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| **SADC AVIATION SAFETY ORGANIZATION (SASO)**  **REGULATIONS** |



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| **COMMUNICATIONS, NAVIGATION & SURVEILLANCE**  **PART I**  **RADIO NAVIGATION AIDS**  **First Edition**  **July 2023** |

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# RECORD OF REVISIONS

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# PART I

# PRELIMINARY PROVISIONS

## Citation and commencement

1. These Regulations may be cited as the SASO Model Civil Aviation (Communication, Navigation & Surveillance) Regulations, 202X
2. These regulations come into operation on the date on which it is published in the [State] Gazette.

## Application

1. These Regulations shall apply to a person or organization providing Communication, Navigation and Surveillance services within designated air spaces and at aerodromes.

## Definitions

1. When the following terms are used in this part, they have the following meanings:
2. **Altitude.** The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL).
3. **Average radius of rated coverage.** The radius of a circle having the same area as the rated coverage.
4. **Area navigation (RNAV).** A method of navigation which permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.
5. **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.
6. **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.
7. **Effective coverage.** The area surrounding an NDB within which bearings can be obtained with an accuracy sufficient for the nature of the operation concerned.
8. **Elevation.** The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.
9. **Essential radio navigation service.** A radio navigation service whose disruption has a significant impact on operations in the affected airspace or aerodrome.
10. **Height.** The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.
11. **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.
12. **Locator.** An LF/MF NDB used as an aid to final approach.
13. **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.
14. **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.

1. **Performance-based navigation (PBN).** Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.
2. **Pressure-altitude.** An atmospheric pressure expressed in terms of altitude which corresponds to that pressure in the Standard Atmosphere.
3. **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.
4. **Radio navigation service.** A service providing guidance information or position data for the efficient and safe operation of aircraft supported by one or more radio navigation aids.
5. **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.
6. **Touchdown.** The point where the nominal glide path intercepts the runway.

# PART II

# 

# RADIO NAVIGATION AIDS

# CHAPTER 2. GENERAL PROVISIONS FOR RADIO NAVIGATION AIDS

## Standard radio navigation aids

1. The standard radio navigation aids shall be:
2. the instrument landing system (ILS) conforming to the Standards contained in CNS.I.006;
3. the global navigation satellite system (GNSS) conforming to the Standards contained in CNS.I.011;
4. the VHF omnidirectional radio range (VOR) conforming to the Standards contained in CNS.I.008;
5. the non-directional radio beacon (NDB) conforming to the Standards contained in CNS.I.009;
6. the distance measuring equipment (DME) conforming to the Standards contained in CNS.I.010.
7. Differences in radio navigation aids in any respect from the Standards of CNS.I.006 to CNS.I.012 shall be published in an Aeronautical Information Publication (AIP).
8. 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).
9. GNSS-specific provisions
10. It shall be permissible to terminate a GNSS satellite service provided by one of its elements CNS.I.011(a) on the basis of at least a six-year advance notice by a service provider.
11. Precision approach radar
12. A precision approach radar (PAR) system, where installed and operated as a radio navigation aid together with equipment for two-way communication with aircraft and facilities for the efficient coordination of these elements with air traffic control, shall conform to the Standards contained in CNS.I.007.

## Ground and flight testing

1. Radio navigation aids of the types covered by the specifications in CNS.I.006 to CNS.I.012 and available for use by aircraft engaged in international air navigation shall be the subject of periodic ground and flight tests.

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

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

## Power supply for radio navigation aids and communication systems

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

## Human Factors considerations

1. Human Factors principles shall be observed in the design and certification of radio navigation aids.

# CHAPTER 3. SPECIFICATIONS FOR RADIO NAVIGATION AIDS

## Specification for ILS

1. Basic requirements
2. The ILS shall comprise the following basic components:
3. VHF localizer equipment, associated monitor system, remote control and indicator equipment;
4. UHF glide path equipment, associated monitor system, remote control and indicator equipment;
5. an appropriate means to enable glide path verification checks.
6. When the DME is used as a component of the ILS, the distance to threshold information, shall be published in accordance with the provisions of Annex 15.
7. Facility Performance Categories I, II and III — ILS shall provide indications at designated remote-control points of the operational status of all ILS ground system components, as follows:

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

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

1. The ILS shall be constructed and adjusted so that, at a specified distance from the threshold, similar instrumental indications in the aircraft represent similar displacements from the course line or ILS glide path as appropriate, irrespective of the particular ground installation in use.
2. The localizer and glide path components specified in (1) a) and b) which form part of a Facility Performance Category I — ILS shall comply at least with the Standards in CNS.I.006(b) and CNS.I.006(d) respectively, excepting those in which application to Facility Performance Category II — ILS is prescribed.
3. The localizer and glide path components specified in (1) a) and b) which form part of a Facility Performance Category II — ILS shall comply with the Standards applicable to these components in a Facility Performance Category I — ILS, as supplemented or amended by the Standards in CNS.I.006(b) and CNS.I.006(d) in which application to Facility Performance Category II — ILS is prescribed.
4. The localizer and glide path components and other ancillary equipment specified in CNS.I.006(a)(1)(3), which form part of a Facility Performance Category III — ILS, shall otherwise comply with the Standards applicable to these components in Facility Performance Categories I and II — ILS, except as supplemented by the Standards in CNS.I.006(b) and CNS.I.006(d) in which application to Facility Performance Category III — ILS is prescribed.
5. To ensure an adequate level of safety, the ILS shall be so designed and maintained that the probability of operation within the performance requirements specified is of a high value, consistent with the category of operational performance concerned.
6. For Facility Performance Category II and III localizers and glide paths, the level of integrity and continuity of service shall be at least Level 3, as defined in CNS.I.006(b)(12)(iv) (localizer) and CNS.I.006(d)(8)(iv) (glide path).
7. At those locations where two separate ILS facilities serve opposite ends of a single runway, and operationally harmful interference would be present if both facilities were transmitting, an interlock shall ensure that only the localizer serving the approach direction in use shall radiate.
8. At locations where ILS facilities serving opposite ends of the same runway or different runways at the same airport use the same paired frequencies, an interlock shall ensure that only one facility shall radiate at a time. When switching from one ILS facility to another, radiation from both shall be suppressed for not less than 20 seconds.
9. At those locations where an ILS facility and a GBAS facility serve opposite approach directions to the same runway, when the approach direction in use is not the direction served by the ILS, the localizer shall not radiate when GBAS low visibility operations that require GAST D are being conducted, except where it can be demonstrated that the localizer signal supports compliance with the requirements in Appendix B, 3.6.8.2.2.5 and 3.6.8.2.2.6 defining the desired to undesired signal ratios and the maximum adjacent channel power tolerable by the GBAS VDB receiver.
10. VHF localizer and associated monitor

*Introduction.* The specifications in this section cover ILS localizers providing either positive guidance information over 360 degrees of azimuth, or providing such guidance only within a specified portion of the front coverage. 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.

1. *General*
2. 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. When an observer faces the localizer from the approach end of a runway, the depth of modulation of the radio frequency carrier due to the 150 Hz tone shall predominate on the observer’s right hand and that due to the 90 Hz tone shall predominate on the observer’s left hand.
4. All horizontal angles employed in specifying the localizer field patterns shall originate from the centre of the localizer antenna system which provides the signals used in the front course sector.
5. *Radio frequency*
6. The localizer shall operate in the band 108 MHz to 111.975 MHz. Where a single radio frequency carrier is used, the frequency tolerance shall not exceed plus or minus 0.005 per cent. Where two radio frequency carriers are used, the frequency tolerance shall not exceed 0.002 per cent and the nominal band occupied by the carriers shall be symmetrical about the assigned frequency. With all tolerances applied, the frequency separation between the carriers shall not be less than 5 kHz nor more than 14 kHz.
7. 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.
8. For Facility Performance Category II localizers, the vertically polarized component of the radiation on the course line shall not exceed that which corresponds to a DDM error of 0.008 when an aircraft is positioned on the course line and is in a roll attitude of 20 degrees from the horizontal.
9. For Facility Performance Category III localizers, the vertically polarized component of the radiation within a sector bounded by 0.02 DDM either side of the course line shall not exceed that which corresponds to a DDM error of 0.005 when an aircraft is in a roll attitude of 20 degrees from the horizontal.
10. For Facility Performance Category III localizers, signals emanating from the transmitter shall contain no components which result in an apparent course line fluctuation of more than 0.005 DDM peak to peak in the frequency band 0.01 Hz to 10 Hz.
11. *Coverage*
12. The localizer shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation within the localizer and glide path coverage sectors. The localizer coverage sector shall extend from the centre of the localizer antenna system to distances of:

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

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

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

except that, where topographical features dictate or operational requirements permit, the limits may be reduced down to 33.3 km (18 NM) within the plus or minus 10-degree sector and 18.5 km (10 NM) within the remainder of the coverage when alternative navigational 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 (2 000 ft) above the elevation of the threshold, or 300 m (1 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher, 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 1 350 m (4 500 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.

1. In all parts of the coverage volume specified in (i), other than as specified in (A), (B) and (C), the field strength shall be not less than 40 microvolts per metre (minus 114 dBW/m2).
2. 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 30 m (100 ft) above the horizontal plane containing the threshold shall be not less than 90 microvolts per metre (minus 107 dBW/m2).
3. 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 microvolts per metre (minus 106 dBW/m2) at a distance of 18.5 km (10 NM) increasing to not less than 200 microvolts per metre (minus 100 dBW/m2) at a height of 15 m (50 ft) above the horizontal plane containing the threshold.
4. For Facility Performance Category III localizers, the minimum field strength on the ILS glide path and within the localizer course sector shall be not less than 100 microvolts per metre (minus 106 dBW/m2) at a distance of 18.5 km (10 NM), increasing to not less than 200 microvolts per metre (minus 100 dBW/m2) at 6 m (20 ft) above the horizontal plane containing the threshold. From this point to a further point 4 m (12 ft) above the runway centre line, and 300 m (1 000 ft) from the threshold in the direction of the localizer, and thereafter at a height of 4 m (12 ft) along the length of the runway in the direction of the localizer, the field strength shall be not less than 100 microvolts per metre (minus 106 dBW/m2).
5. 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 (i) shall not be less than 10 dB.
6. *Course structure*
7. For Facility Performance Category I localizers, bends in the course line shall not have amplitudes which exceed the following:

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

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

|  |  |
| --- | --- |
| *Zone* | *Amplitude (DDM)*  *(95% probability)* |
|  |  |
| Outer limit of coverage to  ILS Point “A” | 0.031 |
|  |  |
| ILS Point “A” to  ILS Point “B” | 0.031 at ILS Point “A”  decreasing at a linear rate to 0.005 at ILS Point “B” |
|  |  |
| ILS Point “B” to the  ILS reference datum | 0.005 |

and, for Facility Performance Category III only:

|  |  |
| --- | --- |
| ILS reference datum to  ILS Point “D” | 0.005 |
|  |  |
| ILS Point “D” to  ILS Point “E” | 0.005 at ILS Point “D”  increasing at a linear rate to  0.010 at ILS Point “E” |

1. *Carrier modulation*
2. 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. 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.
4. The following tolerances shall be applied to the frequencies of the modulating tones:
5. the modulating tones shall be 90 Hz and 150 Hz within plus or minus 2.5 per cent;
6. the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1.5 per cent for Facility Performance Category II installations;
7. the modulating tones shall be 90 Hz and 150 Hz within plus or minus 1 per cent for Facility Performance Category III installations;
8. 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;
9. the total harmonic content of the 150 Hz tone shall not exceed 10 per cent.
10. 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 intermodulate with the 90 Hz and 150 Hz navigation tones or their harmonics to produce fluctuations in the course line, shall not exceed 0.05 per cent modulation depth of the radio frequency carrier.
11. The modulation tones shall be phase-locked so that within the half course sector, the demodulated 90 Hz and 150 Hz wave forms pass through zero in the same direction within:
12. for Facility Performance Categories I and II localizers: 20 degrees; and
13. 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.
14. With two-frequency localizer systems, (C) 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:
15. for Facility Performance Categories I and II localizers: 20 degrees; and
16. for Facility Performance 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 Facility Performance Categories I and II localizers: 20 degrees; and

2) for Facility Performance Category III localizers: 10 degrees,

of phase relative to 150 Hz.

1. Alternative two-frequency localizer systems that employ audio phasing different from the normal in-phase conditions described in (D) 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 (D).
2. For equipment first installed after 1 January 2000, the sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones shall not exceed 60 per cent or be less than 30 per cent within the required coverage.
3. When utilizing a localizer for radiotelephone communications, the sum of the modulation depths of the radio frequency carrier due to the 90 Hz and 150 Hz tones shall not exceed 65 per cent within 10 degrees of the course line and shall not exceed 78 per cent at any other point around the localizer.
4. *Course alignment accuracy*
5. 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:
6. for Facility Performance Category I localizers: plus or minus 10.5 m (35 ft), or the linear equivalent of 0.015 DDM, whichever is less;
7. for Facility Performance Category II localizers: plus or minus 7.5 m (25 ft);
8. for Facility Performance Category III localizers: plus or minus 3 m (10 ft).
9. *Displacement sensitivity*
10. The nominal displacement sensitivity within the half course sector shall be the equivalent of 0.00145 DDM/m (0.00044 DDM/ft) at the ILS reference datum except that for Facility Performance Category I localizers, where the specified nominal displacement sensitivity cannot be met, the displacement sensitivity shall be adjusted as near as possible to that value. For Facility Performance Category I localizers on runway codes 1 and 2, the nominal displacement sensitivity shall be achieved at the ILS Point “B”. The maximum course sector angle shall not exceed six degrees.
11. The lateral displacement sensitivity shall be adjusted and maintained within the limits of plus or minus:
12. 17 per cent of the nominal value for Facility Performance Categories I and II;
13. 10 per cent of the nominal value for Facility Performance Category III.
14. The increase of DDM shall be substantially linear with respect to angular displacement from the front course line (where DDM is zero) up to an angle on either side of the front course line where the DDM is 0.180. From that angle to plus or minus 10 degrees, the DDM shall not be less than 0.180. From plus or minus 10 degrees to plus or minus 35 degrees, the DDM shall not be less than 0.155. Where coverage is required outside of the plus or minus 35 degrees sector, the DDM in the area of the coverage, except in the back course sector, shall not be less than 0.155.
15. *Voice*
16. 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.
17. Facility Performance 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.
18. If the channel is provided, it shall conform with the following Standards:
19. The channel shall be on the same radio frequency carrier or carriers as used for the localizer function, and the radiation shall be horizontally polarized. Where two carriers are modulated with speech, the relative phases of the modulations on the two carriers shall be such as to avoid the occurrence of nulls within the coverage of the localizer.
20. The peak modulation depth of the carrier or carriers due to the radiotelephone communications shall not exceed 50 per cent but shall be adjusted so that:
21. the ratio of peak modulation depth due to the radiotelephone communications to that due to the identification signal is approximately 9:1;
22. the sum of modulation components due to use of the radiotelephone channel, navigation signals and identification signals shall not exceed 95 per cent.
23. The audio frequency characteristics of the radiotelephone channel shall be flat to within 3 dB relative to the level at 1 000 Hz over the range 300 Hz to 3 000 Hz.
24. *Identification*
25. The localizer shall provide for the simultaneous transmission of an identification signal, specific to the runway and approach direction, on the same radio frequency carrier or carriers as used for the localizer function. The transmission of the identification signal shall not interfere in any way with the basic localizer function.
26. The identification signal shall be produced by Class A2A modulation of the radio frequency carrier or carriers using a modulation tone of 1 020 Hz within plus or minus 50 Hz. The depth of modulation shall be between the limits of 5 and 15 per cent except that, where a radiotelephone communication channel is provided, the depth of modulation shall be adjusted so that the ratio of peak modulation depth due to radiotelephone communications to that due to the identification signal modulation is approximately 9:1. 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.
27. The identification signal shall employ the International Morse Code and consist of two or three letters. It may be preceded by the International Morse Code signal of the letter “I”, followed by a short pause where it is necessary to distinguish the ILS facility from other navigational facilities in the immediate area.
28. The identification signal shall be transmitted by dots and dashes at a speed corresponding to approximately seven words per minute, and shall be repeated at approximately equal intervals, not less than six times per minute, at all times during which the localizer is available for operational use. When the transmissions of the localizer are not available for operational use, as, for example, after removal of navigation components, or during maintenance or test transmissions, the identification signal shall be suppressed. The dots shall have a duration of 0.1 second to 0.160 second. The dash duration shall be typically three times the duration of a dot. The interval between dots and/or dashes shall be equal to that of one dot plus or minus 10 per cent. The interval between letters shall not be less than the duration of three dots.
29. *Siting*
30. For Facility Performance Categories II and III, the localizer antenna system shall be located on the extension on the centre line of the runway at the stop end, and the equipment shall be adjusted so that the course lines will be in a vertical plane containing the centre line of the runway served. The antenna height and location shall be consistent with safe obstruction clearance practices.
31. For Facility Performance Category I, the localizer antenna system shall be located and adjusted as in CNS.I.006(b)(10)(i), unless site constraints dictate that the antenna be offset from the centre line of the runway.
32. The offset localizer system shall be located and adjusted in accordance with the offset ILS provisions of the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS) (Doc 8168), Volume II, and the localizer standards shall be referenced to the associated fictitious threshold point.
33. *Monitoring*
34. 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 CNS.I.006(b)(11)(iii)(A), if any of the conditions stated in (ii) persist:
35. radiation to cease; and
36. removal of the navigation and identification components from the carrier.
37. The conditions requiring initiation of monitor action shall be the following:
38. for Facility Performance Category I localizers, a shift of the mean course line from the runway centre line equivalent to more than 10.5 m (35 ft), or the linear equivalent to 0.015 DDM, whichever is less, at the ILS reference datum;
39. for Facility Performance Category II localizers, a shift of the mean course line from the runway centre line equivalent to more than 7.5 m (25 ft) at the ILS reference datum;
40. for Facility Performance Category III localizers, a shift of the mean course line from the runway centre line equivalent to more than 6 m (20 ft) at the ILS reference datum;
41. in the case of localizers in which the basic functions are provided by the use of a single-frequency system, a reduction of power output to a level such that any of the requirements of CNS.I.006(b)(3), CNS.I.006(b)(4) or CNS.I.006(b)(5) are no longer satisfied, or to a level that is less than 50 per cent of the normal level (whichever occurs first);
42. 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 CNS.I.006(b)(3), CNS.I.006(b)(4) and CNS.I.006(b)(5);
43. change of displacement sensitivity to a value differing by more than 17 per cent from the nominal value for the localizer facility.
44. 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 (ii) shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the localizer.
45. The total period referred to under (iii) shall not exceed under any circumstances:

10 seconds for Facility Performance Category I localizers;

5 seconds for Facility Performance Category II localizers;

2 seconds for Facility Performance Category III localizers.

1. Design and operation of the monitor system shall be consistent with the requirement that navigation guidance and identification will be removed and a warning provided at the designated remote control points in the event of failure of the monitor system itself.
2. *Integrity and continuity of service levels and requirements*
3. A localizer shall be assigned a level of integrity and continuity of service as given in (ii) to (v).
4. The localizer level shall be Level 1 if either:
5. the localizer’s integrity of service or its continuity of service, or both, are not demonstrated; or
6. the localizer’s integrity of service and its continuity of service are both demonstrated, but at least one of them does not meet the requirements of Level 2.
7. The localizer level shall be Level 2 if:
8. a) the probability of not radiating false guidance signals is not less than 1 – 1.0 x 10–7 in any one landing; and
9. b) the probability of not losing the radiated guidance is greater than 1 – 4 × 10–6 in any period of 15 seconds (equivalent to 1 000 hours mean time between outages).
10. The localizer level shall be Level 3 if:
11. a) the probability of not radiating false guidance signals is not less than 1 – 0.5 × 10–9 in any one landing; and
12. b) the probability of not losing the radiated guidance is greater than 1 – 2 × 10–6 in any period of 15 seconds (equivalent to 2 000 hours mean time between outages).
13. The localizer level shall be Level 4 if:
14. a) the probability of not radiating false guidance signals is not less than 1 – 0.5 × 10–9 in any one landing; and
15. b) the probability of not losing the radiated guidance is greater than 1 – 2 × 10–6 in any period of 30 seconds (equivalent to 4 000 hours mean time between outages).
16. Interference immunity performance for ILS localizer receiving systems
17. The ILS localizer receiving system shall provide adequate immunity to interference from two-signal, third-order intermodulation products caused by VHF FM broadcast signals having levels in accordance with the following:

2N1 + N2 + 72 ≤ 0

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

and

for VHF FM sound broadcasting signals below 107.7 MHz,

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

*N*1 and *N*2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the ILS localizer receiver input. Neither level shall exceed the desensitization criteria set forth in CNS.I.006(c)(2).

Δf = 108.1 – f1, where f1 is the frequency of N1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

1. 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 |

1. UHF glide path equipment and associated monitor
2. *General*
3. 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.
4. The glide path angle shall be adjusted and maintained within:
5. 0.075 θ from θ for Facility Performance Categories I and II — ILS glide paths;
6. 0.04 θ from θ for Facility Performance Category III — ILS glide paths.
7. The downward extended straight portion of the ILS glide path shall pass through the ILS reference datum at a height ensuring safe guidance over obstructions and also safe and efficient use of the runway served.
8. The height of the ILS reference datum for Facility Performance Categories II and III — ILS shall be 15 m (50 ft). A tolerance of plus 3 m (10 ft) is permitted.

1. *Radio frequency*
2. The glide path equipment shall operate in the band 328.6 MHz to 335.4 MHz. Where a single radio frequency carrier is used, the frequency tolerance shall not exceed 0.005 per cent. Where two carrier glide path systems are used, the frequency tolerance shall not exceed 0.002 per cent and the nominal band occupied by the carriers shall be symmetrical about the assigned frequency. With all tolerances applied, the frequency separation between the carriers shall not be less than 4 kHz nor more than 32 kHz.
3. The emission from the glide path equipment shall be horizontally polarized.
4. 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.
5. *Coverage*
6. The glide path equipment shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation in sectors of 8 degrees in azimuth on each side of the centre line of the ILS glide path, to a distance of at least 18.5 km (10 NM) up to 1.75 θ and down to 0.45 θ above the horizontal or to such lower angle, down to 0.30 θ, as required to safeguard the promulgated glide path intercept procedure.
7. In order to provide the coverage for glide path performance specified in (i), the minimum field strength within this coverage sector shall be 400 microvolts per metre (minus 95 dBW/m2). For Facility Performance Category I glide paths, this field strength shall be provided down to a height of 30 m (100 ft) above the horizontal plane containing the threshold. For Facility Performance Categories II and III glide paths, this field strength shall be provided down to a height of 15 m (50 ft) above the horizontal plane containing the threshold.
8. *ILS glide path structure*
9. 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 |

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

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

1. *Carrier modulation*
2. The nominal depth of modulation of the radio frequency carrier due to each of the 90 Hz and 150 Hz tones shall be 40 per cent along the ILS glide path. The depth of modulation shall not deviate outside the limits of 37.5 per cent to 42.5 per cent.
3. The following tolerances shall be applied to the frequencies of the modulating tones:
4. the modulating tones shall be 90 Hz and 150 Hz within 2.5 per cent for Facility Performance Category I — ILS;
5. the modulating tones shall be 90 Hz and 150 Hz within 1.5 per cent for Facility Performance Category II — ILS;
6. the modulating tones shall be 90 Hz and 150 Hz within 1 per cent for Facility Performance Category III — ILS;
7. the total harmonic content of the 90 Hz tone shall not exceed 10 per cent: additionally, for Facility Performance Category III equipment, the second harmonic of the 90 Hz tone shall not exceed 5 per cent;
8. the total harmonic content of the 150 Hz tone shall not exceed 10 per cent.
9. For Facility Performance Category III glide path equipment, the depth of amplitude modulation of the radio frequency carrier at the power supply frequency or harmonics, or at other noise frequencies, shall not exceed 1 per cent.
10. 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:
11. for Facility Performance Categories I and II — ILS glide paths: 20 degrees;
12. for Facility Performance Category III — ILS glide paths: 10 degrees,

of phase relative to the 150 Hz component, every half cycle of the combined 90 Hz and 150 Hz wave form.

1. With two-frequency glide path systems, (iii) 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:
2. for Facility Performance Categories I and II — ILS glide paths: 20 degrees;
3. for Facility Performance Category III — ILS glide paths: 10 degrees,

of phase relative to 90 Hz.

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

for Facility Performance Categories I and II — ILS glide paths: 20 degrees;

for Facility Performance Category III — ILS glide paths: 10 degrees, of phase relative to 150 Hz.

1. Alternative two-frequency glide path systems that employ audio phasing different from the normal in-phase condition described in 3.1.5.5.3.1 shall be permitted. In these alternative systems, the 90 Hz to 90 Hz phasing and the 150 Hz to 150 Hz phasing shall be adjusted to their nominal values to within limits equivalent to those stated in (A).
2. *Displacement sensitivity*
3. For Facility Performance Category I — ILS glide paths, the nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at angular displacements above and below the glide path between 0.07 θ and 0.14 θ.
4. For Facility Performance Category II — ILS glide paths, the angular displacement sensitivity shall be as symmetrical as practicable. The nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at an angular displacement of:
5. 0.12θbelow path with a tolerance of plus or minus 0.02 θ;
6. 0.12 θ above path with a tolerance of plus 0.02 θ and minus 0.05 θ
7. For Facility Performance Category III — ILS glide paths, the nominal angular displacement sensitivity shall correspond to a DDM of 0.0875 at angular displacements above and below the glide path of 0.12 θ with a tolerance of plus or minus 0.02 θ.
8. 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.
9. For Facility Performance Category I — ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 25 per cent of the nominal value selected.
10. For Facility Performance Category II — ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 20 per cent of the nominal value selected.
11. For Facility Performance Category III — ILS glide paths, the angular displacement sensitivity shall be adjusted and maintained within plus or minus 15 per cent of the nominal value selected.
12. *Monitoring*
13. The automatic monitor system shall provide a warning to the designated control points and cause radiation to cease within the periods specified in CNS.I.006(d) if any of the following conditions persist:
14. shift of the mean ILS glide path angle equivalent to more than minus 0.075 θ to plus 0.10 θ from θ;
15. in the case of ILS glide paths in which the basic functions are provided by the use of a single-frequency system, a reduction of power output to less than 50 per cent of normal, provided the glide path continues to meet the requirements of CNS.I.006(d)(3), CNS.I.006(d)(4) and CNS.I.006(d)(5);
16. in the case of ILS glide paths in which the basic functions are provided by the use of two-frequency systems, a reduction of power output for either carrier to less than 80 per cent of normal, except that a greater reduction to between 80 per cent and 50 per cent of normal may be permitted, provided the glide path continues to meet the requirements of CNS.I.006(d)(3), CNS.I.006(d)(4) and CNS.I.006(d)(5);
17. for Facility Performance Category I — ILS glide paths, a change of the angle between the glide path and the line below the glide path (150 Hz predominating) at which a DDM of 0.0875 is realized by more than the greater of:

i) plus or minus 0.0375 θ; or

1. an angle equivalent to a change of displacement sensitivity to a value differing by 25 per cent from the nominal value;
2. for Facility Performance Categories II and III — ILS glide paths, a change of displacement sensitivity to a value differing by more than 25 per cent from the nominal value;
3. lowering of the line beneath the ILS glide path at which a DDM of 0.0875 is realized to less than 0.7475 θ from horizontal;
4. a reduction of DDM to less than 0.175 within the specified coverage below the glide path sector.
5. The total period of radiation, including period(s) of zero radiation, outside the performance limits specified in CNS.I.006(d)(7)(i) shall be as short as practicable, consistent with the need for avoiding interruptions of the navigation service provided by the ILS glide path.
6. The total period referred to under CNS.I.006(d)(7)(ii) shall not exceed under any circumstances:

6 seconds for Facility Performance Category I — ILS glide paths;

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

1. Design and operation of the monitor system shall be consistent with the requirement that radiation shall cease and a warning shall be provided at the designated remote control points in the event of failure of the monitor system itself.
2. *Integrity and continuity of service levels and requirements*
3. A glide path shall be assigned a level of integrity and continuity of service as given in (ii) to (iv).
4. The glide path level shall be Level 1 if either:
5. the glide path’s integrity of service or its continuity of service, or both, are not demonstrated; or
6. the glide path’s integrity of service and its continuity of service are both demonstrated, but at least one of them does not meet the requirements of Level 2.
7. The glide path level shall be Level 2 if:
8. the probability of not radiating false guidance signals is not less than 1 – 1.0 x 10–7 in any one landing; and
9. the probability of not losing the radiated guidance is greater 1 – 4 × 10–6 in any period of 15 seconds (equivalent to   
   1 000 hours mean time between outages).
10. The glide path level shall be Level 3 or 4 if:
11. the probability of not radiating false guidance signals is not less than 1 – 0.5 × 10–9 in any one landing; and
12. the probability of not losing the radiated guidance is greater than 1 – 2 × 10–6 in any period of 15 seconds (equivalent to 2 000 hours mean time between outages).
13. Localizer and glide path frequency pairing
14. The pairing of the runway localizer and glide path transmitter frequencies of an instrument landing system shall be taken from the following list in accordance with the provisions of CNS.V.010 (Volume V, Chapter 4, 4.2):

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

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

1. Where existing ILS localizers meeting national requirements are operating on frequencies ending in even tenths of a megahertz, they shall be reassigned frequencies, conforming with (1) or (i) as soon as practicable and may continue operating on their present assignments only until this reassignment can be effected.
2. Existing ILS localizers in the international service operating on frequencies ending in odd tenths of a megahertz shall not be assigned new frequencies ending in odd tenths plus one twentieth of a megahertz except where, by regional agreement, general use may be made of any of the channels listed in (1).

## Specification for precision approach radar system

1. The precision approach radar system shall comprise the following elements:
2. The precision approach radar element (PAR).
3. The surveillance radar element (SRE).
4. When the PAR only is used, the installation shall be identified by the term PAR or precision approach radar and not by the term “precision approach radar system”.
5. The precision approach radar element (PAR)
6. *Coverage*
7. The PAR shall be capable of detecting and indicating the position of an aircraft of 15 m2 echoing area or larger, which is within a space bounded by a 20-degree azimuth sector and a 7-degree elevation sector, to a distance of at least 16.7 km (9 NM) from its respective antenna.
8. *Siting*
9. The PAR shall be sited and adjusted so that it gives complete coverage of a sector with its apex at a point 150 m (500 ft) from the touchdown in the direction of the stop end of the runway and extending plus or minus 5 degrees about the runway centre line in azimuth and from minus 1 degree to plus 6 degrees in elevation.
10. *Accuracy*
11. *Azimuth accuracy.* Azimuth information shall be displayed in such a manner that left-right deviation from the on-course line shall be easily observable. The maximum permissible error with respect to the deviation from the on-course line shall be either 0.6 per cent of the distance from the PAR antenna plus 10 per cent of the deviation from the on-course line or 9 m (30 ft), whichever is greater. The equipment shall be so sited that the error at the touchdown shall not exceed 9 m (30 ft). The equipment shall be so aligned and adjusted that the displayed error at the touchdown shall be a minimum and shall not exceed 0.3 per cent of the distance from the PAR antenna or 4.5 m (15 ft), whichever is greater. It shall be possible to resolve the positions of two aircraft which are at 1.2 degrees in azimuth of one another.
12. *Elevation accuracy.* Elevation information shall be displayed in such a manner that up-down deviation from the descent path for which the equipment is set shall be easily observable. The maximum permissible error with respect to the deviation from the on-course line shall be 0.4 per cent of the distance from the PAR antenna plus 10 per cent of the actual linear displacement from the chosen descent path or 6 m (20 ft), whichever is greater. The equipment shall be so sited that the error at the touchdown shall not exceed 6 m (20 ft). The equipment shall be so aligned and adjusted that the displayed error at the touchdown shall be a minimum and shall not exceed 0.2 per cent of the distance from the PAR antenna or 3 m (10 ft), whichever is greater. It shall be possible to resolve the positions of two aircraft that are at 0.6 degree in elevation of one another.
13. *Distance accuracy.* The error in indication of the distance from the touchdown shall not exceed 30 m (100 ft) plus 3 per cent of the distance from the touchdown. It shall be possible to resolve the positions of two aircraft which are at 120 m (400 ft) of one another on the same azimuth.
14. Information shall be made available to permit the position of the controlled aircraft to be established with respect to other aircraft and obstructions. Indications shall also permit appreciation of ground speed and rate of departure from or approach to the desired flight path.
15. Information shall be completely renewed at least once every second.
16. The surveillance radar element (SRE)
17. A surveillance radar used as the SRE of a precision approach radar system shall satisfy at least the following broad performance requirements.
18. *Coverage*
19. The SRE shall be capable of detecting aircraft of 15 m2 echoing area and larger, which are in line of sight of the antenna within a volume described as follows:

The rotation through 360 degrees about the antenna of a vertical plane surface bounded by a line at an angle of 1.5 degrees above the horizontal plane of the antenna, extending from the antenna to 37 km (20 NM); by a vertical line at 37 km (20 NM) from the intersection with the 1.5-degree line up to 2 400 m (8 000 ft) above the level of the antenna; by a horizontal line at 2 400 m (8 000 ft) from 37 km (20 NM) back towards the antenna to the intersection with a line from the antenna at 20 degrees above the horizontal plane of the antenna, and by a 20-degree line from the intersection with the 2 400 m (8 000 ft) line to the antenna.

1. *Accuracy*
2. *Azimuth accuracy.* The indication of position in azimuth shall be within plus or minus 2 degrees of the true position. It shall be possible to resolve the positions of two aircraft which are at 4 degrees of azimuth of one another.
3. *Distance accuracy.* The error in distance indication shall not exceed 5 per cent of true distance or 150 m (500 ft), whichever is the greater. It shall be possible to resolve the positions of two aircraft that are separated by a distance of 1 per cent of the true distance from the point of observation or 230 m (750 ft), whichever is the greater.
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 every 4 seconds.

## Specification for VHF omnidirectional radio range (VOR)

1. General
2. The VOR shall be constructed and adjusted so that similar instrumental indications in aircraft represent equal clockwise angular deviations (bearings), degree for degree from magnetic North as measured from the location of the VOR.
3. 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.
4. The reference and variable phase modulations shall be in phase along the reference magnetic meridian through the station.
5. Radio frequency
6. The VOR shall operate in the band 111.975 MHz to 117.975 MHz except that frequencies in the band 108 MHz to 111.975 MHz may be used when, in accordance with the provisions of CNS.V.010(a) and CNS.V.010(1) (Volume V, Chapter 4, 4.2.1 and 4.2.3.1), the use of such frequencies is acceptable. The highest assignable frequency shall be 117.950 MHz. The channel separation shall be in increments of 50 kHz referred to the highest assignable frequency. In areas where 100 kHz or 200 kHz channel spacing is in general use, the frequency tolerance of the radio frequency carrier shall be plus or minus 0.005 per cent.
7. The frequency tolerance of the radio frequency carrier of all new installations implemented after 23 May 1974 in areas where 50 kHz channel spacing is in use shall be plus or minus 0.002 per cent.
8. In areas where new VOR installations are implemented and are assigned frequencies spaced at 50 kHz from existing VORs in the same area, priority shall be given to ensuring that the frequency tolerance of the radio frequency carrier of the existing VORs is reduced to plus or minus 0.002 per cent.
9. Polarization and pattern accuracy
10. The emission from the VOR shall be horizontally polarized. The vertically polarized component of the radiation shall be as small as possible.
11. The ground station contribution to the error in the bearing information conveyed by the horizontally polarized radiation from the VOR for all elevation angles between 0 and 40 degrees, measured from the centre of the VOR antenna system, shall be within plus or minus 2 degrees.
12. Coverage
13. 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.
14. Modulations of navigation signals
15. The radio frequency carrier as observed at any point in space shall be amplitude modulated by two signals as follows:
16. a subcarrier of 9 960 Hz of constant amplitude, frequency modulated at 30 Hz:
17. for the conventional VOR, the 30 Hz component of this FM subcarrier is fixed without respect to azimuth and is termed the “reference phase” and shall have a deviation ratio of 16 plus or minus 1 (i.e. 15 to 17);

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

1. a 30 Hz amplitude modulation component:
2. 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”;

for the Doppler VOR, this component, of constant phase with relation to azimuth and constant amplitude, is radiated omnidirectionally and is termed the “reference phase”.

1. The nominal depth of modulation of the radio frequency carrier due to the 30 Hz signal or the subcarrier of 9 960 Hz shall be within the limits of 28 per cent and 32 per cent.
2. The depth of modulation of the radio frequency carrier due to the 30 Hz signal, as observed at any angle of elevation up to 5 degrees, shall be within the limits of 25 to 35 per cent. The depth of modulation of the radio frequency carrier due to the 9 960 Hz signal, as observed at any angle of elevation up to 5 degrees, shall be within the limits of 20 to 55 per cent on facilities without voice modulation, and within the limits of 20 to 35 per cent on facilities with voice modulation.
3. The variable and reference phase modulation frequencies shall be 30 Hz within plus or minus 1 per cent.
4. The subcarrier modulation mid-frequency shall be 9 960 Hz within plus or minus 1 per cent.
5. For the conventional VOR, the percentage of amplitude modulation of the 9 960 Hz subcarrier shall not exceed 5 per cent.
6. For the Doppler VOR, the percentage of amplitude modulation of the 9 960 Hz subcarrier shall not exceed 40 per cent when measured at a point at least 300 m (1 000 ft) from the VOR.
7. Where 50 kHz VOR channel spacing is implemented, the sideband level of the harmonics of the 9 960 Hz component in the radiated signal shall not exceed the following levels referred to the level of the 9 960 Hz sideband:

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

1. Voice and identification
2. 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. The peak modulation depth of the carrier on the communication channel shall not be greater than 30 per cent.
4. The audio frequency characteristics of the speech channel shall be within 3 dB relative to the level at 1 000 Hz over the range 300 Hz to 3 000 Hz.
5. The VOR shall provide for the simultaneous transmission of a signal of identification on the same radio frequency carrier as that used for the navigational function. The identification signal radiation shall be horizontally polarized.
6. The identification signal shall employ the International Morse Code and consist of two or three letters. It shall be sent at a speed corresponding to approximately 7 words per minute. The signal shall be repeated at least once every 30seconds and the modulation tone shall be 1 020 Hz within plus or minus 50 Hz.
7. The depth to which the radio frequency carrier is modulated by the code identification signal shall be close to, but not in excess of 10 per cent except that, where a communication channel is not provided, it shall be permissible to increase the modulation by the code identification signal to a value not exceeding 20 per cent.
8. 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.
9. The VOR receiving function shall permit positive identification of the wanted signal under the signal conditions encountered within the specified coverage limits, and with the modulation parameters specified at (5), (6) and (7).
10. Monitoring
11. Suitable equipment located in the radiation field shall provide signals for the operation of an automatic monitor. The monitor shall transmit a warning to a control point, and either remove the identification and navigation components from the carrier or cause radiation to cease if anyone or a combination of the following deviations from established conditions arises:
12. a change in excess of 1 degree at the monitor site of the bearing information transmitted by the VOR;
13. a reduction of 15 per cent in the modulation components of the radio frequency signals voltage level at the monitor of either the subcarrier, or 30 Hz amplitude modulation signals, or both.
14. Failure of the monitor itself shall transmit a warning to a control point and either:
15. remove the identification and navigation components from the carrier; or
16. cause radiation to cease.
17. Interference immunity performance for VOR receiving systems
18. The VOR receiving system shall provide adequate immunity to interference from two signal, third-order intermodulation products caused by VHF FM broadcast signals having levels in accordance with the following:

2*N*1 + *N*2 + 72 ≤ 0

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

and

for VHF FM sound broadcasting signals below 107.7 MHz,

where the frequencies of the two VHF FM sound broadcasting signals produce, within the receiver, a two-signal, third-order intermodulation product on the desired VOR frequency.

N1 and N2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the VOR receiver input. Neither level shall exceed the desensitization criteria set forth in (2).

Δf = 108.1 – f1, where f1 is the frequency of N1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

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

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

## Specification for non-directional radio beacon (NDB)

1. Coverage
2. All notifications or promulgations of NDBs shall be based upon the average radius of the rated coverage.
3. Limitations in radiated power

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

1. Radio frequencies
2. The radio frequencies assigned to NDBs shall be selected from those available in that portion of the spectrum between 190 kHz and 1 750 kHz.
3. 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.
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.
5. Identification
6. 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.
7. The complete identification shall be transmitted at least once every 30 seconds, except where the beacon identification is effected by on/off keying of the carrier. In this latter case, the identification shall be at approximately 1‑minute intervals, except that a shorter interval may be used at particular NDB stations where this is found to be operationally desirable.
8. For NDBs with an average radius of rated coverage of 92.7 km (50 NM) or less that are primarily approach and holding aids in the vicinity of an aerodrome, the identification shall be transmitted at least three times each 30 seconds, spaced equally within that time period.
9. The frequency of the modulating tone used for identification shall be 1 020 Hz plus or minus 50 Hz or 400 Hz plus or minus 25 Hz.
10. Characteristics of emissions
11. Except as provided in (i), all NDBs shall radiate an uninterrupted carrier and be identified by on/off keying of an amplitude modulating tone (NON/A2A).
12. NDBs other than those wholly or partly serving as holding, approach and landing aids, or those having an average radius of rated coverage of less than 92.7 km (50 NM), may be identified by on/off keying of the unmodulated carrier (NON/A1A) if they are in areas of high beacon density and/or where the required rated coverage is not practicable of achievement because of:
13. radio interference from radio stations;
14. high atmospheric noise;
15. local conditions.
16. 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.
17. 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.
18. Unwanted audio frequency modulations shall total less than 5 per cent of the amplitude of the carrier.
19. 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.
20. Monitoring
21. For each NDB, suitable means shall be provided to enable detection of any of the following conditions at an appropriate location:
22. a decrease in radiated carrier power of more than 50 per cent below that required for the rated coverage;
23. failure to transmit the identification signal;
24. malfunctioning or failure of the means of monitoring itself.
25. During the hours of service of a locator, the means of monitoring shall provide for a continuous check on the functioning of the locator as prescribed in (1) a), b) and c).

## Specification for UHF distance measuring equipment (DME)

1. General
2. 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. 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.
4. 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.
5. When a DME is associated with an ILS or VOR for the purpose of constituting a single facility, they shall:
6. be operated on a standard frequency pairing in accordance with CNS.I.010(b)(3)(iii);
7. be collocated within the limits prescribed for associated facilities in (5); and
8. comply with the identification provisions of CNS.I.010(b)(6)(iv).
9. Collocation limits for a DME facility associated with an ILS or VOR facility.
10. Associated VOR and DME facilities shall be collocated in accordance with the following:
11. for those facilities used in terminal areas for approach purposes or other procedures where the highest position fixing accuracy of system capability is required, the separation of the VOR and DME antennas does not exceed 80 m (260 ft);
12. for purposes other than those indicated in a), the separation of the VOR and DME antennas does not exceed 600 m (2 000 ft).
13. Association of DME with ILS
14. The Standards in (b), (c) and (d) denoted by ‡ shall apply only to DME equipment first installed after 1 January 1989.
15. System characteristics
16. *Performance*
17. *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.
18. *Coverage*
19. When associated with a VOR, DME/N coverage shall be at least that of the VOR to the extent practicable.
20. When associated with either an ILS, DME/N coverage shall be at least that of the respective ILS.
21. *Accuracy*
22. *System accuracy.* The accuracy standards specified in CNS.I.010(c)(5) and CNS.I.010(d)(4) shall be met on a 95 per cent probability basis.
23. *Radio frequencies and polarization.* The system shall operate with vertical polarization in the frequency band 960 MHz to 1 215 MHz. The interrogation and reply frequencies shall be assigned with 1MHz spacing between channels.
24. *Channelling*
25. DME operating channels shall be formed by pairing interrogation and reply frequencies and by pulse coding on the paired frequencies.
26. DME operating channels shall be chosen from Table A (located at the end of this Part), of 352 channels in which the channel numbers, frequencies, and pulse codes are assigned.
27. *Channel pairing.* When a DME transponder is intended to operate in association with a single VHF navigation facility in the 108 MHz to 117.95 MHz frequency band, the DME operating channel shall be paired with the VHF channel as given in Table A.
28. *Interrogation pulse repetition frequency*
29. *DME/N.* The interrogator average pulse repetition frequency (PRF) shall not exceed 30 pairs of pulses per second, based on the assumption that at least 95 per cent of the time is occupied for tracking.
30. *DME/N.* If it is desired to decrease the time of search, the PRF may be increased during search but shall not exceed 150 pairs of pulses per second.
31. ‡ *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.
32. *Aircraft handling capacity of the system*
33. The aircraft handling capacity of transponders in an area shall be adequate for the peak traffic of the area or 100 aircraft, whichever is the lesser.
34. *Transponder identification*
35. All transponders shall transmit an identification signal in one of the following forms as required by (v):
36. an “independent” identification consisting of coded (International Morse Code) identity pulses which can be used with all transponders;
37. an “associated” signal which can be used for transponders specifically associated with a VHF navigation facility which itself transmits an identification signal.
38. Both systems of identification shall use signals, which shall consist of the transmission for an appropriate period of a series of paired pulses transmitted at a repetition rate of 1 350 pulse pairs per second, and shall temporarily replace all reply pulses that would normally occur at that time. These pulses shall have similar characteristics to the other pulses of the reply signals.
39. ‡ *DME/N.* Reply pulses shall be transmitted between key down times.
40. The characteristics of the “independent” identification signal shall be as follows:
41. 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
42. 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.
43. The characteristics of the “associated” signal shall be as follows:
44. when associated with a VHF facility, the identification shall be transmitted in the form of dots and dashes (International Morse Code) as in (iii) and shall be synchronized with the VHF facility identification code;
45. 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;
46. Identification implementation
47. The “independent” identification code shall be employed wherever a transponder is not specifically associated with a VHF navigational facility.
48. Wherever a transponder is specifically associated with a VHF navigational facility, identification shall be provided by the “associated” code.
49. When voice communications are being radiated on an associated VHF navigational facility, an “associated” signal from the transponder shall not be suppressed.
50. Detailed technical characteristics of transponder and associated monitor.
51. *Transmitter*
52. *Frequency of operation.* The transponder shall transmit on the reply frequency appropriate to the assigned DME channel [see CNS.I.010(b)(3)(ii)].
53. *Frequency stability.* The radio frequency of operation shall not vary more than plus or minus 0.002 per cent from the assigned frequency.
54. *Pulse shape and spectrum.* The following shall apply to all radiated pulses:
55. *Pulse rise time.*

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

1. Pulse duration shall be 3.5 microseconds plus or minus 0.5 microsecond.
2. Pulse decay time shall nominally be 2.5 microseconds but shall not exceed 3.5 microseconds.
3. 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.
4. For DME/N: the spectrum of the pulse modulated signal shall be such that during the pulse the EIRP contained in a 0.5 MHz band centred on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case shall not exceed 200 mW, and the EIRP contained in a 0.5 MHz band centred on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2 mW. The EIRP contained within any 0.5 MHz band shall decrease monotonically as the band centre frequency moves away from the nominal channel frequency.
5. To ensure proper operation of the thresholding techniques, the instantaneous magnitude of any pulse turn-on transients which occur in time prior to the virtual origin shall be less than one per cent of the pulse peak amplitude. Initiation of the turn-on process shall not commence sooner than 1 microsecond prior to the virtual origin.
6. *Pulse spacing*
7. The spacing of the constituent pulses of transmitted pulse pairs shall be as given in the table in CNS.I.010(c)(4)(i).
8. *DME/N.* The tolerance on the pulse spacing shall be plus or minus 0.25 microsecond.
9. The pulse spacings shall be measured between the half voltage points on the leading edges of the pulses.
10. Peak power output
11. ‡*DME/N.* The peak equivalent isotropically radiated power shall not be less than that required to ensure a peak pulse power density of minus 89 dBW/m2 under all operational weather conditions at any point within coverage specified in CNS.I.010(b)(1)(ii).
12. The transmitter shall operate at a transmission rate, including randomly distributed pulse pairs and distance reply pulse pairs, of not less than 700 pulse pairs per second except during identity. The minimum transmission rate shall be as close as practicable to 700 pulse pairs per second.
13. *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.
14. ‡ *DME/N.* The spurious power level specified in (vi) shall be more than 80 dB below the peak pulse power level.
15. *Out-of-band spurious radiation.* At all frequencies from 10 to 1 800 MHz, but excluding the band of frequencies from 960 to 1 215 MHz, the spurious output of the DME transponder transmitter shall not exceed minus 40 dBm in any one kHz of receiver bandwidth.
16. The equivalent isotropically radiated power of any CW harmonic of the carrier frequency on any DME operating channel shall not exceed minus 10 dBm.
17. *Receiver*
18. *Frequency of operation.* The receiver centre frequency shall be the interrogation frequency appropriate to the assigned DME operating channel [see CNS.I.010(b)(3)(ii)].
19. *Frequency stability.* The centre frequency of the receiver shall not vary more than plus or minus 0.002 per cent from the assigned frequency.
20. *Transponder sensitivity*
21. 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:
22. minus 103 dBW/m2 for DME/N with coverage range greater than 56 km (30 NM);
23. minus 93 dBW/m2 for DME/N with coverage range not greater than 56 km (30 NM);
24. The minimum power densities specified in (A) shall cause the transponder to reply with an efficiency of at least:
25. 70 per cent for DME/N;

1. ‡ *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 (A) up to a maximum of minus 22 dBW/m2 when installed with ILS and minus 35 dBW/m2 when installed for other applications.
2. The transponder sensitivity level shall not vary by more than 1 dB for transponder loadings between 0 and 90 per cent of its maximum transmission rate.
3. ‡ *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.
4. *Noise.* When the receiver is interrogated at the power densities specified in CNS.I.010(c)(2)(iii)(A) to produce a transmission rate equal to 90 per cent of the maximum, the noise generated pulse pairs shall not exceed 5 per cent of the maximum transmission rate.
5. *Bandwidth*
6. The minimum permissible bandwidth of the receiver shall be such that the transponder sensitivity level shall not deteriorate by more than 3 dB when the total receiver drift is added to an incoming interrogation frequency drift of plus or minus 100 kHz.
7. *DME/N.* The receiver bandwidth shall be sufficient to allow compliance with CNS.I.010(b)(1)(iii) when the input signals are those specified in CNS.I.010(d)(1)(iii).
8. Signals greater than 900 kHz removed from the desired channel nominal frequency and having power densities up to the values specified in CNS.I.010(c)(2)(iii)(C) for DME/N shall not trigger the transponder. Signals arriving at the intermediate frequency shall be suppressed at least 80 dB. All other spurious response or signals within the 960 MHz to 1 215 MHz band and image frequencies shall be suppressed at least 75 dB.
9. *Recovery time.* Within 8 microseconds of the reception of a signal between 0 dB and 60 dB above minimum sensitivity level, the minimum sensitivity level of the transponder to a desired signal shall be within 3 dB of the value obtained in the absence of signals. This requirement shall be met with echo suppression circuits, if any, rendered inoperative. The 8 microseconds are to be measured between the half voltage points on the leading edges of the two signals, both of which conform in shape, with the specifications in CNS.I.010(d)(1)(iii).
10. *Spurious radiations.* Radiation from any part of the receiver or allied circuits shall meet the requirements stated in CNS.I.010(c)(1)(vi).
11. *Decoding*
12. The transponder shall include a decoding circuit such that the transponder can be triggered only by pairs of received pulses having pulse duration and pulse spacings appropriate to interrogator signals as described in CNS.I.010(d)(1)(iii) and CNS.I.010(d)(1)(iv).
13. 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.
14. ‡ *DME/N — Decoder rejection.* An interrogation pulse pair with a spacing of plus or minus 2 microseconds, or more, from the nominal value and with any signal level up to the value specified in CNS.I.010(c)(2)(iii)(C) shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent.
15. *Time delay*
16. When a DME is associated only with a VHF facility, the time delay shall be the interval from the half voltage point on the leading edge of the second constituent pulse of the interrogation pair and the half voltage point on the leading edge of the second constituent pulse of the reply transmission. This delay shall be consistent with the following table, when it is desired that aircraft interrogators are to indicate distance from the transponder site.

|  |  | *Pulse pair*  *spacing (µs)* | | *Time delay (µs)* | |
| --- | --- | --- | --- | --- | --- |
|  |  |  | |  | |
| *Channel*  *suffix* | *Operating mode* | *Interrogation* | *Reply* | *1st pulse*  *timing* | *2nd pulse*  *timing* |
|  |  |  |  |  |  |
| X | DME/N | 12 | 12 | 50 | 50 |
| Y | DME/N | 36 | 30 | 56 | 50 |
| W | DME/N | – | – | – | – |
| Z | DME/N | – | – | – | – |

1. ‡ *DME/N.* The time delay shall be the interval from the half voltage point on the leading edge of the first constituent pulse of the interrogation pair and the half voltage point on the leading edge of the first constituent pulse of the reply transmission.
2. *Accuracy*
3. *DME/N.* The transponder shall not contribute more than plus or minus 1 microsecond (150 m (500 ft)) to the overall system error.
4. ‡ *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.
5. ‡ *DME/N.* A transponder associated with a landing aid shall not contribute more than plus or minus 0.5 microsecond (75 m (250 ft)) to the overall system error.
6. *Efficiency*
7. 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 CNS.I.010(b)(5) and at the minimum sensitivity level specified in CNS.I.010(c)(2)(iii)(A) and CNS.I.010(c)(2)(iii)(D).
8. *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.
9. *Monitoring and control*
10. Means shall be provided at each transponder site for the automatic monitoring and control of the transponder in use.
11. *DME/N monitoring action*
12. In the event that any of the conditions specified in (B) occur, the monitor shall cause the following action to take place:
13. a suitable indication shall be given at a control point;
14. the operating transponder shall be automatically switched off; and
15. the standby transponder, if provided, shall be automatically placed in operation.
16. The monitor shall cause the actions specified in (A) if:
17. the transponder delay differs from the assigned value by 1 microsecond (150 m (500 ft)) or more;
18. ‡ in the case of a DME/N associated with a landing aid, the transponder delay differs from the assigned value by 0.5 microsecond (75 m (250 ft)) or more.
19. Means shall be provided so that any of the conditions and malfunctioning enumerated in (B) which are monitored can persist for a certain period before the monitor takes action. This period shall be as low as practicable, but shall not exceed 10 seconds, consistent with the need for avoiding interruption, due to transient effects, of the service provided by the transponder.
20. The transponder shall not be triggered more than 120 times per second for either monitoring or automatic frequency control purposes, or both.
21. *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.
22. Technical characteristics of interrogator
23. does not jeopardize the effective operation of the DME system, e.g. by increasing transponder loading abnormally; and
24. is capable of giving accurate distance readings.
25. *Transmitter*
26. *Frequency of operation.* The interrogator shall transmit on the interrogation frequency appropriate to the assigned DME channel [see CNS.I.010(b)(3)(ii)].
27. *Frequency stability.* The radio frequency of operation shall not vary more than plus or minus 100 kHz from the assigned value.
28. *Pulse shape and spectrum.* The following shall apply to all radiated pulses:
29. *Pulse rise time.*
30. DME/N. Pulse rise time shall not exceed 3 microseconds.
31. Pulse decay time shall nominally be 2.5 microseconds, but shall not exceed 3.5 microseconds.
32. 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.
33. The spectrum of the pulse modulated signal shall be such that at least 90 per cent of the energy in each pulse shall be within 0.5 MHz in a band centred on the nominal channel frequency.
34. To ensure proper operation of the thresholding techniques, the instantaneous magnitude of any pulse turn-on transients which occur in time prior to the virtual origin shall be less than one per cent of the pulse peak amplitude. Initiation of the turn-on process shall not commence sooner than 1 microsecond prior to the virtual origin.
35. *Pulse spacing*
36. The spacing of the constituent pulses of transmitted pulse pairs shall be as given in the table in CNS.I.010(c)(4)(i).
37. *DME/N.* The tolerance on the pulse spacing shall be plus or minus 0.5 microsecond.
38. The pulse spacing shall be measured between the half voltage points on the leading edges of the pulses.
39. *Pulse repetition frequency*
40. The pulse repetition frequency shall be as specified in CNS.I.010(b)(4).
41. The variation in time between successive pairs of interrogation pulses shall be sufficient to prevent false lock-on.
42. *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).
43. *Time delay*
44. The time delay shall be consistent with the table in CNS.I.010(c)(4)(i).
45. *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.
46. ‡ *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.
47. *Receiver*
48. *Frequency of operation.* The receiver centre frequency shall be the transponder frequency appropriate to the assigned DME operating channel [see CNS.I.010(b)(3)(ii)].
49. *Receiver sensitivity*
50. ‡ *DME/N.* The airborne equipment sensitivity shall be sufficient to acquire and provide distance information to the accuracy specified in CNS.I.010(d)(4) for the signal power density specified in CNS.I.010(c)(1)(v)(A).
51. ‡ *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 CNS.I.010(c)(1)(v) and a maximum of minus 18 dBW/m2.
52. *Bandwidth*
53. *DME/N.* The receiver bandwidth shall be sufficient to allow compliance with CNS.I.010(b)(1)(iii), when the input signals are those specified in CNS.I.010(c)(1)(iii).
54. *Interference rejection*
55. 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.
56. ‡ *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.
57. *Decoding*
58. The interrogator shall include a decoding circuit such that the receiver can be triggered only by pairs of received pulses having pulse duration and pulse spacings appropriate to transponder signals as described in CNS.I.010(c)(1)(iv).
59. ‡ *DME/N — Decoder rejection.* A reply pulse pair with a spacing of plus or minus 2 microseconds, or more, from the nominal value and with any signal level up to 42 dB above the receiver sensitivity shall be rejected.
60. *Accuracy*
61. ‡ *DME/N.* The interrogator shall not contribute more than plus or minus 315 m (plus or minus 0.17 NM) or 0.25 per cent of indicated range, whichever is greater, to the overall system error.

## Requirements for the Global Navigation Satellite System (GNSS)

1. General
2. *Functions*
3. The GNSS shall provide position and time data to the aircraft.
4. *GNSS elements*
5. 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:
6. Global Positioning System (GPS) that provides the Standard Positioning Service (SPS) as defined in CNS.I.011(b)(1);
7. Global Navigation Satellite System (GLONASS) that provides the Channel of Standard Accuracy (CSA) navigation signal as defined in CNS.I.011(b)(2);
8. aircraft-based augmentation system (ABAS) as defined in CNS.I.011(b)(3);
9. satellite-based augmentation system (SBAS) as defined in CNS.I.011(b)(4);
10. ground-based augmentation system (GBAS) as defined in CNS.I.011(b)(5);
11. ground-based regional augmentation system (GRAS) as defined in CNS.I.011(b)(5); and
12. aircraft GNSS receiver as defined in CNS.I.011(b)(6).
13. *Space and time reference*
14. *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.
15. *Time reference*. The time data provided by the GNSS to the user shall be expressed in a time scale that takes the Coordinated Universal Time (UTC) as reference.
16. Signal-in-space performance
17. The combination of GNSS elements and a fault-free GNSS user receiver shall meet the signal-in-space requirements defined in Table B (located at the end of this Part).
18. GNSS elements specifications
19. *GPS Standard Positioning Service (SPS) (L1)*
20. *Space and control segment accuracy*
21. *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  Vertical position error | 9 m (30 ft)  15 m (49 ft) | 17 m (56 ft)  37 m (121 ft) |

1. *Time transfer accuracy*. The GPS SPS time transfer errors shall not exceed 40 nanoseconds 95 per cent of the time.
2. *Range domain accuracy*. The range domain error shall not exceed the following limits:
3. range error of any satellite — 30 m (100 ft) with reliability specified in CNS.I.011(b)(1)(iii);
4. 95th percentile range rate error of any satellite — 0.006 m (0.02 ft) per second (global average);
5. 95th percentile range acceleration error of any satellite — 0.002 m (0.006 ft) per second-squared (global average); and
6. 95th percentile range error for any satellite over all time differences between time of data generation and time of use of data — 7.8 m (26 ft) (global average).
7. *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)

1. *Reliability*. The GPS SPS reliability shall be within the following limits:
2. reliability — at least 99.94 per cent (global average); and
3. reliability — at least 99.79 per cent (worst single point average).
4. *Probability of major service failure.* The probability that the user range error (URE) of any satellite will exceed 4.42 times the upper bound on the user range accuracy (URA) broadcast by that satellite without an alert received at the user receiver antenna within 10 seconds shall not exceed 1×10-5 per hour.
5. *Continuity.* The probability of losing GPS SPS signal-in-space (SIS) availability from a slot of the nominal 24-slot constellation due to unscheduled interruption shall not exceed 2×10-4 per hour.
6. *Coverage.* The GPS SPS shall cover the surface of the earth up to an altitude of 3 000 kilometres.
7. *Radio frequency (RF) characteristics*
8. *Carrier frequency*. Each GPS satellite shall broadcast an SPS signal at the carrier frequency of 1 575.42 MHz (GPS L1) using code division multiple access (CDMA).
9. *Signal spectrum*. The GPS SPS signal power shall be contained within a ±12 MHz band (1 563.42 –1 587.42 MHz) centred on the L1 frequency.
10. *Polarization*. The transmitted RF signal shall be right-hand (clockwise) circularly polarized.
11. *Signal power level*. Each GPS satellite shall broadcast SPS navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly-polarized antenna is within the range of –158.5 dBW to –153 dBW for all antenna orientations orthogonal to the direction of propagation.
12. *Modulation*. The SPS L1 signal shall be bipolar phase shift key (BPSK) modulated with a pseudo random noise (PRN) 1.023 MHz coarse/acquisition (C/A) code. The C/A code sequence shall be repeated each millisecond. The transmitted PRN code sequence shall be the Modulo-2 addition of a 50 bits per second navigation message and the C/A code.
13. *GPS time*. GPS time shall be referenced to UTC (as maintained by the U.S. Naval Observatory).
14. *Coordinate system*. The GPS coordinate system shall be WGS-84.
15. *Navigation information*. The navigation data transmitted by the satellites shall include the necessary information to determine:
16. satellite time of transmission;
17. satellite position;
18. satellite health;
19. satellite clock correction;
20. propagation delay effects;
21. time transfer to UTC; and
22. constellation status.
23. *GLONASS Channel of Standard Accuracy (CSA) (L1)*
24. *Space and control segment accuracy*
25. *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  Vertical position error | 5 m (17 ft)  9 m (29 ft) | 12 m (40 ft)  25 m (97 ft) |

1. *Time transfer accuracy*. The GLONASS CSA time transfer errors shall not exceed 700 nanoseconds 95 per cent of the time.
2. *Range domain accuracy*. The range domain error shall not exceed the following limits:
3. range error of any satellite — 18 m (59.7 ft);
4. range rate error of any satellite — 0.02 m (0.07 ft) per second;
5. range acceleration error of any satellite — 0.007 m (0.023 ft) per second squared;
6. root-mean-square range error over all satellites — 6 m (19.9 ft).
7. *Availability*. The GLONASS CSA availability shall be as follows:
8. ≥99 per cent horizontal service availability, average location (12 m, 95 per cent threshold);
9. ≥99 per cent vertical service availability, average location (25 m, 95 per cent threshold);
10. ≥90 per cent horizontal service availability, worst-case location (12 m, 95 per cent threshold);
11. ≥90 per cent vertical service availability, worst-case location (25 m, 95 per cent threshold).
12. *Reliability*. The GLONASS CSA reliability shall be within the following limits:
13. frequency of a major service failure — not more than three per year for the constellation (global average); and
14. reliability — at least 99.7 per cent (global average).
15. *Coverage*. The GLONASS CSA shall cover the surface of the earth up to an altitude of 2 000 km.
16. *RF characteristics*
17. *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).
18. *Signal spectrum.* GLONASS CSA signal power shall be contained within a ±5.75 MHz band centred on each GLONASS carrier frequency.
19. *Polarization*. The transmitted RF signal shall be right-hand circularly polarized.
20. *Signal power level*. Each GLONASS satellite shall broadcast CSA navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is within the range of –161 dBW to –155.2 dBW for all antenna orientations orthogonal to the direction of propagation.
21. *Modulation*
22. Each GLONASS satellite shall transmit at its carrier frequency the navigation RF signal using a BPSK-modulated binary train. The phase shift keying of the carrier shall be performed at π-radians with the maximum error ±0.2 radian. The pseudo-random code sequence shall be repeated each millisecond.
23. The modulating navigation signal shall be generated by the Modulo-2 addition of the following three binary signals:
24. ranging code transmitted at 511 kbits/s;
25. navigation message transmitted at 50 bits/s; and
26. 100 Hz auxiliary meander sequence.
27. *GLONASS time.* GLONASS time shall be referenced to UTC(SU) (as maintained by the National Time Service of Russia).
28. *Coordinate system*. The GLONASS coordinate system shall be PZ-90.
29. *Navigation information.* The navigation data transmitted by the satellite shall include the necessary information to determine:
30. satellite time of transmission;
31. satellite position;
32. satellite health;
33. satellite clock correction;
34. time transfer to UTC; and
35. constellation status.
36. *Aircraft-based augmentation system (ABAS)*
37. *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 CNS.I.011(a)(4).
38. *Satellite-based augmentation system (SBAS)*
39. *Performance*. SBAS combined with one or more of the other GNSS elements and a fault-free receiver shall meet the requirements for system accuracy, integrity, continuity and availability for the intended operation as stated in CNS.I.011(a)(4), throughout the corresponding service area (see CNS.I.011(b)(4)(iii)).
40. SBAS combined with one or more of the other GNSS elements and a fault-free receiver shall meet the requirements for signal-in-space integrity as stated in CNS.I.011(a)(4), throughout the SBAS coverage area.
41. *Functions.* SBAS shall perform one or more of the following functions:
42. ranging: provide an additional pseudo-range signal with an accuracy indicator from an SBAS satellite (CNS.I.011(b)(4)(ii)(A) and Appendix B, 3.5.7.2);
43. GNSS satellite status: determine and transmit the GNSS satellite health status (Appendix B, 3.5.7.3);
44. 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
45. precise differential correction: determine and transmit the ionospheric corrections (Appendix B, 3.5.7.5).
46. *Ranging*
47. Excluding atmospheric effects, the range error for the ranging signal from SBAS satellites shall not exceed 25 m (82 ft) (95 per cent).
48. The probability that the range error exceeds 150 m (490 ft) in any hour shall not exceed 10–5.
49. The probability of unscheduled outages of the ranging function from an SBAS satellite in any hour shall not exceed 10–3.
50. The range rate error shall not exceed 2 m (6.6 ft) per second.
51. The range acceleration error shall not exceed 0.019 m (0.06 ft) per second-squared.
52. *Service area*. An SBAS service area for any approved type of operation shall be a declared area within the SBAS coverage area where SBAS meets the corresponding requirements of CNS.I.011(a)(4).
53. *RF characteristics*
54. *Carrier frequency*. The carrier frequency shall be 1 575.42 MHz.
55. *Signal spectrum*. At least 95 per cent of the broadcast power shall be contained within a ±12 MHz band centred on the L1 frequency. The bandwidth of the signal transmitted by an SBAS satellite shall be at least 2.2 MHz.
56. *SBAS satellite signal power level*
57. Each SBAS satellite placed in orbit before 1 January 2014 shall broadcast navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the antenna port of a 3 dBi linearly polarized antenna is within the range of –161 dBW to –153 dBW for all antenna orientations orthogonal to the direction of propagation.
58. Each SBAS satellite placed in orbit after 31 December 2013 shall comply with the following requirements:
59. The satellite shall broadcast navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at or above the minimum elevation angle for which a trackable GEO signal needs to be provided, the level of the received RF signal at the antenna port of the antenna specified in Appendix B, Table B-88, is at least –164.0 dBW.
60. The minimum elevation angle used to determine GEO coverage shall not be less than 5 degrees for a user near the ground.
61. The level of a received SBAS RF signal at the antenna port of a 0 dBic antenna located near the ground shall not exceed –152.5 dBW.
62. The ellipticity of the broadcast signal shall be no worse than 2 dB for the angular range of ±9.1° from boresight.
63. *Polarization*. The broadcast signal shall be right-hand circularly polarized.
64. *Modulation.* The transmitted sequence shall be the Modulo-2 addition of the navigation message at a rate of 500 symbols per second and the 1 023 bit pseudo-random noise code. It shall then be BPSK-modulated onto the carrier at a rate of 1.023 megachips per second.
65. *SBAS network time (SNT)*. The difference between SNT and GPS time shall not exceed 50 nanoseconds.
66. *Navigation information*. The navigation data transmitted by the satellites shall include the necessary information to determine:
67. SBAS satellite time of transmission;
68. SBAS satellite position;
69. corrected satellite time for all satellites;
70. corrected satellite position for all satellites;
71. ionospheric propagation delay effects;
72. user position integrity;
73. time transfer to UTC; and
74. service level status.
75. *Ground-based augmentation system (GBAS) and ground-based regional augmentation system (GRAS)*
76. *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 CNS.I.011(a)(4) within the service volume for the service used to support the operation as defined in CNS.I.011(b)(5)(iii).
77. *Functions*. GBAS shall perform the following functions:
78. provide locally relevant pseudo-range corrections;
79. provide GBAS-related data;
80. provide final approach segment data when supporting precision approach;
81. provide predicted ranging source availability data; and
82. provide integrity monitoring for GNSS ranging sources.
83. *Service volume*
84. *General requirement for approach services.* The minimum GBAS approach service volume shall be as follows, except where topographical features dictate and operational requirements permit:
85. 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
86. 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) to an upper bound of 3 000 m (10 000 ft) height above threshold (HAT) 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. The lower bound is half the lowest decision height supported or 3.7 m (12 ft), whichever is larger.
87. *Approach services supporting autoland and guided take-off*. The minimum additional GBAS service volume to support approach operations that include automatic landing and roll-out, including during guided take-off, shall be as follows, except where operational requirements permit:
88. Horizontally, within a sector spanning the width of the runway beginning at the stop end of the runway and extending parallel with the runway centre line towards the LTP to join the minimum service volume as described in CNS.I.011(b)(5)(iii)(A).
89. Vertically, between two horizontal surfaces one at 3.7 m (12 ft) and the other at 30 m (100 ft) above the runway centre line to join the minimum service volume as described in CNS.I.011(b)(5)(iii)(A).
90. *GBAS positioning service.* The service volume for the GBAS positioning service shall be where the data broadcast can be received and the positioning service meets the requirements of CNS.I.011(a)(4) and supports the corresponding approved operations.
91. *Data broadcast characteristics*
92. *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.
93. *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.
94. *Modulation*. GBAS data shall be transmitted as 3-bit symbols, modulating the data broadcast carrier by D8PSK, at a rate of 10 500 symbols per second.
95. *Data broadcast RF field strength and polarization*
96. *GBAS/H*
97. A horizontally polarized signal shall be broadcast.
98. The effective isotropically radiated power (EIRP) 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 0.879 volts per metre (–27 dBW/m2) within the GBAS service volume as specified in CNS.I.011(b)(5)(iii)(A). The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst. Within the additional GBAS service volume, as specified in CNS.I.011(b)(5)(iii)(B), the effective isotropically radiated power (EIRP) shall provide for a horizontally polarized signal with a minimum field strength of 215 microvolts per metre (–99 dBW/m2) below 36 ft and down to 12 ft above the runway surface and 650 microvolts per metre (–89.5 dBW/m2) at 36 ft or more above the runway surface.
99. *GBAS/E*
100. When an elliptically polarized signal is broadcast, the horizontally polarized component shall meet the requirements in CNS.I.011(b)(5)(iv)(D)a2, and the effective isotropically radiated power (EIRP) 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 0.555 volts per metre (–31 dBW/m2) within the GBAS service volume. The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst.
101. *Power transmitted in adjacent channel*s. The amount of power during transmission under all operating conditions when measured over a 25 kHz bandwidth centred on the ith adjacent channel shall not exceed the values shown in Table C (located at the end of this Part).
102. *Unwanted emissions.* Unwanted emissions, including spurious and out-of-band emissions, shall be compliant with the levels shown in Table D (located at the end of this Part). The total power in any VDB harmonic or discrete signal shall not be greater than –53 dBm.
103. *Navigation information*. The navigation data transmitted by GBAS shall include the following information:
104. pseudo-range corrections, reference time and integrity data;
105. GBAS-related data;
106. final approach segment data when supporting precision approach; and
107. predicted ranging source availability data.
108. *Aircraft GNSS receiver*
109. 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 SBAS) and Appendix B, 3.6 (for GBAS and GRAS).
110. Resistance to interference
111. GNSS shall comply with performance requirements defined in CNS.I.011(a)(4) and Appendix B, 3.7 in the presence of the interference environment defined in Appendix B, 3.7.
112. Database
113. Aircraft GNSS equipment that uses a database shall provide a means to:
114. update the electronic navigation database; and
115. determine the Aeronautical Information Regulation and Control (AIRAC) effective dates of the aeronautical database.

## System characteristics of airborne ADF receiving systems

1. Accuracy of bearing indication
2. The bearing given by the ADF system shall not be in error by more than plus or minus 5 degrees with a radio signal from any direction having a field strength of 70 microvolts per metre or more radiated from an LF/MF NDB or locator operating within the tolerances permitted by this Annex and in the presence also of an unwanted signal from a direction 90 degrees from the wanted signal and:
3. on the same frequency and 15 dB weaker; or
4. plus or minus 2 kHz away and 4 dB weaker; or
5. plus or minus 6 kHz or more away and 55 dB stronger.

# TABLES FOR CHAPTER 3

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

|  |  |  |  |  | DME parameters | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | Interrogation | | | | Reply | |
|  |  |  |  |  |  | Pulse codes | | |  |  |
| Channel pairing | | | | |  |  | DME/P mode | |  |  |
| DME  channel  number | | VHF  frequency  MHz | MLS  angle  frequency  MHz | MLS  channel  number | Frequency  MHz | DME/N  µs | Initial  approach  µs | Final  approach  µs | Frequency  MHz | Pulse  codes  µs |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 1X | – | – | – | 1 025 | 12 | – | – | 962 | 12 |
| \*\* | 1Y | – | – | – | 1 025 | 36 | – | – | 1 088 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 2X | – | – | – | 1 026 | 12 | – | – | 963 | 12 |
| \*\* | 2Y | – | – | – | 1 026 | 36 | – | – | 1 089 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 3X | – | – | – | 1 027 | 12 | – | – | 964 | 12 |
| \*\* | 3Y | – | – | – | 1 027 | 36 | – | – | 1 090 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 4X | – | – | – | 1 028 | 12 | – | – | 965 | 12 |
| \*\* | 4Y | – | – | – | 1 028 | 36 | – | – | 1 091 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 5X | – | – | – | 1 029 | 12 | – | – | 966 | 12 |
| \*\* | 5Y | – | – | – | 1 029 | 36 | – | – | 1 092 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 6X | – | – | – | 1 030 | 12 | – | – | 967 | 12 |
| \*\* | 6Y | – | – | – | 1 030 | 36 | – | – | 1 093 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 7X | – | – | – | 1 031 | 12 | – | – | 968 | 12 |
| \*\* | 7Y | – | – | – | 1 031 | 36 | – | – | 1 094 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 8X | – | – | – | 1 032 | 12 | – | – | 969 | 12 |
| \*\* | 8Y | – | – | – | 1 032 | 36 | – | – | 1 095 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 9X | – | – | – | 1 033 | 12 | – | – | 970 | 12 |
| \*\* | 9Y | – | – | – | 1 033 | 36 | – | – | 1 096 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 10X | – | – | – | 1 034 | 12 | – | – | 971 | 12 |
| \*\* | 10Y | – | – | – | 1 034 | 36 | – | – | 1 097 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 11X | – | – | – | 1 035 | 12 | – | – | 972 | 12 |
| \*\* | 11Y | – | – | – | 1 035 | 36 | – | – | 1 098 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 12X | – | – | – | 1 036 | 12 | – | – | 973 | 12 |
| \*\* | 12Y | – | – | – | 1 036 | 36 | – | – | 1 099 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 13X | – | – | – | 1 037 | 12 | – | – | 974 | 12 |
| \*\* | 13Y | – | – | – | 1 037 | 36 | – | – | 1 100 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 14X | – | – | – | 1 038 | 12 | – | – | 975 | 12 |
| \*\* | 14Y | – | – | – | 1 038 | 36 | – | – | 1 101 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 15X | – | – | – | 1 039 | 12 | – | – | 976 | 12 |
| \*\* | 15Y | – | – | – | 1 039 | 36 | – | – | 1 102 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \* | 16X | – | – | – | 1 040 | 12 | – | – | 977 | 12 |
| \*\* | 16Y | – | – | – | 1 040 | 36 | – | – | 1 103 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 17X | 108.00 | – | – | 1 041 | 12 | – | – | 978 | 12 |
|  | 17Y | 108.05 | 5 043.0 | 540 | 1 041 | 36 | 36 | 42 | 1 104 | 30 |
|  | 17Z | – | 5 043.3 | 541 | 1 041 | – | 21 | 27 | 1 104 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 18X | 108.10 | 5 031.0 | 500 | 1 042 | 12 | 12 | 18 | 979 | 12 |
|  | 18W | – | 5 031.3 | 501 | 1 042 | – | 24 | 30 | 979 | 24 |
|  | 18Y | 108.15 | 5 043.6 | 542 | 1 042 | 36 | 36 | 42 | 1 105 | 30 |
|  | 18Z | – | 5 043.9 | 543 | 1 042 | – | 21 | 27 | 1 105 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 19X | 108.20 | – | – | 1 043 | 12 | – | – | 980 | 12 |
|  | 19Y | 108.25 | 5 044.2 | 544 | 1 043 | 36 | 36 | 42 | 1 106 | 30 |
|  | 19Z | – | 5 044.5 | 545 | 1 043 | – | 21 | 27 | 1 106 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 20X | 108.30 | 5 031.6 | 502 | 1 044 | 12 | 12 | 18 | 981 | 12 |
|  | 20W | – | 5 031.9 | 503 | 1 044 | – | 24 | 30 | 981 | 24 |
|  | 20Y | 108.35 | 5 044.8 | 546 | 1 044 | 36 | 36 | 42 | 1 107 | 30 |
|  | 20Z | – | 5 045.1 | 547 | 1 044 | – | 21 | 27 | 1 107 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 21X | 108.40 | – | – | 1 045 | 12 | – | – | 982 | 12 |
|  | 21Y | 108.45 | 5 045.4 | 548 | 1 045 | 36 | 36 | 42 | 1 108 | 30 |
|  | 21Z | – | 5 045.7 | 549 | 1 045 | – | 21 | 27 | 1 108 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 22X | 108.50 | 5 032.2 | 504 | 1 046 | 12 | 12 | 18 | 983 | 12 |
|  | 22W | – | 5 032.5 | 505 | 1 046 | – | 24 | 30 | 983 | 24 |
|  | 22Y | 108.55 | 5 046.0 | 550 | 1 046 | 36 | 36 | 42 | 1 109 | 30 |
|  | 22Z | – | 5 046.3 | 551 | 1 046 | – | 21 | 27 | 1 109 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 23X | 108.60 | – | – | 1 047 | 12 | – | – | 984 | 12 |
|  | 23Y | 108.65 | 5 046.6 | 552 | 1 047 | 36 | 36 | 42 | 1 110 | 30 |
|  | 23Z | – | 5 046.9 | 553 | 1 047 | – | 21 | 27 | 1 110 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 24X | 108.70 | 5 032.8 | 506 | 1 048 | 12 | 12 | 18 | 985 | 12 |
|  | 24W | – | 5 033.1 | 507 | 1 048 | – | 24 | 30 | 985 | 24 |
|  | 24Y | 108.75 | 5 047.2 | 554 | 1 048 | 36 | 36 | 42 | 1 111 | 30 |
|  | 24Z | – | 5 047.5 | 555 | 1 048 | – | 21 | 27 | 1 111 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 25X | 108.80 | – | – | 1 049 | 12 | – | – | 986 | 12 |
|  | 25Y | 108.85 | 5 047.8 | 556 | 1 049 | 36 | 36 | 42 | 1 112 | 30 |
|  | 25Z | – | 5 048.1 | 557 | 1 049 | – | 21 | 27 | 1 112 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 26X | 108.90 | 5 033.4 | 508 | 1 050 | 12 | 12 | 18 | 987 | 12 |
|  | 26W | – | 5 033.7 | 509 | 1 050 | – | 24 | 30 | 987 | 24 |
|  | 26Y | 108.95 | 5 048.4 | 558 | 1 050 | 36 | 36 | 42 | 1 113 | 30 |
|  | 26Z | – | 5 048.7 | 559 | 1 050 | – | 21 | 27 | 1 113 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 27X | 109.00 | – | – | 1 051 | 12 | – | – | 988 | 12 |
|  | 27Y | 109.05 | 5 049.0 | 560 | 1 051 | 36 | 36 | 42 | 1 114 | 30 |
|  | 27Z | – | 5 049.3 | 561 | 1 051 | – | 21 | 27 | 1 114 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 28X | 109.10 | 5 034.0 | 510 | 1 052 | 12 | 12 | 18 | 989 | 12 |
|  | 28W | – | 5 034.3 | 511 | 1 052 | – | 24 | 30 | 989 | 24 |
|  | 28Y | 109.15 | 5 049.6 | 562 | 1 052 | 36 | 36 | 42 | 1 115 | 30 |
|  | 28Z | – | 5 049.9 | 563 | 1 052 | – | 21 | 27 | 1 115 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 29X | 109.20 | – | – | 1 053 | 12 | – | – | 990 | 12 |
|  | 29Y | 109.25 | 5 050.2 | 564 | 1 053 | 36 | 36 | 42 | 1 116 | 30 |
|  | 29Z | – | 5 050.5 | 565 | 1 053 | – | 21 | 27 | 1 116 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 30X | 109.30 | 5 034.6 | 512 | 1 054 | 12 | 12 | 18 | 991 | 12 |
|  | 30W | – | 5 034.9 | 513 | 1 054 | – | 24 | 30 | 991 | 24 |
|  | 30Y | 109.35 | 5 050.8 | 566 | 1 054 | 36 | 36 | 42 | 1 117 | 30 |
|  | 30Z | – | 5 051.1 | 567 | 1 054 | – | 21 | 27 | 1 117 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 31X | 109.40 | – | – | 1 055 | 12 | – | – | 992 | 12 |
|  | 31Y | 109.45 | 5 051.4 | 568 | 1 055 | 36 | 36 | 42 | 1 118 | 30 |
|  | 31Z | – | 5 051.7 | 569 | 1 055 | – | 21 | 27 | 1 118 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 32X | 109.50 | 5 035.2 | 514 | 1 056 | 12 | 12 | 18 | 993 | 12 |
|  | 32W | – | 5 035.5 | 515 | 1 056 | – | 24 | 30 | 993 | 24 |
|  | 32Y | 109.55 | 5 052.0 | 570 | 1 056 | 36 | 36 | 42 | 1 119 | 30 |
|  | 32Z | – | 5 052.3 | 571 | 1 056 | – | 21 | 27 | 1 119 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 33X | 109.60 | – | – | 1 057 | 12 | – | – | 994 | 12 |
|  | 33Y | 109.65 | 5 052.6 | 572 | 1 057 | 36 | 36 | 42 | 1 120 | 30 |
|  | 33Z | – | 5 052.9 | 573 | 1 057 | – | 21 | 27 | 1 120 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 34X | 109.70 | 5 035.8 | 516 | 1 058 | 12 | 12 | 18 | 995 | 12 |
|  | 34W | – | 5 036.1 | 517 | 1 058 | – | 24 | 30 | 995 | 24 |
|  | 34Y | 109.75 | 5 053.2 | 574 | 1 058 | 36 | 36 | 42 | 1 121 | 30 |
|  | 34Z | – | 5 053.5 | 575 | 1 058 | – | 21 | 27 | 1 121 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 35X | 109.80 | – | – | 1 059 | 12 | – | – | 996 | 12 |
|  | 35Y | 109.85 | 5 053.8 | 576 | 1 059 | 36 | 36 | 42 | 1 122 | 30 |
|  | 35Z | – | 5 054.1 | 577 | 1 059 | – | 21 | 27 | 1 122 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 36X | 109.90 | 5 036.4 | 518 | 1 060 | 12 | 12 | 18 | 997 | 12 |
|  | 36W | – | 5 036.7 | 519 | 1 060 | – | 24 | 30 | 997 | 24 |
|  | 36Y | 109.95 | 5 054.4 | 578 | 1 060 | 36 | 36 | 42 | 1 123 | 30 |
|  | 36Z | – | 5 054.7 | 579 | 1 060 | – | 21 | 27 | 1 123 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 37X | 110.00 | – | – | 1 061 | 12 | – | – | 998 | 12 |
|  | 37Y | 110.05 | 5 055.0 | 580 | 1 061 | 36 | 36 | 42 | 1 124 | 30 |
|  | 37Z | – | 5 055.3 | 581 | 1 061 | – | 21 | 27 | 1 124 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 38X | 110.10 | 5 037.0 | 520 | 1 062 | 12 | 12 | 18 | 999 | 12 |
|  | 38W | – | 5 037.3 | 521 | 1 062 | – | 24 | 30 | 999 | 24 |
|  | 38Y | 110.15 | 5 055.6 | 582 | 1 062 | 36 | 36 | 42 | 1 125 | 30 |
|  | 38Z | – | 5 055.9 | 583 | 1 062 | – | 21 | 27 | 1 125 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 39X | 110.20 | – | – | 1 063 | 12 | – | – | 1 000 | 12 |
|  | 39Y | 110.25 | 5 056.2 | 584 | 1 063 | 36 | 36 | 42 | 1 126 | 30 |
|  | 39Z | – | 5 056.5 | 585 | 1 063 | – | 21 | 27 | 1 126 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 40X | 110.30 | 5 037.6 | 522 | 1 064 | 12 | 12 | 18 | 1 001 | 12 |
|  | 40W | – | 5 037.9 | 523 | 1 064 | – | 24 | 30 | 1 001 | 24 |
|  | 40Y | 110.35 | 5 056.8 | 586 | 1 064 | 36 | 36 | 42 | 1 127 | 30 |
|  | 40Z | – | 5 057.1 | 587 | 1 064 | – | 21 | 27 | 1 127 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 41X | 110.40 | – | – | 1 065 | 12 | – | – | 1 002 | 12 |
|  | 41Y | 110.45 | 5 057.4 | 588 | 1 065 | 36 | 36 | 42 | 1 128 | 30 |
|  | 41Z | – | 5 057.7 | 589 | 1 065 | – | 21 | 27 | 1 128 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 42X | 110.50 | 5 038.2 | 524 | 1 066 | 12 | 12 | 18 | 1 003 | 12 |
|  | 42W | – | 5 038.5 | 525 | 1 066 | – | 24 | 30 | 1 003 | 24 |
|  | 42Y | 110.55 | 5 058.0 | 590 | 1 066 | 36 | 36 | 42 | 1 129 | 30 |
|  | 42Z | – | 5 058.3 | 591 | 1 066 | – | 21 | 27 | 1 129 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 43X | 110.60 | – | – | 1 067 | 12 | – | – | 1 004 | 12 |
|  | 43Y | 110.65 | 5 058.6 | 592 | 1 067 | 36 | 36 | 42 | 1 130 | 30 |
|  | 43Z | – | 5 058.9 | 593 | 1 067 | – | 21 | 27 | 1 130 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 44X | 110.70 | 5 038.8 | 526 | 1 068 | 12 | 12 | 18 | 1 005 | 12 |
|  | 44W | – | 5 039.1 | 527 | 1 068 | – | 24 | 30 | 1 005 | 24 |
|  | 44Y | 110.75 | 5 059.2 | 594 | 1 068 | 36 | 36 | 42 | 1 131 | 30 |
|  | 44Z | – | 5 059.5 | 595 | 1 068 | – | 21 | 27 | 1 131 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 45X | 110.80 | – | – | 1 069 | 12 | – | – | 1 006 | 12 |
|  | 45Y | 110.85 | 5 059.8 | 596 | 1 069 | 36 | 36 | 42 | 1 132 | 30 |
|  | 45Z | – | 5 060.1 | 597 | 1 069 | – | 21 | 27 | 1 132 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 46X | 110.90 | 5 039.4 | 528 | 1 070 | 12 | 12 | 18 | 1 007 | 12 |
|  | 46W | – | 5 039.7 | 529 | 1 070 | – | 24 | 30 | 1 007 | 24 |
|  | 46Y | 110.95 | 5 060.4 | 598 | 1 070 | 36 | 36 | 42 | 1 133 | 30 |
|  | 46Z | – | 5 060.7 | 599 | 1 070 | – | 21 | 27 | 1 133 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 47X | 111.00 | – | – | 1 071 | 12 | – | – | 1 008 | 12 |
|  | 47Y | 111.05 | 5 061.0 | 600 | 1 071 | 36 | 36 | 42 | 1 134 | 30 |
|  | 47Z | – | 5 061.3 | 601 | 1 071 | – | 21 | 27 | 1 134 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 48X | 111.10 | 5 040.0 | 530 | 1 072 | 12 | 12 | 18 | 1 009 | 12 |
|  | 48W | – | 5 040.3 | 531 | 1 072 | – | 24 | 30 | 1 009 | 24 |
|  | 48Y | 111.15 | 5 061.6 | 602 | 1 072 | 36 | 36 | 42 | 1 135 | 30 |
|  | 48Z | – | 5 061.9 | 603 | 1 072 | – | 21 | 27 | 1 135 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 49X | 111.20 | – | – | 1 073 | 12 | – | – | 1 010 | 12 |
|  | 49Y | 111.25 | 5 062.2 | 604 | 1 073 | 36 | 36 | 42 | 1 136 | 30 |
|  | 49Z | – | 5 062.5 | 605 | 1 073 | – | 21 | 27 | 1 136 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 50X | 111.30 | 5 040.6 | 532 | 1 074 | 12 | 12 | 18 | 1 011 | 12 |
|  | 50W | – | 5 040.9 | 533 | 1 074 | – | 24 | 30 | 1 011 | 24 |
|  | 50Y | 111.35 | 5 062.8 | 606 | 1 074 | 36 | 36 | 42 | 1 137 | 30 |
|  | 50Z | – | 5 063.1 | 607 | 1 074 | – | 21 | 27 | 1 137 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 51X | 111.40 | – | – | 1 075 | 12 | – | – | 1 012 | 12 |
|  | 51Y | 111.45 | 5 063.4 | 608 | 1 075 | 36 | 36 | 42 | 1 138 | 30 |
|  | 51Z | – | 5 063.7 | 609 | 1 075 | – | 21 | 27 | 1 138 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 52X | 111.50 | 5 041.2 | 534 | 1 076 | 12 | 12 | 18 | 1 013 | 12 |
|  | 52W | – | 5 041.5 | 535 | 1 076 | – | 24 | 30 | 1 013 | 24 |
|  | 52Y | 111.55 | 5 064.0 | 610 | 1 076 | 36 | 36 | 42 | 1 139 | 30 |
|  | 52Z | – | 5 064.3 | 611 | 1 076 | – | 21 | 27 | 1 139 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 53X | 111.60 | – | – | 1 077 | 12 | – | – | 1 014 | 12 |
|  | 53Y | 111.65 | 5 064.6 | 612 | 1 077 | 36 | 36 | 42 | 1 140 | 30 |
|  | 53Z | – | 5 064.9 | 613 | 1 077 | – | 21 | 27 | 1 140 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 54X | 111.70 | 5 041.8 | 536 | 1 078 | 12 | 12 | 18 | 1 015 | 12 |
|  | 54W | – | 5 042.1 | 537 | 1 078 | – | 24 | 30 | 1 015 | 24 |
|  | 54Y | 111.75 | 5 065.2 | 614 | 1 078 | 36 | 36 | 42 | 1 141 | 30 |
|  | 54Z | – | 5 065.5 | 615 | 1 078 | – | 21 | 27 | 1 141 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 55X | 111.80 | – | – | 1 079 | 12 | – | – | 1 016 | 12 |
|  | 55Y | 111.85 | 5 065.8 | 616 | 1 079 | 36 | 36 | 42 | 1 142 | 30 |
|  | 55Z | – | 5 066.1 | 617 | 1 079 | – | 21 | 27 | 1 142 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 56X | 111.90 | 5 042.4 | 538 | 1 080 | 12 | 12 | 18 | 1 017 | 12 |
|  | 56W | – | 5 042.7 | 539 | 1 080 | – | 24 | 30 | 1 017 | 24 |
|  | 56Y | 111.95 | 5 066.4 | 618 | 1 080 | 36 | 36 | 42 | 1 143 | 30 |
|  | 56Z | – | 5 066.7 | 619 | 1 080 | – | 21 | 27 | 1 143 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 57X | 112.00 | – | – | 1 081 | 12 | – | – | 1 018 | 12 |
|  | 57Y | 112.05 | – | – | 1 081 | 36 | – | – | 1 144 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 58X | 112.10 | – | – | 1 082 | 12 | – | – | 1 019 | 12 |
|  | 58Y | 112.15 | – | – | 1 082 | 36 | – | – | 1 145 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 59X | 112.20 | – | – | 1 083 | 12 | – | – | 1 020 | 12 |
|  | 59Y | 112.25 | – | – | 1 083 | 36 | – | – | 1 146 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 60X | – | – | – | 1 084 | 12 | – | – | 1 021 | 12 |
| \*\* | 60Y | – | – | – | 1 084 | 36 | – | – | 1 147 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 61X | – | – | – | 1 085 | 12 | – | – | 1 022 | 12 |
| \*\* | 61Y | – | – | – | 1 085 | 36 | – | – | 1 148 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 62X | – | – | – | 1 086 | 12 | – | – | 1 023 | 12 |
| \*\* | 62Y | – | – | – | 1 086 | 36 | – | – | 1 149 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 63X | – | – | – | 1 087 | 12 | – | – | 1 024 | 12 |
| \*\* | 63Y | – | – | – | 1 087 | 36 | – | – | 1 150 | 30 |
| \*\* | 64X | – | – | – | 1 088 | 12 | – | – | 1 151 | 12 |
| \*\* | 64Y | – | – | – | 1 088 | 36 | – | – | 1 025 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 65X | – | – | – | 1 089 | 12 | – | – | 1 152 | 12 |
| \*\* | 65Y | – | – | – | 1 089 | 36 | – | – | 1 026 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 66X | – | – | – | 1 090 | 12 | – | – | 1 153 | 12 |
| \*\* | 66Y | – | – | – | 1 090 | 36 | – | – | 1 027 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 67X | – | – | – | 1 091 | 12 | – | – | 1 154 | 12 |
| \*\* | 67Y | – | – | – | 1 091 | 36 | – | – | 1 028 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 68X | – | – | – | 1 092 | 12 | – | – | 1 155 | 12 |
| \*\* | 68Y | – | – | – | 1 092 | 36 | – | – | 1 029 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
| \*\* | 69X | – | – | – | 1 093 | 12 | – | – | 1 156 | 12 |
| \*\* | 69Y | – | – | – | 1 093 | 36 | – | – | 1 030 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 70X | 112.30 | – | – | 1 094 | 12 | – | – | 1 157 | 12 |
| \*\* | 70Y | 112.35 | – | – | 1 094 | 36 | – | – | 1 031 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 71X | 112.40 | – | – | 1 095 | 12 | – | – | 1 158 | 12 |
| \*\* | 71Y | 112.45 | – | – | 1 095 | 36 | – | – | 1 032 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 72X | 112.50 | – | – | 1 096 | 12 | – | – | 1 159 | 12 |
| \*\* | 72Y | 112.55 | – | – | 1 096 | 36 | – | – | 1 033 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 73X | 112.60 | – | – | 1 097 | 12 | – | – | 1 160 | 12 |
| \*\* | 73Y | 112.65 | – | – | 1 097 | 36 | – | – | 1 034 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 74X | 112.70 | – | – | 1 098 | 12 | – | – | 1 161 | 12 |
| \*\* | 74Y | 112.75 | – | – | 1 098 | 36 | – | – | 1 035 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 75X | 112.80 | – | – | 1 099 | 12 | – | – | 1 162 | 12 |
| \*\* | 75Y | 112.85 | – | – | 1 099 | 36 | – | – | 1 036 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 76X | 112.90 | – | – | 1 100 | 12 | – | – | 1 163 | 12 |
| \*\* | 76Y | 112.95 | – | – | 1 100 | 36 | – | – | 1 037 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 77X | 113.00 | – | – | 1 101 | 12 | – | – | 1 164 | 12 |
| \*\* | 77Y | 113.05 | – | – | 1 101 | 36 | – | – | 1 038 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 78X | 113.10 | – | – | 1 102 | 12 | – | – | 1 165 | 12 |
| \*\* | 78Y | 113.15 | – | – | 1 102 | 36 | – | – | 1 039 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 79X | 113.20 | – | – | 1 103 | 12 | – | – | 1 166 | 12 |
| \*\* | 79Y | 113.25 | – | – | 1 103 | 36 | – | – | 1 040 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 80X | 113.30 | – | – | 1 104 | 12 | – | – | 1 167 | 12 |
|  | 80Y | 113.35 | 5 067.0 | 620 | 1 104 | 36 | 36 | 42 | 1 041 | 30 |
|  | 80Z | – | 5 067.3 | 621 | 1 104 | – | 21 | 27 | 1 041 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 81X | 113.40 | – | – | 1 105 | 12 | – | – | 1 168 | 12 |
|  | 81Y | 113.45 | 5 067.6 | 622 | 1 105 | 36 | 36 | 42 | 1 042 | 30 |
|  | 81Z | – | 5 067.9 | 623 | 1 105 | – | 21 | 27 | 1 042 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 82X | 113.50 | – | – | 1 106 | 12 | – | – | 1 169 | 12 |
|  | 82Y | 113.55 | 5 068.2 | 624 | 1 106 | 36 | 36 | 42 | 1 043 | 30 |
|  | 82Z | – | 5 068.5 | 625 | 1 106 | – | 21 | 27 | 1 043 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 83X | 113.60 | – | – | 1 107 | 12 | – | – | 1 170 | 12 |
|  | 83Y | 113.65 | 5 068.8 | 626 | 1 107 | 36 | 36 | 42 | 1 044 | 30 |
|  | 83Z | – | 5 069.1 | 627 | 1 107 | – | 21 | 27 | 1 044 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 84X | 113.70 | – | – | 1 108 | 12 | – | – | 1 171 | 12 |
|  | 84Y | 113.75 | 5 069.4 | 628 | 1 108 | 36 | 36 | 42 | 1 045 | 30 |
|  | 84Z | – | 5 069.7 | 629 | 1 108 | – | 21 | 27 | 1 045 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 85X | 113.80 | – | – | 1 109 | 12 | – | – | 1 172 | 12 |
|  | 85Y | 113.85 | 5 070.0 | 630 | 1 109 | 36 | 36 | 42 | 1 046 | 30 |
|  | 85Z | – | 5 070.3 | 631 | 1 109 | – | 21 | 27 | 1 046 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 86X | 113.90 | – | – | 1 110 | 12 | – | – | 1 173 | 12 |
|  | 86Y | 113.95 | 5 070.6 | 632 | 1 110 | 36 | 36 | 42 | 1 047 | 30 |
|  | 86Z | – | 5 070.9 | 633 | 1 110 | – | 21 | 27 | 1 047 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 87X | 114.00 | – | – | 1 111 | 12 | – | – | 1 174 | 12 |
|  | 87Y | 114.05 | 5 071.2 | 634 | 1 111 | 36 | 36 | 42 | 1 048 | 30 |
|  | 87Z | – | 5 071.5 | 635 | 1 111 | – | 21 | 27 | 1 048 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 88X | 114.10 | – | – | 1 112 | 12 | – | – | 1 175 | 12 |
|  | 88Y | 114.15 | 5 071.8 | 636 | 1 112 | 36 | 36 | 42 | 1 049 | 30 |
|  | 88Z | – | 5 072.1 | 637 | 1 112 | – | 21 | 27 | 1 049 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 89X | 114.20 | – | – | 1 113 | 12 | – | – | 1 176 | 12 |
|  | 89Y | 114.25 | 5 072.4 | 638 | 1 113 | 36 | 36 | 42 | 1 050 | 30 |
|  | 89Z | – | 5 072.7 | 639 | 1 113 | – | 21 | 27 | 1 050 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 90X | 114.30 | – | – | 1 114 | 12 | – | – | 1 177 | 12 |
|  | 90Y | 114.35 | 5 073.0 | 640 | 1 114 | 36 | 36 | 42 | 1 051 | 30 |
|  | 90Z | – | 5 073.3 | 641 | 1 114 | – | 21 | 27 | 1 051 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 91X | 114.40 | – | – | 1 115 | 12 | – | – | 1 178 | 12 |
|  | 91Y | 114.45 | 5 073.6 | 642 | 1 115 | 36 | 36 | 42 | 1 052 | 30 |
|  | 91Z | – | 5 073.9 | 643 | 1 115 | – | 21 | 27 | 1 052 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 92X | 114.50 | – | – | 1 116 | 12 | – | – | 1 179 | 12 |
|  | 92Y | 114.55 | 5 074.2 | 644 | 1 116 | 36 | 36 | 42 | 1 053 | 30 |
|  | 92Z | – | 5 074.5 | 645 | 1 116 | – | 21 | 27 | 1 053 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 93X | 114.60 | – | – | 1 117 | 12 | – | – | 1 180 | 12 |
|  | 93Y | 114.65 | 5 074.8 | 646 | 1 117 | 36 | 36 | 42 | 1 054 | 30 |
|  | 93Z | – | 5 075.1 | 647 | 1 117 | – | 21 | 27 | 1 054 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 94X | 114.70 | – | – | 1 118 | 12 | – | – | 1 181 | 12 |
|  | 94Y | 114.75 | 5 075.4 | 648 | 1 118 | 36 | 36 | 42 | 1 055 | 30 |
|  | 94Z | – | 5 075.7 | 649 | 1 118 | – | 21 | 27 | 1 055 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 95X | 114.80 | – | – | 1 119 | 12 | – | – | 1 182 | 12 |
|  | 95Y | 114.85 | 5 076.0 | 650 | 1 119 | 36 | 36 | 42 | 1 056 | 30 |
|  | 95Z | – | 5 076.3 | 651 | 1 119 | – | 21 | 27 | 1 056 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 96X | 114.90 | – | – | 1 120 | 12 | – | – | 1 183 | 12 |
|  | 96Y | 114.95 | 5 076.6 | 652 | 1 120 | 36 | 36 | 42 | 1 057 | 30 |
|  | 96Z | – | 5 076.9 | 653 | 1 120 | – | 21 | 27 | 1 057 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 97X | 115.00 | – | – | 1 121 | 12 | – | – | 1 184 | 12 |
|  | 97Y | 115.05 | 5 077.2 | 654 | 1 121 | 36 | 36 | 42 | 1 058 | 30 |
|  | 97Z | – | 5 077.5 | 655 | 1 121 | – | 21 | 27 | 1 058 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 98X | 115.10 | – | – | 1 122 | 12 | – | – | 1 185 | 12 |
|  | 98Y | 115.15 | 5 077.8 | 656 | 1 122 | 36 | 36 | 42 | 1 059 | 30 |
|  | 98Z | – | 5 078.1 | 657 | 1 122 | – | 21 | 27 | 1 059 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 99X | 115.20 | – | – | 1 123 | 12 | – | – | 1 186 | 12 |
|  | 99Y | 115.25 | 5 078.4 | 658 | 1 123 | 36 | 36 | 42 | 1 060 | 30 |
|  | 99Z | – | 5 078.7 | 659 | 1 123 | – | 21 | 27 | 1 060 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 100X | 115.30 | – | – | 1 124 | 12 | – | – | 1 187 | 12 |
|  | 100Y | 115.35 | 5 079.0 | 660 | 1 124 | 36 | 36 | 42 | 1 061 | 30 |
|  | 100Z | – | 5 079.3 | 661 | 1 124 | – | 21 | 27 | 1 061 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 101X | 115.40 | – | – | 1 125 | 12 | – | – | 1 188 | 12 |
|  | 101Y | 115.45 | 5 079.6 | 662 | 1 125 | 36 | 36 | 42 | 1 062 | 30 |
|  | 101Z | – | 5 079.9 | 663 | 1 125 | – | 21 | 27 | 1 062 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 102X | 115.50 | – | – | 1 126 | 12 | – | – | 1 189 | 12 |
|  | 102Y | 115.55 | 5 080.2 | 664 | 1 126 | 36 | 36 | 42 | 1 063 | 30 |
|  | 102Z | – | 5 080.5 | 665 | 1 126 | – | 21 | 27 | 1 063 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 103X | 115.60 | – | – | 1 127 | 12 | – | – | 1 190 | 12 |
|  | 103Y | 115.65 | 5 080.8 | 666 | 1 127 | 36 | 36 | 42 | 1 064 | 30 |
|  | 103Z | – | 5 081.1 | 667 | 1 127 | – | 21 | 27 | 1 064 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 104X | 115.70 | – | – | 1 128 | 12 | – | – | 1 191 | 12 |
|  | 104Y | 115.75 | 5 081.4 | 668 | 1 128 | 36 | 36 | 42 | 1 065 | 30 |
|  | 104Z | – | 5 081.7 | 669 | 1 128 | – | 21 | 27 | 1 065 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 105X | 115.80 | – | – | 1 129 | 12 | – | – | 1 192 | 12 |
|  | 105Y | 115.85 | 5 082.0 | 670 | 1 129 | 36 | 36 | 42 | 1 066 | 30 |
|  | 105Z | – | 5 082.3 | 671 | 1 129 | – | 21 | 27 | 1 066 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 106X | 115.90 | – | – | 1 130 | 12 | – | – | 1 193 | 12 |
|  | 106Y | 115.95 | 5 082.6 | 672 | 1 130 | 36 | 36 | 42 | 1 067 | 30 |
|  | 106Z | – | 5 082.9 | 673 | 1 130 | – | 21 | 27 | 1 067 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 107X | 116.00 | – | – | 1 131 | 12 | – | – | 1 194 | 12 |
|  | 107Y | 116.05 | 5 083.2 | 674 | 1 131 | 36 | 36 | 42 | 1 068 | 30 |
|  | 107Z | – | 5 083.5 | 675 | 1 131 | – | 21 | 27 | 1 068 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 108X | 116.10 | – | – | 1 132 | 12 | – | – | 1 195 | 12 |
|  | 108Y | 116.15 | 5 083.8 | 676 | 1 132 | 36 | 36 | 42 | 1 069 | 30 |
|  | 108Z | – | 5 084.1 | 677 | 1 132 | – | 21 | 27 | 1 069 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 109X | 116.20 | – | – | 1 133 | 12 | – | – | 1 196 | 12 |
|  | 109Y | 116.25 | 5 084.4 | 678 | 1 133 | 36 | 36 | 42 | 1 070 | 30 |
|  | 109Z | – | 5 084.7 | 679 | 1 133 | – | 21 | 27 | 1 070 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 110X | 116.30 | – | – | 1 134 | 12 | – | – | 1 197 | 12 |
|  | 110Y | 116.35 | 5 085.0 | 680 | 1 134 | 36 | 36 | 42 | 1 071 | 30 |
|  | 110Z | – | 5 085.3 | 681 | 1 134 | – | 21 | 27 | 1 071 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 111X | 116.40 | – | – | 1 135 | 12 | – | – | 1 198 | 12 |
|  | 111Y | 116.45 | 5 085.6 | 682 | 1 135 | 36 | 36 | 42 | 1 072 | 30 |
|  | 111Z | – | 5 085.9 | 683 | 1 135 | – | 21 | 27 | 1 072 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 112X | 116.50 | – | – | 1 136 | 12 | – | – | 1 199 | 12 |
|  | 112Y | 116.55 | 5 086.2 | 684 | 1 136 | 36 | 36 | 42 | 1 073 | 30 |
|  | 112Z | – | 5 086.5 | 685 | 1 136 | – | 21 | 27 | 1 073 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 113X | 116.60 | – | – | 1 137 | 12 | – | – | 1 200 | 12 |
|  | 113Y | 116.65 | 5 086.8 | 686 | 1 137 | 36 | 36 | 42 | 1 074 | 30 |
|  | 113Z | – | 5 087.1 | 687 | 1 137 | – | 21 | 27 | 1 074 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 114X | 116.70 | – | – | 1 138 | 12 | – | – | 1 201 | 12 |
|  | 114Y | 116.75 | 5 087.4 | 688 | 1 138 | 36 | 36 | 42 | 1 075 | 30 |
|  | 114Z | – | 5 087.7 | 689 | 1 138 | – | 21 | 27 | 1 075 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 115X | 116.80 | – | – | 1 139 | 12 | – | – | 1 202 | 12 |
|  | 115Y | 116.85 | 5 088.0 | 690 | 1 139 | 36 | 36 | 42 | 1 076 | 30 |
|  | 115Z | – | 5 088.3 | 691 | 1 139 | – | 21 | 27 | 1 076 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 116X | 116.90 | – | – | 1 140 | 12 | – | – | 1 203 | 12 |
|  | 116Y | 116.95 | 5 088.6 | 692 | 1 140 | 36 | 36 | 42 | 1 077 | 30 |
|  | 116Z | – | 5 088.9 | 693 | 1 140 | – | 21 | 27 | 1 077 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 117X | 117.00 | – | – | 1 141 | 12 | – | – | 1 204 | 12 |
|  | 117Y | 117.05 | 5 089.2 | 694 | 1 141 | 36 | 36 | 42 | 1 078 | 30 |
|  | 117Z | – | 5 089.5 | 695 | 1 141 | – | 21 | 27 | 1 078 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 118X | 117.10 | – | – | 1 142 | 12 | – | – | 1 205 | 12 |
|  | 118Y | 117.15 | 5 089.8 | 696 | 1 142 | 36 | 36 | 42 | 1 079 | 30 |
|  | 118Z | – | 5 090.1 | 697 | 1 142 | – | 21 | 27 | 1 079 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 119X | 117.20 | – | – | 1 143 | 12 | – | – | 1 206 | 12 |
|  | 119Y | 117.25 | 5 090.4 | 698 | 1 143 | 36 | 36 | 42 | 1 080 | 30 |
|  | 119Z | – | 5 090.7 | 699 | 1 143 | – | 21 | 27 | 1 080 | 15 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 120X | 117.30 | – | – | 1 144 | 12 | – | – | 1 207 | 12 |
|  | 120Y | 117.35 | – | – | 1 144 | 36 | – | – | 1 081 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 121X | 117.40 | – | – | 1 145 | 12 | – | – | 1 208 | 12 |
|  | 121Y | 117.45 | – | – | 1 145 | 36 | – | – | 1 082 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 122X | 117.50 | – | – | 1 146 | 12 | – | – | 1 209 | 12 |
|  | 122Y | 117.55 | – | – | 1 146 | 36 | – | – | 1 083 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 123X | 117.60 | – | – | 1 147 | 12 | – | – | 1 210 | 12 |
|  | 123Y | 117.65 | – | – | 1 147 | 36 | – | – | 1 084 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 124X | 117.70 | – | – | 1 148 | 12 | – | – | 1 211 | 12 |
| \*\* | 124Y | 117.75 | – | – | 1 148 | 36 | – | – | 1 085 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 125X | 117.80 | – | – | 1 149 | 12 | – | – | 1 212 | 12 |
| \*\* | 125Y | 117.85 | – | – | 1 149 | 36 | – | – | 1 086 | 30 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 126X | 117.90 | – | – | 1 150 | 12 | – | – | 1 213 | 12 |
| \*\* | 126Y | 117.95 | – | – | 1 150 | 36 | – | – | 1 087 | 30 |
| \*\* These channels are reserved exclusively for national allotments.  \*\* These channels may be used for national allotment on a secondary basis.  The primary reason for reserving these channels is to provide protection for the secondary surveillance radar (SSR) system.   108.0 MHz is not scheduled for assignment to ILS service. The associated DME operating channel No. 17X may be assigned for emergency use. The reply frequency of channel No. 17X (i.e. 978 MHz) is also utilized for the operation of the universal access transceiver (UAT). Standards and Recommended Practices for UAT are found in Annex 10, Volume III, Part I, Chapter 12. | | | | | | | | | | |

**Table B.    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×10–7/h | 5 min | 1 – 1× 10–4/h  to 1 – 1×10–8/h | 0.99 to  0.99999 |
|  |  |  |  |  |  |  |
| En-route,  Terminal | 0.74 km  (0.4 NM) | N/A | 1 – 1× 10–7/h | 15 s | 1 – 1× 10–4/h  to 1 – 1×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× 10–7/h | 10 s | 1 – 1×10–4/h  to 1 – 1×10–8/h | 0.99 to  0.99999 |
|  |  |  |  |  |  |  |
| Approach operations with vertical guidance (APV-I)  (Note 8) | 16.0 m  (52 ft) | 20 m  (66 ft) | 1 – 2× 10–7  in any  approach | 10 s | 1 – 8× 10–6  per 15 s | 0.99 to  0.99999 |
|  |  |  |  |  |  |  |
| Approach operations with vertical guidance (APV-II)  (Note 8) | 16.0 m  (52 ft) | 8.0 m  (26 ft) | 1 – 2× 10–7  in any  approach | 6 s | 1 – 8× 10–6  per 15 s | 0.99 to  0.99999 |
|  |  |  |  |  |  |  |
| Category I precision approach (Note 7) | 16.0 m  (52 ft) | 6.0 m to 4.0 m (20 ft to 13 ft)  (Note 6) | 1 – 2× 10–7  in any  approach | 6 s | 1 – 8× 10–6  per 15 s | 0.99 to  0.99999 |
| *NOTES.—*  1. The 95th percentile values for GNSS position errors are those required for the intended operation at the lowest height above threshold (HAT), if applicable. 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: | | | | | | |

**Table C.    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. | | |

**Table D.    GBAS broadcast unwanted emissions**

| Frequency | Relative unwanted  emission level  (Note 2) | Maximum unwanted  emission level  (Note 1) |
| --- | --- | --- |
|  |  |  |
| 9 kHz to 150 kHz | –93 dBc  (Note 3) | –55 dBm/1 kHz  (Note 3) |
| 150 kHz to 30 MHz | –103 dBc  (Note 3) | –55 dBm/10 kHz  (Note 3) |
| 30 MHz to 106.125 MHz | –115 dBc | –57 dBm/100 kHz |
| 106.425 MHz | –113 dBc | –55 dBm/100 kHz |
| 107.225 MHz | –105 dBc | –47 dBm/100 kHz |
| 107.625 MHz | –101.5 dBc | –53.5 dBm/10 kHz |
| 107.825 MHz | –88.5 dBc | –40.5 dBm/10 kHz |
| 107.925 MHz | –74 dBc | –36 dBm/1 kHz |
| 107.9625 MHz | –71 dBc | –33 dBm/1 kHz |
| 107.975 MHz | –65 dBc | –27 dBm/1 kHz |
| 118.000 MHz | –65 dBc | –27 dBm/1 kHz |
| 118.0125 MHz | –71 dBc | –33 dBm/1 kHz |
| 118.050 MHz | –74 dBc | –36 dBm/1 kHz |
| 118.150 MHz | –88.5 dBc | –40.5 dBm/10 kHz |
| 118.350 MHz | –101.5 dBc | –53.5 dBm/10 kHz |
| 118.750 MHz | –105 dBc | –47 dBm/100 kHz |
| 119.550 MHz | –113 dBc | –55 dBm/100 kHz |
| 119.850 MHz to 1 GHz | –115 dBc | –57 dBm/100 kHz |
| 1 GHz to 1.7 GHz | –115 dBc | –47 dBm/1 MHz |
| *NOTES.—*  1. The maximum unwanted emission level (absolute power) applies if the authorized transmitter power exceeds 150 W.  2. The relative unwanted emission level is to be computed using the same bandwidth for desired and unwanted signals. This may require conversion of the measurement for unwanted signals done using the bandwidth indicated in the maximum unwanted emission level column of this table.  3. This value is driven by measurement limitations. Actual performance is expected to be better.  4. The relationship is linear between single adjacent points designated by the adjacent channels identified above. | | |

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