near to the point at which zero indication is required as is practicable.

7.3.5 *Accuracy*

7.3.5.1 *DME/N.* The transponder shall not contribute more than plus or minus 1 microsecond (150 m (500 ft)) to the overall system error.

7.3.5.1.1 *DME/N* The contribution to the total system error due to the combination of the transponder errors, transponder location coordinate errors, propagation effects and random pulse interference effects shall be not greater than plus or minus 340 m (0.183 NM) plus 1.25 per cent of distance measure.

7.3.5.1.2 *DME/N.* The combination of the transponder errors, transponder location coordinate errors, propagation effects and random pulse interference effects shall not contribute more than plus or minus 185 m (0.1 NM) to the overall system error.

7.3.5.2 *DME/N.*A transponder associated with a landing aid shall not contribute more than plus or minus 0.5 microsecond (75 m (250 ft)) to the overall system error.

7.3.5.3 *DME/P — FA mode*

7.3.5.3.1 *Accuracy standard 1.* The transponder shall not contribute more than plus or minus 10 m (plus or minus 33 ft) PFE and plus or minus 8 m (plus or minus 26 ft) CMN to the overall system error.

7.3.5.3.2 *Accuracy standard 2.* The transponder shall not contribute more than plus or minus 5 m (plus or minus 16 ft) PFE and plus or minus 5 m (plus or minus 16 ft) CMN to the overall system error.

7.3.5.4 *DME/P — IA mode.* The transponder shall not contribute more than plus or minus 15 m (plus or minus 50 ft) PFE and plus or minus 10 m (plus or minus 33 ft) CMN to the overall system error.

7.3.6 *Efficiency*

7.3.6.1 The transponder reply efficiency shall be at least 70 per cent for DME/N and DME/P (IA mode) and 80 per cent for DME/P (FA mode) at all values of transponder loading up to the loading corresponding to 7.2.5 and at the minimum sensitivity level specified in 7.3.2.3.1 and 7.3.2.3.5.

7.3.6.2 *Transponder dead time.* The transponder shall be rendered inoperative for a period normally not to exceed 60 microseconds after a valid interrogation decode has occurred. In extreme cases when the geographical site of the transponder is such as to produce undesirable reflection problems, the dead time may be increased but only by the minimum amount necessary to allow the suppression of echoes for DME/N and DME/P IA mode.

7.3.6.2.1 In DME/P the IA mode dead time shall not blank the FA mode channel and vice versa.

7.3.7 *Monitoring and control*

7.3.7.1 Means shall be provided at each transponder site for the automatic monitoring and control of the transponder in use.

7.3.7.2 *DME/N monitoring action*

7.3.7.2.1 In the event that any of the conditions specified in 7.3.7.2.2 occur, the monitor shall cause the following action to take place:

a) a suitable indication shall be given at a control point;
b) the operating transponder shall be automatically switched off; and
c) the standby transponder, if provided, shall be automatically placed in operation.

7.3.7.2.2 The monitor shall cause the actions specified in 7.3.7.2.1 if:

a) the transponder delay differs from the assigned value by 1 microsecond (150 m (500 ft)) or more; (b) in the case of a DME/N associated with a landing aid, the transponder delay differs from the assigned value by 0.5 microsecond (75 m (250 ft)) or more.

7.3.7.2.3 The monitor shall cause the actions specified in 7.3.7.2.1 if the spacing between the first and second pulse of the transponder pulse pair differs from the nominal value specified in the table following 7.3.4.1 by 1 microsecond or more..

7.3.7.2.4 The monitor shall also cause a suitable indication to be given at a control point if any of the following conditions arise:

a) a fall of 3 dB or more in transponder transmitted power output;

b) a fall of 6 dB or more in the minimum transponder receiver sensitivity (provided that this is not due to the action of the receiver automatic gain reduction circuits);
c) the spacing between the first and second pulse of the transponder reply pulse pair differs from the normal value specified in 7.3.1.4 by 1 microsecond or more;

d) variation of the transponder receiver and transmitter frequencies beyond the control range of the reference circuits (if the operating frequencies are not directly crystal controlled).
7.3.7.2.5 Means shall be provided so that any of the conditions and malfunctioning enumerated in 7.3.7.2.2, 7.3.7.2.3 and 7.3.7.2.4 which are monitored can persist for a certain period before the monitor takes action. This period shall be as low as practicable, but shall not exceed 10 seconds, consistent with the need for avoiding interruption, due to transient effects, of the service provided by the transponder.
.

7.3.7.2.6 The transponder shall not be triggered more than 120 times per second for either monitoring or automatic frequency control purposes, or both.
7.3.7.3 *DME/P monitoring action*

7.3.7.3.1 The monitor system shall cause the transponder radiation to cease and provide a warning at a control point if any of the following conditions persist for longer than the period specified:
a) there is a change in transponder PFE that exceeds the limits specified in either
7.3.5.3 or 7.3.5.4 for more than one second. If the FA mode limit is exceeded, but the IA mode limit is maintained, the IA mode may remain operative;

b) there is a reduction in the EIRP to less than that necessary to satisfy the requirements specified in 7.3.1.5.3 for a period of more than one second;
c) there is a reduction of 3 dB or more in the transponder sensitivity necessary to satisfy the requirements specified in 7.3.2.3 for a period of more than five seconds in FA mode and ten seconds in IA mode (provided that this is not due to the action of the receiver automatic sensitivity reduction circuits);
d) the spacing between the first and second pulse of the transponder reply pulse pair differs from the value specified in the table in 7.3.4.1 by 0.25 microsecond or more for a period of more than one second.

7.3.7.3.2 The monitor shall cause a suitable indication to be given at a control point if there is an increase above 0.3 microseconds or a decrease below 0.2 microseconds of the reply pulse partial rise time which persists for more than one second.
7.3.7.3.3 The period during which erroneous guidance information is radiated shall not exceed the periods specified in 7.3.7.3.1. Attempts to clear a fault by resetting the

primary ground equipment or by switching to standby ground equipment, if fitted, shall be completed within this time. If the fault is not cleared within the time allowed, the radiation shall cease. After shutdown, no attempt shall be made to restore service until a period of 20 seconds has elapsed.

7.3.7.3.4 The transponder shall not be triggered for monitoring purposes more than 120 times per second in the IA mode and 150 times per second in the FA mode.
7.3.7.3.5 *DME/N and DME/P monitor failure.* Failure of any part of the monitor itself shall automatically produce the same results as the malfunctioning of the element being monitored.

7.4 Technical characteristics of interrogator
7.4.1 *Transmitter*

7.4.1.1 *Frequency of operation.* The interrogator shall transmit on the interrogation frequency appropriate to the assigned DME channel (see 7.2.3).
7.4.1.2 *Frequency stability.* The radio frequency of operation shall not vary more than plus or minus 100 kHz from the assigned value.

7.4.1.3 *Pulse shape and spectrum.* The following shall apply to all radiated pulses:

a) *Pulse rise time.*
1) *DME/N.* Pulse rise time shall not exceed 3 microseconds.

2) *DME/P.* Pulse rise time shall not exceed 1.6 microseconds. For the FA mode, the pulse shall have a partial rise time of 0.25 plus or minus 0.05 microsecond. With respect to the FA mode and accuracy standard 1, the slope of the pulse in the partial rise time shall not vary by more than plus or minus 20 per cent. For accuracy standard 2 the slope shall not vary by more than plus or minus 10 per cent.

b) Pulse duration shall be 3.5 microseconds plus or minus 0.5 microsecond.
c) Pulse decay time shall nominally be 2.5 microseconds, but shall not exceed 3.5 microseconds.

d) The instantaneous amplitude of the pulse shall not, at any instant between the point of the leading edge which is 95 per cent of maximum amplitude and the point of the trailing edge which is 95 per cent of the maximum amplitude, fall below a value which is 95 per cent of the maximum voltage amplitude of the pulse.
e) The spectrum of the pulse modulated signal shall be such that at least 90 per cent of the energy in each pulse shall be within 0.5 MHz in a band centred on the nominal channel frequency.

f) To ensure proper operation of the thresholding techniques, the instantaneous magnitude of any pulse turn-on transients which occur in time prior to the virtual origin shall be less than one per cent of the pulse peak amplitude. Initiation of the turn-on process shall not commence sooner than 1 microsecond prior to the virtual origin.

7.4.1.4 *Pulse spacing*
7.4.1.4.1 The spacing of the constituent pulses of transmitted pulse pairs shall be as given in the table in 7.3.4.1
7.4.1.4.2 *DME/N.* The tolerance on the pulse spacing shall be plus or minus 0.5

microsecond.

7.4.1.4.3 *DME/N.* The tolerance on the pulse spacing shall be plus or minus 0.25 microsecond.
7.4.1.4.4 *DME/P.* The tolerance on the pulse spacing shall be plus or minus 0.25 microsecond.

7.4.1.4.5 The pulse spacing shall be measured between the half voltage points on the leading edges of the pulses.
7.4.1.5 *Pulse repetition frequency*

7.4.1.5.1 The pulse repetition frequency shall be as specified in 7.2.4

7.4.1.5.2 The variation in time between successive pairs of interrogation pulses shall be sufficient to prevent false lock-on.
7.4.1.5.3 *DME/P.* In order to achieve the system accuracy specified in 7.2.1.4, the variation in time between successive pairs of interrogation pulses shall be sufficiently random to decorrelate high frequency multipath errors.
7.4.1.6 *Spurious radiation.* During intervals between transmission of individual pulses, the spurious pulse power received and measured in a receiver having the same characteristics of a DME transponder receiver, but tuned to any DME interrogation or reply frequency, shall be more than 50 dB below the peak pulse power received and measured in the same receiver tuned to the interrogation frequency in use during the transmission of the required pulses. This provision shall apply to all spurious pulse transmissions. The spurious CW power radiated from the interrogator on any DME interrogation or reply frequency shall not exceed 20 microwatts (minus 47 dBW).
7.4.1.7 The spurious pulse power received and measured under the conditions stated in 7.4.1.6 above shall be 80 dB below the required peak pulse power received.

7.4.1.8 *DME/P.* The peak EIRP shall not be less than that required to ensure the power densities in 7.3.2.3.1 under all operational weather conditions.

7.4.2 *Time delay*
7.4.2.1 The time delay shall be consistent with the table in 7.3.4.1.

7.4.2.2 *DME/N.* The time delay shall be the interval between the time of the half voltage point on the leading edge of the second constituent interrogation pulse and the time at which the distance circuits reach the condition corresponding to zero distance indication.

7.4.2.3 *DME/N.* The time delay shall be the interval between the time of the half voltage point on the leading edge of the first constituent interrogation pulse and the time at which the distance circuits reach the condition corresponding to zero distance indication.
7.4.2.4 *DME/P — IA mode.* The time delay shall be the interval between the time of the half voltage point on the leading edge of the first constituent interrogation

pulse and the time at which the distance circuits reach the condition corresponding to zero distance indication.

7.4.2.5 *DME/P — FA mode.* The time delay shall be the interval between the virtual origin of the leading edge of the first constituent interrogation pulse and the time at which the distance circuits reach the condition corresponding to zero distance indication. The time of arrival shall be measured within the partial rise time of the pulse.

7.4.3 *Receiver*

7.4.3.1 *Frequency of operation.* The receiver centre frequency shall be the transponder frequency appropriate to the assigned DME operating channel (see 7.2.3.3).

7.4.3.2 *Receiver sensitivity*

7.4.3.2.1 *DME/N.* The airborne equipment sensitivity shall be sufficient to acquire and provide distance information to the accuracy specified in 7.4.4 for the signal power density specified in 7.3.1.5.2.

7.4.3.2.2 *DME/P.* The airborne equipment sensitivity shall be sufficient to acquire and provide distance information to the accuracy specified in 7.4.4.2 and 7.4.4.3 for the signal power densities specified in 7.3.1.5.3.

7.4.3.2.3 *DME/N.* The performance of the interrogator shall be maintained when the power density of the transponder signal at the interrogator antenna is between the minimum values given in 7.3.1.5 and a maximum of minus18 dBW/m2.

7.4.3.2.4 *DME/P.* The performance of the interrogator shall be maintained when the power density of the transponder signal at the interrogator antenna is between the minimum values given in 7.3.1.5 and a maximum of minus 18 dBW/m2.

7.4.3.3 *Bandwidth*

7.4.3.3.1 *DME/N.* The receiver bandwidth shall be sufficient to allow compliance with 7.2.1.3, when the input signals are those specified in 7.3.1.3

7.4.3.3.2 *DME/P — IA mode.* The receiver bandwidth shall be sufficient to allow compliance with 7.2.1.3 when the input signals are those specified in 7.3.1.3. The 12- dB bandwidth shall not exceed 2 MHz and the 60-dB bandwidth shall not exceed 10 MHz.

7.4.3.3.3 *DME/P — FA mode.* The receiver bandwidth shall be sufficient to allow compliance with 7.2.1.3 when the input signals are those specified 7.4.1.3. The 12-dB bandwidth shall not exceed 6 MHz and the 60-dB bandwidth shall not exceed 20 MHz.

7.4.3.4 *Interference rejection*

7.4.3.4.1 When there is a ratio of desired to undesired co-channel DME signals of at least 8 dB at the input terminals of the airborne receiver, the interrogator shall display distance information and provide unambiguous identification from the stronger signal.

7.4.3.4.2 *DME/N.* DME signals greater than 900 kHz removed from the desired channel nominal frequency and having amplitudes up to 42 dB above the threshold sensitivity shall be rejected.

7.4.3.4.3 *DME/P.* DME signals greater than 900 kHz removed from the desired channel nominal frequency and having amplitudes up to 42 dB above the threshold sensitivity shall be rejected.

7.4.3.5 *Decoding*

7.4.3.5.1 The interrogator shall include a decoding circuit such that the receiver can be triggered only by pairs of received pulses having pulse duration and pulse spacings appropriate to transponder signals as described in 7.3.1.4

7.4.3.5.2 *DME/N — Decoder rejection.* A reply pulse pair with a spacing of plus or minus 2 microseconds, or more, from the nominal value and with any signal level up to 42 dB above the receiver sensitivity shall be rejected.

7.4.3.5.3 *DME/P — Decoder rejection.* A reply pulse pair with a spacing of plus or minus 2 microseconds, or more, from the nominal value and with any signal level up to 42 dB above the receiver sensitivity shall be rejected.

7.4.4 *Accuracy*

7.4.4.1 *DME/N.* The interrogator shall not contribute more than plus or minus 315 m (plus or minus 0.17 NM) or 0.25 per cent of indicated range, whichever is greater, to the overall system error.

7.4.4.2 *DME/P — IA mode.* The interrogator shall not contribute more than plus or minus 30 m (plus or minus 100 ft) to the overall system PFE and not more than plus or minus 15 m (plus or minus 50 ft) to the overall system CMN.

7.4.4.3 DME/P — FA mode

7.4.4.3.1 *Accuracy standard 1.* The interrogator shall not contribute more than plus or minus 15 m (plus or minus 50 ft) to the overall system PFE and not more than plus or minus 10 m (plus or minus 33 ft) to the overall system CMN.

7.4.4.3.2 *Accuracy standard 2.* The interrogator shall not contribute more than plus or minus 7 m (plus or minus 23 ft) to the overall system PFE and not more than plus or minus 7 m (plus or minus 23 ft) to the overall system CMN.

7.4.4.4 DME/P. The interrogator shall achieve the accuracy specified in 7.2.1.3 with a system efficiency of 50 percent or more.

8.0 Specification for en-route VHF marker beacons (75 MHz)

8.1 Equipment

8.1.1 *Frequencies.* The emissions of an en-route VHF marker beacon shall have a radio frequency of 75 MHz plus or minus 0.005 per cent.

8.1.2 *Characteristics of emissions*

8.1.2.1 .1 Radio marker beacons shall radiate an uninterrupted carrier modulated to a depth of not less than 95 per cent or more than 100 per cent. The total harmonic content of the modulation shall not exceed 15 per cent.

8.1.2.2 The frequency of the modulating tone shall be 3 000 Hz plus or minus 75 Hz.

8.1.2.3 The radiation shall be horizontally polarized.

8.1.2.4 *Identification.* If a coded identification is required at a radio marker beacon, the modulating tone shall be keyed so as to transmit dots or dashes or both in an appropriate sequence. The mode of keying shall be such as to provide a dot-and-dash

duration together with spacing intervals corresponding to transmission at a rate equivalent to approximately six to ten words per minute. The carrier shall not be interrupted during identification.

8.1.2.5 *Determination of coverage.* The limits of coverage of marker beacons shall be determined on the basis of the field strength specified in 4.2.3.

8.1.2.6 *Radiation pattern.*
The radiation pattern of a marker beacon normally shall be such that the polar axis is vertical, and the field strength in the pattern is symmetrical about the polar axis in the plane or planes containing the flight paths for which the marker beacon is intended.

8.1.3 *Monitoring.*
For each marker beacon, suitable monitoring equipment shall be provided which will show at an appropriate location:
a) a decrease in radiated carrier power below 50 per cent of normal;
b) a decrease of modulation depth below 70 per cent;
c) a failure of keying.

9.0 Requirements for the Global Navigation Satellite System (GNSS)

9.1 Table 9-1 Signal in space performance requirements

Typical operation	Accuracy horizontal 95% (Notes 1 and 3)	Accuracy vertical 95% (Notes 1 and 3)	Integrity (Note 2)	Time-to-alert (Note 3)	Continuity (Note 4)	Availability (Note 5)
En-route	3.7 km (2.0 NM)	N/A	$1 - 1 \times 10^{-7}$/h	5 min	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
En-route, Terminal	0.74 km (0.4 NM)	N/A	$1 - 1 \times 10^{-7}$/h	15 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Initial approach, Intermediate approach, Non-precision approach (NPA), Departure	220 m (720 ft)	N/A	$1 - 1 \times 10^{-7}$/h	10 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Approach operations with vertical guidance (APV-I) (Note 8)	16.0 m (52 ft)	20 m (66 ft)	$1 - 2 \times 10^{-7}$ in any approach	10 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Approach operations with vertical guidance (APV-II) (Note 8)	16.0 m (52 ft)	8.0 m (26 ft)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Category I precision approach (Note 7)	16.0 m (52 ft)	6.0 m to 4.0 m (20 ft to 13 ft) (Note 6)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999

NOTES.
1. The 95th percentile values for GNSS position errors are those required for the intended operation at the lowest height above threshold (HAT), if applicable.
2. The definition of the integrity requirement includes an alert limit against which the requirement can be assessed. For Category I precision approach, a vertical alert limit (VAL) greater than 10 m for a specific system design may only be used if a system- specific safety analysis has been completed. These alert limits are:

Typical operation	Horizontal alert limit	Vertical alert limit
En-route (oceanic/continental low density)	7.4 km (4 NM)	N/A
En-route (continental)	3.7 km (2 NM)	N/A
En-route, Terminal	1.85 km (1 NM)	N/A
NPA	556 m (0.3 NM)	N/A
APV-I	40 m (130 ft)	50 m (164 ft)
APV- II	40 m (130 ft)	20.0 m (66 ft)
Category I precision approach	40 m (130 ft)	35.0 m to 10.0 m (115 ft to 33 ft)

3. The accuracy and time-to-alert requirements include the nominal performance of a fault-free receiver.
4. Ranges of values are given for the continuity requirement for en-route, terminal, initial approach, NPA and departure operations, as this requirement is dependent upon several factors including the intended operation, traffic density, complexity of airspace and availability of alternative navigation aids. The lower value given is the minimum requirement for areas with low traffic density and airspace complexity. The higher value given is appropriate for areas with high traffic density and airspace complexity. Continuity requirements for APV and Category I operations apply to the average risk (over time) of loss of service, normalized to a 15-second exposure time.
5. A range of values is given for the availability requirements as these requirements are dependent upon the operational need which is based upon several factors including
6.
the frequency of operations, weather environments, the size and duration of the outages, availability of alternate navigation aids, radar coverage, traffic density and reversionary operational procedures. The lower values given are the minimum availabilities for which a system is considered to be practical but are not adequate to replace non-GNSS navigation aids. For en-route navigation, the higher values given are adequate for GNSS to be the only navigation aid provided in an area. For approach and departure, the higher values given are based upon the availability requirements at airports with a large amount of traffic assuming that operations to or from multiple runways are affected but reversionary operational procedures ensure the safety of the operation.

7. A range of values is specified for Category I precision approach. The 4.0 m (13 feet) requirement is based upon ILS specifications and represents a conservative derivation from these specifications.
8. GNSS performance requirements for Category II and III precision approach operations are under review and will be included at a later date.

9. The terms APV-I and APV-II refer to two levels of GNSS approach and landing operations with vertical guidance (APV) and these terms are not necessarily intended to be used operationally.

9.2 GNSS elements specifications
9.2.1 *GPS Standard Positioning Service (SPS) (L1)*

9.2.1.1 *Space and control segment accuracy*

9.2.1.1.1 *Positioning accuracy*. The GPS SPS position errors shall not exceed the following limits:

	Global average 95% of the time	Worst site 95% of the time
Horizontal position error	9 m (30ft)	17 m (56ft)
Vertical position error	15 m (49ft)	37 m (121ft)

9.2.1.1.2 *Time transfer accuracy*. The GPS SPS time transfer errors shall not exceed 40 nanoseconds 95 per cent of the time.
9.2.1.1.3 *Range domain accuracy*. The range domain error shall not exceed the following limits:
a) range error of any satellite 30 m (100 ft) with reliability specified in 9.2.1.3;
b) 95th percentile range rate error of any satellite 0.006 m (0.002 ft) per second (global average);
c) 95th percentile range acceleration error of any satellite 0.002 m (0.006 ft) per second-squared (global average) and
d) 95th percentile range error for any satellites over all time differences between time of data generation and time of use of data 7.8 m (26 ft) (global average).
9.2.1.2 *Availability*. The GPS SPS availability shall be as follows:

≥ 99 per cent horizontal service availability, average location (17 m 95 per cent threshold)
≥99 per cent vertical service availability, average location (37 m 95 per cent threshold) ≥90 per cent horizontal service availability, worst-case location (17 m 95 per cent threshold) ≥90 per cent vertical service availability, worst-case location (37 m 95 per cent threshold)

9.2.1.3 *Reliability*. The GPS SPS reliability shall be within the following limits:

a) reliability at least 99.94 per cent (global average); and
c) reliability at least 99.79 per cent (worst single point average).

9.2.1.4 *Probability of major service failure.* The probability that the user range error (URE) of any satellite will exceed 4.42 times the upper bound on the user range accuracy (URA) broadcast by that satellite without an alert received at the user receiver antenna within 10 seconds shall not exceed 1×10-5per hour.

9.2.1.5 *Continuity.* The probability of losing GPS SPS signal-in-space (SIS) availability from a slot of the nominal 24-slot constellation due to unscheduled interruption shall not exceed 2×10-4 per hour.

9.2.1.6 *Coverage.* The GPS SPS shall cover the surface of the earth up to an altitude of 3 000 kilometres.

9.2.1.7 *Radio frequency (RF) characteristics*

9.2.1.7.1 *Carrier frequency*. Each GPS satellite shall broadcast an SPS signal at the carrier frequency of 1575.42 MHz (GPS L1) using code division multiple access (CDMA).

9.2.1.7.2 *Signal spectrum*. The GPS SPS signal power shall be contained within a ±12 MHz band (1563.42 – 1587.42 MHz) centred on the L1 frequency.

9.2.1.7.3 *Polarization*. The transmitted RF signal shall be right-hand (clockwise) circularly polarized.

9.2.1.7.4 *Signal power level*. Each GPS satellite shall broadcast SPS navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of 158.5 dBW to 153 dBW for all antenna orientations orthogonal to the direction of propagation.

9.2.1.7.5 *Modulation*. The SPS L1 signal shall be bipolar phase shift key (BPSK) modulated with a pseudo random noise (PRN) 1.023 MHz coarse/acquisition (C/A) code. The C/A code sequence shall be repeated each millisecond. The transmitted PRN code sequence shall be the Modulo-2 addition of 50 bits per second navigation message and the C/A code.

9.2.1.8 *GPS time*. GPS time shall be referenced to UTC (as maintained by the U.S. Naval Observatory).

9.2.1.9 *Coordinate system*. The GPS coordinate system shall be WGS-84.

9.2.1.10 *Navigation information*. The navigation data transmitted by the satellites shall include the necessary information to determine:
a) satellite time of transmission;
b) satellite position;
c) satellite health;
d) satellite clock correction;
e) propagation delay effects;
f) time transfer to UTC; and
g) constellation status.

9.2.2 ***GLONASS Channel of Standard Accuracy (CSA) (L1)***
9.2.2.1 *Space and control segment accuracy*

9.2.2.1.1 *Positioning accuracy*. The GLONASS CSA position errors shall not exceed the following limits:

	Global average 95% of the time	Worst site 95% of the time
Horizontal position error	5 m (17 ft)	12 m (40 ft)
Vertical position error	9 m (29 ft)	25 m (97 ft)

9.2.2.1.2 *Time transfer accuracy*. The GLONASS CSA time transfer errors shall not exceed 700 nanoseconds 95 per cent of the time.
9.2.2.1.3 *Range domain accuracy*. The range domain error shall not exceed the following limits:
a) range error of any satellite 18 m (59.7 ft);
b) range rate error of any satellite 0.02 m (0.07 ft) per second;
c) range acceleration error of any satellite 0.007 m (0.023 ft) per second squared;
d) root-mean-square range error over all satellites 6 m (19.9 ft).

9.2.2.2 *Availability*. The GLONASS CSA availability shall be as follows:
a) ≥99 per cent horizontal service availability, average location (12 m, 95 per cent threshold);
b) ≥99 per cent vertical service availability, average location (25 m, 95 per cent threshold);
c) ≥90 per cent horizontal service availability, worst-case location (12 m, 95 per cent threshold);
d) ≥90 per cent vertical service availability, worst-case location (25 m, 95 per cent threshold).

9.2.2.3 *Reliability*. The GLONASS CSA reliability shall be within the following limits:
a) frequency of a major service failure not more than three per year for the constellation (global average); and
b) reliability at least 99.7 per cent (global average).

9.2.2.4 *Coverage*. The GLONASS CSA shall cover the surface of the earth up to an altitude of 2 000 km.

9.2.2.5 *RF characteristics*
9.2.2.5.1 *Carrier frequency.* Each GLONASS satellite shall broadcast CSA navigation signal at its own carrier frequency in the L1 (1.6 GHz) frequency band using frequency division multiple access (FDMA).
9.2.2.5.2 *Signal spectrum.* GLONASS CSA signal power shall be contained

within a
±5.75 MHz band centred on each GLONASS carrier frequency.

9.2.2.5.3 *Polarization*. The transmitted RF signal shall be right-hand circularly polarized.
9.2.2.5.4 *Signal power level*. Each GLONASS satellite shall broadcast CSA navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna

is within the range of 161 dBW to 155.2 dBW for all antenna orientations orthogonal to the direction of propagation.
9.2.2.5.5 *Modulation*
9.2.2.5.5.1 Each GLONASS satellite shall transmit at its carrier frequency the navigation RF signal using a BPSK modulated binary train. The phase shift keying of the carrier shall be performed at -radians with the maximum error ±0.2 radian. The pseudo-random code sequence shall be repeated each millisecond.
9.2.2.5.5.2 The modulating navigation signal shall be generated by the Modulo- 2 addition of the following three binary signals:
a) ranging code transmitted at 511 kbits/s;
b) navigation message transmitted at 50 bits/s; and
c) 100 Hz auxiliary meander sequence.
9.2.2.6 *GLONASS time.* GLONASS time shall be referenced to UTC(SU) (as maintained by the National Time Service of Russia).

9.2.2.7 *Coordinate system*. The GLONASS coordinate system shall be PZ-90.
9.2.2.8 *Navigation information.* The navigation data transmitted by the satellite shall include the necessary information to determine:
a) satellite time of transmission;
b) satellite position;
c) satellite health;
d) satellite clock correction;
e) time transfer to UTC; and
f) constellation status.

9.2.3 *Aircraft-based augmentation system (ABAS)*

9.2.3.1 *Performance*. The ABAS function combined with one or more of the core satellite
9.2.3.2 Constellationsons and both a fault free GNSS receiver and fault-free aircraft system used for the ABAS function shall meet the requirements for accuracy, integrity, continuity and availability as stated in 9.0.
9.2.3.3 advanced receiver autonomous integrity monitoring (ARAIM). If the ABAS function implements ARAIM using integrity support data (ISD), the function shall meet the corresponding requirements

9.2.3.4 Satellite-based augmentation system (SBAS)
9.2.3.5 SBAS system and service description. SBAS shall consist of a non-aircraft subsystem and an aircraft subsystem.The SBAS non-aircraft subsystem shall

provide data and corrections for the GNSS ranging signals over one or two GNSS frequencies broadcast from a satellite to the aircraft subsystem. The SBAS non-aircraft subsystem shall broadcast on the L1 frequency to support the L1 SBAS service and/or on the L5 frequency to support the DFMC SBAS service

9.2.3.6 *Performance*. SBAS combined with one or more of the other GNSS elements and a fault-free receiver shall meet the requirements for system accuracy, integrity, continuity and availability for the intended operation as stated in 9.0.
9.2.3.7 *Functions.* SBAS shall perform one or more of the following functions:
a) ranging: provide an additional pseudo-range signal with an accuracy indicator from an SBAS satellite;
b) GNSS satellite status: determine and transmit the GNSS satellite health status;
c) basic differential correction: provide GNSS satellite ephemeris and clock corrections (fast and long-term) to be applied to the pseudo-range measurements from satellites; and
d) precise differential correction: determine and transmit the ionospheric corrections.

9.2.3.7.1 *Ranging*
9.2.3.7.1.1 Excluding atmospheric effects, the range error for the ranging signal from SBAS satellites shall not exceed 25 m (82 ft) (95 per cent).
9.2.3.7.1.2 The probability that the range error exceeds 150 m (490 ft) in any hour shall not exceed 10–5.
9.2.3.7.1.3 The probability of unscheduled outages of the ranging function from an SBAS satellite in any hour shall not exceed 10–3.
9.2.3.7.1.4 The range rate error shall not exceed 2 m (6.6 ft) per second.
9.2.4.2.1.5 The range acceleration error shall not exceed 0.019 m (0.06 ft) per second-squared.
9.2.3.8 *Service area*. The SBAS service area shall be a defined area within an SBAS coverage area where SBAS meets the requirements of 9.0 and supports the corresponding approved operations.

9.2.3.9 *RF characteristics*
9.2.3.9.1 *Carrier frequency.* The carrier frequency shall be 1 575.42 MHz.
9.2.3.9.2 *Signal spectrum*. At least 95 per cent of the broadcast power shall be contained within a ±12 MHz band centred on the L1 frequency. The bandwidth of the signal transmitted by an SBAS satellite shall be at least 2.2 MHz.
9.2.3.9.3 *SBAS satellite signal power level*.

9.2.3.9.3.1 Each SBAS satellite placed in orbit before 1 January 2014 shall broadcast navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is within the range of –161 dBW to –153 dBW for all antenna orientations orthogonal to the direction of propagation.

9.2.3.9.3.2 Each SBAS satellite placed in orbit after 31 December 2013 shall comply with the following requirements:

a) The satellite shall broadcast navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at or above the minimum elevation angle for which a trackable GEO signal needs to be provided, the level of the received RF signal at the antenna port of the antenna is at least –164.0 dBW.

(b) Minimum elevation angle. The minimum elevation angle used to determine GEO coverage shall not be less than 5 degrees for a user near the ground.
(c) The level of a received SBAS RF signal at the antenna port of a 0 dBic antenna located near the ground shall not exceed –152.5 dBW.
(d) The ellipticity of the broadcast signal shall be no worse than 2 dB for the angular range of ±9.1° from boresight.

9.2.3.9.4 *Polarization*. The broadcast signal shall be right-hand circularly polarized.

9.2.3.9.5 *Modulation.* The transmitted sequence shall be the Modulo-2 addition of the navigation message at a rate of 500 symbols per second and the 1 023 bit pseudo- random noise code. It shall then be BPSK-modulated onto the carrier at a rate of 1.023 megachips per second.

9.2.3.10 *SBAS network time (SNT)*. The difference between SNT and GPS time shall not exceed 50 nanoseconds.
9.2.3.11 *Navigation information*. The navigation data transmitted by the satellites shall include the necessary information to determine:
a) SBAS satellite time of transmission;
b) SBAS satellite position;
c) corrected satellite time for all satellites;
d) corrected satellite position for all satellites;
e) ionospheric propagation delay effects;
f) user position integrity;
g) time transfer to UTC; and
h) service level status.

9.2.4 ***Ground-based augmentation system (GBAS) and ground-based regional augmentation system (GRAS)***
9.2.4.1 *Performance*. GBAS combined with one or more of the other GNSS elements and a fault-free GNSS receiver shall meet the requirements for system accuracy, continuity, availability and integrity for the intended operation as stated in 9.0.

9.2.4.2 *Functions*. GBAS shall perform the following functions:
a) provide locally relevant pseudo-range corrections;
b) provide GBAS-related data;
c) provide final approach segment data when supporting precision approach;
d) provide predicted ranging source availability data; and
e) provide integrity monitoring for GNSS ranging sources.

9.2.4.3 *Coverage*

9.2.4.3.1 *Category I precision approach and approach with vertical guidance.* The GBAS coverage to support each Category I precision approach or approach with vertical guidance shall be as follows, except where topographical features dictate and operational requirements permit:

9.2.4.3.2
a) laterally, beginning at 140 m (450 ft) each side of the landing threshold point/fictitious threshold point (LTP/FTP) and projecting out ±35 degrees either side of the final approach path to 28 km (15 NM) and ±10 degrees either side of the final approach path to 37 km (20 NM); and
b) vertically, within the lateral region, up to the greater of 7 degrees or 1.75 promulgated glide path angle (GPA) above the horizontal with an origin at the glide path interception point (GPIP) and 0.45 GPA above the horizontal or to such lower angle, down to 0.30 GPA, as required, to safeguard the promulgated glide path intercept procedure. This coverage applies between 30 m (100 ft) and 3000 m (10 000 ft) height above threshold (HAT).

9.2.4.3.2.1 For Category I precision approach, the data broadcast as specified in
9.2.5.1 shall extend down to 3.7 m (12 ft) above the runway surface.

9.2.5.3.2.2 The data broadcast shall be omni-directional when required to support the intended applications.
9.2.4.3.3 *GBAS positioning service.* The GBAS positioning service area shall be that area where the data broadcast can be received and the positioning service meets the requirements of 9.0 and supports the corresponding approved operations.

9.2.4.4 *Data broadcast characteristics*
9.2.4.4.1 *Carrier frequency*. The data broadcast radio frequencies used shall be selected from the radio frequencies in the band 108 to 117.975 MHz. The lowest assignable frequency shall be 108.025 MHz and the highest assignable frequency shall be 117.950 MHz. The separation between assignable frequencies (channel spacing) shall be 25 kHz.

9.2.4.4.2 *Access technique*. A time division multiple access (TDMA) technique shall be used with a fixed frame structure. The data broadcast shall be assigned one to eight slots.

9.2.4.4.3 *Modulation*. GBAS data shall be transmitted as 3-bit symbols, modulating the data broadcast carrier by D8PSK, at a rate of 10 500 symbols per second.

9.2.4.4.4 *Data broadcast RF field strength and polarization*

9.2.4.4.4.1 *GBAS/H*
9.2.4.4.4.1.1 A horizontally polarized signal shall be broadcast.

9.2.4.4.4.1.2 The effective radiated power (ERP) shall provide for a horizontally polarized signal with a minimum field strength of 215 microvolts per metre (–99 dBW/m2) and a maximum field strength of 0.350 volts per metre

(–35 dBW/m2)

9.2.4.4.4.1.3
within the GBAS coverage volume. The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst. The RF phase offset between the HPOL and any VPOL components shall be such that the minimum signal power is achieved for HPOL users throughout the coverage volume.

9.2.4.4.4.2 *GBAS/E*

9.2.4.4.4.2.1 An elliptically polarized signal shall be broadcast whenever practical.

9.2.4.4.4.2.2 When an elliptically polarized signal is broadcast, the horizontally polarized component shall meet the requirements in 9.2.5.4.4.1.2, and the effective radiated power (ERP) shall provide for a vertically polarized signal with a minimum field strength of 136 microvolts per metre (–103 dBW/m2) and a maximum field strength of 0.221 volts per metre (–39 dBW/m2) within the GBAS coverage volume. The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst. The RF phase offset between the HPOL and VPOL components, shall be such that the minimum signal power is achieved for HPOL and VPOL users throughout the coverage volume.

9.2.4.4.5 *Power transmitted in adjacent channel*s. The amount of power during transmission under all operating conditions when measured over a 25 kHz bandwidth centred on the i^{th} adjacent channel shall not exceed the values shown in Table 9.2.5.4- 1.

Table 9.2.5.4.5-1 GBAS broadcast power transmitted in adjacent channels

Table 3.7.3.5-1. GBAS broadcast power transmitted in adjacent channels

Channel	Relative power	Maximum power
1st adjacent	–40 dBc	12 dBm
2nd adjacent	–65 dBc	–13 dBm
4th adjacent	–74 dBc	–22 dBm
8th adjacent	–88.5 dBc	–36.5 dBm
16th adjacent	–101.5 dBc	–49.5 dBm
32nd adjacent	–105 dBc	–53 dBm
64th adjacent	–113 dBc	–61 dBm
76th adjacent and beyond	–115 dBc	–63 dBm

NOTES.—
1. The maximum power applies if the authorized transmitter power exceeds 150 W.
2. The relationship is linear between single adjacent points designated by the adjacent channels identified above.

9.2.4.4.6 *Unwanted emissions.* Unwanted emissions, including spurious and out-of-band emissions, shall be compliant with the levels shown in Table 9.2.5.4.6-2. The total power in any VDB harmonic or discrete signal shall not be greater than –53 dBm.

Table 9.2.5.4.6-2 GBAS broadcast unwanted emissions

Frequency	Relative unwanted emission level (Note 2)	Maximum unwanted emission level (Note 1)
9 kHz to 150 kHz	–93 dBc (Note 3)	–55 dBm/1 kHz (Note 3)
150 kHz to 30 MHz	–103 dBc (Note 3)	–55 dBm/10 kHz (Note 3)
30 MHz to 106.125 MHz	–115 dBc	–57 dBm/100 kHz
106.425 MHz	–113 dBc	–55 dBm/100 kHz
107.225 MHz	–105 dBc	–47 dBm/100 kHz
107.625 MHz	–101.5 dBc	–53.5 dBm/10 kHz
107.825 MHz	–88.5 dBc	–40.5 dBm/10 kHz
107.925 MHz	–74 dBc	–36 dBm/1 kHz
107.9625 MHz	–71 dBc	–33 dBm/1 kHz
107.975 MHz	–65 dBc	–27 dBm/1 kHz
118.000 MHz	–65 dBc	–27 dBm/1 kHz
118.0125 MHz	–71 dBc	–33 dBm/1 kHz
118.050 MHz	–74 dBc	–36 dBm/1 kHz
118.150 MHz	–88.5 dBc	–40.5 dBm/10 kHz
118.350 MHz	–101.5 dBc	–53.5 dBm/10 kHz
118.750 MHz	–105 dBc	–47 dBm/100 kHz
119.550 MHz	–113 dBc	–55 dBm/100 kHz
119.850 MHz to 1 GHz	–115 dBc	–57 dBm/100 kHz
1 GHz to 1.7 GHz	–115 dBc	–47 dBm/1 MHz

NOTES.—
1. The maximum unwanted emission level (absolute power) applies if the authorized transmitter power exceeds 150 W.
2. The relative unwanted emission level is to be computed using the same bandwidth for desired and unwanted signals. This may require conversion of the measurement for unwanted signals done using the bandwidth indicated in the maximum unwanted emission level column of this table.
3. This value is driven by measurement limitations. Actual performance is expected to be better.
4. The relationship is linear between single adjacent points designated by the adjacent channels identified above.

9.2.4.5 *Navigation information*. The navigation data transmitted by GBAS shall include the following information:
(a) pseudo-range corrections, reference time and integrity data;
(b) GBAS-related data;
(c) final approach segment data when supporting precision approach; and
(d) predicted ranging source availability data.

9.2.5 *Aircraft GNSS receiver*
The aircraft GNSS receiver shall process the signals of those GNSS elements that it intends to use.

9.3 Resistance to interference
9.3.1 GNSS shall comply with performance requirements defined in 9.0 in the presence of the interference environment.

9.4 Database
9.4.1 Aircraft GNSS equipment that uses a database shall provide a means to:
(a) update the electronic navigation database; and
(b) determine the Aeronautical Information Regulation and Control (AIRAC) effective dates of the aeronautical database.

10.0 System characteristics of airborne ADF receiving systems

10.1 Accuracy of bearing indication

10.1.1 The bearing given by the ADF system shall not be in error by more than plus or minus 5 degrees with a radio signal from any direction having a field strength of 70 microvolts per metre or more radiated from an LF/MF NDB or locator operating within the tolerances permitted by this Manual and in the presence also of an unwanted signal from a direction 90 degrees from the wanted signal and:

(a) on the same frequency and 15 dB weaker; or
(b) plus or minus 2 kHz away and 4 dB weaker; or
(c) plus or minus 6 kHz or more away and 55 dB stronger".

Dodoma,
22nd December, 2025

MAKAME M. MBARAWA,
Minister for Transport