Democratic Socialist Republic of Sri Lanka

Civil Aviation Authority of Sri Lanka

Implementing Standard

(Issued under Sec. 120, Civil Aviation Act No. 14 of 2010)

Title: Compliance to Annex-10 –Aeronautical Telecommunications (Volume 1)

Reference No. : IS-10-(i)-all **S.N .:** 034 **Date:** 1st September 2019

Pursuant to Sec.120 of the Civil Aviation Act No.14 of 2010, Director General of Civil Aviation shall have the power to issue, whenever he considers it necessary or appropriate to do so, such Implementing Standards for the purpose of giving effect to any of the provisions of the Civil Aviation Act, any regulations or rules made thereunder including the Articles of the Convention on International Civil Aviation which are specified in the Schedule to the Act.

Accordingly, the undersigned being the Director General of Civil Aviation do hereby issue the Implementing Standards as mentioned in the Attachment hereto (Ref: Attachment No. IS-10-(i)-all -Att), for the purpose of giving effect to the provisions in the aforementioned Act and Standards & Procedures described under Article 37 of the Convention, which are specified in the Attachment.

These Implementing Standards shall come into force with immediate effect and remain in force unless revoked.

Attention is also drawn to sec. 103 of the Act, which states inter alia that failure to comply with Implementing Standard is an offence.

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Director General of Civil Aviation and
Chief Executive Officer

Civil Aviation Authority of Sri Lanka
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Enclosure: Attachment No. IS-10-(i)-all – Att.

Implementing Standards

Title: Compliance to Annex-10- Aeronautical Telecommunications (Volume 1)

GENERAL:

i. Requirements contained in this document are based on the amendment 90 of ICAO Annex 10 – "Aeronautical Telecommunication" Radio Navigational Aids

ii. The requirements contained in this document are applicable to holders of Aeronautical Telecommunication Service Providers and Service providers of Aeronautical Aids for Communication Navigation and Surveillance (CNS) in Sri Lanka.

iii. Aeronautical Telecommunication Service Providers and the Service Providers of Aeronautical Communication Navigation and Surveillance (CNS) in Sri Lanka shall strictly comply with the requirements published in this document.

iv. This document supersedes the Implementing Standard 034, Second Edition, and Revision 01, issued by the DGCA. Accordingly Implementing Standard 034 Second Edition, Revision 01 shall be treated as null and void.

v. This document may be amended from time to time and the amendments will be reflected with a vertical line on the right side of the text.

AERONAUTICAL TELECOMMUNICATION

RADIO NAVIGATIONAL AIDS

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Record of Amendments

Rev. Number	Date	Entered by
Revision 01	01.01.2017	ANSI
Revision 02	01.09.2019	SCAI ATM-TECH

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CHAPTER - 1 - DEFINITIONS

When the following terms are used in this volume, they have the following meanings:

Altitude **–** The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL).

Area navigation (RNAV) **–** A method of navigation which permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Note – Area navigation includes performance-based navigation as well as other operations that do not meet the definition of performance-based navigation.

Effective acceptance bandwidth **–** The range of frequencies with respect to the assigned frequency for which reception is assured when all receiver tolerances have been taken into account.

Effective adjacent channel rejection **–** The rejection that is obtained at the appropriate adjacent channel frequency when all relevant receiver tolerances have been taken into account.

Elevation **–** The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Essential radio navigation service **–** A radio navigation service whose disruption has a significant impact on operations in the affected airspace or aerodrome.

Fan marker beacon **–** A type of radio beacon, the emissions of which radiate in a vertical fan-shaped pattern.

Height **–** The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

Human Factors principles **–** Principles which apply to design, certification, training, operations and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance.

Mean power (of a radio transmitter) **–** The average power supplied to the antenna transmission line by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions.

Note – A time of 1/10 second during which the mean power is greatest will be selected normally.

Navigation specification **–** A set of aircraft and flight crew requirements needed to support performance-based navigation operations within a defined airspace. There are two kinds of navigation specifications;

Required navigation performance (RNP) specification: A navigation specification based on area navigation that includes the requirement for performance monitoring and alerting, designated by the prefix RNP, e.g. RNP 4, RNP APCH.

Area navigation (RNAV) specification: A navigation specification based on area navigation that does not include the requirement for performance monitoring and alerting, designated by the prefix RNAV, e.g. RNAV 5, RNAV1

Note - Performance-based Navigation (PBN) Manual *(Doc 9613), Volume II, contains detailed guidance on navigation specifications.*

Note 2 – The term RNP, previously defined as "a statement of the navigation performance necessary for operation within a defined airspace", has been removed from this IS as the concept of RNP has been overtaken by the concept of PBN. The term RNP in this IS is now solely used in the context of navigation specifications that require performance monitoring and alerting, e.g. RNP 4 refers to the aircraft and operating requirements, including a 4 NM lateral performance with on-board performance monitoring and alerting that are detailed in Doc 9613.

Performance-based navigation (PBN) – Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.

Note – Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept.

Pressure-altitude – An atmospheric pressure expressed in terms of altitude which corresponds to that pressure in the Standard Atmosphere.

Protected service volume – A part of the facility coverage where the facility provides a particular service in accordance with relevant SARPs and within which the facility is afforded frequency protection.

Radio navigation service – A service providing guidance information or position data for the efficient and safe operation of aircraft supported by one or more radio navigation aids.

***Touchdown* –** The point where the nominal glide path intercepts the runway.

Note – "Touchdown "as defined above is only a datum and is not necessarily the actual point at which the aircraft will touch the runway.

***Z marker beacon* –** A type of radio beacon, the emissions of which radiate in a vertical cone-shaped pattern.

CHAPTER - 2 GENERAL PROVISIONS FOR RADIO NAVIGATION AIDS

2.1 Standard radio navigation aids

2.1.1 The standard radio navigation aids shall be:

(a) The instrument landing system (ILS) conforming to the Standards contained in Chapter 3, 3.1;

(b) The VHF omnidirectional radio range (VOR) conforming to the Standards contained in Chapter 3, 3.11;

(c) The non-directional radio beacon (NDB) conforming to the Standards contained in Chapter 3, 3.7;

(d) The distance measuring equipment (DME) conforming to the Standards contained in Chapter 3, 3.3; and

Note 1 – Since visual reference is essential for the final stages of approach and landing, the installation of a radio navigation aid does not obviate the need for visual aids to approach and landing in conditions of low visibility.

Note 2 – Categories of precision approach and landing operations are classified in Annex 6, Part I, Chapter 1.

Note - Information on operational objectives associated with ILS facility performance categories is given in Attachment C, 2.1 and 2.14 of Annex 10 Vol. 1.

2.1.2 Differences in radio navigation aids in any respect from the Standards of Chapter 3 shall be published in an Aeronautical Information Publication (AIP).

2.1.3 Wherever there is installed a radio navigation aid that is neither an ILS nor an MLS, but which may be used in whole or in part with aircraft equipment designed for use with the ILS or MLS, full details of parts that may be so used shall be published in an Aeronautical Information Publication (AIP).

Note – This provision is to establish a requirement for promulgation of relevant information rather than to authorize such installations.

2.1.4 Precision approach radar

2.1.4.1 A precision approach radar (PAR) system, where installed and operated as a radio navigation aid together with equipment for two-way communication with aircraft and facilities for the efficient coordination of these elements with air Traffic control, shall conform to the Standards contained in Chapter 3, 3.2.

Note 1 –The precision approach radar (PAR) element of the precision approach radar system may be installed and operated without the surveillance radar element (SRE), when it is determined that the SRE is not necessary to meet the Requirements of air traffic control for the handling of aircraft.

Note 2 – Although SRE is not considered, in any circumstances, a satisfactory alternative to the precision approach radar system, the SRE may be installed and operated without the PAR for the assistance of air traffic control in handling Aircraft intending to use a radio navigation aid, or for surveillance radar approaches and departures.

2.1.5 when a radio navigation aid is provided to support precision approach and landing, it should be supplemented, as necessary, by source or sources of guidance information which, when used in conjunction with appropriate procedures, will provide effective guidance to, and efficient coupling (manual or automatic) with, the desired reference path.

Note – DME, GNSS, NDB, VOR and aircraft navigation systems have been used for such purposes.

2.2 Ground and flight testing

2.2.1 Radio navigation aids of the types covered by the specifications in Chapter 3 and available for use by aircraft engaged in national and international air navigation shall be the subject of periodic ground and flight tests.

2.2.2 Periodicity of Testing

2.2.2.1 All Navigational Aids except NDBs shall be flight calibrated at a regular time interval not greater than 365 days. With respect to NDBs, time interval shall not be greater than 730 days.

2.2.2.2 All Navigational Aids shall be ground tested at a regular time interval not greater than 30 days.

2.2.2.3 Any deviation to the conditions stated in 2.2.2.1 & 2.2.2.2 shall be approved by the DGCA

2.3 Provision of information on the operational status of radio navigation services

2.4 Aerodrome control towers and units providing approach control service shall be provided with information on the Operational status of radio navigation services essential for approach, landing and take-off at the aerodrome(s) with which they are concerned, on a timely basis consistent with the use of the service(s) involved. Power supply for radio navigation aids and communication systems

Radio navigation aids and ground elements of communication systems of the types specified in Annex 10 shall be provided with suitable power supplies and means to ensure continuity of service consistent with the use of the service(s) involved.

2.5 Human Factors considerations

2.5.1 Human Factors principles should be observed in the design and certification of radio navigation aids.

Note – Guidance material on Human Factors principles can be found in the Human Factors Training Manual *(Doc 9683) and Circular 249* (Human Factors Digest No.11 — Human Factors in CNS/ATM Systems).

CHAPTER - 3 SPECIFICATIONS FOR RADIO NAVIGATION AIDS

Note – Specifications concerning the siting and construction of equipment and installations on operational areas aimed at reducing the hazard to aircraft to a minimum are contained in Implementing Standard 030, Chapter 8.

3.1 Specification for ILS

3.1.1 Definitions

Angular displacement sensitivity **–** The ratio of measured DDM to the corresponding angular displacement from the appropriate reference line.

Antenna port. A point where the received signal power is specified. For an active antenna, the antenna port is a fictitious point between the antenna elements and the antenna pre-amplifier. For a passive antenna, the antenna port is the output of the antenna itself.

Axial ratio. The ratio, expressed in decibels, between the maximum output power and the minimum output power of an antenna to an incident linearly polarized wave as the polarization orientation is varied over all directions perpendicular to the direction of propagation

Back course sector **–** The course sector which is situated on the opposite side of the localizer from the runway.

Course line **–** The locus of points nearest to the runway centre line in any horizontal plane at which the DDM is zero.

Course sector **–** A sector in a horizontal plane containing the course line and limited by the loci of points nearest to the course line at which the DDM is 0.155.

DDM — Difference in depth of modulation **–** The percentage modulation depth of the larger signal minus the percentage modulation depth of the smaller signal, divided by 100.

Displacement sensitivity (localizer) **–** The ratio of measured DDM to the corresponding lateral displacement from the appropriate reference line.

Facility Performance Category I — ILS **–** An ILS which provides guidance information from the coverage limit of the ILS to the point at which the localizer course line intersects the ILS glide path at a height of 60 m (200 ft) or less above the horizontal plane containing the threshold.

Note –This definition is not intended to preclude the use of Facility Performance Category I — ILS below the height of 60 m (200 ft), with visual reference where the quality of the guidance provided permits, and where satisfactory operational procedures have been established.

Facility Performance Category II — ILS **–** An ILS which provides guidance information from the coverage limit of the ILS to the point at which the localizer course line intersects the ILS glide path at a height of 15 m (50 ft) or less above the horizontal plane containing the threshold.

Facility Performance Category III — ILS – An ILS which, with the aid of ancillary equipment where necessary, provides guidance information from the coverage limit of the facility to, and along, the surface of the runway.

Front course sector **–** The course sector which is situated on the same side of the localizer as the runway.

Half course sector **–** The sector, in a horizontal plane containing the course line and limited by the loci of points nearest to the course line at which the DDM is0.0775.

Half ILS glide path sector **–** The sector in the vertical plane containing the ILS glide path and limited by the loci of points nearest to the glide path at which the DDM is 0.0875.

ILS continuity of service **–** That quality which relates to the rarity of radiated signal interruptions. The level of continuity of service of the localizer or the glide path is expressed in terms of the probability of not losing the radiated guidance signals.

ILS glide path **–** That locus of points in the vertical plane containing the runway centre line at which the DDM is zero, which, of all such loci, is the closest to the horizontal plane.

ILS glide path angle **–** The angle between a straight line which represents the mean of the ILS glide path and the horizontal.

ILS glide path sector **–** The sector in the vertical plane containing the ILS glide path and limited by the loci of points nearest to the glide path at which the DDM is0.175.

Note – The ILS glide path sector is located in the vertical plane containing the runway centre line, and is divided by the radiated glide path in two parts called upper sector and lower sector, referring respectively to the sectors above and below the glide path.

ILS integrity **–** That quality which relates to the trust which can be placed in the correctness of the information supplied by the facility. The level of integrity of the localizer or the glide path is expressed in terms of the probability of not radiating false guidance signals.

ILS Point "A" **–** A point on the ILS glide path measured along the extended runway centre line in the approach direction a distance of 7.5 km (4 NM) from the threshold.

ILS Point "B" **–** A point on the ILS glide path measured along the extended runway centre line in the approach direction a distance of 1 050 m (3 500 ft) from the threshold.

ILS Point "C" **–** A point through which the downward extended straight portion of the nominal ILS glide path passes at a height of 30 m (100 ft) above the horizontal plane containing the threshold.

ILS Point "D" **–** A point 4 m (12 ft) above the runway centre line and 900 m (3 000 ft) from the threshold in the direction of the localizer.

ILS Point "E" **–** A point 4 m (12 ft) above the runway centre line and 600 m (2 000 ft) from the stop end of the runway in the direction of the threshold.

ILS reference datum (Point "T") – A point at a specified height located above the intersection of the runway centre line and the threshold and through which the downward extended straight portion of the ILS glide path passes.

Two-frequency glide path system – An ILS glide path in which coverage is achieved by the use of two independent radiation field patterns spaced on separate carrier frequencies within the particular glide path channel.

Two-frequency localizer system – A localizer system in which coverage is achieved by the use of two independent radiation field patterns spaced on separate carrier frequencies within the particular localizer VHF channel.

3.1.2 Basic requirements

3.1.2.1 *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.

3.1.2.1.1 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.

3.1.2.1.2 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.

3.1.2.1.3 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 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 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 1 – 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 2.8.1).Timeliness requirements applicable to the ILS integrity monitoring functions that protect aircraft from ILS malfunctions are specified in 3.1.3.10.3.1 and 3.1.5.7.3.1.

Note 2 – It is intended that the air traffic system is likely to call for additional provisions which may be found essential for the attainment of full operational Category III capability, e.g. to provide additional lateral and longitudinal guidance during the landing roll-out, and taxiing, and to ensure enhancement of the integrity and reliability of the system.

3.1.2.2 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.

3.1.2.2.1 The localizer and glide path components specified in 3.1.3.1 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.

3.1.2.2.2 The localizer and glide path components specified in 3.1.3.1 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.

3.1.2.2.3 The localizer and glide path components and other ancillary equipment specified in 3.1.2.1.1, 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.

3.1.2.2.4 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.

3.1.2.3 At those locations where two separate ILS facilities serve opposite ends of a single runway, an interlock shall ensure that only the localizer serving the approach direction in use shall radiate, except where the localizer in operational use is Facility Performance Category I — ILS and no operationally harmful interference results.

3.1.2.4 *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.*

3.1.3 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.

3.1.3.1 *General*

3.1.3.1.1 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.

3.1.3.1.2 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.

3.1.3.1.3 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.

3.1.3.2 *Radio frequency*

3.1.3.2.1 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.

3.1.3.2.2 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.

3.1.3.2.2.1 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.

3.1.3.2.2.2 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.

3.1.3.2.2.3 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 band0.01 Hz to10 Hz.

3.1.3.3 *Coverage*

3.1.3.3.1 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 overage is provided; Except that, where topographical features dictate or operational requirementspermit, 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 facilitiesprovidesatisfactory coverage withinthe 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 localize antenna and inclined at 7 degrees above the horizontal.

3.1.3.3.2 In all parts of the coverage volume specified in 3.1.3.3.1, other than as specified in 3.1.3.3.2.1, 3.1.3.3.2.2 and3.1.3.3.2.3, the field strength shall be not less than 40 microvolt's per meter (minus 114 dBW/m^2).

Note – This minimum field strength is required to permit satisfactory operational usage of ILS localizer facilities.

3.1.3.3.2.1 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 microvolt's per meter (minus 107 dBW/m^2).

3.1.3.3.2.2 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 microvolt's per meter (minus 106 dBW/m^2) at a distance of 18.5 km (10NM) increasing to not less than 200 microvolt's per meter (minus100 dBW/m^2) at a height of 15 m (50 ft) above the horizontal plane containing the threshold.

3.1.3.3.2.3 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 microvolts per meter (minus 106 dBW/m^2) at a distance of 18.5 km (10NM), increasing to not less than 200 microvolts per meter (minus 100 dBW/m^2) 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, and300 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 microvolts per meter (minus 106 dBW/m^2).

Note – The field strengths given in 3.1.3.3.2.2 and 3.1.3.3.2.3 are necessary to provide the signal-to-noise ratio required for improved integrity.

3.1.3.3.3 Above 7 degrees, the signals should be reduced to as low a value as practicable.

Note 1 – The requirements in 3.1.3.3.1, 3.1.3.3.2.1, 3.1.3.3.2.2 and 3.1.3.3.2.3 are based on the assumption that the aircraft is heading directly toward the facility.

3.1.3.3.4 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 3.1.3.3.1 shall not be less than 10 dB.

3.1.3.4 *Course structure*

3.1.3.4.1 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

3.1.3.4.2 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 “B”	0.031 at ILS Point “A” ILS Point decreasing at a linear rate to 0.005 at ILS Point “B”
ILS Point “B” to the ILS reference datum Category III only:	0.005 and, for
ILS reference datum to ILS Point“D”	0.005
ILS Point “D” to	0.005 at ILS Point “D”

ILS Point "E" increasing at a linear rate to 0.010 at ILS Point "E"

Note 1 – The amplitudes referred to in 3.1.3.4.1 and 3.1.3.4.2 are the DDMs due to bends as realized on the mean course line, when correctly adjusted.

3.1.3.5 *Carrier modulation*

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

3.1.3.5.2 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.

3.1.3.5.3 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.

3.1.3.5.3.1 For Facility Performance Category I — ILS, the modulating tones should be 90 Hz and150 Hz within plus or minus 1.5 per cent where practicable.

3.1.3.5.3.2 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 intermodulation 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.

3.1.3.5.3.3 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.

Note – The definition of phase relationship in this manner is not intended to imply a requirement to measure the phase within the half course sector.

3.1.3.5.3.4 With two-frequency localizer systems, 3.1.3.5.3.3 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 waveforms 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 150Hz.

3.1.3.5.3.5 Alternative two-frequency localizer systems that employ audio phasing different from the normal in-phase conditions described in 3.1.3.5.3.4 shall be permitted. In this alternative system, the 90 Hz to 90 Hz phasing and the 150 Hz to150 Hz phasing shall be adjusted to their nominal values to within limits equivalent to those stated in 3.1.3.5.3.4.

Note – This is to ensure correct airborne receiver operation in the region away *from the course line where the two carrier signal strengths are approximately equal.*

3.1.3.5.3.6 The sum of the modulation depths of the radio frequency carrier due to the 90 Hz and150 Hz tones should not exceed 60 per cent or be less than 30 per cent within the required coverage.

3.1.3.5.3.6.1 For equipment first installed after 1 January 2000, the sum of the modulation depths of the radiofrequency 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.

Note 1 – If the sum of the modulation depths is greater than 60 per cent for Facility Performance Category I localizers, the nominal displacement sensitivity may be adjusted as provided for in 3.1.3.7.1 to achieve the above modulation limit.

Note 2 – For two-frequency systems, the standard for maximum sum of modulation depths does not apply at or near azimuths where the course and clearance carrier signal levels are equal in amplitude (i.e. at azimuths where both transmitting systems have a significant contribution to the total modulation depth).

3.1.3.5.3.7 When utilizing a localizer for radio telephone 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.

3.1.3.5.4 Undesired frequency and phase modulation on ILS localizer radio frequency carriers that can affect the displayed DDM values in localizer receivers should be minimized to the extent practical.

3.1.3.6 *Course alignment accuracy*

3.1.3.6.1 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 (35ft), or the linear equivalent of 0.015 DDM, whichever is less;

b) for Facility Performance Category II localizers: plus or minus 7.5 m (25ft);

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

3.1.3.6.2 Facility Performance Category II localizers, the mean course line should 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.

Note 1- It is intended that Facility Performance Category II and III installations be *adjusted and maintained so that the limits specified in 3.1.3.6.1 and 3.1.3.6.2 are reached on very rare occasions. It is further intended that design and operation of the total ILS ground system be of sufficient integrity to accomplish this aim.*

Note 2 – It is intended that new Category II installations are to meet the requirements of 3.1.3.6.2.

3.1.3.7 Displacement sensitivity

3.1.3.7.1 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 maximum course sector angle shall not exceed six degrees.

Note – Runway codes 1 and 2 are defined in IS 30.

3.1.3.7.2 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.

3.1.3.7.3 Facility Performance Category II — ILS, displacement sensitivity should be adjusted and maintained within the limits of plus or minus 10 per cent where practicable.

Note — The figures given in 3.1.3.7.1, 3.1.3.7.2 and 3.1.3.7.3 are based upon a nominal sector width of 210 m (700 ft) at the appropriate point, i.e. ILS Point "B" on runway codes 1 and 2, and the ILS reference datum on other runways.

3.1.3.7.4 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.

Note 1 – The linearity of change of DDM with respect to angular displacement is particularly important in the neighborhood of the course line.

Note 2 – The above DDM in the 10-35 degree sector is to be considered a minimum requirement for the use of ILS as a landing aid. Wherever practicable, a higher DDM, e.g. 0.180, is advantageous to assist high speed aircraft to execute large angle intercepts at operationally desirable distances provided that limits on modulation percentage given in 3.1.3.5.3.6 are met.

Note 3 – Wherever practicable, the localizer capture level of automatic flight control systems is to be set at or below 0.175 DDM in order to prevent false localizer captures.

3.1.3.8 Identification

3.1.3.8.1 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.

3.1.3.8.2 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. 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.

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

3.1.3.8.4 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 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.

3.1.3.9 Siting

3.1.3.9.1 For Facility Performance Category 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.

3.1.3.9.2 For Facility Performance Category I, the localizer antenna system shall be located and adjusted as in centre line of the runway.

3.1.3.9.2.1 The offset localizer system shall be located and adjusted in accordance with the offset ILS provisions of the *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.

3.1.3.10 Monitoring

3.1.3.10.1 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 3.1.3.10.3.1, if any of the conditions stated in 3.1.3.10.2 persist:

a) radiation to cease; and

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

3.1.3.10.2 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 3.1.3.3, 3.1.3.4 or 3.1.3.5 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 between80 per cent and 50 per cent of normal may be permitted, provided the localizer continues to meet the requirements of 3.1.3.3, 3.1.3.4 and 3.1.3.5;

Note –It is important to recognize that a frequency change resulting in a loss of the frequency difference specified in 3.1.3.2.1 may produce a hazardous condition. This problem is of greater operational significance for Category II and III installations. As necessary, this problem can be dealt with through special monitoring provisions or highly reliable circuitry.

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

Note – In selecting the power reduction figure to be employed in monitoring referred to in 3.1.3.10.2 e), particular attention is directed to vertical and horizontal lobe structure (vertical lobbing due to different antenna heights) of the combined radiation systems when two carriers are employed.

Large changes in the power ratio between carriers may result in low clearance areas and false courses in the off-course areas to the limits of the vertical coverage requirements specified in 3.1.3.3.1.

3.1.3.10.2.1 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 should 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.

3.1.3.10.3 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 3.1.3.10.2 shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the localizer.

3.1.3.10.3.1 The total period referred to under 3.1.3.10.3 shall not exceed under any circumstances:

10 seconds for Category I localizers;

5 seconds for Category II localizers;

2 seconds for Category III localizers.

Note 1 – The total time periods specified are never-to-be-exceeded limits and are intended to protect aircraft in the final stages of approach against prolonged or repeated periods of localizer guidance outside the monitor limits. For this reason, they include not only the initial period of outside tolerance operation but also the total of any or all periods of outside tolerance radiation including period(s) of zero radiation and time required to remove the navigation and identification *components from the carrier, which might occur during action to restore service, for example, in the course of consecutive monitor functioning and consequent changeover(s) to localizer equipment or elements thereof.*

Note 2– From an operational point of view, the intention is that no guidance outside the monitor limits be radiated after the time periods given, and that no further attempts be made to restore service until a period in the order of 20 seconds has elapsed.

3.1.3.10.3.2 Where practicable, the total period under3.1.3.10.3.1 should be reduced so as not to exceed two seconds for Category II localizers and one second for Category III localizers

3.1.3.10.4 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.

3.1.3.11 Integrity and continuity of service requirements

3.1.3.11.1 The probability of not radiating false guidance signals shall not be less than $1 - 0.5 \times 10^{-9}$ in any one landing for Facility Performance Categories II and III localizers.

3.1.3.11.2 The probability of not radiating false guidance signals should not be less than $1 - 1.0 \times 10^{-7}$ in any one landing for Facility Performance Category I localizers.

3.1.3.11.3 The probability of not losing the radiated guidance signal shall be greater than:

(a) $1 - 2 \times 10^{-6}$ 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) $1 - 2 \times 10^{-6}$ 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).

3.1.3.11.4 The probability of not losing the radiated guidance signal should exceed $1 - 4 \times 10^{-6}$ in any period of 15 seconds for Facility Performance Category I localizers (equivalent to 1 000 hours mean time between outages).

3.1.4 Interference immunity performance for ILS localizer receiving systems

3.1.4.1 *The ILS localizer receiving system shall provide adequate immunity to interference from two-signal, third order intermodulation products caused byVHF 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 intermodulation 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 in 3.1.4.2.

$\Delta f = 108.1 - f_1$, where f_1 is the frequency of N_1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

3.1.4.2 *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:*

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

Note 1 – The relationship is linear between adjacent points designated by the above frequencies.

3.1.5 UHF glide path equipment and associated monitor

Note - θ is used in this paragraph to denote the nominal glide path angle.

3.1.5.1 *General*

3.1.5.1.1 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 predominating below the path and the 90 Hz tone predominating above the path to at least an angle equal to 1.75 θ.

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

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

(a) 0.075 θ from θ for Facility Performance Categories I and II — ILS glide paths;

(b) 0.04 θ from θ for Facility Performance Category III — ILS glide paths.

3.1.5.1.3 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.

3.1.5.1.4 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.

3.1.5.1.5 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.

Note 1 – In arriving at the above height values for the ILS reference datum, a maximum vertical distance of 5.8 m (19 ft) between the path of the aircraft glide path antenna and the path of the lowest part of the wheels at the threshold was assumed. For aircraft exceeding this criterion, appropriate steps may have to be taken either to maintain adequate clearance at threshold or to adjust the permitted operating minima.

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

3.1.5.2 Radio frequency

3.1.5.2.1 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.

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

3.1.5.2.3 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.

3.1.5.3 *Coverage*

3.1.5.3.1 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 least 18.5 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.

3.1.5.3.2 In order to provide the coverage for glide path performance specified in 3.1.5.3.1, the minimum field strength within this coverage sector shall be 400 microvolts per meter (minus 95 dBW/m^2). 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.

Note1 – The requirements in the foregoing paragraphs are based on the assumption that the aircraft is heading directly toward the facility.

3.1.5.4 *ILS glide path structure*

3.1.5.4.1 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 Point “C”	0.035 to ILS

3.1.5.4.2 For Facility Performance Category 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

Note 1 – The amplitudes referred to in 3.1.5.4.1 and 3.1.5.4.2 are the DDMs due to bends as realized on the mean ILS glide path correctly adjusted.

Note 2 – In regions of the approach where ILS glide path curvature is significant, bend amplitudes are calculated from the mean curved path, and not the downward extended straight line.

3.1.5.5 *Carrier modulation*

3.1.5.5.1 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.

3.1.5.5.2 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.

3.1.5.5.2.1 For Facility Performance Category I — ILS, the modulating tones shall be 90 Hz an 150 Hz within plus or minus 1.5 per cent where practicable.

3.1.5.5.2.2 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.

3.1.5.5.3 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.

Note 1 – The definition of phase relationship in this manner is not intended to imply a requirement for measurement of phase within the ILS half glide path sector.

3.1.5.5.3.1 With two-frequency glide path systems, 3.1.5.5.3 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 150Hz.

3.1.5.5.3.2 Alternative two-frequency glide path systems that employ audio phasing different from the normal in-phase condition described in 3.1.5.5.3.1 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 3.1.5.5.3.1.

Note – This is to ensure correct airborne receiver operation within the glide path sector where the two carrier signal strengths are approximately equal.

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

3.1.5.6 Displacement sensitivity

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

Note – The above is not intended to preclude glide path systems which inherently have asymmetrical upper and lower sectors.

3.1.5.6.2 For Facility Performance Category I — ILS glide paths, the nominal angular displacement sensitivity should 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 should be as symmetrical as practicable within the limits specified in 3.1.5.6.1.

3.1.5.6.3 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:

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

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

3.1.5.6.4 For Facility Performance Category III — ILS glide paths, the nominal 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.

3.1.5.6.5 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.

3.1.5.6.6 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.

3.1.5.6.7 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.

3.1.5.6.8 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.

3.1.5.7 Monitoring

3.1.5.7.1 The automatic monitor system shall provide a warning to the designated control points and cause radiation to cease within the periods specified in

3.1.5.7.1.1 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 3.1.5.3, 3.1.5.4 and 3.1.5.5;

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 3.1.5.3, 3.1.5.4 and 3.1.5.5;

Note – It is important to recognize that a frequency change resulting in a loss of the frequency difference specified in 3.1.5.2.1 may produce a hazardous condition. This problem is of greater operational significance for Categories II and III installations. As necessary, this problem can be dealt with through special monitoring provisions or highly reliable circuitry.

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 Category 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; realized to less than 0.7475 θ from horizontal;

f) a reduction of DDM to less than 0.175 within the specified coverage below the glide path sector.

Note 1 – The value of 0.7475 θ from horizontal is intended to ensure adequate obstacle clearance. This value was derived from other parameters of the glide path and monitor specification. Since the measuring accuracy to four significant figures is not intended, the value of 0.75 θ may be used as a monitor limit for this purpose. Guidance on obstacle clearance criteria is given in the Procedures for Air Navigation Services- Aircraft Operations (PANS-OPS) *(Doc 8168).*

Note 2 – Subparagraphs f) and g) are not intended to establish a requirement for a separate monitor to protect against deviation of the lower limits of the half-sector below 0.7475 θ from horizontal.

Note 3 – At glide path facilities where the selected nominal angular displacement sensitivity corresponds to an angle below the ILS glide path which is close to or at the maximum limits specified in 3.1.5.6, it may be necessary to adjust the monitor operating limits to protect against sector deviations below 0.7475 θ from horizontal.

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

3.1.5.7.3 The total period of radiation, including period(s) of zero radiation, outside the performance limits specified in 3.1.5.7.1 shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the ILS glide path.

3.1.5.7.3.1 The total period referred to under 3.1.5.7.3 shall not exceed under any circumstances:

6 seconds for Category I — ILS glide paths;

2 seconds for Categories II and III — ILS glide paths.

Note 1 – The total time periods specified are never-to-be-exceeded limits and are intended to protect aircraft in the final stages of approach against prolonged or repeated periods of ILS glide path guidance outside the monitor limits. For this reason, they include not only the initial period of outside tolerance operation but also the total of any or all periods of outside tolerance radiation, including periods of zero radiation, which might occur during action to restore service, for example, in the course of consecutive monitor functioning and consequent *change overs to glide path equipment's or elements thereof.*

Note 2 – From an operational point of view, the intention is that no guidance outside the monitor limits be radiated after the time periods given, and that no further attempts be made to restore service until a period in the order of 20 seconds has elapsed.

3.1.5.7.3.2 Where practicable, the total period specified under 3.1.5.7.3.1 for Categories II and III — ILS glide paths should not exceed 1 second.

3.1.5.7.4 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.

3.1.5.8 Integrity and continuity of service requirements

3.1.5.8.1 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.

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

3.1.5.8.3 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).

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

3.1.6 Localizer and glide path frequency pairing

3.1.6.1 The pairing of the runway localizer and glide path transmitter frequencies of an instrument landing system shall be taken from the following list in accordance with the provisions of Volume V, Chapter 4, 4.2:

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

3.1.6.1.1 In those regions where the requirements for runway localizer and glide path transmitter frequencies of an instrument landing system do not justify more 20 pairs, they shall be selected sequentially, as required, from the following list:

Sequence number	*Localizer (MHz)*	*Glide path (MHz)*
1	110.3	335.0
2	109.9	333.8
3	109.5	332.6
4	110.1	334.4
5	109.7	333.2
6	109.3	332.0
7	109.1	331.4

3.1.6.2 *Where existing ILS localizers meeting national requirements are operating on frequencies ending in even tenths of a megahertz, they shall be reassigned frequencies, conforming with 3.1.6.1 or 3.1.6.1.1 as soon as practicable and may continue operating on their present assignments only until this reassignment can be effecte*

3.1.6.3 *Existing ILS localizers in the international service operating on frequencies ending in odd tenths of a megahertz shall not be assigned new frequencies ending in odd tenths plus one twentieth of a megahertz except where, by regional agreement, general use may be made of any of the*

Sequence number	*Localizer (MHz)*	*Glide path (MHz)*
8	110.9	330.8
9	110.7	330.2
10	110.5	329.6
11	108.1	334.7
12	108.3	334.1
13	108.5	329.9
14	108.7	330.5
15	108.9	329.3
16	111.1	331.7
17	111.3	332.3
18	111.5	332.9
19	111.7	333.5
20	111.9	331.1

channels listed in 3.1.6.1 (see Volume V, Chapter 4, 4.2).

3.1.7 VHF marker beacons

3.1.7.1 General

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

b) A marker beacon shall conform to the requirements prescribed in 3.1.7. 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 3.1.7.6.5 shall apply.

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

3.1.7.1.1 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 3.1.7.

3.1.7.1.2 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 3.1.7.5.1.

3.1.7.2 Radio frequency

3.1.7.2.1 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.

3.1.7.3 *Coverage*

3.1.7.3.1 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 (500ft plus or minus 160ft);

b) *middle marker:* 300 m plus or minus 100 m (1 000 ft plus or minus 325ft);

c) *outer marker:* 600 m plus or minus 200 m (2 000 ft plus or minus 650ft).

3.1.7.3.2 The field strength at the limits of coverage specified in 3.1.7.3.1 shall be1.5 millivolts per meter (minus 82 dBW/m^2). In addition, the field strength within the coverage area shall rise to at least 3.0 millivolts per meter (minus 76 dBW/m^2).

Note 1 – In the design of the ground antenna, it is advisable to ensure that an adequate rate of change of field strength is provided at the edges of coverage. It is also advisable to ensure that aircraft within the localizer course sector will receive visual indication.

Note 2 – Satisfactory operation of a typical airborne marker installation will be obtained if the sensitivity is so adjusted that visual indication will be obtained when the field strength is 1.5 millivolts per meter (minus 82 dBW/m^2).

3.1.7.4 *Modulation*

3.1.7.4.1 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.

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

3.1.7.5 *Identification*

3.1.7.5.1 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.

3.1.7.6 *Siting*

3.1.7.6.1 The inner marker, , shall be located so as to indicate in low visibility conditions the imminence of arrival at the runway threshold.

3.1.7.6.1.1 If the radiation pattern is vertical, the inner marker, should 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.

Note – It is intended that the inner marker pattern should intercept the downward extended straight portion of the nominal ILS glide path at the lowest decision height applicable in Category II operations.

Note 2 - Care must be exercised in siting the inner marker to avoid interference between the inner and middle markers.

3.1.7.6.1.2 If the radiation pattern is other than vertical, the equipment should 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.

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

3.1.7.6.2.1 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.

3.1.7.6.2.2 If the radiation pattern is other than vertical, the equipment should 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 3.1.7.6.2.1.

3.1.7.6.3 The outer marker shall be located so as to provide height, distance and equipment functioning checks to aircraft on intermediate and final approach.

3.1.7.6.3.1 the outer marker should be located 7.2 km (3.9NM) 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.

3.1.7.6.4 If the radiation pattern is vertical, the outer marker should 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 should 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.

3.1.7.6.5 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 Annex 15.

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

3.1.7.6.5.2 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.

3.1.7.6.5.3 The DME in 3.1.7.6.5 shall conform to the specification in 3.5.

3.1.7.7 *Monitoring*

3.1.7.7.1 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.

3.1.7.7.2 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.

3.2 Specification for Precision Approach Radar System

Note – Slant distances are used throughout this specification.

3.2.1 The precision approach radar system shall comprise the following elements:

3.2.1.1 *The precision approach radar element (PAR).*

3.2.1.2 *The surveillance radar element (SRE).*

3.2.2 When the PAR only is used, the installation shall be identified by the term PAR or precision approach radar and not by the term "precision approach radar system".

Note – Provisions for the recording and retention of radar data are contained in, IS 025 Chapter 6.

3.2.3 The precision approach radar element (PAR)

3.2.3.1 *Coverage*

3.2.3.1.1 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.

Note – For guidance in determining the significance of the echoing areas of aircraft, the following table is included:

private flyer (single-engined): 5 to 10 m^2;

small twin-engined aircraft: from 15 m^2;

medium twin-engined aircraft: from 25 m^2;

four- engined aircraft: from 50 to 100 m^2.

3.2.3.2 *Siting*

3.2.3.2.1 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.

Note 1 – Paragraph 3.2.3.2.1 can be met by siting the equipment with a set-back from the touchdown, in the direction of the stop end of the runway, of 915 m (3 000 ft) or more, for an offset of 120 m (400 ft) from the runway centre line, or of 1 200 m (4 000 ft) or more, for an offset of 185 m (600 ft) when the equipment is aligned to scan plus or minus 10 degrees about the centre line of the runway.

Alternatively, if the equipment is aligned to scan 15 degrees to one side and 5 degrees to the other side of the centre line of the runway, then the minimum set-back can be reduced to685 m (2 250 ft) and 915 m (3 000 ft) for offsets of 120 m (400 ft) and 185 m (600 ft) respectively.

3.2.3.3 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.

3.2.3.3.1 *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.

3.2.3.3.2 *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.

3.2.3.4 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.

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

3.2.4 The surveillance radar element (SRE)

3.2.4.1 Surveillance radar used as the SRE of a precision approach radar system shall satisfy at least the following broad performance required.

3.2.4.1.1 Coverage

3.2.4.1.2 The SRE shall be capable of detecting aircraft of 15 m^2 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.

3.2.4.1.3 Efforts should 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)*;

— for *20 degrees*, read *30 degrees*.

3.2.4.2 Accuracy

3.2.4.2.1 *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.

3.2.4.2.2 *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.

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

3.2.4.3 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.

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

3.3 Specification for VHF omnidirectional radio range (VOR)

3.3.1 General

3.3.1.1 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.

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.

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

Note – The reference and variable phase modulations are in phase when the maximum value of the sum of the radio frequency carrier and the side band energy due to the variable phase modulation occurs at the same time as the highest instantaneous frequency of the reference phase modulation.

3.3.2 Radio frequency

3.3.2.1 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 Volume V, Chapter 4, 4.2.1 and 4.2.3.1, the use of such frequencies is acceptable. The highest assignable frequency shall be117.950 MHz. The channel separation shall be in increments of 50 kHz referred to the highest assignable frequency. In areas where 100 kHz or 200 kHz channel spacing is in general use, the frequency tolerance of the radio frequency carrier shall be plus or minus 0.005 per cent.

3.3.2.2 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.

3.3.2.3 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.*

3.3.3 Polarization and pattern accuracy

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

Note – It is not possible at present to state quantitatively the maximum permissible magnitude of the vertically polarized component of the radiation from the VOR. (Information is provided in the Manual on Testing of Radio Navigation Aids *(Doc 8071) as to flight checks that can be carried out to determine the effects of vertical polarization on the bearing accuracy.)*

3.3.3.2 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.

3.3.4 Coverage

3.3.4.1 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.

3.3.4.2 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 should be 90 microvolts per meter or minus 107 dBW/m^2.

3.3.5 Modulations of navigation signals

3.3.5.1 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 30Hz:

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 of16 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”.

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

Note – This requirement applies to the transmitted signal observed in the absence of multipath.

3.3.5.3 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.

Note – When modulation is measured during flight testing under strong dynamic multipath conditions, variations in the received modulation percentages are to be expected.
Short-term variations beyond these values may be acceptable. The Manual on Testing of Radio Navigation Aids *(Doc 8071) contains additional information on the application of airborne modulation tolerances.*

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

3.3.5.5 The sub carrier modulation mid-frequency shall be 9 960 Hz within plus or minus 1 per cent.

3.3.5.6

a) For the conventional VOR, the percentage of amplitude modulation of the 9 960 Hz subcarrier shall not exceed 5 per cent.

b) For the Doppler VOR, the percentage of amplitude modulation of the 9 960Hz subcarrier shall not exceed 40 per cent when measured at a point at least 300m (1 000 ft) from the VOR.

3.3.5.7 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	0dB reference
2nd harmonic	–30dB
3rd harmonic	-50dB
4th harmonic and above	–60dB

3.3.6 Voice and identification

3.3.6.1 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.

3.3.6.2 The peak modulation depth of the carrier on the communication channel shall not be greater than 30 per cent.

3.3.6.3 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.

3.3.6.4 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.

3.3.6.5 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.

3.3.6.5.1 The identification signal should be transmitted at least three times each 30 seconds, spaced equally within that time period. One of these identification signals may take the form of voice identification.

Note – Where a VOR and DME are associated in accordance with 3.5.2.5, the identification provisions of 3.5.3.6.4 influence the VOR identification.

3.3.6.6 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.

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

3.3.6.7 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.

3.3.6.8 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 3.3.6.5, 3.3.6.6 and 3.3.6.7.

3.3.7 Monitoring

3.3.7.1 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 anyo ne 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.

3.3.7.2 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

3.3.8 Interference immunity performance for VOR receiving systems

3.3.8.1 The VOR receiving system shall provide adequate immunity to interference from two signal, third-order intermodulation 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 intermodulation product on the desired VOR frequency.

N_1 and N_2 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 3.3.8.2.

$\Delta f = 108.1 - f_1$, where f_1 is the frequency of N_1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

3.3.8.2 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

Note – The relationship is linear between adjacent points designated by the above frequencies.

3.4 Specification for non-directional radio beacon (NDB)

3.4.1 Definitions

Average radius of rated coverage – The radius of a circle having the same area as the rated coverage.

Effective coverage – The area surrounding an NDB within which bearings can be obtained with an accuracy sufficient for the nature of the operation concerned.

Locator – An LF/MF NDB used as an aid to final approach.

Note – A locator usually has an average radius of rated coverage of between 18.5 and 46.3 km (10 and 25 NM).

Rated coverage – The area surrounding an NDB within which the strength of the vertical field of the ground wave exceeds the minimum value specified for the geographical area in which the radio beacon is situated.

Note – The above definition is intended to establish a method of rating radio beacons on the normal coverage to be expected in the absence of sky wave transmission and/or anomalous propagation from the radio beacon concerned or interference from other LF/MF facilities, but taking into account the atmospheric noise in the geographical area concerned.

3.4.2 Coverage

3.4.2.1 The minimum value of field strength in the rated coverage of an NDB should be 70°microvolts per meter.

Note – The selection of locations and times at which the field strength is measured is important in order to avoid abnormal results for the locality concerned; locations on air routes in the area around the beacon are operationally most significant.

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

Note 1 – In classifying radio beacons in areas where substantial variations in rated coverage may occur diurnally and seasonally, such variations should be taken into account.

Note 2 – Beacons having an average radius of rated coverage of between 46.3 and 278 km (25 and 150 NM) may be designated by the nearest multiple of 46.3 km (25NM) to the average radius of rated coverage, and beacons of rated coverage over 278 km (150 NM) to the nearest multiple of 92.7 km (50NM).

3.4.2.3 where the rated coverage of an NDB is materially different in various operationally significant sectors, its classification should 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 should be kept to a minimum and preferably should not exceed two.

Note – The average radius of a given sector of the rated coverage is equal to the radius of the corresponding circle-sector of the same area. Example:

150/210° – 30°

100/30° – 210°.

3.4.3 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.

3.4.4 Radio frequencies

3.4.4.1 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.

3.4.4.2 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.

3.4.4.3 *where two locators are used as supplements to an ILS, the* frequency separation between the carriers of the two should 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.

3.4.4.4 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.

Note – Additional guidance on the operation of locator beacons on common frequency channels is contained in Volume V, Chapter 3, 3.2.2.

3.4.5 Identification

3.4.5.1 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.

3.4.5.2 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.

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

3.4.5.3 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.

3.4.5.4 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.

3.4.6 Characteristics of emissions

Note –The following specifications are not intended to preclude employment of modulations or types of modulations that may be utilized in NDBs in addition *to those specified for identification, including simultaneous identification and voice modulation, provided that these additional modulations do not materially affect the operational performance of the NDBs in conjunction with currently used airborne direction finders, and provided their use does not cause harmful interference to other NDB services.*

3.4.6.1 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).

3.4.6.1.1 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.

Note – In selecting the types of emission, the possibility of confusion, arising from an aircraft tuning from a NON/A2A facility to a NON/A1A facility without changing the radio compass from "MCW" to "CW" operation, will need to be kept in mind.

3.4.6.2 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.

3.4.6.3 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.

Note 1 – The foregoing requirement necessitates as high a percentage modulation as practicable, together with maintenance of an adequate radiated carrier power during identification.

Note 2 – With a direction-finder pass band of plus or minus 3 kHz about the carrier, a signal to noise ratio of 6 dB at the limit of rated coverage will, in general, meet the foregoing requirement.

3.4.6.4 The carrier power of an NDB with NON/A2A emissions should 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 may be accepted.

3.4.6.5 Unwanted audio frequency modulations shall total less than 5 per cent of the amplitude of the carrier.

Note – Reliable performance of airborne automatic direction-finding equipment (ADF) may be seriously prejudiced if the beacon emission contains modulation by an audio frequency equal or close to the loop switching frequency or its second harmonic. The loop switching frequencies in currently used equipment lie between30 Hz and 120 Hz.

3.4.6.6 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.

Note – Article S3 of the ITU Radio Regulations contains the general provisions with respect to technical characteristics of equipment and emissions. The Radio Regulations contain specific provisions relating to necessary bandwidth, frequency tolerance; spurious emissions and classification of emissions.

3.4.7 Siting of locators

3.4.7.1 where locators are used as a supplement to the ILS, they should 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 should 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 should be selected, taking into account the relevant obstacle clearance provisions of the PANS-OPS (Doc 8168).

3.4.7.2 where locators are installed at both the middle and outer marker positions, they should 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.

3.4.8 Monitoring

3.4.8.1 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.

3.4.8.2 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 should be capable of detecting such power supply modulation on the carrier in excess of 5 per cent.

3.4.8.3 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 3.4.8.1 a), b) and c).

3.4.8.4 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 3.4.8.1 a), b) and c).

3.5 Specification for UHF distance measuring equipment (DME)

Note – In the following section, provision is made for two types of DME facility: DME/N for general application and DME/P as outlined in 3.11.3.

3.5.1 Definitions

Control motion noise (CMN) **–** That portion of the guidance signal error which causes control surface, wheel and column motion and could affect aircraft attitude angle during coupled flight, but does not cause aircraft displacement from the desired course and/or glide path. (See 3.11.)

DME dead time **–** A period immediately is following the decoding of a valid interrogation during which a received interrogation will not cause a reply to be generated.

Note – Dead time is intended to prevent the transponder from replying to echoes resulting from multipath effects.

DME/N **–** Distance measuring equipment, primarily serving operational needs of en- route or TMA navigation, where the “N” stands for narrow spectrum characteristics.

DME/P **–** The distance measuring element of the MLS, where the “P” stands for precise distance measurement. The spectrum characteristics are those of DME/N.

Equivalent isotropically radiated power (EIRP) **–** The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).

Final approach (FA) mode **–** The condition of DME/P operation which supports flight operations in the final approach and runway regions.

Initial approach (IA) mode – The condition of DME/P operation which supports those flight operations outside the final approach region and which is interoperable with DME/N.

Key down time **–** The time during which a dot or dash of a Morse character is being transmitted.
MLS approach reference datum – A point on the minimum glide path at a specified height above the threshold. (See 3.11.)

MLS datum point **–** The point on the runway centre line closest to the phase centre of the approach elevation antenna. (See 3.11.)

Mode W, X, Y, Z *– A method of coding the DME transmissions by time spacing pulses of a pulse pair, so that each frequency can be used more than once.*

Partial rise time **–** The time as measured between the 5 and 30 per cent amplitude points on the leading edge of the pulse envelope, i.e. between points h and i on Figures 3-1 and 3-2.

Path following error (PFE) **–** That portion of the guidance signal error which could cause aircraft displacement from the desired course and/or glide path. (See 3.11.)

Pulse amplitude –The maximum voltage of the pulse envelope, i.e. A in Figure 3-1.

Pulse decay time – The time as measured between the 90 and 10 per cent amplitude points on the trailing edge of the pulse envelope, i.e. between points e and g on Figure 3-1.

Pulse code. – The method of differentiating between W, X, Y and Z modes and between FA and IA modes.

Pulse duration – The time interval between the 50 per cent amplitude point on leading and trailing edges of the pulse envelope, i.e. between points b and f on Figure 3-1.

Pulse rise time **–** The time as measured between the 10 and 90 per cent amplitude points on the leading edge of the pulse envelope, i.e. between points a and c on Figure 3-1.

Reply efficiency **–** The ratio of replies transmitted by the transponder to the total of received valid interrogations.

Search. –The condition which exists when the DME interrogator is attempting to acquire and lock onto the response to its own interrogations from the selected transponder.

System efficiency **–** The ratio of valid replies processed by the interrogator to the total of its own interrogations.

Track – The condition which exists when the DME interrogator has locked onto replies in response to its own interrogations, and is continuously providing a distance measurement.

Transmission rate **–** The average number of pulse pairs transmitted from the transponder per second.

Virtual origin **–** The point at which the straight line through the 30 per cent and 5 per cent amplitude points on the pulse leading edge intersects the 0 per cent amplitude axis (see Figure 3 -2).

3.5.2 General

3.5.2.1 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.

3.5.2.2 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.

3.5.2.3 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.

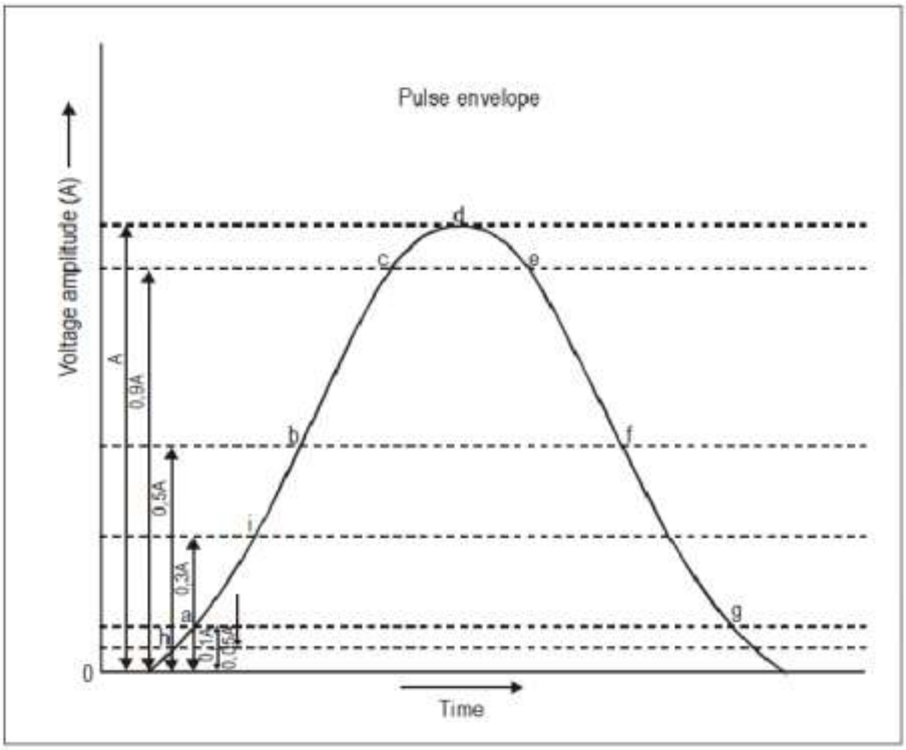

Figure 3-1

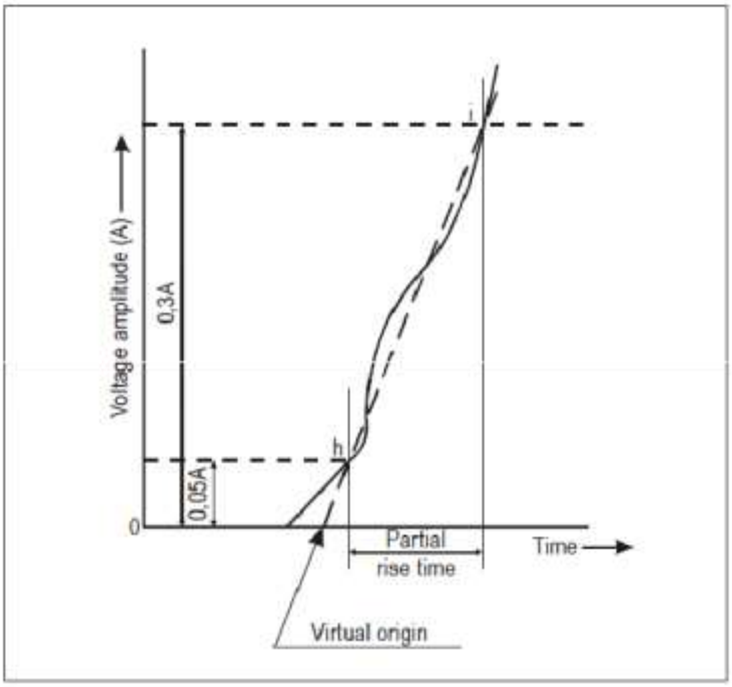

Figure 3-2

3.5.2.4 *When a DME is associated with an ILS, or VOR for the purpose of constituting a single facility, they shall:*

a. be operated on a standard frequency pairing in accordance with 3.5.3.3.4;

b. be collocated within the limits prescribed for associated facilities in 3.5.2.6;and

c. comply with the identification provisions of .5.3.6.4.

3.5.2.5 Collocation limits for a DME facility associated with an ILS, or VOR facility

3.5.2.5.1 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 000ft).

3.5.2.5.2 Association of DME with ILS

3.5.3 System characteristics

3.5.3.1 *Performance*

3.5.3.1.1 *Range.* 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.

3.5.3.1.2 *Coverage*

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

3.5.3.1.2.2 When associated with either an ILS, DME/N coverage shall be at least that of the respective ILS.

3.5.3.1.3 Accuracy

3.5.3.1.3.1 System accuracy. The accuracy standards specified in 3.5.4.5 and 3.5.5.4 shall be met on a 95 per cent probability basis.

Radio frequencies and polarization –

3.5.3.2 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.

3.5.3.3 *Channeling*

3.5.3.3.1 DME operating channels shall be formed by pairing interrogation and reply frequencies and by pulse coding on the paired frequencies.

3.5.3.3.2 DME operating channels shall be chosen from Table A (located at the end of this chapter), of 352 channels in which the channel numbers, frequencies, and pulse codes are assigned.

3.5.3.3.3 *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, the DME operating channel shall be paired with the VHF channel as given in Table A.

Note – There may be instances when a DME channel will be paired with both the ILS frequency and an MLS channel (see Volume V, Chapter 4, 4.3).

3.5.3.4 *Interrogation pulse repetition frequency*

Note – If the interrogator operates on more than one channel in one second, the following specifications apply to the sum of interrogations on all channels

3.5.3.4.1 *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.

3.5.3.4.2 *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

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

3.5.3.4.4 *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.

Note 1 – A pulse repetition frequency (PRF) of 5 pulse pairs per second for aircraft on the ground may be exceeded if the *aircraft requires accurate range information.*

Note 2 – It is intended that all PRF changes be achieved by automatic means.

3.5.3.4 Aircraft handling capacity of the system

3.5.3.5.1 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.

3.5.3.5.2 where the peak traffic in an area exceeds 100 aircraft, the transponder should be capable of handling that peak traffic.

3.5.3.6 Transponder identification

3.5.3.6.1 All transponders shall transmit an identification signal in one of the following forms as required by 3.5.3.6.5:

a) an "independent" identification consisting of coded (International MorseCode) 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 facility which itself transmit an identification signal.

3.5.3.6.2 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.

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

3.5.3.6.2.2 *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, should be transmitted 100 microseconds plus or minus 10 microseconds after each identity pair.

3.5.3.6.3 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.

Note – The tone identification signal is transmitted at a repetition rate of 1 350 pps. This frequency may be used directly in the airborne equipment as an aural output for the pilot, or other frequencies may be generated at the option of the interrogator designer (see 3.5.3.6.2).

3.5.3.6.4 The characteristics of the "associated" signal shall be as follows:

a. when associated with a VHF facility, the identification shall be transmitted in the form of dots and dashes (International Morse Code) as in 3.5.3.6.3 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 facility identification, where these are provided, transmitted during the remaining periods;

3.5.3.6.5 Identification implementation

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

3.5.4 Detailed technical characteristics of transponder and associated monitor

3.5.4.1 Transmitter

3.5.4.1.1 *Frequency of operation* – The transponder shall transmit on the reply frequency appropriate to the assigned DME channel (see 3.5.3.3.3).

3.5.4.1.2 *Frequency stability* – The radio frequency of operation shall not vary more than plus or minus 0.002 per cent from the assigned frequency.

3.5.4.1.3 *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.

b) Pulse duration shall be 3.5 microseconds plus or minus 0.5 microseconds.

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: 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.

Note – Guidance material relating to the pulse spectrum measurement is provided in Document EUROCAE ED-57 (including Amendment No. 1).

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.

Note 1 – The time "during the pulse" encompasses the total interval from the beginning of pulse transmission to its end. For practical reasons, this interval may be measured between the 5 per cent points on the leading and trailing edges of the pulse envelope

Note 2 – The power contained in the frequency bands specified in 3.5.4.1.3 e) is the average power during the pulse. Average power in a given frequency band is the energy contained in this frequency band divided by the time of pulse transmission according to Note 1.

3.5.4.1.4 Pulse spacing

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

3.5.4.1.4.2 *DME/N* – The tolerance on the pulse spacing shall be plus or minus 0.25 micro second.

3.5.4.1.4.3 *DME/N* - The tolerance on the DME/N pulse spacing should be plus or minus 0.10 micro second.

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

3.5.4.1.4 Peak power output

3.5.4.1.5.1 *DME/N* – The peak EIRP should not be less than that required to ensure a peak pulse power density of approximately minus 83 dBW/m^2 at the maximum specified service range and level.

3.5.4.1.5.2 *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/m^2 under all operational weather conditions at any point within coverage specified in 3.5.3.1.2.

Note – Although the Standard in 3.5.4.1.5.2 implies an improved interrogator receiver sensitivity, it is intended that the power density specified in 3.5.4.1.5.1 be available at the maximum specified service range and level.The peak power of the constituent pulses of any pair of pulses shall not differ by more than 1 dB.

3.5.4.1.5.3 The reply capability of the transmitter should 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).

3.5.4.1.5.4 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.

Note – Operating DME transponders with quiescent transmission rates close to 700 pulse pairs per second will minimize the effects of pulse interference, particularly to other aviation services such as GNSS.

3.5.4.1.6 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.

3.5.4.1.6.1 *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.

3.5.4.1.6.2 *Out-of-band spurious radiation* – At all frequencies from 10 to 1 800MHz, 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.

3.5.4.1.6.3 The equivalent isotropically radiated power of any CW harmonic of the carrier frequency on any DME operating channel shall not exceed minus 10 dBm.

3.5.4.2 Receiver

3.5.4.2.1 *Frequency of operation* – The receiver centre frequency shall be the interrogation frequency appropriate to the assigned DME operating channel (see 3.5.3.3.3).

3.5.4.2.2 *Frequency stability* – The centre frequency of the receiver shall not vary more than plus or minus 0.002 per cent from the assigned frequency.

3.5.4.2.3 Transponder sensitivity

3.5.4.2.3.1 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/m^2 for DME/N with coverage range greater than 56 km (30 NM);

b. minus 93 dBW/m^2 for DME/N with coverage range not greater than 56 km (30 NM);

3.5.4.2.3.2 The minimum power densities specified in 3.5.4.2.3.1 shall cause the transponder to reply with an efficiency of at least:

a) 70 per cent for DME/N;

3.5.4.2.3.3 *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 3.5.4.2.3.1 up to a maximum of minus 22 dBW/m^2 when installed with ILS and minus 35 dBW/m^2 when installed for other applications.

3.5.4.2.3.4 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.

3.5.4.2.3.5 *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.

3.5.4.2.4 Load limiting

3.5.4.2.4.1 *DME/N* –when transponder loading exceeds 90 per cent of the maximum transmission rate, the receiver sensitivity should 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 should be at least 50 dB.)

3.5.4.2.5 *Noise.*

When the receiver is interrogated at the power densities specified in 3.5.4.2.3.1 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.

3.5.4.2.6 *Bandwidth* –

3.5.4.2.6.1 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.

3.5.4.2.6.2 *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 3.5.5.1.3.

3.5.4.2.6.3 Signals greater than 900 kHz removed from the desired channel nominal frequency and having power densities up to the values specified in 3.5.4.2.3.3 for DME/N 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.

3.5.4.2.6.4 *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 3.5.5.1.3.

3.5.4.2.7 *Spurious radiations* – Radiation from any part of the receiver or allied circuits shall meet the requirements stated in 3.5.4.1.6.

3.5.4.2.8 *CW and echo suppression*

CW and echo suppression should be adequate for the sites at which the transponders will be used.

Note – In this connection, echoes mean undesired signals caused by multipath transmission (reflections, etc.).

3.5.4.2.9 Protection against interference

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

3.5.4.3 Decoding

3.5.4.3.1 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 spacing's appropriate to interrogator signals as described in 3.5.5.1.3 and 3

3.5.4.3.2 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.

3.5.4.3.3 *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 3.5.4.2.3.3 shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.

3.5.4.3 Time delay

3.5.4.4.1 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.

		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	–

Note 1.-W and X are multiplexed on the same frequency.

Note 2.-Z and Y are multiplexed on the same frequency.

3.5.4.4.2 For the DME/N the transponder time delay should 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.

Note – Modes not allowing or the full 15 microseconds range of adjustment in transponder time delay may only be adjustable to the limits given by the transponder circuit delay and recovery time.

3.5.4.4.2.1 *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.

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

Note 1 – It is desirable that the radius of the sphere at the surface of which zero indication is given be kept as small as possible in order to keep the zone of ambiguity to a minimum.

3.5.4.5 Accuracy

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

3.5.4.5.1.1 *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 should be not greater than plus or minus 340 m (0.183 NM) plus 1.25 per cent of distance measure.

Note – This error contribution limit includes errors from all causes except the airborne equipment, and assumes that the airborne equipment measures time delay based on the first constituent pulse of a pulse pair.

3.5.4.5.1.2 *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.

Note – This error contribution limit includes errors from all causes except the airborne equipment, and assumes that the airborne equipment measures time delay based on the first constituent pulse of a pulse pair.

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

3.5.4.6 Efficiency

3.5.4.6.1 The transponder reply efficiency shall be at least 70 per cent for DME/N at all values of transponder loading up to the loading corresponding to 3.5.3.5 and at the minimum sensitivity level specified in 3.5.4.2.3.1 and 3.5.4.2.3.5.

Note – When considering the transponder reply efficiency value, account is to be taken of the DME dead time and of the loading introduced by the monitoring function.

3.5.4.6.2 *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.

3.5.4.7 Monitoring and control

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

3.5.4.7.2 DME/N monitoring action

3.5.4.7.2.1 In the event that any of the conditions specified in 3.5.4.7.2.2 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.

3.5.4.7.2.2 The monitor shall cause the actions specified in 3.5.4.7.2.1 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.

3.5.4.7.2.3 The monitor should cause the actions specified in3.5.4.7.2.1 if the spacing between the first and second pulse of the transponder pulse pair differs from the nominal value specified in the table following 3.5.4.4.1 by1 microsecond or more.

3.5.4.7.2.4 The monitor should 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 3.5.4.1.4 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).

3.5.4.7.2.5 Means shall be provided so that any of the conditions and malfunctioning enumerated in 3.5.4.7.2.2, 3.5.4.7.2.3 and 3.5.4.7.2.4 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.

3.5.4.7.2.6 The transponder shall not be triggered more than 120 times per second for either monitoring or automatic frequency control purposes, or both.

3.5.5 Technical characteristics of interrogator

Note – The following subparagraphs specify only those interrogator parameters which must be defined to ensure that the interrogator:

a) does not jeopardize the effective operation of the DME system, e.g. by increasing transponder loading abnormally; and

b) is capable of giving accurate distance readings.

3.5.5.1 Transmitter

3.5.5.1.1 *Frequency of operation* – The interrogator shall transmit on the interrogation frequency appropriate to the assigned DME channel (see 3.5.3.3.3).

Note – This specification does not preclude the use of airborne interrogators having less than the total number of operating channels.

3.5.5.1.2 *Frequency stability* – The radio frequency of operation shall not vary more than plus or minus 100 kHz from the assigned value.

3.5.5.1.3 *Pulse shape and spectrum* – The following shall apply to all radiated pulses:

a) *Pulse rise time.*

DME/N – Pulse rise time shall not exceed 3 microseconds.

b) Pulse duration shall be 3.5 microseconds plus or minus 0.5 microseconds.

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.

Note 1 – The lower limit of pulse rise time (see 3.5.5.1.3 a)) and decay time (see3.5.5.1.3 c)) are governed by the spectrum requirements in 3.5.5.1.3 e).

Note 2 – While 3.5.5.1.3 e) calls for a practically attainable spectrum, it is desirable to strive for the following spectrum control characteristics: the spectrum of the pulse modulated signal is such that the power contained in a 0.5 MHz band centred on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency is, in each case, at least 23 dB below the power contained in a 0.5 MHz band centred on the nominal channel frequency. The power contained in a 0.5 MHz band centred on frequencies 2 MHz above and 2 MHz below the nominal channel frequency is, in each case, at least 38 dB below the powerbcontained in a 0.5 MHz band centred on the nominal channel frequency. Any additional lobe of the spectrum is of less amplitude than the adjacent lobe nearer the nominal channel frequency.

3.5.5.1.4 Pulse spacing

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

3.5.5.1.4.2 *DME/N* – The tolerance on the pulse spacing shall be plus or minus 0.5 micro second.

3.5.5.1.4.3 *DME/N* – The tolerance on the pulse spacing should be plus or minus 0.25 micro second.

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

3.5.5.1.5 Pulse repetition frequency

3.5.5.1.5.1 The pulse repetition frequency shall be as specified in 3.5.3.4.

3.5.5.1.5.2 The variation in time between successive pairs of interrogation pulses shall be sufficient to prevent false lock-on.

3.5.5.1.6 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).

Note – Although spurious CW radiation between pulses is limited to levels not exceeding minus 47 dBW, States are cautioned that where DME interrogators and secondary surveillance radar transponders are employed in the same aircraft, it may be necessary to provide protection to airborne SSR in the band 1 015 MHz to 1 045MHz. This protection may be provided by limiting conducted and radiated CW to a level of the order of minus 77 dBW. Where this level cannot be achieved, the required degree of protection may be provided in planning the relative location of the SSR and DME aircraft antennas. It is to be noted that only a few of these frequencies are utilized in the VHF/DME pairing plan.

3.5.5.1.7 The spurious pulse power received and measured under the conditions stated in 3.5.5.1.6 should be 80dB below the peak pulse power received.

Note – Reference 3.5.5.1.6 and 3.5.5.1.7 — although limitation of spurious CW radiation between pulses to levels not exceeding 80 dB below the peak pulse power received is recommended, States are cautioned that where users employ airborne secondary surveillance radar transponders in the same aircraft, it may be necessary to limit direct and radiated CW to not more than 0.02 microwatt in the frequency band 1 015 MHz to 1 045 MHz. It is to be noted that only a few of these frequencies are utilized in the VHF/DME pairing plan.

3.5.5.2 Time delay

3.5.5.2.1 The time delay shall be consistent with the table in 3.5.4.4.1.

3.5.5.2.2 *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.

3.5.5.2.3 *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.

3.5.5.3 Receiver

3.5.5.3.1 *Frequency of operation.* The receiver centre frequency shall be the transponder frequency appropriate to the assigned DME operating channel (see 3.5.3.3.3).

3.5.5.3.2 Receiver sensitivity

3.5.5.3.2.1 *DME/N* – The airborne equipment sensitivity shall be sufficient to acquire and provide distance information to the accuracy specified in 3.5.5.4 for the signal power density specified in 3.5.4.1.5.2.

Note – Although the Standard in 3.5.5.3.2.1 is for DME/N interrogators, the receiver sensitivity is better than that necessary in order to operate with the power density of DME/N transponders given in 3.5.4.1.5.1 in order to assure interoperability with the IA mode of DME/P transponders.

3.5.5.3.2.2 *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 3.5.4.1.5 and a maximum of minus 18 dBW/m^2.

3.5.5.3.3 *Bandwidth*

3.5.5.3.3.1 *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 3.5.4.1.3.

3.5.5.3.4 Interference rejection

3.5.5.3.4.1 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.

Note – Co-channel refers to those reply signals that utilize the same frequency and the same pulse pair spacing.

3.5.5.3.4.2 *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.

3.5.5.3.5 Decoding

3.5.5.3.5.1 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 spacing's appropriate to transponder signals as described in 3.5.4.1.4.

3.5.5.3.5.2 *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.

3.5.5.4 Accuracy

3.5.5.4.1 *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.

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

3.6.1 Equipment

3.6.1.1 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.

3.6.1.2 Characteristics of emissions

3.6.1.2.1 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.

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

3.6.1.2.3 The radiation shall be horizontally polarized.

3.6.1.2.4 *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.

3.6.1.2.5 Coverage and radiation pattern

Note – The coverage and radiation pattern of marker beacons will ordinarily be established by Director General of Civil Aviation on the basis of operational requirements, taking into account recommendations of regional meetings. The most desirable radiation pattern would be one that:

a) in the case of fan marker beacons, results in lamp operation only when the aircraft is within a rectangular parallelepiped, symmetrical about the vertical line through the marker beacon and with the major and minor axes adjusted in accordance with the flight path served;

b) in the case of a Z marker beacon, results in lamp operation only when the aircraft is within a cylinder, the axis of which is the vertical line through the marker beacons. In practice, the production of such patterns is impracticable and a compromise radiation pattern is necessary.

In Attachment C of Annex 10 Vol.1, antenna systems currently in use and which have proved generally satisfactory are described for guidance. Such designs and any new designs providing a closer approximation to the most desirable radiation pattern outlined above will normally meet operational requirements.

3.6.1.2.6 *Determination of coverage* – The limits of coverage of marker beacons shall be determined on the basis of the field strength specified in 3.1.7.3.2.

3.6.1.2.7 *Radiation pattern.* The radiation pattern of a marker beacon normally should 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.

Note – Difficulty in siting certain marker beacons may make it necessary to accept a polar axis that is not vertical.

3.6.1.3 *Monitoring –For each marker beacon, suitable monitoring equipment should 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.

3.7 Requirements for the Global Navigation Satellite System (GNSS)

3.7.1 Definitions

Aircraft- based augmentation system (ABAS) - An augmentation system that augments and/or Integrates the information obtained from the other GNSS elements with information available on board the aircraft.

Alert - An indication provided to other aircraft systems or annunciation to the pilot to identify that an operating parameter of a navigation system is out of tolerance.
Alert limit- For a given parameter measurement, the error tolerance not to be exceeded without issuing an alert.

Channel of standard accuracy (CSA) - The specified level of positioning, velocity and timing accuracy that is available to any GLONASS user on a continuous, worldwide basis.

Core satellite constellation(s) - The core satellite constellations are GPS and GLONASS.

Global navigation satellite system (GNSS) - A worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation.

Global navigation satellite system (GLONASS) - The satellite navigation system operated by the Russian Federation.

Global positioning system (GPS) - The satellite navigation system operated by the United States.

GNSS position error - The difference between the true position and the position determined by the GNSS receiver.

Ground-based augmentation system (GBAS)- An augmentation system in which the user receives augmentation information directly from a ground-based transmitter.

Ground-based regional augmentation system (GRAS) - An augmentation system in which the user receives augmentation information directly from one of a group of ground-based transmitters covering a region.

Integrity - A measure of the trust that can be placed in the correctness of the information supplied by the total system .Integrity includes the ability of a system to provide timely and valid warnings to the user (alerts).

Pseudo-range- The difference between the time of transmission by a satellite and reception by a GNSS receiver multiplied by the speed of light in a vacuum, including bias due to the difference between a GNSS receiver and satellite time reference .

Satellite-based augmentation system (SBAS) - A wide coverage augmentation system in which the user receives augmentation information from a satellite-based transmitter.

Standard positioning service (SPS) - The specified level of positioning, velocity and timing accuracy that is available to any global positioning system (GPS) user on a continuous, worldwide basis.

Time-to-alert - The maximum allowable time elapsed from the onset of the navigation system being out of tolerance until the equipment enunciates the alert.

3.7.2. General

3.7.2.1 Functions

3.7.2.1.1 The GNSS shall provide position and time data to the aircraft.

Note - These data are derived from pseudo-range measurements between an aircraft equipped with a GNSS receiver and various signal sources on satellites or on the ground.

3.7.2.2 GNSS elements

3.7.2.2.1 The GNSS navigation service shall be provided using various combinations of the following elements installed on the ground, on satellites and/or on board the aircraft:

a) Global Positioning System (GPS) that provides the Standard Positioning Service (SPS) as defined in 3.7.3.1;

b) Global Navigation Satellite System (GLONASS) that provides the Channel of Standard Accuracy (CSA) navigation signal as defined in 3.7.3.2;

c) aircraft-based augmentation system (ABAS) as defined in 3.7.3.3;

d) satellite-based augmentation system (SBAS) as defined in 3.7.3.4;

e) ground-based augmentation system (GBAS) as defined in 3.7.3.5;

f) ground-based regional augmentation system (GRAS) as defined in 3.7.3.5; and

g) aircraft GNSS receiver as defined in 3.7.3.6.

3.7.2.3 Space and time reference

3.7.2.3.1 Space reference: The position information provided by the GNSS to the user shall be expressed in terms of the World Geodetic System — 1984 (WGS-84) geodetic reference datum.

Note 1— SARPs for WGS-84 are contained in IS 031Chapter 2, Chapter 2 IS 026, IS 030 Volumes I and II Chapter 2 and IS 028, Chapter 3.

Note 2— If GNSS elements using other than WGS-84 coordinates are employed, appropriate conversion parameters are to be applied.

3.7.2.3.2 Time reference. The time data provided by the GNSS to the user shall be expressed in a time scale that takes the Universal Time Coordinated (UTC) as reference.

3.7.2.4 Signal-in-space performance

3.7.2.4.1 The combination of GNSS elements and a fault-free GNSS user receiver shall meet the signal-in-space requirements defined in Table 3.7.2.4-1 (located at the end of section 3.7 of annex 10 volume 1).

Note — The concept of a fault-free user receiver is applied only as a means of defining the performance of combinations of different GNSS elements. The fault-free receiver is assumed to be a receiver with nominal accuracy and time-to-alert performance. Such a receiver is assumed to have no failures that affect the integrity, availability and continuity performance.

3.7.3 GNSS elements specifications

3.7.3.1 GPS Standard Positioning Service (SPS) (L1)

3.7.3.1.1 Space and control segment accuracy

Note- The following accuracy standards do not include atmospheric or receiver errors as described in Attachment D, 4.1.2 of Annex 10 Volume 1.

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

Global average	95% of the time	
Horizontal position error	13 m (43 ft)	36 m (118 ft)
Vertical position error	22 m (72 ft)	77 m (253 ft)

3.7.3.1.1.2 Time transfer accuracy: The GPS SPS time transfer errors shall not exceed 40 nanoseconds 95 per cent of the time.

3.7.3.1.1.3 Range domain accuracy. The range domain error shall not exceed the following limits:

a) range error of any satellite — the larger of:
— 30 m (100 ft); or

— 4.42 times the broadcast user range accuracy (URA), not to exceed 150 m (490 ft);

3.8 System characteristics of airborne ADF receiving systems

3.8.1 Accuracy of bearing indication

3.8.1.1 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 meter or more radiated from an LF/MF NDB or locator operating within the tolerances permitted by this Annex 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. International Alphabet No. 5(IA5) using bits b1 to b5 with b1 transmitted first. Alphanumeric data characters in other data words shall be encoded in accordance with

Note – The above bearing error is exclusive of aircraft magnetic compass error.

Table A. DME/MLS angle, DME/VOR and DME/ILS/MLS channelling and pairing

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
*1X	–	–	–	1 025	12	–	–	962	12
**1Y	–	–	–	1 025	36	–	–	1 088	30
*2X	–	–	–	1 026	12	–	–	963	12
**2Y	–	–	–	1 026	36	–	–	1 089	30
*3X	–	–	–	1 027	12	–	–	964	12
**3Y				1 027	36			1 090	30
*4X	–	–	–	1 028	12	–	–	965	12
**4Y	–	–	–	1 028	36	–	–	1 091	30
*5X	–	–	–	1 029	12	–	–	966	12
**5Y	–	–	–	1 029	36	–	–	1 092	30
*6X	–	–	–	1 030	12	–	–	967	12
**6Y	–	–	–	1 030	36	–	–	1 093	30
*7X	–	–	–	1 031	12	–	–	968	12
**7Y	–	–	–	1 031	36	–	–	1 094	30
*8X	–	–	–	1 032	12	–	–	969	12
**8Y	–	–	–	1 032	36	–	–	1 095	30
*9X	–	–	–	1 033	12	–	–	970	12
**9Y	–	–	–	1 033	36	–	–	1 096	30
*10X	–	–	–	1 034	12	–	–	971	12
**10Y	–	–	–	1 034	36	–	–	1 097	30
*11X	–	–	–	1 035	12	–	–	972	12
**11Y	–	–	–	1 035	36	–	–	1 098	30
*12X	–	–	–	1 036	12	–	–	973	12
**12Y	–	–	–	1 036	36	–	–	1 099	30
*13X	–	–	–	1 037	12	–	–	974	12
**13Y				1 037	36			1 100	30
*14X	–	–	–	1 038	12	–	–	975	12
**14Y	–	–	–	1 038	36	–	–	1 101	30
*15X	–	–	–	1 039	12	–	–	976	12
**15Y	–	–	–	1 039	36	–	–	1 102	30
*16X	–	–	–	1 040	12	–	–	977	12
**16Y	–	–	–	1 040	36	–	–	1 103	30

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
∇17X	108.00	-	-	1 041	12	-	-	978	12
17Y	108.05	5 043.0	540	1 041	36	36	42	1 104	30
17Z	-	5 043.3	541	1 041	-	21	27	1 104	15
18X	108.10	5 031.0	500	1 042	12	12	18	979	12
18W	-	5 031.3	501	1 042	-	24	30	979	24
18Y	108.15	5 043.6	542	1 042	36	36	42	1 105	30
18Z	-	5 043.9	543	1 042	-	21	27	1 105	15
19X	108.20	-	-	1 043	12	-	-	980	12
19Y	108.25	5 044.2	544	1 043	36	36	42	1 106	30
19Z	-	5 044.5	545	1 043	-	21	27	1 106	15
20X	108.30	5 031.6	502	1 044	12	12	18	981	12
20W	-	5 031.9	503	1 044	-	24	30	981	24
20Y	108.35	5 044.8	546	1 044	36	36	42	1 107	30
20Z	-	5 045.1	547	1 044	-	21	27	1 107	15
21X	108.40	-	-	1 045	12	-	-	982	12
21Y	108.45	5 045.4	548	1 045	36	36	42	1 108	30
21Z	-	5 045.7	549	1 045	-	21	27	1 108	15
22X	108.50	5 032.2	504	1 046	12	12	18	983	12
22W	-	5 032.5	505	1 046	-	24	30	983	24
22Y	108.55	5 046.0	550	1 046	36	36	42	1 109	30
22Z	-	5 046.3	551	1 046	-	21	27	1 109	15
23X	108.60	-	-	1 047	12	-	-	984	12
23Y	108.65	5 046.6	552	1 047	36	36	42	1 110	30
23Z	-	5 046.9	553	1 047	-	21	27	1 110	15
24X	108.70	5 032.8	506	1 048	12	12	18	985	12
24W	-	5 033.1	507	1 048	-	24	30	985	24
24Y	108.75	5 047.2	554	1 048	36	36	42	1 111	30
24Z	-	5 047.5	555	1 048	-	21	27	1 111	15
25X	108.80	-	-	1 049	12	-	-	986	12
25Y	108.85	5 047.8	556	1 049	36	36	42	1 112	30
25Z	-	5 048.1	557	1 049	-	21	27	1 112	15
26X	108.90	5 033.4	508	1 050	12	12	18	987	12
26W	-	5 033.7	509	1 050	-	24	30	987	24
26Y	108.95	5 048.4	558	1 050	36	36	42	1 113	30
26Z	-	5 048.7	559	1 050	-	21	27	1 113	15
27X	109.00	-	-	1 051	12	-	-	988	12
27Y	109.05	5 049.0	560	1 051	36	36	42	1 114	30
27Z	-	5 049.3	561	1 051	-	21	27	1 114	15

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
28X	109.10	5 034.0	510	1 052	12	12	18	989	12
28W	–	5 034.3	511	1 052	–	24	30	989	24
28Y	109.15	5 049.6	562	1 052	36	36	42	1 115	30
28Z	–	5 049.9	563	1 052	–	21	27	1 115	15
29X	109.20	–	–	1 053	12	–	–	990	12
29Y	109.25	5 050.2	564	1 053	36	36	42	1 116	30
29Z	–	5 050.5	565	1 053	–	21	27	1 116	15
30X	109.30	5 034.6	512	1 054	12	12	18	991	12
30W	–	5 034.9	513	1 054	–	24	30	991	24
30Y	109.35	5 050.8	566	1 054	36	36	42	1 117	30
30Z	–	5 051.1	567	1 054	–	21	27	1 117	15
31X	109.40	–	–	1 055	12	–	–	992	12
31Y	109.45	5 051.4	568	1 055	36	36	42	1 118	30
31Z	–	5 051.7	569	1 055	–	21	27	1 118	15
32X	109.50	5 035.2	514	1 056	12	12	18	993	12
32W	–	5 035.5	515	1 056	–	24	30	993	24
32Y	109.55	5 052.0	570	1 056	36	36	42	1 119	30
32Z	–	5 052.3	571	1 056	–	21	27	1 119	15
33X	109.60	–	–	1 057	12	–	–	994	12
33Y	109.65	5 052.6	572	1 057	36	36	42	1 120	30
33Z	–	5 052.9	573	1 057	–	21	27	1 120	15
34X	109.70	5 035.8	516	1 058	12	12	18	995	12
34W	–	5 036.1	517	1 058	–	24	30	995	24
34Y	109.75	5 053.2	574	1 058	36	36	42	1 121	30
34Z	–	5 053.5	575	1 058	–	21	27	1 121	15
35X	109.80	–	–	1 059	12	–	–	996	12
35Y	109.85	5 053.8	576	1 059	36	36	42	1 122	30
35Z	–	5 054.1	577	1 059	–	21	27	1 122	15
36X	109.90	5 036.4	518	1 060	12	12	18	997	12
36W	–	5 036.7	519	1 060	–	24	30	997	24
36Y	109.95	5 054.4	578	1 060	36	36	42	1 123	30
36Z	–	5 054.7	579	1 060	–	21	27	1 123	15
37X	110.00	–	–	1 061	12	–	–	998	12
37Y	110.05	5 055.0	580	1 061	36	36	42	1 124	30
37Z	–	5 055.3	581	1 061	–	21	27	1 124	15
38X	110.10	5 037.0	520	1 062	12	12	18	999	12
38W	–	5 037.3	521	1 062	–	24	30	999	24
38Y	110.15	5 055.6	582	1 062	36	36	42	1 125	30
38Z	–	5 055.9	583	1 062	–	21	27	1 125	15

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
39X	110.20	–	–	1 063	12	–	–	1 000	12
39Y	110.25	5 056.2	584	1 063	36	36	42	1 126	30
39Z	–	5 056.5	585	1 063	–	21	27	1 126	15
40X	110.30	5 037.6	522	1 064	12	12	18	1 001	12
40W	–	5 037.9	523	1 064	–	24	30	1 001	24
40Y	110.35	5 056.8	586	1 064	36	36	42	1 127	30
40Z	–	5 057.1	587	1 064	–	21	27	1 127	15
41X	110.40	–	–	1 065	12	–	–	1 002	12
41Y	110.45	5 057.4	588	1 065	36	36	42	1 128	30
41Z	–	5 057.7	589	1 065	–	21	27	1 128	15
42X	110.50	5 038.2	524	1 066	12	12	18	1 003	12
42W	–	5 038.5	525	1 066	–	24	30	1 003	24
42Y	110.55	5 058.0	590	1 066	36	36	42	1 129	30
42Z	–	5 058.3	591	1 066	–	21	27	1 129	15
43X	110.60	–	–	1 067	12	–	–	1 004	12
43Y	110.65	5 058.6	592	1 067	36	36	42	1 130	30
43Z	–	5 058.9	593	1 067	–	21	27	1 130	15
44X	110.70	5 038.8	526	1 068	12	12	18	1 005	12
44W	–	5 039.1	527	1 068	–	24	30	1 005	24
44Y	110.75	5 059.2	594	1 068	36	36	42	1 131	30
44Z	–	5 059.5	595	1 068	–	21	27	1 131	15
45X	110.80	–	–	1 069	12	–	–	1 006	12
45Y	110.85	5 059.8	596	1 069	36	36	42	1 132	30
45Z	–	5 060.1	597	1 069	–	21	27	1 132	15
46X	110.90	5 039.4	528	1 070	12	12	18	1 007	12
46W	–	5 039.7	529	1 070	–	24	30	1 007	24
46Y	110.95	5 060.4	598	1 070	36	36	42	1 133	30
46Z	–	5 060.7	599	1 070	–	21	27	1 133	15
47X	111.00	–	–	1 071	12	–	–	1 008	12
47Y	111.05	5 061.0	600	1 071	36	36	42	1 134	30
47Z	–	5 061.3	601	1 071	–	21	27	1 134	15
48X	111.10	5 040.0	530	1 072	12	12	18	1 009	12
48W	–	5 040.3	531	1 072	–	24	30	1 009	24
48Y	111.15	5 061.6	602	1 072	36	36	42	1 135	30
48Z	–	5 061.9	603	1 072	–	21	27	1 135	15
49X	111.20	–	–	1 073	12	–	–	1 010	12
49Y	111.25	5 062.2	604	1 073	36	36	42	1 136	30
49Z	–	5 062.5	605	1 073	–	21	27	1 136	15

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
50X	111.30	5 040.6	532	1 074	12	12	18	1 011	12
50W	–	5 040.9	533	1 074	–	24	30	1 011	24
50Y	111.35	5 062.8	606	1 074	36	36	42	1 137	30
50Z	–	5 063.1	607	1 074	–	21	27	1 137	15
51X	111.40	–	–	1 075	12	–	–	1 012	12
51Y	111.45	5 063.4	608	1 075	36	36	42	1 138	30
51Z	–	5 063.7	609	1 075	–	21	27	1 138	15
52X	111.50	5 041.2	534	1 076	12	12	18	1 013	12
52W	–	5 041.5	535	1 076	–	24	30	1 013	24
52Y	111.55	5 064.0	610	1 076	36	36	42	1 139	30
52Z	–	5 064.3	611	1 076	–	21	27	1 139	15
53X	111.60	–	–	1 077	12	–	–	1 014	12
53Y	111.65	5 064.6	612	1 077	36	36	42	1 140	30
53Z	–	5 064.9	613	1 077	–	21	27	1 140	15
54X	111.70	5 041.8	536	1 078	12	12	18	1 015	12
54W	–	5 042.1	537	1 078	–	24	30	1 015	24
54Y	111.75	5 065.2	614	1 078	36	36	42	1 141	30
54Z	–	5 065.5	615	1 078	–	21	27	1 141	15
55X	111.80	–	–	1 079	12	–	–	1 016	12
55Y	111.85	5 065.8	616	1 079	36	36	42	1 142	30
55Z	–	5 066.1	617	1 079	–	21	27	1 142	15
56X	111.90	5 042.4	538	1 080	12	12	18	1 017	12
56W	–	5 042.7	539	1 080	–	24	30	1 017	24
56Y	111.95	5 066.4	618	1 080	36	36	42	1 143	30
56Z	–	5 066.7	619	1 080	–	21	27	1 143	15
57X	112.00	–	–	1 081	12	–	–	1 018	12
57Y	112.05	–	–	1 081	36	–	–	1 144	30
58X	112.10	–	–	1 082	12	–	–	1 019	12
58Y	112.15	–	–	1 082	36	–	–	1 145	30
59X	112.20	–	–	1 083	12	–	–	1 020	12
59Y	112.25	–	–	1 083	36	–	–	1 146	30
**60X	–	–	–	1 084	12	–	–	1 021	12
**60Y	–	–	–	1 084	36	–	–	1 147	30
**61X	–	–	–	1 085	12	–	–	1 022	12
**61Y	–	–	–	1 085	36	–	–	1 148	30
**62X	–	–	–	1 086	12	–	–	1 023	12
**62Y	–	–	–	1 086	36	–	–	1 149	30
**63X	–	–	–	1 087	12	–	–	1 024	12
**63Y	–	–	–	1 087	36	–	–	1 150	30

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
**64X	–	–	–	1 088	12	–	–	1 151	12
**64Y	–	–	–	1 088	36	–	–	1 025	30
**65X				1 089	12			1 152	12
**65Y	–	–	–	1 089	36	–	–	1 026	30
**66X	–	–	–	1 090	12	–	–	1 153	12
**66Y	–	–	–	1 090	36	–	–	1 027	30
**67X	–	–	–	1 091	12	–	–	1 154	12
**67Y	–	–	–	1 091	36	–	–	1 028	30
**68X	–	–	–	1 092	12	–	–	1 155	12
**68Y	–	–	–	1 092	36	–	–	1 029	30
**69X	–	–	–	1 093	12	–	–	1 156	12
**69Y	–	–	–	1 093	36	–	–	1 030	30
70X	112.30	–	–	1 094	12	–	–	1 157	12
**70Y	112.35	–	–	1 094	36	–	–	1 031	30
71X	112.40	–	–	1 095	12	–	–	1 158	12
**71Y	112.45	–	–	1 095	36	–	–	1 032	30
72X	112.50	–	–	1 096	12	–	–	1 159	12
**72Y	112.55	–	–	1 096	36	–	–	1 033	30
73X	112.60	–	–	1 097	12	–	–	1 160	12
**73Y	112.65	–	–	1 097	36	–	–	1 034	30
74X	112.70	–	–	1 098	12	–	–	1 161	12
**74Y	112.75	–	–	1 098	36	–	–	1 035	30
75X	112.80			1 099	12			1 162	12
**75Y	112.85	–	–	1 099	36	–	–	1 036	30
76X	112.90	–	–	1 100	12	–	–	1 163	12
**76Y	112.95	–	–	1 100	36	–	–	1 037	30
77X	113.00	–	–	1 101	12	–	–	1 164	12
**77Y	113.05	–	–	1 101	36	–	–	1 038	30
78X	113.10	–	–	1 102	12	–	–	1 165	12
**78Y	113.15	–	–	1 102	36	–	–	1 039	30
79X	113.20	–	–	1 103	12	–	–	1 166	12
**79Y	113.25	–	–	1 103	36	–	–	1 040	30
80X	113.30	–	–	1 104	12	–	–	1 167	12
80Y	113.35	5 067.0	620	1 104	36	36	42	1 041	30
80Z	–	5 067.3	621	1 104	–	21	27	1 041	15

Channel pairing				DME parameters						
				Interrogation					Reply	
					Pulse codes					
						DME/P mode				
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs		Frequency MHz	Pulse codes µs
81X	113.40	–	–	1 105	12	–	–		1 168	12
81Y	113.45	5 067.6	622	1 105	36	36	42		1 042	30
81Z	–	5 067.9	623	1 105	–	21	27		1 042	15
82X	113.50	–	–	1 106	12	–	–		1 169	12
82Y	113.55	5 068.2	624	1 106	36	36	42		1 043	30
82Z	–	5 068.5	625	1 106	–	21	27		1 043	15
83X	113.60	–	–	1 107	12	–	–		1 170	12
83Y	113.65	5 068.8	626	1 107	36	36	42		1 044	30
83Z	–	5 069.1	627	1 107	–	21	27		1 044	15
84X	113.70	–	–	1 108	12	–	–		1 171	12
84Y	113.75	5 069.4	628	1 108	36	36	42		1 045	30
84Z	–	5 069.7	629	1 108	–	21	27		1 045	15
85X	113.80	–	–	1 109	12	–	–		1 172	12
85Y	113.85	5 070.0	630	1 109	36	36	42		1 046	30
85Z	–	5 070.3	631	1 109	–	21	27		1 046	15
86X	113.90	–	–	1 110	12	–	–		1 173	12
86Y	113.95	5 070.6	632	1 110	36	36	42		1 047	30
86Z	–	5 070.9	633	1 110	–	21	27		1 047	15
87X	114.00	–	–	1 111	12	–	–		1 174	12
87Y	114.05	5 071.2	634	1 111	36	36	42		1 048	30
87Z	–	5 071.5	635	1 111	–	21	27		1 048	15
88X	114.10	–	–	1 112	12	–	–		1 175	12
88Y	114.15	5 071.8	636	1 112	36	36	42		1 049	30
88Z	–	5 072.1	637	1 112	–	21	27		1 049	15
89X	114.20	–	–	1 113	12	–	–		1 176	12
89Y	114.25	5 072.4	638	1 113	36	36	42		1 050	30
89Z	–	5 072.7	639	1 113	–	21	27		1 050	15
90X	114.30	–	–	1 114	12	–	–		1 177	12
90Y	114.35	5 073.0	640	1 114	36	36	42		1 051	30
90Z	–	5 073.3	641	1 114	–	21	27		1 051	15
91X	114.40	–	–	1 115	12	–	–		1 178	12
91Y	114.45	5 073.6	642	1 115	36	36	42		1 052	30
91Z	–	5 073.9	643	1 115	–	21	27		1 052	15
92X	114.50	–	–	1 116	12	–	–		1 179	12
92Y	114.55	5 074.2	644	1 116	36	36	42		1 053	30
92Z	–	5 074.5	645	1 116	–	21	27		1 053	15
93X	114.60	–	–	1 117	12	–	–		1 180	12
93Y	114.65	5 074.8	646	1 117	36	36	42		1 054	30
93Z	–	5 075.1	647	1 117	–	21	27		1 054	15

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
94X	114.70	–	–	1 118	12	–	–	1 181	12
94Y	114.75	5 075.4	648	1 118	36	36	42	1 055	30
94Z	–	5 075.7	649	1 118	–	21	27	1 055	15
95X	114.80	–	–	1 119	12	–	–	1 182	12
95Y	114.85	5 076.0	650	1 119	36	36	42	1 056	30
95Z	–	5 076.3	651	1 119	–	21	27	1 056	15
96X	114.90	–	–	1 120	12	–	–	1 183	12
96Y	114.95	5 076.6	652	1 120	36	36	42	1 057	30
96Z	–	5 076.9	653	1 120	–	21	27	1 057	15
97X	115.00	–	–	1 121	12	–	–	1 184	12
97Y	115.05	5 077.2	654	1 121	36	36	42	1 058	30
97Z	–	5 077.5	655	1 121	–	21	27	1 058	15
98X	115.10	–	–	1 122	12	–	–	1 185	12
98Y	115.15	5 077.8	656	1 122	36	36	42	1 059	30
98Z	–	5 078.1	657	1 122	–	21	27	1 059	15
99X	115.20	–	–	1 123	12	–	–	1 186	12
99Y	115.25	5 078.4	658	1 123	36	36	42	1 060	30
99Z	–	5 078.7	659	1 123	–	21	27	1 060	15
100X	115.30	–	–	1 124	12	–	–	1 187	12
100Y	115.35	5 079.0	660	1 124	36	36	42	1 061	30
100Z	–	5 079.3	661	1 124	–	21	27	1 061	15
101X	115.40	–	–	1 125	12	–	–	1 188	12
101Y	115.45	5 079.6	662	1 125	36	36	42	1 062	30
101Z	–	5 079.9	663	1 125	–	21	27	1 062	15
102X	115.50	–	–	1 126	12	–	–	1 189	12
102Y	115.55	5 080.2	664	1 126	36	36	42	1 063	30
102Z	–	5 080.5	665	1 126	–	21	27	1 063	15
103X	115.60	–	–	1 127	12	–	–	1 190	12
103Y	115.65	5 080.8	666	1 127	36	36	42	1 064	30
103Z	–	5 081.1	667	1 127	–	21	27	1 064	15
104X	115.70	–	–	1 128	12	–	–	1 191	12
104Y	115.75	5 081.4	668	1 128	36	36	42	1 065	30
104Z	–	5 081.7	669	1 128	–	21	27	1 065	15
105X	115.80	–	–	1 129	12	–	–	1 192	12
105Y	115.85	5 082.0	670	1 129	36	36	42	1 066	30
105Z	–	5 082.3	671	1 129	–	21	27	1 066	15
106X	115.90	–	–	1 130	12	–	–	1 193	12
106Y	115.95	5 082.6	672	1 130	36	36	42	1 067	30
106Z	–	5 082.9	673	1 130	–	21	27	1 067	15

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
107X	116.00	–	–	1 131	12	–	–	1 194	12
107Y	116.05	5 083.2	674	1 131	36	36	42	1 068	30
107Z	–	5 083.5	675	1 131	–	21	27	1 068	15
108X	116.10	–	–	1 132	12	–	–	1 195	12
108Y	116.15	5 083.8	676	1 132	36	36	42	1 069	30
108Z	–	5 084.1	677	1 132	–	21	27	1 069	15
109X	116.20	–	–	1 133	12	–	–	1 196	12
109Y	116.25	5 084.4	678	1 133	36	36	42	1 070	30
109Z	–	5 084.7	679	1 133	–	21	27	1 070	15
110X	116.30	–	–	1 134	12	–	–	1 197	12
110Y	116.35	5 085.0	680	1 134	36	36	42	1 071	30
110Z	–	5 085.3	681	1 134	–	21	27	1 071	15
111X	116.40	–	–	1 135	12	–	–	1 198	12
111Y	116.45	5 085.6	682	1 135	36	36	42	1 072	30
111Z	–	5 085.9	683	1 135	–	21	27	1 072	15
112X	116.50	–	–	1 136	12	–	–	1 199	12
112Y	116.55	5 086.2	684	1 136	36	36	42	1 073	30
112Z	–	5 086.5	685	1 136	–	21	27	1 073	15
113X	116.60	–	–	1 137	12	–	–	1 200	12
113Y	116.65	5 086.8	686	1 137	36	36	42	1 074	30
113Z	–	5 087.1	687	1 137	–	21	27	1 074	15
114X	116.70	–	–	1 138	12	–	–	1 201	12
114Y	116.75	5 087.4	688	1 138	36	36	42	1 075	30
114Z	–	5 087.7	689	1 138	–	21	27	1 075	15
115X	116.80	–	–	1 139	12	–	–	1 202	12
115Y	116.85	5 088.0	690	1 139	36	36	42	1 076	30
115Z	–	5 088.3	691	1 139	–	21	27	1 076	15
116X	116.90	–	–	1 140	12	–	–	1 203	12
116Y	116.95	5 088.6	692	1 140	36	36	42	1 077	30
116Z	–	5 088.9	693	1 140	–	21	27	1 077	15
117X	117.00	–	–	1 141	12	–	–	1 204	12
117Y	117.05	5 089.2	694	1 141	36	36	42	1 078	30
117Z	–	5 089.5	695	1 141	–	21	27	1 078	15
118X	117.10	–	–	1 142	12	–	–	1 205	12
118Y	117.15	5 089.8	696	1 142	36	36	42	1 079	30
118Z	–	5 090.1	697	1 142	–	21	27	1 079	15
119X	117.20	–	–	1 143	12	–	–	1 206	12
119Y	117.25	5 090.4	698	1 143	36	36	42	1 080	30
119Z	–	5 090.7	699	1 143	–	21	27	1 080	15

Channel pairing				DME parameters					
				Interrogation				Reply	
					Pulse codes				
						DME/P mode			
DME channel number	VHF frequency MHz	MLS angle frequency MHz	MLS channel number	Frequency MHz	DME/N µs	Initial approach µs	Final approach µs	Frequency MHz	Pulse codes µs
120X	117.30	–	–	1 144	12	–	–	1 207	12
120Y	117.35	–	–	1 144	36	–	–	1 081	30
121X	117.40	–	–	1 145	12	–	–	1 208	12
121Y	117.45	–	–	1 145	36	–	–	1 082	30
122X	117.50	–	–	1 146	12	–	–	1 209	12
122Y	117.55	–	–	1 146	36	–	–	1 083	30
123X	117.60	–	–	1 147	12	–	–	1 210	12
123Y	117.65	–	–	1 147	36	–	–	1 084	30
124X	117.70	–	–	1 148	12	–	–	1 211	12
**124Y	117.75	–	–	1 148	36	–	–	1 085	30
125X	117.80	–	–	1 149	12	–	–	1 212	12
**125Y	117.85	–	–	1 149	36	–	–	1 086	30
126X	117.90	–	–	1 150	12	–	–	1 213	12
**126Y	117.95	–	–	1 150	36	–	–	1 087	30

* These channels are reserved exclusively for national allotments.

** These channels may be used for national allotment on a secondary basis. The primary reason for reserving these channels is to provide protection for the secondary surveillance radar (SSR) system.

∇ 108.0 MHz is not scheduled for assignment to ILS service. The associated DME operating channel No. 17X may be assigned for emergency use. The reply frequency of channel No. 17X (i.e. 978 MHz) is also utilized for the operation of the universal access transceiver (UAT). Standards and Recommended Practices for UAT are found in Annex 10, Volume III, Part I, Chapter 12.