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GOVERNMENT OF INDIA

OFFICE OF DIRECTOR GENERAL OF CIVIL AVIATION

TECHNICAL CENTRE, OPP SAFDARJANG AIRPORT, NEW DELHI

CIVIL AVIATION REQUIREMENTS
SECTION 9 – AIR SPACE AND AIR TRAFFIC MANAGEMENT
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Subject : **Aeronautical Telecommunications – Radio Navigation Aids**

INTRODUCTION

In pursuant to Article 28 of the Convention on International Civil Aviation each contracting State undertakes to provide in its territory, air navigation facilities to facilitate air navigation and also adopt and put into operation the appropriate standard systems for communication procedures, codes, markings, signals etc., in accordance with standards which may be recommended or established from time to time, pursuant to the Convention. International Civil Aviation Organization adopts and amends from time to time, as may be necessary, international standards and recommended practices and procedures for Aeronautical Telecommunications – Radio Navigation Aids in Annex 10 Volume I.

This CAR is issued under the provisions of Rule 29C and Rule 133A of the Aircraft Rules, 1937 for the requirements to be followed in respect of Aeronautical Telecommunications – Radio Navigation Aids.

This CAR is issued in supersession of CAR Section 4 Series 'D' Part II dated 12th July 2006.

1. DEFINITIONS

Note 1.0 *All references to "Radio Regulations" are to the Radio Regulations published by the International Telecommunication Union (ITU). Radio Regulations are amended from time to time by the decisions embodied in the Final Acts of World Radio communication Conferences held normally every two to three years. Further information on the ITU processes as they relate to aeronautical radio system frequency use is contained in the Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including statement of approved ICAO policies (Doc 9718).*

Note 2.0 *Intentionally left blank*

***Note 3.0—** The terminology used in this CAR to refer to instrument approach operations is based on a previous version of the Annex 6 classification of instrument approach and landing operations. It can be mapped to the Annex 6 definitions as follows:*

Performance requirements in support of instrument approach operations		
Annex 10 system performance		Annex 6 method - Approach operation category
Non-precision approach (NPA)		2D-Type A (1)
Approach with vertical guidance (APV)		3D-Type A (2)
Precision approach (PA)	Category I, DH equal to or greater than 75 m (250 ft)	3D-Type A (3)
	Category I, DH equal to or greater than 60 m (200 ft) and less than 75 m (250 ft)	3D-Type B - CAT I (3)
	Category II	3D-Type B - CAT II
	Category III	3D-Type B - CAT III
(1) Without vertical guidance. (2) With barometric or SBAS vertical guidance. (3) With ILS, MLS, GBAS or SBAS vertical guidance.		

When the following terms are used in this CAR, 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).

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.

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, RNAV 1.

Note.1— The Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, contains detailed guidance on navigation specifications.

Note 2. — The term RNP as previously defined as “a statement of the navigation performance, necessary for operation within a defined airspace”, has been removed from this Annex as the concept of RNP has been overtaken by the concept of PBN. The term RNP in this Annex is now solely used in 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 the PBN Manual (Doc 9613).

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.

Touchdown: The point where the nominal glide path intercepts the runway.

Global navigation satellite system (GNSS)

1.1 A standard aid to navigation shall be the global navigation satellite system (GNSS) conforming to the Standards contained in Chapter 2, 2.

Note 1.— It is intended that any change in, or addition to, Standards in Chapter 2, 2 that will require the replacement of GNSS equipment can become applicable on the basis of a six-year advance notice.

Note 2.— GNSS is expected to support all phases of flight and aerodrome surface operations, however, present SARPs provide for en-route, terminal and approach and landing operations down to Category I precision approach.

1.2 It shall be permissible to terminate a GNSS satellite service provided by one of its elements (Chapter 2, 2.2) on the basis of at least a six-year advance notice by a service provider.

1.3 Recording and retention of GNSS data

1.3.1 Recommendation.— A State that approves GNSS-based operations should ensure that GNSS data relevant to those operations are recorded.

Note 1.— These recorded data are primarily intended for use in accident and incident investigations. They may also support periodic confirmation that accuracy, integrity, continuity and availability are maintained within the limits required for the operations approved.

Note 2.— Guidance material on the recording of GNSS parameters is contained in Attachment D, 11.

1.3.2 Recommendation.— Recordings should be retained for a period of at least fourteen days. When the recordings are pertinent to accident and incident investigations, they should be retained for longer periods until it is evident that they will no longer be required.

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)
b) the VHF Omni-directional radio range (VOR)
c) the global navigation satellite system (GNSS) confirming to the Standards contained in Chapter 3.3.7
d) the non-directional beacon (NDB)
e) the distance measuring equipment (DME)
f) the en-route VHF marker beacon

Note1: Since radio navigation is essential for the final stages of approach and landing, the installation of non-visual aids does not obviate the need for visual aids to approach and landing in conditions of low visibility.

2.1.2. Differences in radio navigation aids in any respect of provisions in para 3 of this CAR shall be published in an Aeronautical Information Publication (AIP).

2.1.3. Wherever there is installed a radio navigation aid that is not an ILS but which may be used in whole or in part with aircraft equipment designed for use with the ILS, full details of parts that may be so used shall be published in an Aeronautical Information Publication (AIP).

Note: This provision is to establish requirement for promulgation of relevant information rather than to authorize such installation

2.1.4 GNSS-specific provisions

2.1.4.1 It shall be permissible to terminate a GNSS satellite service provided by one of its elements (Chapter 3, 3.7.2) on the basis of at least a six-year advance notice by a service provider.

2.1.4.2 The service provider shall *ensure that GNSS data relevant to the provision of GNSS services for GNSS operations are recorded.*

Note 1— the recorded data are primarily intended for use in accident and incident investigations. They may also support periodic confirmation that accuracy, integrity, continuity and availability are maintained within the limits required for the operations approved.

Note 2 – Guidance material on the recording of GNSS parameters is contained in Attachment D,11.

2.1.4.3 *Recordings should be retained for a period of at least 14 days. When the recordings are pertinent to accident and incident investigations, they should be retained for longer periods until it is evident that they will no longer be required.*

2.1.5 Intentionally left blank.

2.1.5.1 Intentionally left blank.

2.1.5.2 The SRE may be installed and operated without the PAR for:

a) the assistance of air traffic control in handling aircraft intending to use a radio navigation aid, or for;

b) Surveillance radar approaches and departures.

2.1.6 When a radio navigation aid is provided to support precision approach and landing it should be supplemented by a source of guidance information which, when used in conjunction with appropriate procedures, will provide effective guidance to the desired reference path.

Note:VOR, NDB, DME, GNSS and aircraft navigation systems have been established for purposes mentioned above.

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 international air navigation are subject of periodic ground and flight tests.

Note: NDB shall not be subjected to periodic flight tests.

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

2.3.1 Aerodrome control towers and units providing approach control service shall be provided without delay with information on the operational status of radio navigation aids essential for approach, landing and take-off at the aerodrome(s) with which they are concerned.

2.4 Power supply for radio navigation aids and communication systems

2.4.1 Radio navigation aids and ground elements of communication systems shall be provided with suitable power supplies and means to ensure continuity of service consist 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).

3. Specifications For Radio Navigation Aids

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.

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

Course line: The locus of the 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 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 60m(200ft) or less above the horizontal plane containing the threshold.

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 15m (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 place containing the course line and limited by the loci of points nearest to the course line at which the DGM is 0.0775.

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 is 0.175.

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 050m (3500ft) 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 30m (100ft) above the horizontal plane containing the threshold.

ILS Point "D": A point 4m (12ft) above the runway centre line and 900m (3000ft) from the threshold in the direction of localizer.

ILS Point "E": A point 4m (12ft) above the runway centre line and 600m (2000ft) 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 (See figure 1).

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.

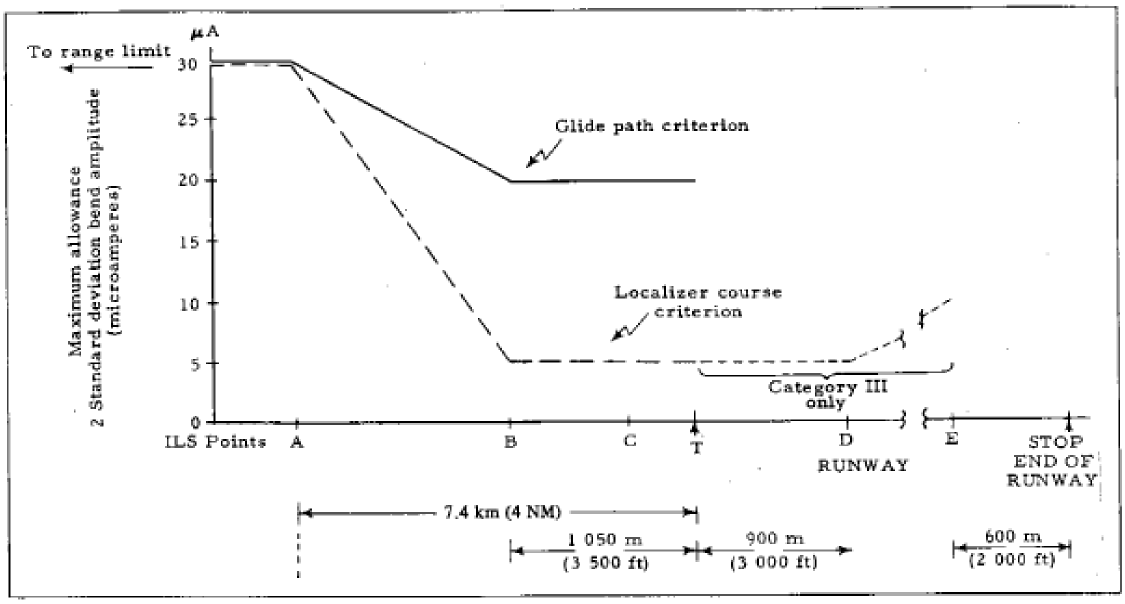


Figure 1

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) VHF marker beacons, or a distance measuring equipment (DME) in accordance with para 3.5, together with associated monitor system and remote control and status indicator equipment.

3.1.2.1.1 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 the 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 3.1.3.11.3.1 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 offull 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 displacement from the course line or ILS glide path as appropriate, irrespective of the particular ground installations in use.

3.1.2.3 The localizer and glide path components specified in 3.2.1. a) And b) above which form part of a facility Performance Category I – ILS shall comply at least with the provisions in para 3.1.3 and 3.1.5 below respectively, excepting those in which application to Facility Performance Category II –ILS is prescribed.

3.1.2.4 The localizer and glide path components specified in 3.1.2.1 a) and b) above 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 – ILD, as supplemented or amended by the provisions in para 3.1.3 and 3.1.5 below in which application to facility Performance Category II – ILS is prescribed.

3.1.2.5 The localizer and glide path components and ancillary equipment specified in 3.1.2.1.1 above, which form part of a Facility Performance Category III – ILS, shall otherwise comply with the provisions applicable to these components in Facility Performance Categories I and II – ILS, except as supplemented by the Standards specified is of a high value, consistent with category of operational performance.

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

3.1.2.7 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.

3.1.2.7.1.1 At those locations where two separate ILS facilities serve opposite ends of a single runway and where a facility performance Category I – ILS is to be used for auto coupled approaches and landing in visual conditions, an interlock shall ensure that only the localizer serving the approach direction in use radiates providing the other localizer is not required for simultaneous operational use.

3.1.2.7.2 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 on 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

The provisions of 3.1.3 cover ILS localizers providing wither positive guidance information over 360 degrees of azimuth, or providing such guidance only with a specified portion of the front coverage (see para 3.1.3.7.4 below). 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 his right hand and that due to the 90 Hz tone shall predominate o his 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 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, the 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 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 in 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.

3.1.3.2.3 For Facility Performance Category III localizers, the signals emanating from the transmitter shall contain no components which result in a apparent course line fluctuation of more than 0.005 DDM peak to peak in the frequency band 01.01 Hz to 10 Hz.

3.1.3.3 Coverage

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

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

b) 31.5 km (17NM) between 10 degrees and 35 degrees from the front course line;

c) 18.5 km (10 NM) outside of plus or minus 35 degrees from the front course line if coverage is provided;

except that, where topographical features dictate or operation requirements permit, the limits may be reduced down to 33.3 km (18NM) within the plus or minus 10 degree sector and 18.5 km (10NM) within the remainder of the coverage when alternative navigational means provide satisfactory coverage within the intermediate approach area. The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2000ft) above the elevation the threshold, or 300m (1000ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher, except that, where needed to protect ILS performance and if operational requirements permit, the lower limit of coverage at angles beyond 15 degrees from the front course line shall be raised linearly from its height at 15 degrees to as high as 1350m (4500 ft) above the elevation of the threshold at 35 degrees from the front course line. Such signals shall be receivable, to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7 degrees above the horizontal.

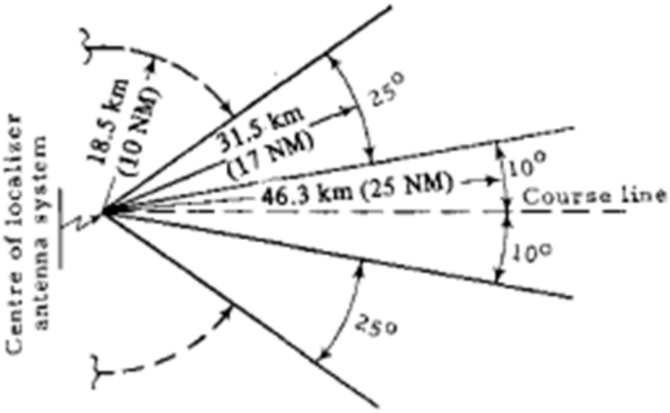
Note:- Where intervening obstacles penetrate the lower surface, it is intended that guidance need not be provided at less than line –of-sight heights.

3.1.3.3.2 In all parts of the coverage volume specified in 3.1.3.3.1 above, other than as specified in 3.1.3.3.2.1, 3.1.3.3.2.2 and 3.1.3.3.2.3 below, the field strength shall be not less than 50 micro volts per meter (minus 114dbW/m^2). This field strength is required to permit satisfactory operational usage of ILS localizer facilities.

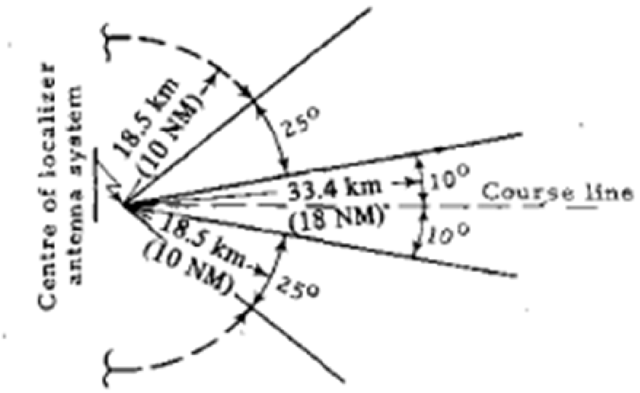
3.1.3.3.2.1 For Facility Performance Category I localizers, the minimum field strength on the ILS glide path and within the localizer course sector from a distance of 18.5 km (10 NM) to a height of 60m (200ft) above the horizontal place containing the threshold shall be not less than 90 micro volts per meter (minus 107 db W/ 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 per meter (minus 106 dB W/m^2) at a distance of 18.5 km (10NM) increasing to not less than 200 µ volts per meter (minus 100 dB W/m^2) at height of 15m (50 ft) above the horizontal plane containing the threshold. This field strength is necessary to provide the signal to noise ration required for improve integrity.

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 μ volts per meter (minus 106 dB W/m^2) at a distance of 18.5km (10 NM), increasing to not less than 200 μ volts per meter (minus 100 dB W/m^2) at 6 m (20ft) above the horizontal plane containing the threshold. From this point to a further point 4 m (12 ft) above the runway centre line, and 300m (1000ft) from the threshold in the direction of the localizer, and thereafter at height of 4m (12ft) along the length of the runway in the direction of the localizer, the field strength shall be not less than 100 μ volts per meter (minus 106 dB W/m^2). This field strength is necessary to provide the signal to noise ratio required for improved integrity.



When topographical features dictate or operational requirements and alternative navigation facilities permit, the following coverage may be provided:



Note.— If coverage as prescribed in Chapter 3, 3.1.3.3.1 is required outside the plus or minus 35-degree sector, this is provided to 18.5 km (10 NM), as indicated by the broken arc above.

Figure 2 Localizer Coverage with respect to azimuth

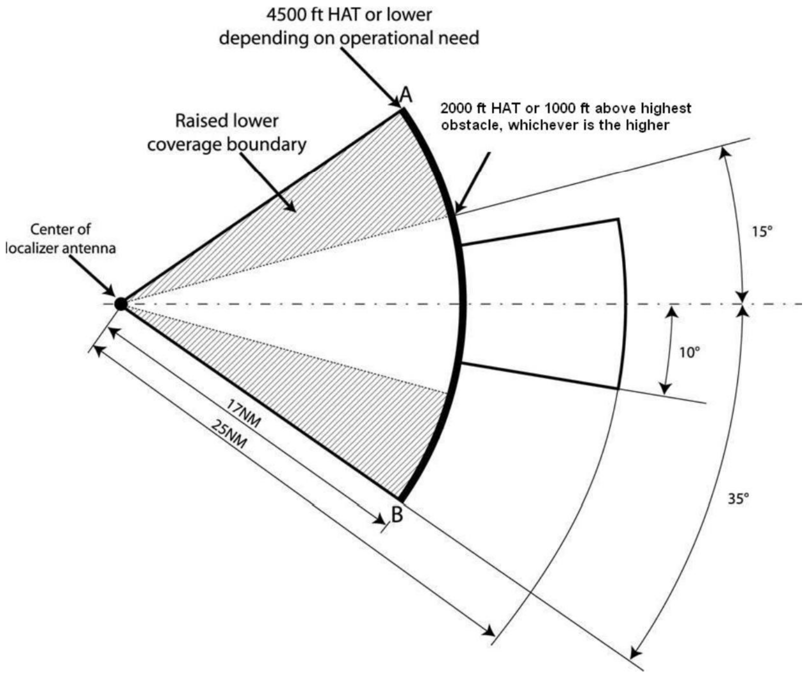


Figure 2A Reduced Localizer Coverage with respect to azimuth

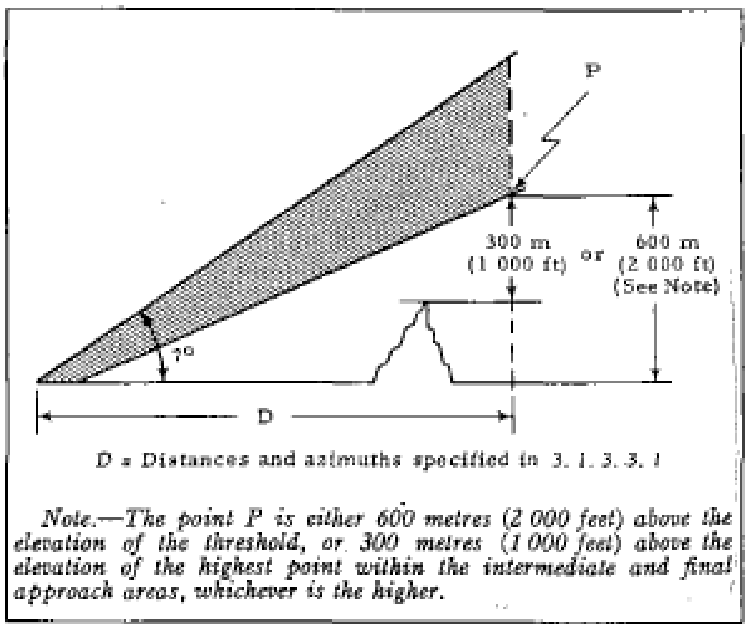


Figure 3.

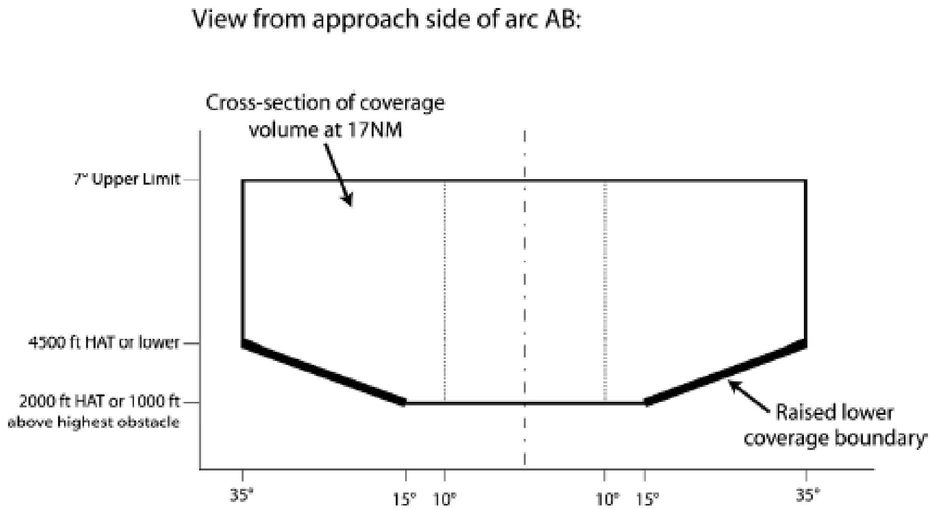


Figure 3A Reduced Localizer Coverage with respect to elevation

Note: Because of the siting problems and terrain limitations, some localizers may not meet the standard coverage area described above. In such cases approach plate design will assure aircraft remain within areas of adequate signal coverage and such information will be duly annotated on the approach plate.

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

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 above shall not be less than 10 dB.

3.1.3.3.5 For facility performance Category III localizers, the ratio of the two carrier signal strengths in space within the front course sector should not be less than 16 dB.

3.1.3.4 Course structure

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

Zone	**Amplitude (DDM)** (95% Probability)
Outer limit of coverage to ILS point “A”	0.031
ILS point “A” to ILS Point “B”	0.031 at ILS Point “A” decreasing at a linear rate to 0.015 at ILS point “B”
ILS Point “B” to ILS Point “C”	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 ILS Point “B”	0.031 at ILS Point “A” decreasing at a linear rate to 0.005 at ILS point “B”
ILS point “B” to ILS reference datum	0.005
and, for Category	
ILS reference datum to ILS Point “D”	0.005
ILS Point “D” to ILS Point “E”	0.005 at ILS Point “D” increasing at a linear rate to 0.010 at ILS Point “E”

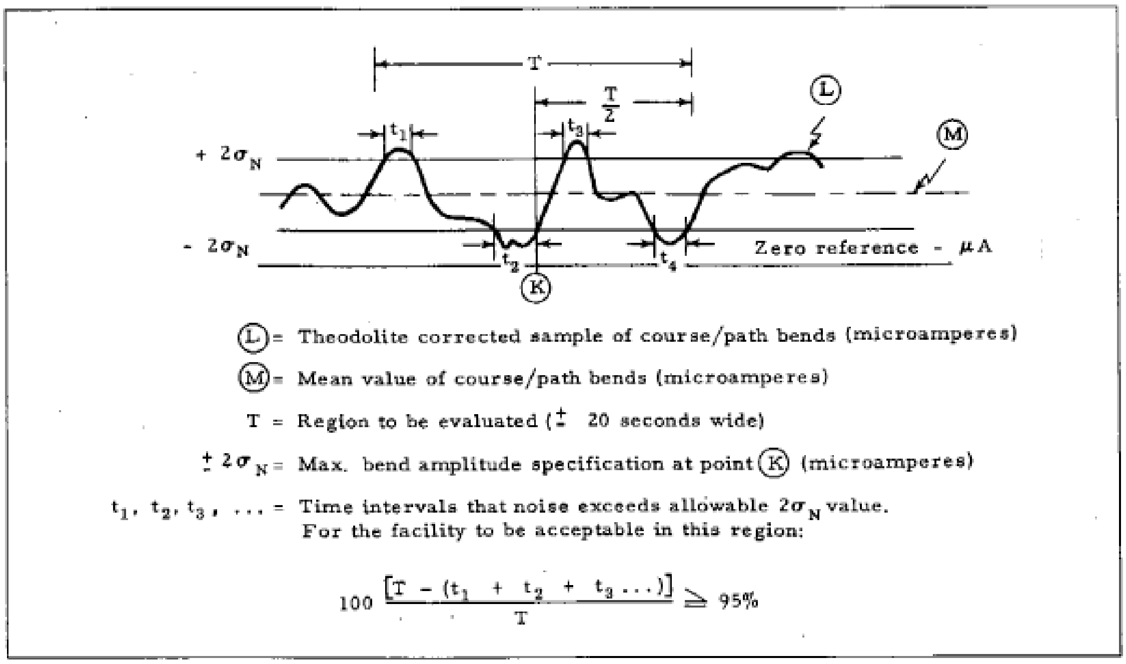


Figure 4

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 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 150Hz within plus or minus 1.5 per cent for facility performance category II installations;

c) the modulating tones shall be 90 Hz and 150Hz 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 and 150 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 inter modulate with the 90 Hz and 150 Hz navigational 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 demodulation 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.

3.1.3.5.3.4. With two-frequency localizer systems, 3.1.3.5.3.3 above 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
c) for category III localizers: 10 degrees,

of phase relative to 90 Hz. Similarly, the 150 Hz tones of the two carriers shall be phase locked so that the demodulated wave forms pass through zero in the same direction within:

1) for categories I and II localizers: 20 degrees; and

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

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 above shall be permitted. In this alternative system, the 90 Hz to 90 Hz phasing and the 150 Hz to 150 Hz phasing shall be adjusted to their nominal values to within limits equivalent to those stated in 3.1.3.5.3.4 above.

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.

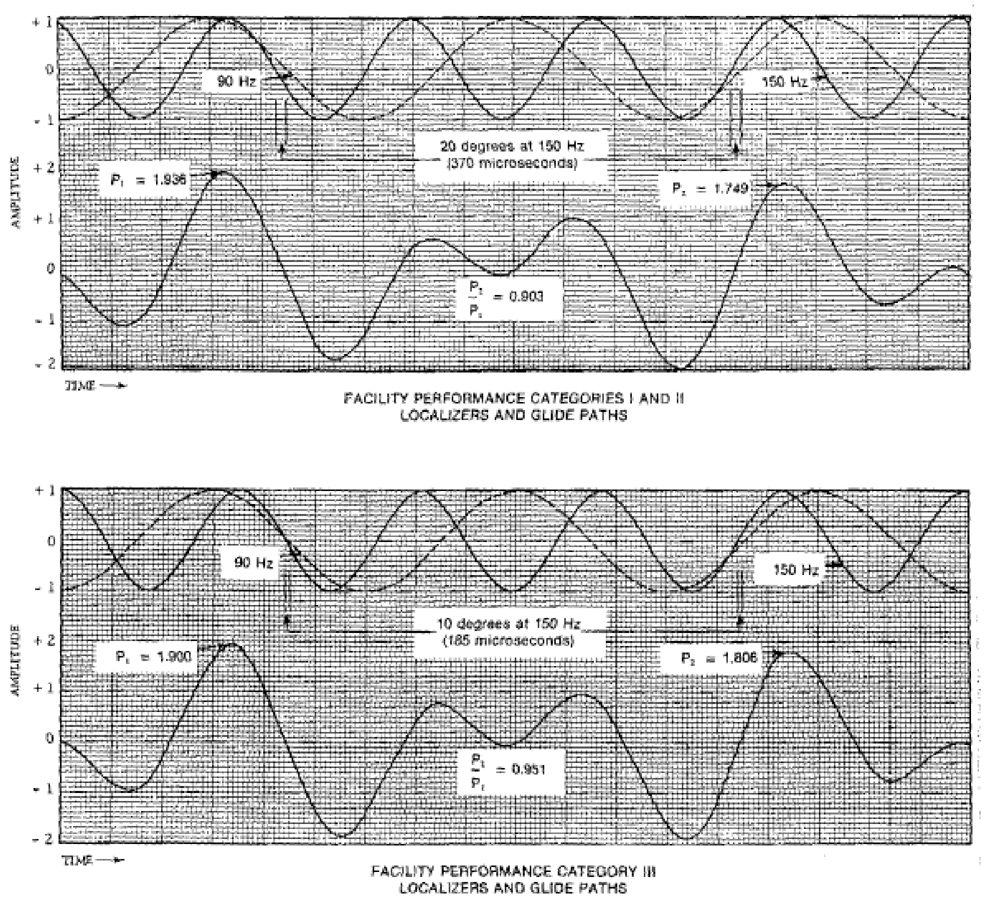
3.1.3.5.3.6. The sum of the modulations depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones should not exceed 60 per cent or be less than 30 per cent within the required coverage.

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

Note 1: If the sum of the modulation depths is greater than 60 percent for Facility Performance Category 1 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)

Note 3: The standard for minimum sum of modulation depths is based on the malfunctioning alarm level being set as high as 30 per cent.



The accompanying graphs illustrate a method that can be used to measure the relative phase relationship between the 90 Hz and 150 Hz tones. The upper portion of each graph shows the individual waveforms and their relationship at the limit of phase differences allowed by Chapter 3, 3.1.3.5.3.3 and 3.1.5.5.3. The lower portion shows the combined waveforms as would be seen on an oscilloscope. By taking the ratio of P_1 and P_2, which gives a value equal to or less than unity, it is possible to determine if the phasing is within tolerance. For Categories I and II ILS the ratio should be greater than 0.903 and for Category III the ratio should be greater than 0.951.

Figure 5 ILS Wave forms illustrating relative audio phasing of the 90 Hz & 150 Hz tones.

3.1.3.5.3.7. When utilizing a localizer for radiotelephone communications, the sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones shall not exceed 65 percent with 10 degrees of the course line and shall not exceed 78 percent 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 10.5m (35ft), or the linear equivalent of 0.015 DDM, whichever is less;

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

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

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

3.1.3.7 Displacement sensitivity

3.1.3.7.1 The normal 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 the 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 6 degrees.

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 For Facility Performance Category II –ILS, displacement sensitivity should be adjusted and maintained with the limits of plus or minus 10 percent where practicable.

Note:The figures given in 3.1.3.7.1, 3.1.3.7.2 & 3.1.3.7.3 above are based up on a nominal sector width of 210m (700 feet) at the appropriate time i.e. ILS point “B” on runway codes 1&2 and the ILS reference datum on other runways.

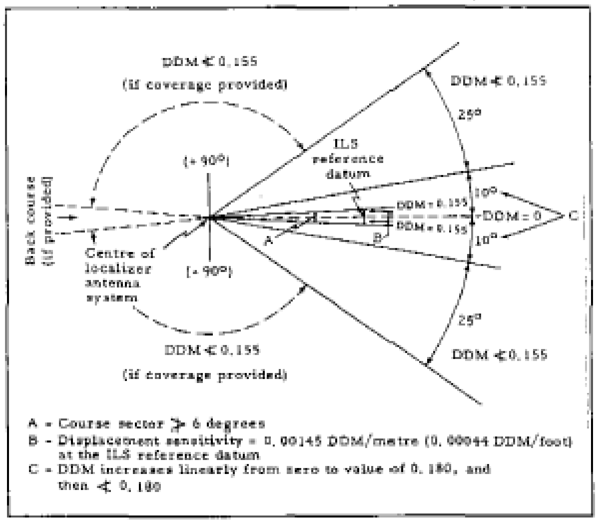


Figure 6 Difference in depth of modulation and displacement sensitivity

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 that 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 of 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 a 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 Voice

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

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

3.1.3.8.3 If the channel is provided, it shall conform with the following standards:

3.1.3.8.3.1 The channel shall be on the same radio frequency carrier or carriers as used for the localizer function and the rad8iation shall be horizontally polarized. Where to carriers are modulated with speech, the relative phases of the modulations on the two carriers shall be such as to avoid the occurrence of nulls within the coverage of the localizer.

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

a) the ratio of peak modulation depth due to the radiotelephone communications to that due to identification signal is approximately 9:1;
b) the sum of modulation components due to use of the radiotelephone channel, navigational signals and identification signals shall not exceed 95 per cent.

3.1.3.8.3.3 The audio frequency characteristics of the radiotelephone channel shall be flat to with 3 dB relative to the level at 1000 Hz over the range 300 Hz to 3000 Hz

3.1.3.9 Identification

3.1.3.9.1 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 of carriers as used for the localizer function. The transmission of the identification signal shall not interfere in any way with the basic localizer function.

3.1.3.9.2 The identification signal shall be produced by Class A2A modulation of the radio frequency carrier or carriers using a modulation tone of 1020 Hz within plus or minus 50 Hz. The depth of modulation shall be between the limits of 5 and 15 per cent except that, where a radiotelephone communication channel is provided, the depth of modulation shall be adjusted so that the ratio of peak modulation depth due to radiotelephone communications to that due to the identification signal modulation is approximately 9:1 (see 3.1.3.8.3.2 above). 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.

3.1.3.9.3 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 facilities from other navigational facilities in the immediate area.

3.1.3.9.4 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 transmission of the localizer is not available for operational use, as, for example, after removal of navigational components, or during maintenance or test transmissions, the identification signal shall be suppressed. The dots shall have a duration of 0.1 second to 0.160 second. The dash duration shall be typically three times the duration of a dot. The interval between dots and/or dashes shall be equal to that of one dot plus or minus 10 percent. The interval between letters shall not be less than the duration of three dots.

3.1.3.10 Siting

3.1.3.10.1 For Facility Performance Categories II and III the localizer antenna system shall be located on the extension of 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.

3.1.3.10.2 For Facility Performance Category I, the localizer antenna system shall be located and adjusted as in 3.1.3.10.1, unless site constraints dictate that the antenna be offset from the centre line of the runway.

3.1.3.10.2.1 The offset localizer system shall be located and adjusted in accordance with the offset ILS provisions of the PANS-OPS (Doc 8168), Volume II, and the localizer standards shall be referenced to the associated fictitious threshold point.

3.1.3.11 Monitoring

3.1.3.11.1 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 3.1.3.11.3.1 below, if any of the conditions stated in 3.1.3.11.2 below persists:

a) radiation to cease

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

3.1.3.11.2 The condition requiring monitor action shall be the following;

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

b) for Facility Performance Category II localizer, a shift of 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 localizer, a shift of the mean course line from the runway center line equivalent to more than 6m (20ft) at the ILS reference datum ;

d) in the case of localizer 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 percent of the normal level (whichever comes first)

e) in the case of localizers in which the basic functions are provided by the use of a two-frequency system, a reduction of power output for either carrier to less than 80 per cent of normal, except that a greater reduction to between 80 per cent and 50 per cent of normal may be permitted, provided the localizer continues to meet the requirements of 3.1.3.3, 3.1.3.4 and 3.1.3.5 above.

Note: It is important to recognize that frequency change resulting in a loss of the frequency difference specified in 3.1.3.2.1 above may produce hazardous condition. This problem 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.

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 3.1.3.11.2 e) above, 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 results 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 above.

3.1.3.11.2.1 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.

3.1.3.11.3 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 3.1.3.11.2 above shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the localizer.

3.1.3.11.3.1 The total period referred to under 3.1.3.11.3 shall not exceed under any circumstances :

10 seconds for Category I localizers;
5 seconds for Category II localizers;
2 seconds for Category III localizers.

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 periods(s) of zero radiation, and time required to remove the navigation and identification component from the carrier, which might occur during action to restore service, for example, in the course of consecutive monitor functioning and consequent change-over(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.

3.1.3.11.3.2 Where practicable, the total period under 3.1.3.11.3.1 should be reduced so as not to exceed two seconds for Category II localizers and one second for Category III localizers.

3.1.3.11.4 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.

3.1.3.12 Integrity and continuity of service requirements.

3.1.3.12.1 The probability of not radiating false guidance signals shall not be less than 10.5x10-9 in any one landing for Facility Performance Categories II and III localizers.

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

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

a) $1\text{-}2\text{x}10^{-6}$ in any period of 15 seconds for Facility Performance Category II localizers or localizers intended to be used for the full range for Category III A operations (equivalent to 2000 hours mean time between outages) ; and

b) $1\text{-}2\text{x}10^{-6}$ 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 4000 hours mean time between outages).

3.1.3.12.4 The probability of not losing the radiated guidance signal should exceed 1-4x10 in any period of 15 seconds for Facility Performance Category I localizers (equivalent to 1000 hours mean time between outages).

3.1.4 Interference immunity performance for ILS localizer receiving system.

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

$$2N_1+N_2+\mathbf{72} \leq 0$$

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

$$2N_1+N_2+3(24-20\log \Delta f/0.4) \leq 0$$

for VHF FM sound broadcasting signals below 107.7 MHz,

where the frequencies of the two VHF FM sound broadcasting signals procedure, within the receiver, a two-signal, third-order inter-modulation product on the desired ILS localizer frequency.

N1 and N2 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.

F=108.1-f1, where f1 is the frequency of N1, 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)	**Maximum level of unwanted signal at receiver input (dBm)**
88-102	+15
104	+10
106	+ 5
107.9	-10

3.1.4.3 Intentionally left blank.

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 should be 3 degrees. ILS glide path angles in excess of 3 degrees should not be used except where alternative means of satisfying 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 RWY 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 (50ft). A tolerance of plus 3 m (10ft) is permitted.

3.1.5.1.5 The height of the ILS reference datum for facility performance category I - ILS should be 15 m (50 Feet). A tolerance of plus 3m (10) feet is permitted.

3.1.5.1.6 The height of the ILS reference datum for facility performance category I - ILS used on short precision approach RWY codes 1 and 2 should be 12m (40ft). A tolerance of plus 6m (20ft) is permitted.

3.1.5.2 Radio Frequency

3.1.5.2.1 The glide path equipment shall operate in the bank 328.6 MHz to 335.4 MHz. Where a single radio frequency carrier is used, the frequency tolerance shall not exceed 0.005 percent. Where two carrier glide path systems are used, the frequency tolerance shall not exceed 0.002 percent 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 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 (10nm) 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 above, the minimum field strength within this coverage sector shall be 400 μ volts per metre (minus 95 dbW/meter square). For facility performance category I glide paths, this field strength shall be provided down to a height of 30m (100ft) 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 (50ft) above the horizontal plane containing the threshold.

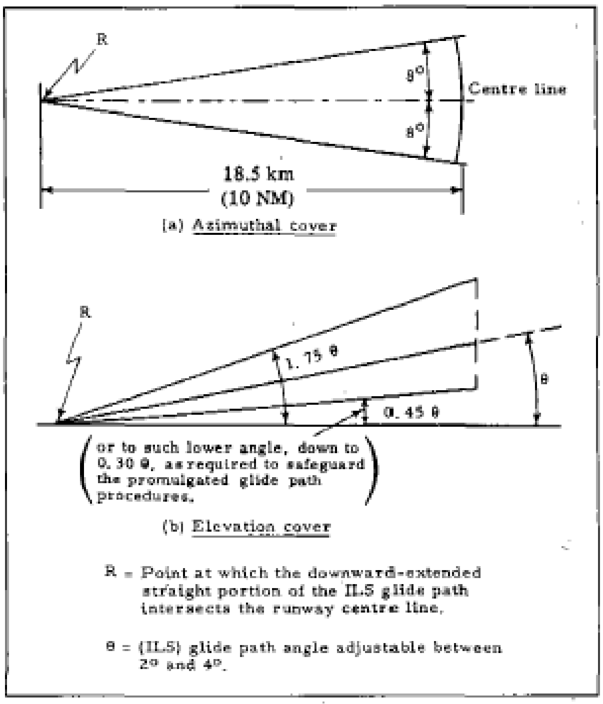


Figure 7

Note: Because of the siting problems and terrain limitations, some glide paths may not meet the standard coverage area described above. The information regarding such glide paths shall be published in AIP for each specific system.

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 to ILS point "C"	0.035

3.1.5.4.2 For facility performance categories II and III, ILS glide paths, bends in the glide path shall not have amplitudes which exceed the following.

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

3.1.5.5 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 percent along the ILS glide path. The depth of modulation shall not deviate outside the limits of 37.5 percent to 42.5 percent.

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 percent for facility performance category I – ILS.

b) The modulating tones shall be 90 Hz and 150 Hz within 1.5 percent for facility performance category II – ILS.

c) The modulating tones shall be 90 Hz and 150 Hz within 1 percent for facility performance category III – ILS.

d) The total harmonic content of the 90 Hz tone shall not exceed 10 percent. Additionally, for facility performance category III equipment, the second harmonic of the 90 Hz tone shall not exceed 5 percent.

e) The total harmonic content of the 150 Hz tone shall not exceed 10 percent.

3.1.5.5.2.1 For facility performance category I—ILS the modulating tones should be 90 Hz and 150 Hz within plus or minus 1.5 percent 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 percent.

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 path: 10 degrees

of phase relative to the 150 Hz components, every half cycle of the combined 90 Hz and 150 Hz wave form. (refer fig C-6 above)

3.1.5.5.3.1 With two frequency glide path systems, 3.1.5.5.3 above 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 cat I and II ILS glide paths 20 degrees.

b) For cat III ILS glide paths 10 degrees.

of phase relative to 90 Hz. Similarly, 150 Hz tones of the two carriers shall be phased locked so that the demodulated waveforms pass through zero in the same direction, within;

1) for Category I and II - ILS glide paths: 20 degrees;
2) for Category III ILS Glide paths : 10 degrees off phase relative to 150 Hz.

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 above 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 3.1.5.5.3.1 above.

3.1.5.6 Displacement sensitivity:

3.1.5.6.1 For facility performance CAT 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.

3.1.5.6.2 For facility performance CAT I ILS glide paths, the nominal angular displacement sensitivity should correspond to a DDM of 0.0875 at 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 above.

3.1.5.6.3 For facility performance CAT 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.
b) 0.012 θ above path with a tolerance of plus 0.02 θ and minus 0.05 θ.

3.1.5.6.4 For facility performance CAT 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 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 CAT I ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 25 percent of the nominal value selected.

3.1.5.6.7 For facility performance CAT II ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 20 percent of the nominal value selected.

3.1.5.6.8 For facility performance CAT III ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 15 percent 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 3.1.5.7.3.1 if any of the following conditions persist:

a) Shift of the mean ILS glide path angle equivalent to more than minus 0.075 deg to plus 0.10 deg from deg.

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 percent 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 percent of normal, except that a greater reduction to between 80 percent and 50 percent 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.

d) For facility performance CAT 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 deg 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 CAT II and III ILS glide paths, a change of displacement sensitivity to a value differing by more than 25 percent from the nominal value.

f) Lowering of the line beneath the ILS glide path at which a DDM of 0.0875 is realized to less than 0.7475 deg from horizontal.

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

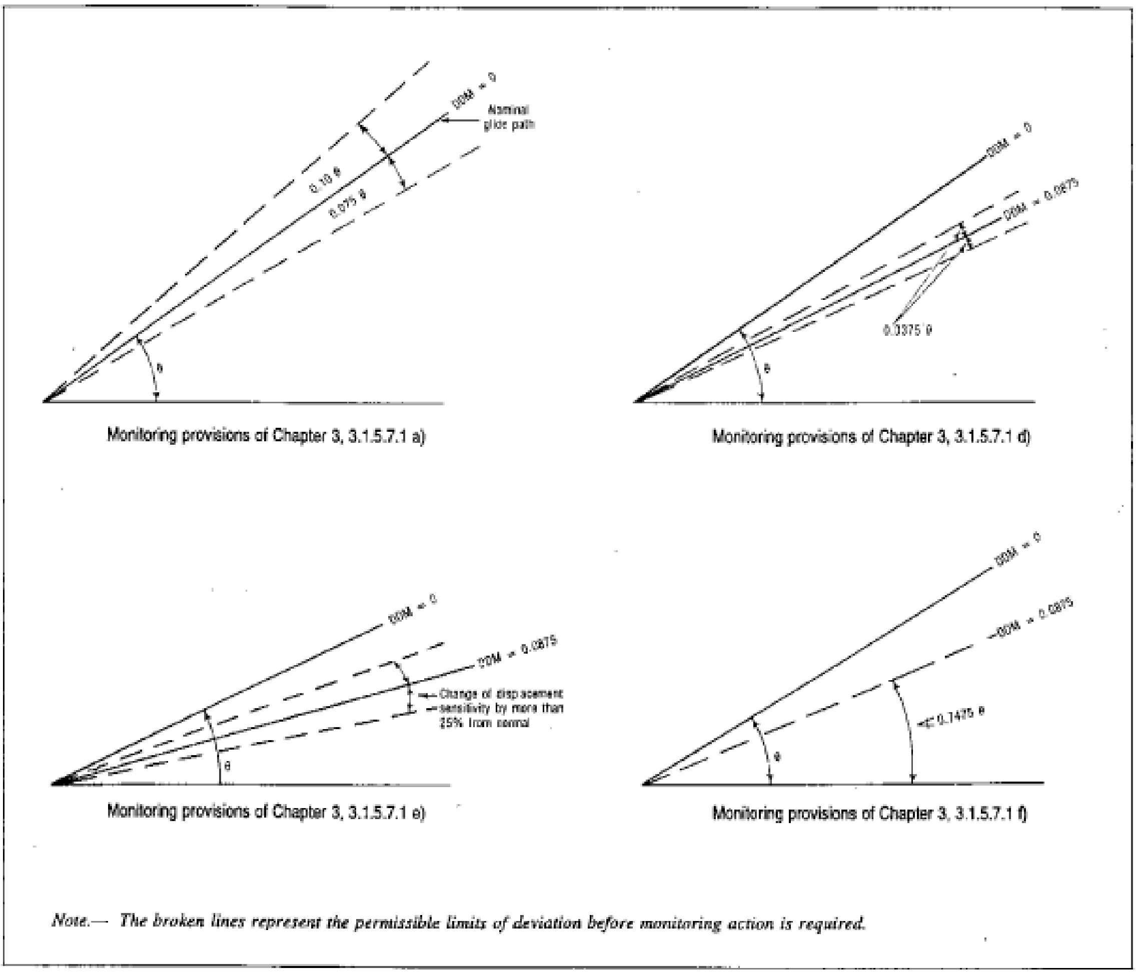


Figure 8

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.

Note 2: Sub paragraphs 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 sec 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 periods 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 CAT I ILS glide paths
2 seconds for CAT 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 changeover to glide path equipments 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 above 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 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 x 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 shall not be less than 1- 1.0 x 10^{-7} in any one landing for Facility Performance Category II glide paths.

3.1.5.8.3 The probability of not losing the radiated guidance signal shall be greater than 1- 2 x 10^{-6} in any period of 15 seconds for Facility Performance Categories II and II glide paths (equivalent to 2000 hours mean time between outages).

3.1.5.8.4 The probability of not losing the radiated guidance signal should exceed 1- 4 x 10^{-6} in any period of 15 seconds for Facility Performance Category I glide paths (equivalent 10 00 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 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)	
108.1	334.7	
108.15		334.55
108.3	334.1	
108.35		333.95
108.5	329.9	
108.55		329.75
108.7	330.5	
108.75		330.35
108.9	329.3	
108.95		329.15
109.1	331.4	
109.15		331.25
109.3	332.0	
109.35		331.85
109.5	332.6	
109.55		332.45
109.7	333.2	
109.75		333.05
109.9	333.8	
109.95		333.65
110.1	334.4	
110.15		334.25
110.3	335.0	
110.35		334.85
110.5	329.6	

110.55		329.45
110.7	330.2	
110.75		330.05
110.9	330.8	
110.95		330.65
111.1	331.7	
111.15		331.55
111.3	332.3	
111.35		332.15
111.5	332.9	
111.55		332.75
111.7	333.5	
111.75		333.35
111.9	331.1	
111.95		333.95

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 than 20 pairs, they shall be selected sequentially, as required, from the following list:

Sequence Number	Localizer (MHz)	Glide (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
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

3.1.6.2 Where existing ILS localizers meeting national requirements are operating on frequencies ending even tenths of megahertz, they shall be re-assigned 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 re-assignment can be effected.

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 0odd tenths plus one twentieth of megahertz except where, by regional agreement, general use may be made of any of the channels listed in 3.1.6.1 (see CAR Section 4 Series 'D' Part VI Para 4.4.2).

3.1.7 VHF Marker beacons

3.1.7.1 General

a) There shall be two market beacons in each installation except as provided in 3.1.7.6.5. A third marker beacon may be added whenever, in the opinion of the Competent Authority, an additional beacon is required because of operational procedures at particular site.

b) The marker beacons shall conform to the requirements prescribed in 3.1.7. When the installation comprises only two market beacons, the requirements applicable to the middle marker and to the outer marker shall be complied with.

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 localizer, it shall conform to the marker beacon characteristics specified 3.1.7.

3.1.7.1.2 Identification signals of marker beacons used in conjunction with the back course of 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:** (where installed): 150 m plus of minus 50 m (500 ft plus or minus 160ft)

b) **Middle marker:** 300 m plus or minus 100m (1000ft plus of minus 325 ft)

c) **Outer marker:** 600m plus or minus 200m (2000ft 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 be 1.5 millivolts per metre (minus 82 dB W/m^2). In addition, the field strength within the coverage area shall rise to at least 3.0 millivolts per metre (76 dB W/m^2).

Note 1: Satisfactory operation of 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 metre (minus 82 dB W/m^2).

3.1.7.4 Modulation

3.1.7.4.1 The modulation frequencies shall be as follows:

a) **Inner marker:** (when installed): 3000Hz

b) **Middle marker:** 1300 Hz:

c) **Outer marker:** 400 Hz

The frequency tolerance of the above frequencies shall be plus of 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 per cent.

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:** (when installed): 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, when installed, 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, when installed, should be located between 75 m (250ft) and 450 m (1500 ft) from the threshold and at not more than 30 m (100ft) from the extended centre line of the runway.

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 should be located 1050m (3500ft) plus or minus 150 m (500ft), 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 with 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 market beacon component of the ILS, shall be published in accordance with the provisions of CAR Section 4 Series ‘X’ Part II.

3.1.7.6.5.1 When so used, the DME shall provide distance information operationally equivalent to that furnished by Marker Beacons.

3.1.7.6.5.2 When used as an alternative for the Middle Marker, the DME shall be frequency paired with ILS Localizer and sited so as to minimize the error in distance information.

3.1.7.6.5.3 The DME in 3.1.7.6.6 above shall conform to the specification in 3.5 below.

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 should 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

3.2.1 Intentionally left blank

3.2.2 Intentionally left blank

3.2.3 Intentionally left blank

3.2.4 The Surveillance Radar element (SRE)

3.2.4.1 A Surveillance Radar used as SRE of a Precision Approach Radar System shall satisfy at least the following broad performance requirements.

3.2.4.2 Coverage

3.2.4.2.1 The SRE shall be capable of detecting aircraft of 50 m square echoing area and larger, which are in light of sight of the antenna within a volume described as follows:

The rotation through 360 degrees about the antenna of 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 line up to 2004 m (8000 ft) above the level of antenna; by a horizontal line at 2004 m (8000 ft) from 37 Km (20 NM) back towards the antenna to the intersection with a line from the antenna at 20 º above the horizontal plane of the antenna, and by a 20 º line from the intersection with the 2004 m (8000 ft) line to the antenna.

3.2.4.2.2 Efforts should be made in development to increase the coverage on an aircraft of 50 m square echoing area to at least the volume obtained by amending 3.2.4.2.1 above with the following substitution.

-- for 1.5 º, read 0.5 º
-- for 37 Km (20 NM), read 46.3 Km (20 NM)
-- for 2400 m (8000 ft), read 3000 m (10000 ft)
-- for 20 º, read 30 º

3.2.4.3 Accuracy

3.2.4.3.1 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 position of two aircraft which are at 4 º of azimuth of one another.

3.2.4.3.2 Distance Accuracy: The error in distance indication shall not exceed 5 percent of true distance or 150 m, whichever is the greater. It shall be possible to resolve the position of two aircraft that are separated by a distance of 1 percent of the true distance from the point of observation or 230 m whichever is greater.

3.2.4.3.2.1 The error in distance indication should not exceed 3 percent of the true distance of 150 m, whichever is the greater.

3.2.4.4 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 ever 4 seconds.

3.2.4.5 Efforts should be made to reduce, as far as possible, the disturbance caused by ground echoes.

3.3 Specification for VHF Omni Directional 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 (bearing), degree for degree from magnetic North as measured from the location of the VOR.

3.3.1.2 The VOR shall radiate a radio frequency carrier with which are 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.

3.3.1.3 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 sideband 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. The channel separation shall be in increments of 50 KHZ. The frequency tolerance of the radio frequency carrier where 50 KHz channel spacing is in use shall be plus or minus 0.002 per cent. The highest assignable frequency shall be 117.950 MHz The channel separation shall be in increments of 50 KHz referred to the highest assignable frequency. In areas where 100 KHz or 200 KHz channel spacing is in general use, the frequency tolerance of the radio frequency is in general use, the frequency tolerance of the radio frequency carrier shall be plus or minus 0.005 percent.

3.3.2.2 The frequency tolerance of the radio frequency carrier of all installations in India where 50 KHz channel spacing is in use shall be plus or minus 0.002 percent.

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 percent.

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.

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 elevations angles between 0 to 40 degrees, measured from the center 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 satisfactorily operation of a typical aircraft installation at the minimum service level at the maximum specified service radius should be 90 micro volt per meter or minus 107 db W/m square.

3.3.5 Modulation of navigational signals:

3.3.5.1 The radio frequency carrier as observed at any point in space shall be amplitude modulated by two signals as described below:

a) a sub carrier of 9960 Hz of constant amplitude, frequency modulated at 30 Hz r)

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

2) For the Doppler VOR, the phase of the 30 Hz component varies with azimuth and is termed the “variable phase” and shall have a deviation ratio of 16 plus or minus 1 (i.e. 15 to 17) when observed at any angle of elevation up to 15 degrees, with a minimum deviation ratio of 11 when observed at any angle of elevation above 15 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 30 Hz signal or sub carrier of 9960 Hz shall be within the limits of 28 percent and 32 percent.

3.3.5.3 The depth of modulation of the radio frequency carrier due to the 30 Hz, as observed at any angle of elevation up to 5 degrees, shall be within 25 to 35 percent. The depth of modulation of the radio frequency carrier due to the 9960 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. Doc 8071 contains additional information on 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 percent.

3.3.5.5 The sub carrier modulation mid-frequency shall be 9960 Hz within plus or minus 1 percent.

3.3.5.6 a) For the conventional VOR, the percentage of amplitude modulation of the 9960 Hz sub carrier shall not exceed 5 percent.

b) For the Doppler VOR, the percentage of amplitude modulation of the 9960 Hz subcarrier shall not exceed 40 percent when measured at a point at least 300 m (1000ft) from the VOR.

3.3.5.7 Where 50 KHz VOR channel spacing is implemented, the sideband level of the harmonics of the 9960 Hz component in the radiated signal shall not exceed the following levels referred to the level of the 9960 Hz sideband:

Subcarrier	Level
9960Hz	0 dB reference
2nd Harmonics	- 30 dB
3rd Harmonics	-50 dB
4th Harmonics & above	-60 dB

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 percent.

3.3.6.3 The audio frequency characteristics of the speech channel shall be within 3dB relative to the level 1000Hz over the range 300Hz to 3000Hz.

3.3.6.4 The VOR shall provides 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 minutes. The signal shall be repeated at least once every 30 seconds and the Modulation tone shall be 1020Hz within plus or minus 50Hz.

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.

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 percent 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 to 20 percent.

3.3.6.6.1 If the VOR provide the simultaneous communication channel ground to air, the modulation depth of the code identification signal should be 5 plus or minus 1 percent 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 signal conditions encountered within the specified coverage limits, and with the modulation parameters specified at 2.6.5, 2.6.7 and 2.6.9 above

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 to a control point and either remove the identification and navigational components from the carrier or cause radiation to cease if any one or a combination of the following deviations from established arises:

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

b) A reduction of 15 percent in the modulation components of the radio frequency signals voltage level at the monitor of either the sub carrier, or 30 Hz amplitude modulation signals or both.

Note: Where it is not possible to provide status indication to a control point, the same shall be published in AIP.

3.3.7.2 Failure of Monitor itself shall transmit a warning to a control point and either:

a) By removing the identification and navigations 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 signals, third order inter-modulation products caused by VHF FM broadcast signals having levels in accordance with the following:

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

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

$$2N_1 + N_2 + 3\,(24 - 20 \log \Delta f / 0.4) \leq 0$$

for VHF FM sound broadcasting signals below 107.7 MHz,

where the frequencies of the two VHF FM sound broadcasting signals produced, within the receiver, at two signal, third order inter-modulation 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 below.

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

3.3.8.2 The VOR receiving system shall not 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
88 – 102	+ 15 dBm
104	+ 10 dBm
106	+ 5 dBm
107.9	- 10 dBm

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 areas as the rated coverage.

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

Locator: An LF/MF NDB used 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 micro volts 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 150NM) 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 (150NM) 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 factors, its classifications 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.

3.4.3 Limitations in radiated power

The power radiated from an NDB shall not exceed by more than 2dB 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 1750 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 15KHZ to ensure correct operation of the radio compass and preferably not more than 25KHZ 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.

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 the on/off keying of the carrier. In this latter case, the identification shall be at approximately I-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 rate 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 from identification shall be 1020 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 conjunctions 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 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 (50NM), may be identified by on/off keying of the un modulated carrier (NON/AIA) 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/AIA 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: The foregoing requirement necessitates as high a percentage modulation as practicable, together with maintenance of an adequate radiated carrier power during identification.

3.4.6.4 The carrier power of an NDB with NON/A2A emissions should not fall when the identify 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 between 30 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.

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 location to those applying when an ILS is installed should be selected, taking into account the relevant obstacle clearance provisions of the ICAO Doc 8168 – Procedures for Air Navigation Services (Aircraft Operations)

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 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) above.

3.4.8.4 During the hours of service of an NDB other than a locator, the means of monitoring should 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 1: In the following section, provision is made for two type of DME facility: DME/N for general application and DME/P as outlined in 3.11.3 below.

3.5.1 Definition

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 below)

DME dead time: A period immediately following the decoding of a valid interrogation during which a received interrogation will not cause a reply to be generated. (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 enroute of TMA navigation, where the “N” stands for narrow spectrum characteristics ~~(to be distinguished from “W”).~~

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 (E.I.R.P.): 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).

Key down time: The time during which a dot or dash or a Morse character is being transmitted.

Mode W, X, Y, Z, A Method of coding DME transmission 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 hand I on Figure 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 below).

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 point e and g on Figure 3-1.

Pulse code: The method 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 on to 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)

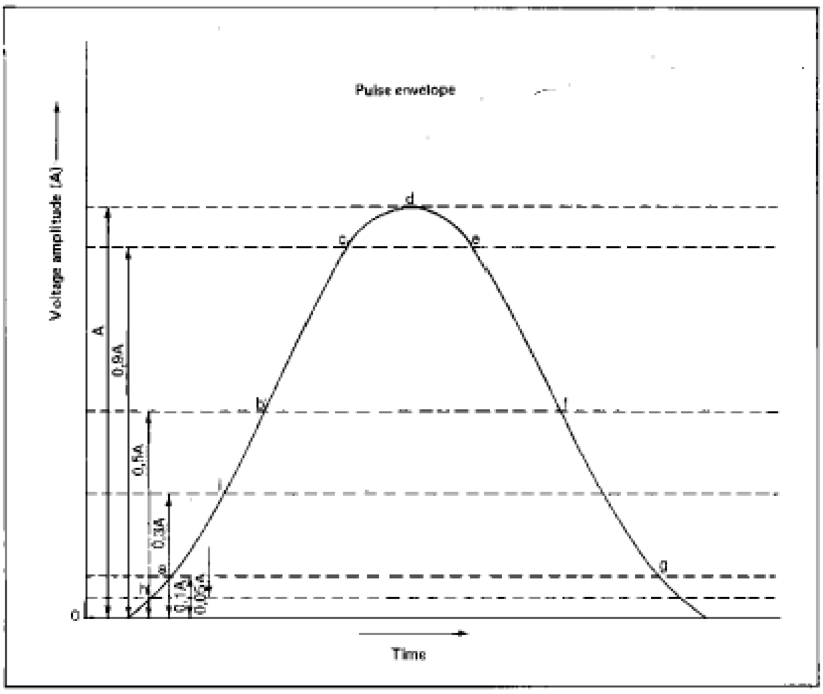


Figure 3 - 1

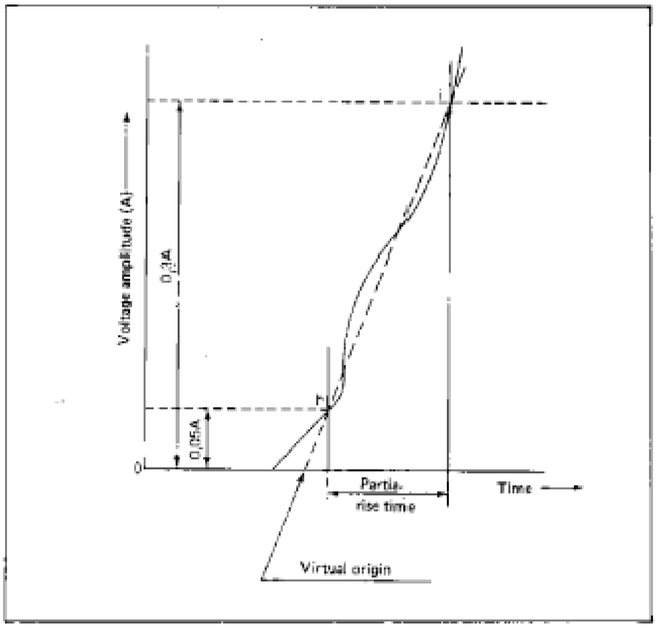


Figure 3 - 2

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.

3.5.2.4 Intentionally left blank

3.5.2.5 When a DME associated with either an ILS or VOR for the purpose of constituting a single facility, they shall be considered to be associated in a manner complying with para 2.2.2 only when :

a) they shall be operated on a standard frequency pairing in accordance with 3.5.3.3.5 below;

b) they shall be Collocated within the limits prescribed for associated facilities in 3.5.2.6 below;

c) they shall comply with the identification provisions of 3.5.3.6.4 below.

3.5.2.6 Collocation limits for a DME facility associated with an ILS. MLS or VOR facility

3.5.2.6.1 Associated VOR and DME facilities shall be collocated in accordance with following:

a) for those facilities used in terminal areas for approach purpose 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 80m (260ft)

b) for purposes other than those indicated in a) the separation of the VOR and DME antennas does not exceed 600m (2000ft).

3.5.2.6.2 Association of DME with ILS

3.5.2.6.2.1 When DME is used as an alternative to ILS marker beacons, the DME should be located on the airport so that the zero range indication will be a point near the Runway.

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

3.5.2.6.2.3 The use of DME as an alternative to the Middle Marker beacon assumes a DME system accuracy of 0.37 km (0.2NM) or better and resolution of the air bore indication such as to allow this accuracy to be attained.

3.5.2.6.2.4 When DME is used as an alternative for the outer marker, frequency pairing is preferred to simplify pilot operation and to enable aircraft with two ILS receivers to use both receivers on the ILS channels.

3.5.2.6.2.5 When the DME is frequency paired with the localizer, the DME transponder identification should be obtained by the "associated" signal from the frequency paired localizer

3.5.2.7 The Standards in 3.5.3, 3.5.4 and 3.5.5 denoted by ‡ shall apply only to DME equipment first installed after 1 January 1989.

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 and DME/N coverage shall be at least that of the VOR to the extent practicable.

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

3.5.3.1.3 Accuracy

3.5.3.1.3.1 System accuracy: The accuracy standards specified in 3.5.3.1.3.4, 3.5.4.5 and 3.5.5.4 shall be met on at 95 percent probability basis.

3.5.3.2 Radio frequencies and polarization: The system shall operate with vertical polarization in the frequency band 960 MHz to 1215 MHz. The interrogation and reply frequencies shall be assigned with 1 MHz 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 Intentionally left blank

3.5.3.3.3 DME operating channels shall be chosen from Table A of 352 channels in which the channel numbers, frequencies, and pulse codes are assigned.

3.5.3.3.4 Channel pairing: When a DME transponder is intended to operate in association with a single VHF navigation facility in the 108 MHz to 117.95 MHz frequency band and the DME operating channel shall be paired with the VHF channel as given in table A.

3.5.3.4 Interrogation pulse repetition frequency

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 percent of the time is occupied for tracing.

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 airs of pulses per second.

3.5.3.4.3 DME/N: After 15000 pairs of pulses have been transmitted without acquiring indication of distance, the PRF should not exceeds 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.

3.5.3.5 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 of 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 below:

a) An “independent” identification consisting of coded (international Morse Code) identity pulses which can be used with all transponders.

b) An “associated” signal which can be used for transponders specifically associated with a VHF navigation facility which itself transmits 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 1350 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 below. These pulses shall have similar characteristics to the other pulses of the reply signals.

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

3.5.3.6.2.2DME/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 1350 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 above)

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

3.5.3.6.5.2 Wherever a transponder is specifically associated with a VHF navigational facility identification shall be provided by the “associated” code.

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

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 above).

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: DME/N 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 E.I.R.P contained in a 05 MHz band centered 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 E.I.R.P contained in a 05 MHz band centered on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2mW.The E.I.R.P contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.

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

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.

3.5.4.1.4.2DME/N The tolerance on the pulse spacing shall be plus or minus 0.25 microsecond.

3.5.4.1.4.3DME/N The tolerance on the DME/N pulse spacing should be plus or minus 01.10 microsecond.

3.5.4.1.4.4 Intentionally left blank

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

3.5.4.1.5 Peak power output

3.5.4.1.5.1DME/N The E.I.R.P power should not be less than that required to ensure a peak pulse power density of minus 89 Dbw/m^2 under all l operational weather conditions at any point within coverage specified in 3.5.3.1.2 above.

3.5.4.1.5.2DME / N. The peak equivalent isotropically radiated power shall not be less than that required to ensure peak pulse power density of minus 89 dBW / m^2 under all operational weather condition at any point with in coverage specified in 3.5.3.1.2 above.

Note: Although the Standard 3.5.4.1.5.2 above implies an improved interrogator receiver sensitivity, it is intended that the power density specified in 3.5.4.1.5.1 above be available at the maximum specified service range and level.

3.5.4.1.5.3 Intentionally left blank

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

3.5.4.1.5.5 The reply capability of the transmitter should be such that the transponder should be capable of continuous operation at a transmission rate of 2700 plus or minus 90 pulse pairs per second (if 100 aircraft are to be served).

3.5.4.1.5.6 The transmitter shall operate at a transmission rate, including randomly distributed pulse pairs and distance reply pulse pairs, of not less than 700 pulse pairs per seconds except during identity. The minimum transmission rate shall be as close as practicable to 700 pulse pairs per seconds.

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 above shall be more than 80 dB below the peak pulse power level.

3.5.4.1.6.2 Intentionally left blank

3.5.4.1.6.3 **Out of band spurious radiation:** At all frequencies from 10 to 1800 MHz but excluding the band of frequencies from 960 to 1215 MHz, the spurious output of the DME transponder transmitter shall not exceed minus 40 dBm in any one kHz of receiver bandwidth.

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

3.5.4.2 Receiver

3.5.4.2.1 Frequency of operation: The receiver center frequency shall be the interrogation frequency appropriate to the assigned DME operating channel (see 3.5.3.3.3 above)

3.5.4.2.2 Frequency stability: The centre frequency of the receiver shall not vary more than plus or minus 0.002 percent from the assigned frequency.

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 minus103 dBW/m^2 for DME/N.

3.5.4.2.3.2 The minimum power densities specified in 3.5.4.2.3.1 above shall cause the transponder to reply with an efficiency of at least 70 percent 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 above 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 Intentionally left blank

3.5.4.2.3.5 The transponder sensitivity level shall not vary by more than 1 dB for transponder loadings between 0 and 90 percent of its maximum transmission rate.

3.5.4.2.3.6 DME/N .When the spacing of an interrogator pulse pair varies from the nominal value by up to plus or minus 1 microsecond, the receiver sensitivity shall not be reduced by more than 1 Db.

3.5.4.2.4 Load limiting:

3.5.4.2.4.1 DME/N: When transponder loading exceeds 90 percent 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 above to produce a transmission rate equal to 90 percent of the maximum, the noise generated pulse pairs shall not exceed 5 per cent of the maximum transmission rate.

3.5.4.2.6 Band width

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 then 3dB 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 above when the input signals are those specified in 3.5.5.1.3 below.

3.5.4.2.6.3 Intentionally left blank

3.5.4.2.6.4 Intentionally left blank

3.5.4.2.6.5 Signals greater than 900 kHz removed from the desired channel nominal frequency and having power densities up to the values specified in 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 80dB. All other spurious response or signals within the 9mmhz to 1215 MHz band and image frequencies shall be suppressed at least 75 dB.

3.5.4.2.7 Recovery time. Within 8 micro second of the reception of a signal between 0db and 60db above minimum sensitivity level, the minimum sensitivity level of the transponder to a desired signal shall be within 3db of the value obtained in the absence of signals. This requirement shall be met with echo suppression circuits, if any rendered in operative. 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 3.5.1.3 below.

3.5.4.2.8 Spurious Radiations: Radiation from any part of the receiver or allied circuits shall meet the requirements stated in 3.5.4.1.6 above

3.5.4.2.9 CW and echo suppression: CW and echo suppression should be adequate for the sites at which the transponder will be used.

Note: In this connection, echoes mean undesired signals caused by multi path transmission (reflection, etc).

3.5.4.2.10 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 appropriate to interrogator signals as described in 3.5.5.1.3 and3.5.5.1.4 below.

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 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.

3.5.4.4 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 half voltage point on the reply transmission. This delay shall be consistent with the following table, when it is desired that aircraft interrogations are to indicate distance from transponder site.

Channel Suffix	Operating mode	Pulse pair spacing (micro µs)		Time delay (micro µs)	
		Interr.	Reply	1st pulse timing	2nd Pulse timing
X	DME/N	12	12	50	50
Y	DME/N	36	30	56	50

3.5.4.4.2 Intentionally left blank

3.5.4.4.3 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 micro-seconds and the nominal value of the time delay, to permit aircraft interrogations to indicate zero distance at a specific point remote from the transponder site.

Note: Modes not allowing for 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

3.5.4.4.3.1DME/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.

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

Note: 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 (500ft) to the over-all system error.

3.5.4.5.1.1DME/N..— The contribution to the total system error due to the combination of the transponder errors, transponder location co-ordinate 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 tie 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 (75m (250ft) to the over-all 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 above and at the minimum sensitivity level specified in 3.5.4.2.3.1 and 3.5.4.2.3.5 above.

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 below 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.

Note : Where it is not possible to provide status indication to a control point, the same shall be published in AIP.

3.5.4.7.2.2 The monitor shall cause the actions specified in 3.5.4.7.2.1 above if:

a) the transponder delay differs from the assigned value by 1 microseconds(75m(500ft)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 microseconds(75m(250ft) or more;

3.5.4.7.2.3 The monitor should cause the action specified in 3.5.4.7.2.1 above 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 above by 1 microsecond or more.

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

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

b) a fall of 6dB 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 above 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 above which are monitored can persist for a certain period before the monitor takes the 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.

3.5.4.7.3 DME/P monitoring action

3.5.4.7.3.1 Intentionally left blank
3.5.4.7.3.2 Intentionally left blank
3.5.4.7.3.3 Intentionally left blank
3.5.4.7.3.4 Intentionally left blank

3.5.4.7.3.5 DME/N monitor failure: Failure of any part of the monitor itself shall automatically produce the same results as the malfunctioning of the element being monitored.

3.5.5 Technical characteristics of interrogator

Note: The following sub paragraph specifies 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 above)

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** for DME/N shall not exceed 3 micro seconds.

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

c) **Pulse decay time** shall normally 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 percent of maximum amplitude and the point of trailing edge which id 95 percent of the maximum amplitude, fall below a value which is 95 percent of the maximum voltage amplitude of the pulse.

e) The spectrum of the pulse modulated signal shall be such that at least 90 percent of the energy in each pulse shall be within 0.5 MHz in a band centered on the nominal channel frequency.

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

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 above.

3.5.5.1.4.2 DME/N. The tolerance on the pulse spacing shall be plus or minus 0.5 microseconds.

3.5.5.1.4.3 DME/N The tolerance on the pulse spacing should be plus or minus 0.25 microseconds.

3.5.5.1.4.4 Intentionally left blank

3.5.5.1.4.5 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 above.

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 applied in the same aircraft, it may be necessary to provide protection to airborne SSR in the band 1 015 MHz to 1 045 MHz. This protection may be provided by limiting conducted and radiated CW to a level of the order of minus 77 dBW. Where this level can not 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 condition stated in 3.5.5.1.6 above should be 80 dB below the required peak pulse power received.

Note: Reference 3.5.5.1.6 and 3.5.5.1.7 above—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 transponder 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 above.

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 above).

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 below for the signal power density specified in 3.5.4.1.5.2 above.

3.5.5.3.2.2 Intentionally left blank

3.5.5.3.2.3 DME/N. The performance of the interrogator shall be maintained when the power density of the transponder signal at the interrogator antenna is between the minimum values given in 3.5.4.1.5 above and a maximum of minus18 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 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 micro seconds, 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 315m (plus or minus 0.17NM) or 0.25 per cent of indicated range, whichever is greater to overall system error.

3.6 Intentionally left blank

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.

GAGAN: GPS Aided GEO Augmented Navigation, An Indian SBAS

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.

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) Intentionally Left Blank

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 Annex 4, Chapter 2, Annex 11, Chapter 2, Annex 14, Volumes I and II,Chapter 2 and Annex 15, 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

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.*

Table 3.7.2.4-1 Signal-in-space performance requirements

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

NOTES-

1.*The 95th-percentile values for GNSS position errors are those required for the intended operation at the lowest height above threshold (HAT), if applicable. Detailed requirements are specified in Appendix B and guidance material is given in Attachment D. 3.2.*

2.*The definition of the integrity requirement includes an alert limit against which the requirement can be assessed. For Category I precision approach, a vertical alert limit (VAL) greater than 10 m for a specific system design may only be used if a system-specific safety analysis has been completed. Further guidance on the alert limits is provided in Attachment D. 3.3.6 to 3.3.10. These alert limits are:*

Typical operation	Horizontal alert limit	Vertical alert limit
En-route (oceanic/continental low density)	7.4 km (4 NM)	N/A

En-route (continental)	3.7 km (2 NM)	N/A
En-route, Terminal	1.85 km (1 NM)	N/A
NPA	556 m (0.3 NM)	N/A
APV-I	40 m (130 ft)	50 m (164 ft)
APV-II	40 m (130 ft)	20.0 m (66 ft)
Category I precision approach	40 m (130 ft)	35.0 m to 10.0 m (115 ft to 33 ft)

***3.** The accuracy and time-to-alert requirements include the nominal performance of a fault-free receiver.*

***4.** Ranges of values are given for the continuity requirement for en-route, terminal, initial approach, NPA and departure operations, as this requirement is dependent upon several factors including the intended operation, traffic density, complexity of airspace and availability of alternative navigation aids. The lower value given is the minimum requirement for areas with low traffic density and airspace complexity. The higher value given is appropriate for areas with high traffic density and airspace complexity (see Attachment D. 3.4.2). Continuity requirements for APV and Category I operations apply to the average risk (over time) of loss of service, normalized to a 15-second exposure time (see Attachment D. 3.4.3).*

***5.** A range of values is given for the availability requirements as these requirements are dependent upon the operational need which is based upon several factors including the frequency of operations, weather environments, the size and duration of the outages, availability of alternate navigation aids, radar coverage, traffic density and reversionary operational procedures. The lower values given are the minimum availabilities for which a system is considered to be practical but are not adequate to replace non-GNSS navigation aids. For en-route navigation, the higher values given are adequate for GNSS to be the only navigation aid provided in an area. For approach and departure, the higher values given are based upon the availability requirements at airports with a large amount of traffic assuming that operations to or from multiple runways are affected but reversionary operational procedures ensure the safety of the operation (see Attachment D, 3.5).*

***6.** A range of values is specified for Category I precision approach. The 4.0 m (13 feet) requirement is based upon ILS specifications and represents a conservative derivation from these specifications (see Attachment D, 3.2.7).*

***7.** GNSS performance requirements for Category II and III precision approach operations are under review and will be included at a later date.*

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

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.They apply under the conditions specified in Appendix B,3.1.3.1.1*

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

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 —30m(100 ft)with reliability specified in 3.7.3.1.3

b) 95th percentile range rate error of any satellite —0.006m (0.02ft) per second;(global average);

c) 95th percentile range acceleration error of any satellite —0.002m (0.006ft) per second-squared(global average); and

d) 95th percentile range error for any satellites over all time differences between time of data generation and time of use of data 7.8m (26 ft) (global average).

3.7.3.1.2 *Availability*. The GPS SPS availability shall be as follows:

≥99 per cent horizontal service availability, average location (17 m 95 per cent threshold)

≥99 per cent vertical service availability, average location (37 m 95 per cent threshold)

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

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

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

a) Reliability — at least 99.94 per cent (global average); and

b) Reliability — at least 99.79 per cent (worst single point average).

3.7.3.1.4 Probability of major service failure. The probability that the user range error (URE) of any satellite will exceed 4.42 times the upper bound on the user range accuracy (URA) broadcast by that satellite without an alert received at the user receiver antenna within 10 seconds shall not exceed $1x10^{-5}$ per hour.

Note.— The different alert indications are described in the United States Department of Defense, *Global Positioning System - Standard Positioning Service - Performance Standard,* 4th Edition, September 2008, Section 2.3.4.

3.7.3.1.5 Continuity. The probability of losing GPS SPS signal-in-space (SIS) availability from a slot of the nominal 24-slot constellation due to unscheduled interruption shall not exceed $2x10^{-4}$ per hour

3.7.3.1.6 Coverage. The GPS SPS shall cover the surface of the earth up to an altitude of 3000 kilometres.

Note.— Guidance material on GPS accuracy, availability, reliability and coverage is given in Attachment D, 4.1

3.7.3.1.7 Intentionally left blank.

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

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

3.7.3.1.10 ***Navigation information.*** The navigation data transmitted by the satellites shall include the necessary information to determine:

a) satellite time of transmission;
b) satellite position;
c) satellite health;
d) satellite clock correction;
e) propagation delay effects;
f) time transfer to UTC; and

g) constellation status.

Note.— *Structure and contents of data are specified in Appendix B, 3.1.1.2 and 3.1.1.3, respectively.*

3.7.3.2 *GLONASS Channel of Standard Accuracy (CSA) (L1)*

Note.— *In this section, the term GLONASS refers to all satellites in the constellation. Standards relating only to GLONASS-M satellites are qualified accordingly.*

3.7.3.2.1 *Space and control segment accuracy*

Note.— *The following accuracy Standards do not include atmospheric or receiver errors as described in Attachment D, 4.2.2*

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

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

3.7.3.2.1.2*Time transfer accuracy.* The GLONASS CSA time transfer errors shall not exceed 700 nanoseconds 95 per cent of the time.

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

a) range error of any satellite — 18 m (59.7 ft);
b) range rate error of any satellite — 0.02 m (0.07 ft) per second;
c) range acceleration error of any satellite — 0.007 m (0.023 ft) per second squared;
d) root-mean-square range error over all satellites — 6 m (19.9 ft).

3.7.3.2.2 *Availability.* The GLONASS CSA availability shall be as follows:

a) ≥99 per cent horizontal service availability, average location (12 m, 95 percent threshold);
b) ≥99 per cent vertical service availability, average location (25 m, 95 percent threshold);
c) ≥90 per cent horizontal service availability, worst-case location (12 m, 95 per cent threshold);
d) ≥90 per cent vertical service availability, worst-case location (25 m, 95 per cent threshold).

3.7.3.2.3 *Reliability.* The GLONASS CSA reliability shall be within the following limits:

a) frequency of a major service failure — not more than three per year for the constellation (global average); and
b) reliability — at least 99.7 per cent (global average).

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

Note.— *Guidance material on GLONASS accuracy, availability, reliability and coverage is given in Attachment D, 4.2.*

3.7.3.2.5 ***RF characteristics***

Note.— *Detailed RF characteristics are specified in Appendix B, 3.2.1.1.*

3.7.3.2.5.1 *Carrier frequency.* Each GLONASS satellite shall broadcast CSA navigation signal at its own carrier frequency in the L1 (1.6 GHz) frequency band using frequency division multiple access (FDMA).

Note 1.— *GLONASS satellites may have the same carrier frequency but in this case they are located in antipodal slots of the same orbital plane.*

Note 2.— *GLONASS-M satellites will broadcast an additional ranging code at carrier frequencies in the L2 (1.2 GHz) frequency band using FDMA.*

3.7.3.2.5.2 ***Signal spectrum.*** GLONASS CSA signal power shall be contained within a ±5.75 MHz band centered on each GLONASS carrier frequency.

3.7.3.2.5.3 ***Polarization*****.** The transmitted RF signal shall be right-hand circularly polarized.

3.7.3.2.5.4 ***Signal power level*****.** Each GLONASS satellite shall broadcast CSA navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the output of a 3 dBi linearly polarized antenna is within the range of –161 dBW to –155.2 dBW for all antenna orientations orthogonal to the direction of propagation.

Note 1.— *The power limit of 155.2 dBW is based on the predetermined characteristics of a user antenna, atmospheric losses of 0.5 dB and an error of an angular position of a satellite that does not exceed one degree (in the direction causing the signal level to increase).*

Note 2.— *GLONASS-M satellites will also broadcast a ranging code on L2 with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the output of a 3 dBi linearly polarized antenna is not less then –167 dBW for all antenna orientations orthogonal to the direction of propagation.*

3.7.3.2.5.5 Modulation

3.7.3.2.5.5.1 Each GLONASS satellite shall transmit at its carrier frequency the navigation RF signal using a BPSKmodulated binary train. The phase shift keying of the carrier shall be performed at π-radians with the maximum error ±0.2 radian. The pseudo-random code sequence shall be repeated each millisecond.

3.7.3.2.5.5.2 The modulating navigation signal shall be generated by the Modulo-2 addition of the following three binary signals:
a) ranging code transmitted at 511 kbits/s;
b) navigation message transmitted at 50 bits/s; and
c) 100 Hz auxiliary meander sequence.

3.7.3.2.6 ***GLONASS time.*** GLONASS time shall be referenced to UTC(SU) (as maintained by the National Time Service of Russia).

3.7.3.2.7 ***Coordinate system.*** The GLONASS coordinate system shall be PZ-90.

Note.— *Conversion from the PZ-90 coordinate system used by GLONASS to the WGS-84 coordinates is defined in Appendix B, 3.2.5.2.*

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

Note.— *Structure and contents of data are specified in Appendix B, 3.2.1.2 and 3.2.1.3, respectively.*

3.7.3.3 ***Aircraft-based augmentation system (ABAS)***

3.7.3.3.1 ***Performance.*** The ABAS function combined with one or more of the other GNSS elements and both a fault-free GNSS receiver and fault-free aircraft system used for the ABAS function shall meet the requirements for accuracy, integrity, continuity and availability as stated in 3.7.2.4.

3.7.3.4 ***Satellite-based augmentation system (SBAS)- GAGAN***

3.7.3.4.1 ***Performance.*** GAGAN combined with one or more of the other GNSS elements and a fault-free receiver shall meet the requirements for system accuracy, integrity, continuity and availability for the intended operation as stated in 3.7.2.4.

Note.— *GAGAN complements the core satellite constellation(s) by increasing accuracy, integrity, continuity and availability of navigation provided within a service area, typically including multiple aerodromes.*

3.7.3.4.2 ***Functions.*** GAGAN shall perform one or more of the following functions:

a) Intentionally left Blank

b) GNSS satellite status: determine and transmit the GNSS satellite health status (Appendix B, 3.5.7.3);

c) Basic differential correction: provide GNSS satellite ephemeris and clock corrections (fast and long-term) to be applied to the pseudo-range measurements from satellites (Appendix B, 3.5.7.4); and

d) Precise differential correction: determine and transmit the Ionospheric corrections (Appendix B, 3.5.7.5).

3.7.3.4.2.1 Intentionally left blank

3.7.3.4.3 ***Service area*****.** The GAGAN service area shall be a defined area where GAGAN meets the requirements of 3.7.2.4 and supports the corresponding approved operations.

Note 1.— *The coverage area is that area within which the SBAS broadcast can be received (e.g. the geostationary satellite footprints).*

Note 2.— *SBAS coverage and service areas are discussed in Attachment D, 6.2.*

3.7.3.4.4 ***RF characteristics***

Note.— *Detailed RF characteristics are specified in Appendix B, 3.5.2.*

3.7.3.4.4.1 ***Carrier frequency.*** The carrier frequency shall be 1 575.42 MHz.

3.7.3.4.4.2 ***Signal spectrum.*** At least 95 per cent of the broadcast power shall be contained within a ±12 MHz band centered on the L1 frequency. The bandwidth of the signal transmitted by an SBAS satellite shall be at least 2.2 MHz.

3.7.3.4.4.3 Signal power level

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

3.7.3.4.4.3.2 Each SBAS satellite placed in orbit after 31 December 2013 shall broadcast navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at or above the minimum elevation angle for which a trackable GEO signal needs to be provided, the level of the received RF signal at the output of the antenna specified in Appendix B, Table B-87, is at least –164.0 dBW.

3.7.3.4.4.3.2.1 ***Minimum elevation angle*****.** The minimum elevation angle used to determine GEO coverage shall not be less than 5 degrees for a user near the ground.

3.7.3.4.4.3.2.2 The level of a received GAGAN RF signal at the output of a 0 dBic antenna located near the ground shall not exceed –152.5 dBW.

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

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

3.7.3.4.5 ***GAGAN network time (GNT)*****.** The difference between GNT and GPS time shall not exceed 50 nanoseconds.

3.7.3.4.6 ***Navigation information.*** The navigation data transmitted by the satellites shall include the necessary information to determine:

a) GAGAN satellite time of transmission;
b) GAGAN satellite position;
c) Corrected satellite time for all satellites;
d) Corrected satellite position for all satellites;
e) Ionospheric propagation delay effects;
f) User position integrity;
g) Time transfer to UTC; and
h) Service level status.

Note.— *Structure and contents of data are specified in Appendix B, 3.5.3 and 3.5.4, respectively.*

3.7.3.5 ***Ground-based augmentation system (GBAS)***

Note: *Except where specifically annotated, reference to approach with vertical guidance (APV) means APV-I and APV-II.*

3.7.3.5.1 ***Performance*****.** GBAS combined with one or more of the other GNSS elements and a fault-free GNSS receiver shall meet the requirements for system accuracy, continuity, availability and integrity for the intended operation as stated in 3.7.2.4.

Note— *GBAS is intended to support all types of approach, landing, departure and surface operations and may support en-route and terminal operations. The following SARPs are developed to support Category I precision approach, approach with vertical guidance, and a GBAS positioning service. In order to achieve interoperability and enable efficient spectrum utilization, it is intended that the data broadcast is the same for all operations.*

3.7.3.5.2 ***Functions.*** GBAS shall perform the following functions:

a) provide locally relevant pseudo-range corrections;
b) provide GBAS-related data;
c) provide final approach segment data when supporting precision approach;
d) provide predicted ranging source availability data; and
e) provide integrity monitoring for GNSS ranging sources.

3.7.3.5.3 ***Coverage***

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

a) laterally, beginning at 140 m (450 ft) each side of the landing threshold point/fictitious threshold point (LTP/FTP) and projecting out ±35 degrees either side of the final approach path to 28 km (15 NM) and ±10 degrees either side of the final approach path to 37 km (20 NM); and

b) vertically, within the lateral region, up to the greater of 7 degrees or 1.75 promulgated glide path angle (GPA) above the horizontal with an origin at the glide path interception point (GPIP) and 0.45 GPA above the horizontal or to such lower angle, down to 0.30 GPA, as required, to safeguard the promulgated glide path intercept procedure. This coverage applies between 30 m (100 ft) and 3 000 m (10 000 ft) height above threshold (HAT).

Note.— *LTP/FTP and GPIP are defined in Appendix B, 3.6.4.5.1.*

3.7.3.5.3.1.1 **Recommendation.—** *For Category I precision approach, the data broadcast as specified in 3.7.3.5.4 should extend down to 3.7 m (12 ft) above the runway surface.*

3.7.3.5.3.1.2 **Recommendation.—***The data broadcast should be omni-directional when required to support the intended applications.*

Note.— *Guidance material concerning coverage for Category I precision approach and APV is provided in Attachment D, 7.3.*

3.7.3.5.3.2 ***GBAS positioning service.*** The GBAS positioning service area shall be that area where the data broadcast can be received and the positioning service meets the requirements of 3.7.2.4 and supports the corresponding approved operations.

Note — *Guidance material concerning the positioning service coverage is provided in Attachment D, 7.3.*

3.7.3.5.4 ***Data broadcast characteristics***

Note — *RF characteristics are specified in Appendix B, 3.6.2.*

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

Note 2.— *ILS/GBAS geographical separation criteria and geographical separation criteria for GBAS and VHF communication services operating in the 118 – 137 MHz band are under development. Until these criteria are defined and included in SARPs, it is intended that frequencies in the band 112.050 – 117.900 MHz will be used.*

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

Note.— *Two slots is the nominal assignment. Some GBAS facilities that use multiple VHF data broadcast (VDB) transmit antennas to improve VDB coverage may require assignment of more than two time slots. Guidance on the use of multiple antennas is given in Attachment D, 7.12.4;*

3.7.3.5.4.3Modulation. GBAS data shall be transmitted as 3-bit symbols, modulating the data broadcast carrier by D8PSK, at a rate of 10 500 symbols per second.

3.7.3.5.4.4Data broadcast RF field strength and polarization

Note.— *GBAS can provide a VHF data broadcast with either horizontal (GBAS/H) or elliptical (GBAS/E) polarization that employs both horizontal polarization (HPOL) and vertical polarization (VPOL) components. Aircraft using a VPOL component will not be able to conduct operations with GBAS/H equipment. Relevant guidance material is provided in Attachment D, 7.1.*

3.7.3.5.4.4.1GBAS/H

3.7.3.5.4.4.1.1 A horizontally polarized signal shall be broadcast.

3.7.3.5.4.4.1.2 The effective radiated power (ERP) shall provide for a horizontally polarized signal with a minimum field strength of 215 microvolts per metre (–99 dBW/m2) and a maximum field strength of 0.350 volts per metre (–35 dBW/m2) within the GBAS coverage volume. The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst. The RF phase offset between the HPOL and any VPOL components shall be such that the minimum signal power defined in Appendix B, 3.6.8.2.2.3 is achieved for HPOL users throughout the coverage volume.

3.7.3.5.4.4.2GBAS/E

3.7.3.5.4.4.2.1 Recommendation.—*An elliptically polarized signal should be broadcast whenever practical*.

3.7.3.5.4.4.2.2 When an elliptically polarized signal is broadcast, the horizontally polarized component shall meet the requirements in 3.7.3.5.4.4.1.2, and the effective radiated power (ERP) shall provide for a vertically polarized signal with a minimum field strength of 136 microvolts per metre (–103 dBW/m2) and a maximum field strength of 0.221 volts per metre (–39 dBW/m2) within the GBAS coverage volume. The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst. The RF phase offset between the HPOL and VPOL components, shall be such that the minimum signal power defined in Appendix B, 3.6.8.2.2.3 is achieved for HPOL and VPOL users throughout the coverage volume.

Note.— *The minimum and maximum field strengths in 3.7.3.5.4.4.1.2 and 3.7.3.5.4.4.2.2 are consistent with a minimum receiver sensitivity of –87 dBm and minimum distance of 200 m (660 ft) from the transmitter antenna for a coverage range of 43 km (23 NM).*

3.7.3.5.4.5 *Power transmitted in adjacent channels*. The amount of power during transmission under all operating conditions when measured over a 25 kHz bandwidth centered on the i^{th} adjacent channel shall not exceed the values shown in Table 3.7.3.5-1.

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

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

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

3.7.3.5.4.6 *Unwanted emissions.* Unwanted emissions, including spurious and out-of-band emissions, shall be compliant with the levels shown in Table 3.7.3.5-2. Total power in any VDB harmonic or discrete signal shall not be greater than –53 dBm.

Table 3.7.3.5-2. GBAS broadcast unwanted emissions

Frequency Relative unwanted Maximum unwanted

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

NOTES.—

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

3.7.3.5.5 ***Navigation information.*** The navigation data transmitted by GBAS shall include the following information:

a) pseudo-range corrections, reference time and integrity data;
b) GBAS-related data;
c) final approach segment data when supporting precision approach; and
d) predicted ranging source availability data.

Note.— *Structure and contents of data are specified in Appendix B, 3.6.3.*

3.7.3.6 ***Aircraft GNSS receiver***

3.7.3.6.1 The aircraft GNSS receiver shall process the signals of those GNSS elements that it intends to use as specified in , Appendix B, 3.1 (for GPS), Appendix B, 3.2 (for GLONASS), Appendix B, 3.3 (for combined GPS and GLONASS), Appendix B, 3.5 (for GAGAN) and Appendix B, 3.6 (for GBAS).

3.7.4 Resistance to interference

3.7.4.1 GNSS shall comply with performance requirements defined in 3.7.2.4 and Appendix B, 3.7 in the presence of the interference environment defined in Appendix B, 3.7.

Note.— *GPS and GLONASS operating in the frequency band 1559 – 1610 MHz are classified by the ITU as providing a radio navigation satellite service (RNSS) and aeronautical radio navigation service (ARNS) and are afforded special spectrum protection status for RNSS. In order to achieve the performance objectives for precision approach guidance to be supported by the GNSS and its augmentations, RNSS/ARNS is intended to remain the only global allocation in the 1 559 –1 610 MHz band and emissions from systems in this and adjacent frequency bands are intended to be tightly controlled by national and/or international regulation.*

3.7.5 Database

Note.— *SARPs applicable to aeronautical data are provided in relevant CARS for Aeronautical charts, Air Traffic Management, Aerodrome and Ground Aids and Aeronautical Information Service.*

3.7.5.1 Aircraft GNSS equipment that uses a database shall provide a means to:

a) Update the electronic navigation database; and
b) Determine the Aeronautical Information Regulation and Control (AIRAC) effective dates of the aeronautical database.

Note.— *Guidance material on the need for a current navigation database in aircraft GNSS equipment is provided in Attachment D, 11.*

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3.9 System characteristics of airborne ADF receiving systems

3.9.1 Accuracy of bearing indication

3.9.1.1 The bearing given by the ADF system shall not be in error by more than plus or minus 5 degrees with a radio signal from any direction having a field strength of 70 microvolts per metre or more radiated from an LF/MF NDB 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.

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

(M. Sathiyavathy)
Director General of Civil Aviation

Table A. DME/VOR and DME/ILS channeling and pairing

Channel pairing		DMR Parameters			
		Interrogation		Reply	
DME Channel Number	VHF Frequency MHz	Frequency MHz	Pulse code DME/N Micro Sec	Frequency MHz	Pulse codes Micro Sec
*1X	-	1025	12	962	12
**1Y	-	1025	36	1088	30
*2X	-	1026	12	963	12
**2Y	-	1026	36	1089	30
*3X	-	1027	12	964	12
**3Y	-	1027	36	1090	30
*4X	-	1028	12	965	12
**4Y	-	1028	36	1091	30
*5X	-	1029	12	966	12
**5Y	-	1029	36	1092	30
*6X	-	1030	12	967	12
**6Y	-	1030	36	1093	30
*7X	-	1031	12	968	12
**7Y	-	1031	36	1094	30
*8X	-	1032	12	969	12
**8Y	-	1032	36	1095	30
*9X	-	1033	12	970	12
**9Y	-	1033	36	1096	30
*10X	-	1034	12	971	12
**10Y	-	1034	36	1097	30
*11X	-	1035	12	972	12
**11Y	-	1035	36	1098	30
*12X	-	1036	12	973	12
**12Y	-	1036	36	1099	30
*13X	-	1037	12	974	12
**13Y	-	1037	36	1100	30
*14X	-	1038	12	975	12
**14Y	-	1038	36	1101	30
*15X	-	1039	12	976	12
**15Y	-	1039	36	1102	30
*16X	-	1040	12	977	12
**16Y	-	1040	36	1103	30
17X	108.00	1041	12	978	12
17Y	108.05	1041	36	1104	30
18X	108.10	1042	12	979	12
18Y	108.15	1042	36	1105	30
19X	108.20	1043	12	980	12
19Y	108.25	1043	36	1106	30

Channel pairing		DMR Parameters			
		Interrogation		Reply	
DME Channel Number	VHF Frequency MHz	Frequency MHz	Pulse code DME/N Micro Sec	Frequency MHz	Pulse codes Micro Sec
20X	108.30	1044	12	981	12
20Y	108.35	1044	36	1107	30
21X	108.40	1045	12	982	12
21Y	108.45	1045	36	1108	30
22X	108.50	1046	12	983	12
22Y	108.55	1046	36	1109	30
23X	108.60	1047	12	984	12
23Y	108.65	1047	36	1110	30
24X	108.70	1048	12	985	12
24Y	108.75	1048	36	1111	30
25X	108.80	1049	12	986	12
25Y	108.85	1049	36	1112	30
26X	108.90	1050	12	987	12
26Y	108.95	1050	36	1113	30
27X	109.00	1051	12	988	12
27Y	109.05	1051	36	1114	30
28X	109.10	1052	12	989	12
28Y	109.15	1052	36	1115	30
29X	109.20	1053	12	990	12
29Y	109.25	1053	36	1116	30
30X	109.30	1054	12	991	12
30Y	109.35	1054	36	1117	30
31X	109.40	1055	12	992	12
31Y	109.45	1055	36	1118	30
32X	109.50	1056	12	993	12
32Y	109.55	1056	36	1119	30
33X	109.60	1057	12	994	12
33Y	109.65	1057	36	1120	30
34X	109.70	1058	12	995	12
34Y	109.75	1058	36	1121	30
35X	109.80	1059	12	996	12
35Y	109.85	1059	36	1122	30
36X	109.90	1060	12	997	12
36Y	109.95	1060	36	1123	30
37X	110.00	1061	12	998	12
37Y	110.05	1061	36	1124	30
38X	110.10	1062	12	999	12
38Y	110.15	1062	36	1125	30

Channel pairing		DMR Parameters			
		Interrogation		Reply	
DME Channel Number	VHF Frequency MHz	Frequency MHz	Pulse code DME/N Micro Sec	Frequency MHz	Pulse codes Micro Sec
39X	110.20	1063	12	1000	12
39Y	110.25	1063	36	1126	30
40X	110.30	1064	12	1001	12
40Y	110.35	1064	36	1127	30
41X	110.40	1065	12	1002	12
41Y	110.45	1065	36	1128	30
42X	110.50	1066	12	1003	12
42Y	110.55	1066	36	1129	30
43X	110.60	1067	12	1004	12
43Y	110.65	1067	36	1130	30
44X	110.70	1068	12	1005	12
44Y	110.75	1068	36	1131	30
45X	110.80	1069	12	1006	12
45Y	110.85	1069	36	1132	30
46X	110.90	1070	12	1007	12
46Y	110.95	1070	36	1133	30
47X	111.00	1071	12	1008	12
47Y	1110.5	1071	36	1134	30
48X	111.10	1072	12	1009	12
48Y	111.15	1072	36	1135	30
49X	111.20	1073	12	1010	12
49Y	111.25	1073	36	1136	30
50X	111.30	1074	12	1011	12
50Y	111.35	1074	36	1137	30
51X	111.40	1075	12	1012	12
51Y	111.45	1075	36	1138	30
52X	111.50	1076	12	1013	12
52Y	111.55	1076	36	1139	30
53X	111.60	1077	12	1014	12
53Y	111.65	1077	36	1140	30
54X	111.70	1078	12	1015	12
54Y	111.75	1078	36	1141	30
55X	111.80	1079	12	1016	12
55Y	111.85	1079	36	1142	30
56X	111.90	1080	12	1017	12
56Y	111.95	1080	36	1143	30
57X	112.00	1081	12	1018	12
57Y	112.05	1081	36	1144	30

Channel pairing		DMR Parameters			
		Interrogation		Reply	
DME Channel Number	VHF Frequency MHz	Frequency MHz	Pulse code DME/N Micro Sec	Frequency MHz	Pulse codes Micro Sec
58X	112.10	1082	12	1019	12
58Y	112.15	1082	36	1145	30
59X	112.20	1083	12	1020	12
59Y	112.25	1083	36	1146	30
**60X	-	1084	12	1021	12
**60Y	-	1084	36	1147	30
**61X	-	1085	12	1022	12
**61Y	-	1085	36	1148	30
**62X	-	1086	12	1023	12
**62Y	-	1086	36	1149	30
**63X	-	1087	12	1024	12
**63Y	-	1087	36	1150	30
**64X	-	1088	12	1151	12
**64Y	-	1088	36	1025	30
**65X	-	1089	12	1152	12
**65Y	-	1089	36	1026	30
**66X	-	1090	12	1153	12
**66Y	-	1090	36	1027	30
**67X	-	1091	12	1154	12
**67Y	-	1091	36	1028	30
**68X	-	1092	12	1155	12
**68Y	-	1092	36	1029	30
**69X	-	1093	12	1156	12
**69Y	-	1093	36	1030	30
70X	112.30	1094	12	1157	12
**70Y	112.35	1094	36	1031	30
71X	112.40	1095	12	1158	12
**71Y	112.45	1095	36	1032	30
72X	112.50	1096	12	1159	12
**72Y	112.55	1096	36	1033	30
73X	112.60	1097	12	1160	12
**73Y	112.65	1097	36	1034	30
74X	112.70	1098	12	1161	12
**74Y	112.75	1098	36	1035	30
75X	112.80	1099	12	1162	12
**75Y	112.85	1099	36	1036	30
76X	112.90	1100	12	1163	12
**76Y	112.95	1100	36	1037	30

Channel pairing		DMR Parameters			
		Interrogation		Reply	
DME Channel Number	VHF Frequency MHz	Frequency MHz	Pulse code DME/N Micro Sec	Frequency MHz	Pulse codes Micro Sec
77X	113.00	1101	12	1164	12
**77Y	113.05	1101	36	1038	30
78X	113.10	1102	12	1165	12
**78Y	113.15	1102	36	1039	30
79X	113.20	1103	12	1166	12
**79Y	113.25	1103	36	1040	30
80X	113.30	1104	12	1167	12
80Y	113.35	1104	36	1041	30
81X	113.40	1105	12	1168	12
81Y	113.45	1105	36	1042	30
82X	113.50	1106	12	1169	12
82Y	113.55	1106	36	1043	30
83X	113.60	1107	12	1170	12
83Y	113.65	1107	36	1044	30
84X	113.70	1108	12	1171	12
84Y	113.75	1108	36	1045	30
85X	113.80	1109	12	1172	12
85Y	113.85	1109	36	1046	30
86X	113.90	1110	12	1173	12
86Y	113.95	1110	36	1047	30
87X	114.00	1111	12	1174	12
87Y	114.05	1111	36	1048	30
88X	114.10	1112	12	1175	12
88Y	114.15	1112	36	1049	30
89X	114.20	1113	12	1176	12
89Y	114.25	1113	36	1050	30
90X	114.30	1114	12	1177	12
90Y	114.35	1114	36	1051	30
91X	114.40	1115	12	1178	12
91Y	114.45	1115	36	1052	30
92X	114.50	1116	12	1179	12
92Y	114.55	1116	36	1053	30
93X	114.60	1117	12	1180	12
93Y	114.65	1117	36	1054	30
94X	114.70	1118	12	1181	12
94Y	114.75	1118	36	1055	30
95X	114.80	1119	12	1182	12
95Y	114.85	1119	36	1056	30

Channel pairing		DMR Parameters			
		Interrogation		Reply	
DME Channel Number	VHF Frequency MHz	Frequency MHz	Pulse code DME/N Micro Sec	Frequency MHz	Pulse codes Micro Sec
96X	114.90	1120	12	1183	12
96Y	114.95	1120	36	1057	30
97X	115.00	1121	12	1184	12
97Y	115.05	1121	36	1058	30
98X	115.10	1122	12	1185	12
98Y	115.15	1122	36	1059	30
99X	115.20	1123	12	1186	12
99Y	115.25	1123	36	1060	30
100X	115.30	1124	12	1187	12
100Y	115.35	1124	36	1061	30
101X	115.40	1125	12	1188	12
101Y	115.45	1125	36	1062	30
102X	115.50	1126	12	1189	12
102Y	115.55	1126	36	1063	30
103X	115.60	1127	12	1190	12
103Y	115.65	1127	36	1064	30
104X	115.70	1128	12	1191	12
104Y	115.75	1128	36	1065	30
105X	115.80	1129	12	1192	12
105Y	115.85	1129	36	1066	30
106X	115.90	1130	12	1193	12
106Y	115.95	1130	36	1067	30
107X	116.00	1131	12	1194	12
107Y	116.05	1131	36	1068	30
108X	116.10	1132	12	1195	12
108Y	116.15	1132	36	1069	30
109X	116.20	1133	12	1196	12
109Y	116.25	1133	36	1070	30
110X	116.30	1134	12	1197	12
110Y	116.35	1134	36	1071	30
111X	116.40	1135	12	1198	12
111Y	116.45	1135	36	1072	30
112X	116.50	1136	12	1199	12
112Y	116.55	1136	36	1073	30
113X	116.60	1137	12	1200	12
113Y	116.65	1137	36	1074	30
114X	116.70	1138	12	1201	12
114Y	116.75	1138	36	1075	30

Channel pairing		DMR Parameters			
		Interrogation		Reply	
DME Channel Number	VHF Frequency MHz	Frequency MHz	Pulse code DME/N Micro Sec	Frequency MHz	Pulse codes Micro Sec
115X	116.80	1139	12	1202	12
115Y	116.85	1139	36	1076	30
116X	116.90	1140	12	1203	12
116Y	116.95	1140	36	1077	30
117X	117.00	1141	12	1204	12
117Y	117.05	1141	36	1078	30
118X	117.10	1142	12	1205	12
118Y	117.15	1142	36	1079	30
119X	117.20	1143	12	1206	12
119Y	117.25	1143	36	1080	30
120X	117.30	1144	12	1207	12
120Y	117.35	1144	36	1081	30
121X	117.40	1145	12	1208	12
121Y	117.45	1145	36	1082	30
122X	117.50	1146	12	1209	12
122Y	117.55	1146	36	1083	30
123X	117.60	1147	12	1210	12
123Y	117.65	1147	36	1084	30
124X	118.70	1148	12	1211	12
**124Y	117.75	1148	36	1085	30
125X	117.80	1149	12	1212	12
**125Y	117.85	1149	36	1086	30
126X	117.90	1150	12	1213	12
**126Y	117.95	1150	36	1087	30

***These channels are reserved exclusively for national allotments.**
****These channels may be used for national allotment on a secondary basis.**