Republic of the Philippines
Department of Transportation
CIVIL AVIATION AUTHORITY OF THE PHILIPPINES
Office of the Director General

MEMORANDUM CIRCULAR NO.: 38-16

TO : **ALL CONCERNED**

FROM : **DIRECTOR GENERAL**

SUBJECT : **AMENDMENT TO PHILIPPINE CIVIL AVIATION REGULATIONS - AIR NAVIGATION SERVICES (CAR-ANS) PART 6 INCORPORATING AMENDMENT 85 TO ICAO ANNEX 10 VOLUME 1**

REFERENCE:

1. Philippine Civil Aviation Regulations- Air Navigation Services Part 6
2. ICAO Annex 10 Volume 1; Amendment 85
3. Regulations Amendment Procedures
4. Board Resolution No. 2012-054 dated 28 September 2012

Pursuant to the powers vested in me under the Republic Act 9497, otherwise known as the Civil Aviation Authority Act of 2008 and in accordance with the Board Resolution No.: 2012-054 dated 28 September 2012, I hereby approve the incorporation of ICAO Annex 10 Volume 1 Amendment No. 85 to the Philippine Civil Aviation Regulations – Air Navigation Services (CAR-ANS) Part 6.

ORIGINAL REGULATION:

CAR-ANS Part 6

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6.3. **SPECIFICATIONS FOR RADIO NAVIGATION AIDS**

6.3.1 **Specification for ILS**

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6.3.1.3 VHF localizer and associated monitor

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6.3.1.3.3 Coverage

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

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

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

18.5 km (10 NM) outside of plus or minus 35 degrees if coverage is provided;

except that, where topographical features dictate or operational requirements permit, the limits may be reduced to 33.3 km (18 NM) within the plus or minus 10-degree sector and 18.5 km (10 NM) within the remainder of the coverage when alternative navigational facilities provide satisfactory coverage within the intermediate approach area. The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2 000 ft) above the elevation of the threshold, or 300 m (1 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher. Such signals shall be receivable, to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7 degrees above the horizontal.

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APPENDIX B. TECHNICAL SPECIFICATIONS FOR THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

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6.3.2 Global navigation satellite system (GLONASS) channel of standard accuracy (CSA) (L1)

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6.3.2.5 COORDINATE SYSTEM

6.3.2.5.1 PZ-90 (*Parameters of common terrestrial ellipsoid and gravitational field of the earth 1990*). The GLONASS broadcast ephemeris shall describe a position of transmitting antenna phase centre of a given satellite in the PZ-90 earth-centred earth-fixed reference frame.

6.3.2.5.2 *Conversion between PZ-90 and WGS-84*. The following conversion parameters shall be used to obtain position coordinates in WGS-84 from position coordinates in PZ-90 (Version 2):

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{WGS-84} = \begin{bmatrix} -1.1 \\ -0.3 \\ -0.9 \end{bmatrix} + (1 - 0.12 \times 10^{-6}) \begin{bmatrix} 1 & -0.82 \times 10^{-6} & 0 \\ +0.82 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{PZ-90}$$

Note.— X, Y and Z are expressed in metres.

6.3.2.5.2.1 The conversion error shall not exceed 1.5 metres (1 sigma) along each coordinate axis.

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ATTACHMENT C. INFORMATION AND MATERIAL FOR GUIDANCE IN THE APPLICATION OF THE STANDARDS AND RECOMMENDED PRACTICES FOR ILS, VOR, PAR, 75 MHz MARKER BEACONS (EN-ROUTE), NDB AND DME

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2. Material concerning ILS installations

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2.1.10 *Guidance on operational aspects of improving the performance of the ILS localizer in respect to bends*

2.1.10.1 *Introduction.* Owing to site effects at certain locations, it is not always possible to produce with simple standard ILS installations localizer courses that are sufficiently free from troublesome bends or irregularities. At such installations, it will often be possible to reduce bends and irregularities in the localizer course to a satisfactory extent by various methods, most of which require acceptance of some deviation from the specification for ILS set forth in this CAR-ANS, together with possible penalties from an operational aspect.

2.1.10.2 *Methods of effecting improvement.* In general, improvements in localizer courses from the aspect of bends or irregularities may be effected by restriction of radiation in particular directions so as to avoid or minimize reflection from objects that give rise to the bends. In the majority of instances where special treatment is required, this may be achieved by screens placed and designed to reduce the radiation in the direction of the object. Where reflecting objects are numerous or of large dimensions, however, it may be necessary to restrict almost all the radiation from the localizer to a narrow sector centered on the course line. Each method introduces certain disadvantages which should be weighed for the individual installation in the light of the specific operational application to be made of the installation and the following considerations.

2.1.10.3 *Disadvantages of methods of effecting improvements mentioned above*

2.1.10.3.1 The use of screens limiting radiation in selected directions will, in general, give rise to a reduction of the clearance between the two modulation signals of the ILS in some other direction, with the consequence that the ILS indicator needle may move towards the centre when the aircraft is passing through areas in that direction. It is considered however that, in general, such deviations are not operationally significant or may be overcome by suitable procedures. In certain applications including the use of screens or reflectors to reinforce signals in the course sector, the use of screens or reflectors will modify the range and characteristics of the back course of the localizer. Here again, it is considered that the effects are unlikely to be operationally significant unless operational use is being made of the back course. In this latter case, it may be necessary to provide an additional facility to supplement or replace the back course.

2.1.10.3.2Where it is necessary to limit radiation from the localizer over a wide sector and confine most of it to a sector centred on the front course of the localizer in order to reduce bends sufficiently, the disadvantages will, in general, be as follows:

a) Orientation information from the localizer in the sector in which radiation is limited will no longer be available or will be unreliable.

b) It will not be practicable to carry out a preliminary check of the performance of the aircraft receiver through the flag system until the aircraft is within the sector centred on the course line.

c) In the area outside the sector centred on the course line, sufficient radiation may occur in particular directions to operate the ILS indicator in the aircraft in an erratic manner, giving rise to false indications.

d) The loss of the back course.

2.1.10.3.3 In respect to a), it is considered that orientation information is necessary but that practice has shown that such information is preferably obtained in any event from an auxiliary aid such as a locator. Such an auxiliary aid would be necessary if radiation from the localizer is confined to a narrow sector centred on the course line. In respect to b), it is considered that the loss of a receiver check prior to entry into the sector centred on the course line could be operationally accepted.

2.1.10.3.4 The disadvantage indicated in c) may, in some instances, be a serious drawback. In general, it is considered that acceptance of this disadvantage will depend on the extent to which false indications will occur at a particular site and on the procedures established or specified for the use of the ILS installation. In practice, it is possible to establish procedures so that no use is made of the localizer signals until the aircraft is able to check that it is in the usable sector. Experience has shown at one installation in operational use that, procedurally, no difficulty has arisen through the existence of erratic indications in the off-course sector. It is considered that the question of whether or not the off-course signal characteristics due to reduction of radiation in a narrow sector may be accepted operationally is a matter for individual assessment at each location concerned.

2.1.10.3.5 The loss of the back course indicated in d) may have several disadvantages. At some locations, the back course serves a useful function through intersection with other aids for facilitating procedures in the area concerned. Also, the back course often provides a useful aid in missed approach procedures and can often be used to simplify approach for landing when conditions require that the landing direction be opposite to the direction for which the ILS is primarily installed. Loss of the back course will, in general, require the provision of a substitute aid or aids, and the principal disadvantage in suppressing the back course may be considered in terms of the additional expense of a substitute aid or aids.

2.1.10.4 *Extent to which sector centred on course line may be narrowed.* It is considered that a radiation sector 10 degrees each side of the localizer course line would be the minimum sector that could be accepted operationally. It is desirable that the characteristics of the signal from the localizer be identical with those specified in CAR-ANS 6.3 within the region in the immediate vicinity (region from DDMs 0.155 to zero) of the course line and approximate closely to them out to 10 degrees, so that the indications of the ILS indicator and the signals fed to a coupling device, if used, will correspond to the standard ILS throughout any manoeuvres necessary in the transition from the approach to the localizer to establishment on course line.

2.1.10.5 It should be realized, however, that for an increased runway length, the localizer course sector wherein proportional guidance is provided will be narrower as a result of adjusting the localizer to the sensitivity specified in CAR-ANS 6.3, 6.3.1.3.7.1. Although a proportional guidance signal is provided on each side of the course line up to a level of 0.180 DDM, the level above 0.150 DDM may not be usable by the automatic airborne system during the intercept manoeuvre unless that system is armed within the sector in which a minimum of 0.180 DDM is provided (e.g. plus or minus 10 degrees). It is advantageous to permit the localizer capture mode of the automatic airborne system to be armed at off-course angles greater than 10 degrees; consequently it is desirable to maintain a minimum DDM of 0.180 through a wider sector than plus or minus 10 degrees wherever practical.

2.1.10.6 *Further possibilities.* If the disadvantages arising from the use of the restricted coverage and modified signal characteristics discussed in2.1.10.3 are unacceptable, possibilities exist through the use of two radio frequency carriers to provide the coverage and signal characteristics that would maintain the essential information provided by a standard ILS in the suppressed sector while, at the same time, maintaining in the regions about the course sector the objective of the restricted coverage system. It may be necessary to employ this more elaborate system at aerodromes with high multipath environments. Additional guidance on two radio frequency carrier coverage is provided in 2.7.

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2.5 Diagrams (Figures C-6 to C-12 illustrate certain of the Standards contained in CAR-ANS 6.3)

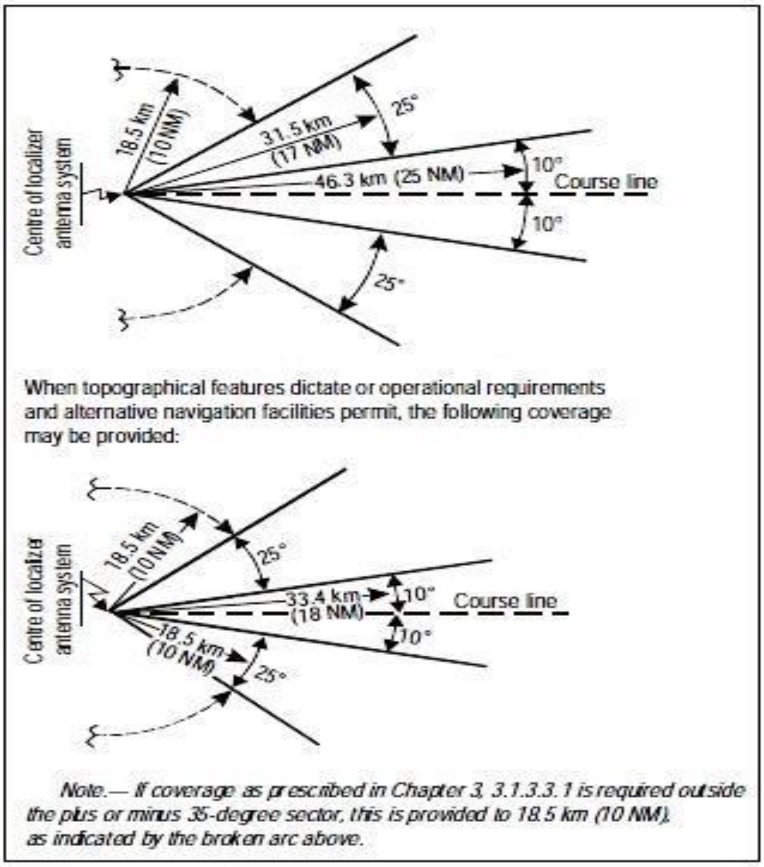

Figure C-7. Localizer coverage with respect to azimuth

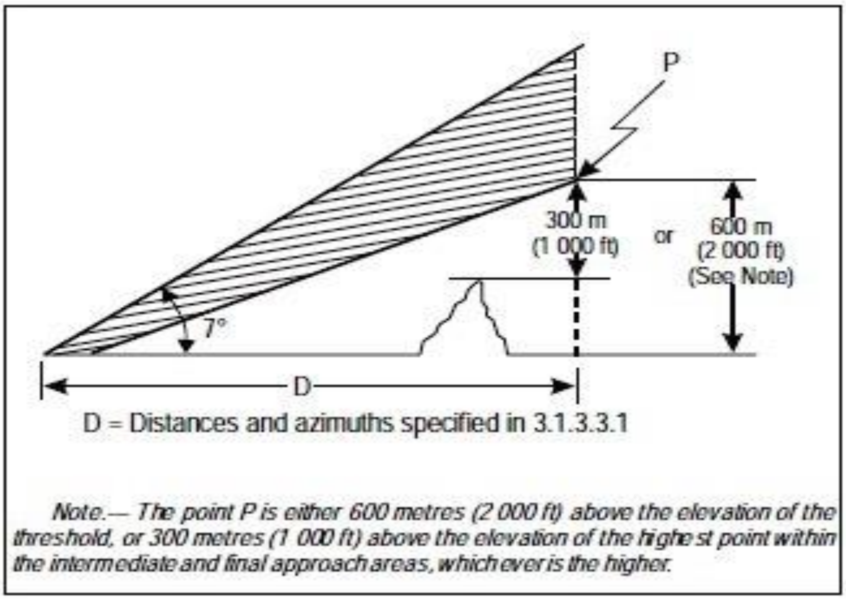

Figure C-8. Localizer coverage with respect to elevation

ATTACHMENT D. INFORMATION AND MATERIAL FOR GUIDANCE IN THE APPLICATION OF THE GNSS STANDARDS AND RECOMMENDED PRACTICES

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3.2 Accuracy

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3.2.7 A range of vertical accuracy values is specified for Category I precision approach operations which bounds the different values that may support an equivalent operation to ILS. A number of values have been derived by different groups, using different interpretations of the ILS standards. The lowest value from these derivations was adopted as a conservative value for GNSS; this is the minimum value given for the range. Because this value is conservative, and because GNSS error characteristics are different from ILS, it may be possible to achieve Category I operations using larger values of accuracy and alert limits within the range. The larger values would result in increased availability for the operation. The maximum value in the range has been proposed as a suitable value, subject to validation.

3.2.8 Specific alert limits have been defined for each augmentation system. For GBAS, technical provision has been made to broadcast the alert limit to aircraft. GBAS standards require the alert limit of 10 m. For SBAS, technical provisions have been made to standardize the alert limit through an updateable database (see Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System (GPS/WAAS) Airborne Equipment (RTCA/DO-229C).

3.3 Integrity and time-to-alert

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3.3.5 For APV and precision approach operations, integrity requirements for GNSS signal-in-space requirements of CAR-ANS 6.3, Table 6.3.7.2.4-1, were selected to be consistent with ILS requirements.

3.3.6 Alert limits for typical operations are provided in Note 2 to Table 6.3.7.2.4-1. A range of alert limits is specified for precision approach operations, reflecting potential differences in system design that may affect the operation. In ILS, monitor thresholds for key signal parameters are standardized, and the monitors themselves have very low measurement noise on the parameter that is being monitored. With differential GNSS, some system monitors have comparably large measurement uncertainty whose impact must be considered on the intended operation. In all cases, the effect of the alert limit is to restrict the satellite-user geometry to one where the monitor performance (typically in the pseudorange domain) is acceptable when translated into the position domain.

3.3.7 The smallest precision approach vertical alert limit (VAL) value (10 m) was derived based on the monitor performance of ILS as it could affect the glideslope at a nominal decision altitude of 200 ft above the runway threshold. By applying this alert limit, the GNSS error under faulted conditions can be directly compared to ILS error under faulted conditions, such that the GNSS errors are less than or equal to ILS errors. For those fault conditions with comparably large monitor noise in GNSS, this results in monitor thresholds that are more stringent than ILS.

3.3.8 The largest precision approach vertical alert limit value (35 m) was derived to ensure obstacle clearance equivalent to ILS for those error conditions which can be modelled as a bias during the final approach, taking into account that the aircraft decision altitude is independently derived from barometric pressure. An assessment has been conducted of the worst-case effect of a latent bias error equal to the alert limit of 35 m, concluding that adequate obstacle clearance protection is provided on the approach and missed approach (considering the decision altitude would be reached early or late, using an independent barometric altimeter). It is important to recognize that this assessment only addressed obstacle clearance and is limited to those error conditions which can be modelled as bias errors. Analysis has shown 35 m bias high and low conditions can be tolerated up to the approach speed category (category A through D) glide path angle limits in ICAO Doc 8168 without impinging on the ILS obstacle clearance surfaces.

3.3.9 Since the analysis of a 35 m VAL is limited in scope, a system-level safety analysis should be completed before using any value greater than 10 m for a specific system design. The safety analysis should consider obstacle clearance criteria and risk of collision due to navigation error, and the risk of unsafe landing due to navigation error, given the system design characteristics and operational environment (such as the type of aircraft conducting the approach and the supporting airport infrastructure). With respect to the collision risk, it is sufficient to confirm that the assumptions identified in 3.3.8 are valid for the use of a 35 m VAL. With respect to an unsafe landing, the principal mitigation for a navigation error is pilot intervention during the visual segment. Limited operational trials, in conjunction with operational expertise, have indicated that navigation errors of less than 15 m consistently result in acceptable touchdown performance. For errors larger than 15 m, there can be a significant increase in the flight crew workload and potentially a significant reduction in the safety margin, particularly for errors that shift the point where the aircraft reaches the decision altitude closer to the runway threshold where the flight crew may attempt to land with an unusually high rate of descent. The hazard severity of this event is major (see Doc 9859, Safety Management Manual). One acceptable means to manage the risks in the visual segment is for the system to comply with the following criteria:

a) the fault-free accuracy is equivalent to ILS. This includes system 95 per cent vertical NSE less than 4 m, and fault-free system vertical NSE exceeding 10 m with a probability less than 10-7 for each location where the operation is to be approved. This assessment is performed over all environmental and operational conditions under which the service is declared available;

b) under system failure conditions, the system design is such that the probability of an error greater than 15 m is lower than 10-5, so that the likelihood of occurrence is remote. The fault conditions to be taken into account are the ones affecting either the core constellations or the GNSS augmentation under consideration. This probability is to be understood as the combination of the occurrence probability of a given failure with the probability of detection for applicable monitor(s). Typically, the probability of a single fault is large enough that a monitor is required to satisfy this condition.

3.3.10 For GBAS, technical provision has been made to broadcast the alert limit to aircraft. GBAS standards require the alert limit of 10 m. For SBAS, technical provisions have been made to specify the alert limit through an updateable database (see Attachment C).

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4.2 GLONASS

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4.2.2 *Accuracy*. Accuracy is measured with a representative receiver and a measurement interval of 24 hours for any point within the coverage area. The positioning and timing accuracy are for the signal-in space (SIS) only and do not include such error sources as: ionosphere, troposphere, interference, receiver noise or multipath. The accuracy is derived based on the worst two of 24 satellites being removed from the constellation and a 7metre constellation RMS SIS user range error (URE).

4.2.3 *Range domain accuracy*. Range domain accuracy is conditioned by the satellite indicating a healthy status and transmitting standard accuracy code and does not account for satellite failures outside of the normal operating characteristics. Range domain accuracy limits can be exceeded during satellite failures or anomalies while uploading data to the satellite. Exceeding the range error limit constitutes a major service failure as described in 4.2.6. The range rate error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. The range acceleration error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. The root-mean-square range error accuracy is the average of the RMS URE of all satellites over any 24-hour interval for any point within the coverage area. Under nominal conditions, all satellites are maintained to the same standards, so it is appropriate for availability modelling purposes to assume that all satellites have a 7-metre RMS SIS URE. The standards are restricted to range domain errors allocated to space and control segments.

4.2.4 *Availability*. Availability is the percentage of time over any 24-hour interval that the predicted 95 per cent positioning error (due to space and control segment errors) is less than its threshold, for any point within the coverage area. It is based on a 12-metre horizontal 95 per cent threshold and a 9325-metre vertical 95 per cent threshold, using a representative receiver and operating within the coverage area over any 24-hour interval. The service availability assumes the worst combination of two satellites out of service.

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4.2.6 *Major service failure*. A major service failure is defined as a condition over a time interval during which a healthy GLONASS satellite's ranging signal error (excluding atmospheric and receiver errors) exceeds the range error limit of 30m (as defined in CAR-ANS Part 6, 6.3.7.3.2.1.3 a)) and/or failures in radio frequency characteristics of the CSA ranging signal, navigation message structure or navigation message contents that deteriorate the CSA receiver's ranging signal reception or processing capabilities.

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AMENDED REGULATION:

CAR-ANS PART 6:

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6.3. SPECIFICATIONS FOR RADIO NAVIGATION AIDs

6.3.1 Specification for ILS

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

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

Note.— If both localizers radiate there is a possibility of interference to the localizer signals in the threshold region. Additional guidance material is contained in 2.1.9 and 2.13 of Attachment C.

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

Note.— Additional guidance material on the operation of localizers on the same frequency channel is contained in 2.1.9 of Attachment C and Volume V, Chapter 4.

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6.3.1.3 VHF localizer and associated monitor

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6.3.1.3.3 Coverage

Note.— Guidance material on localizer coverage is given in 2.1.10 and Figures C-7A, C-7B, C-8A and C-8B of Attachment C.

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

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

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

18.5 km (10 NM) outside of plus or minus 35 degrees 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.

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

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

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

6.3.6.1.3 *Monitoring.* For each marker beacon, suitable monitoring equipment shall be provided which will show at an appropriate location:

a) a decrease in radiated carrier power below 50 per cent of normal;

b) a decrease of modulation depth below 70 per cent;

c) a failure of keying.

6.3.7 Requirements for the Global Navigation Satellite System (GNSS)

6.3.7.1 Definitions

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

Alert. An indication provided to other aircraft systems or annunciation to the pilot to identify that an operating parameter of a navigation system is out of tolerance.

Alert limit. For a given parameter measurement, the error tolerance not to be exceeded without issuing an alert.

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

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

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

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

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

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

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

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

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

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

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

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

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

6.3.7.2 General

6.3.7.2.1 *Functions*

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

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

6.3.7.2.2 *GNSS elements*

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

a) Global Positioning System (GPS) that provides the Standard Positioning Service (SPS) as defined in 6.3.7.3.1;

b) Global Navigation Satellite System (GLONASS) that provides the Channel of Standard Accuracy (CSA) navigation signal as defined in 6.3.7.3.2;

c) aircraft-based augmentation system (ABAS) as defined in 6.3.7.3.3;

d) satellite-based augmentation system (SBAS) as defined in 6.3.7.3.4;

e) ground-based augmentation system (GBAS) as defined in 6.3.7.3.5;

f) ground-based regional augmentation system (GRAS) as defined in 6.3.7.3.5; and

g) aircraft GNSS receiver as defined in 6.3.7.3.6.

6.3.7.2.3 *Space and time reference*

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

Note 1.— SARPs for WGS-84 are contained in CAR-ANS Part 4, CAR-ANS Part 11, CAR-ANS Part 15 and MOS-Aerodromes.

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

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

6.3.7.2.4 *Signal-in-space performance*

6.3.7.2.4.1 The combination of GNSS elements and a fault-free GNSS user receiver shall meet the signal-in-space requirements defined in Table 6.3.7.2.4-1 (located at the end of section 6.3.7).

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

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

a) range error of any satellite — the larger of:
 — 30 m (100 ft); or
 — 4.42 times the broadcast user range accuracy (URA), not to exceed 150 m (490 ft);

b) range rate error of any satellite — 0.02 m (0.07 ft) per second;

c) range acceleration error of any satellite — 0.007 m (0.02 ft) per second-squared; and

d) root-mean-square range error over all satellites — 6 m (20 ft).

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

≥99 per cent horizontal service availability, average location (36 m 95 per cent threshold)
≥99 per cent vertical service availability, average location (77 m 95 per cent threshold)
≥90 per cent horizontal service availability, worst-case location (36 m 95 per cent threshold)
≥90 per cent vertical service availability, worst-case location (77 m 95 per cent threshold)

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

a) frequency of a major service failure — not more than three per year for the constellation (global average);

b) reliability — at least 99.94 per cent (global average); and

c) reliability — at least 99.79 per cent (single point average).

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

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

6.3.7.3.1.5 *Radio frequency (RF) characteristics*

Note.— Detailed RF characteristics are specified in Appendix B, 3.1.1.1.

6.3.7.3.1.5.1 *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).

Note.— A new civil frequency will be added to the GPS satellites and will be offered by the United States for critical safety-of-life applications. SARPs for this signal may be developed at a later date.

6.3.7.3.1.5.2 *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.

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

6.3.7.3.1.5.4 *Signal power level*. Each GPS satellite shall broadcast SPS navigation signals with sufficient power such that, at all unobstructed locations near the ground from which the satellite is observed at an elevation angle of 5 degrees or higher, the level of the received RF signal at the output of a 3 dBi linearly-polarized antenna is within the range of –160 dBW to –153 dBW for all antenna orientations orthogonal to the direction of propagation.

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

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

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

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

a) satellite time of transmission;

b) satellite position;

c) satellite health;

d) satellite clock correction;

e) propagation delay effects;

f) time transfer to UTC; and

g) constellation status.

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

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

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

6.3.7.3.2.1 *Accuracy*

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

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

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

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

a) range error of any satellite —18 m (59.7 ft);

b) range rate error of any satellite —0.02 m (0.07 ft) per second;

c) range acceleration error of any satellite —0.007 m (0.023 ft) per second squared;

d) root-mean-square range error over all satellites —6 m (19.9 ft).

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

a) ≥99 per cent horizontal service availability, average location (12 m, 95 per cent threshold);

b) ≥99 per cent vertical service availability, average location (25 m, 95 per cent threshold);

c) ≥90 per cent horizontal service availability, worst-case location (12 m, 95 per cent threshold);

d) ≥90 per cent vertical service availability, worst-case location (25 m, 95 per cent threshold).

6.3.7.3.2.3 *Reliability*. The GLONASS CSA reliability shall be at least 99.98 per cent (global average).

6.3.7.3.2.4 *Coverage*. The GLONASS CSA coverage shall be at least 99.9 per cent (global average).

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

6.3.7.3.2.5 *RF characteristics*

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

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

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

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

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

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

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

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

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

6.3.7.3.2.5.5 *Modulation*

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

6.3.7.3.2.5.5.2 The modulating navigation signal shall be generated by the Modulo-2 addition of the following three binary signals:

a) ranging code transmitted at 511 kbits/s;

b) navigation message transmitted at 50 bits/s; and

c) 100 Hz auxiliary meander sequence.

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

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

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

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

a) satellite time of transmission;

b) satellite position;

c) satellite health;

d) satellite clock correction;

e) time transfer to UTC; and

f) constellation status.

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

6.3.7.3.3 *Aircraft-based augmentation system (ABAS)*

6.3.7.3.3.1 *Performance*. The ABAS function combined with one or more of the other GNSS elements and both a fault free GNSS receiver and fault-free aircraft system used for the ABAS function shall meet the requirements for accuracy, integrity, continuity and availability as stated in 6.3.7.2.4.

6.3.7.3.4 *Satellite-based augmentation system (SBAS)*

6.3.7.3.4.1 *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 6.3.7.2.4.

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

6.3.7.3.4.2 *Functions.* SBAS shall perform one or more of the following functions:

a) ranging: provide an additional pseudo-range signal with an accuracy indicator from an SBAS satellite (6.3.7.3.4.2.1 and Appendix B, 3.5.7.2);

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

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

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

Note.— If all the functions are provided, SBAS in combination with core satellite constellation(s) can support departure, en-route, terminal and approach operations including Category I precision approach. The level of performance that can be achieved depends upon the infrastructure incorporated into SBAS and the ionospheric conditions in the geographic area of interest.

6.3.7.3.4.2.1 *Ranging*

6.3.7.3.4.2.1.1 Excluding atmospheric effects, the range error for the ranging signal from SBAS satellites shall not exceed 25 m (82 ft) (95 per cent).

6.3.7.3.4.2.1.2 The probability that the range error exceeds 150 m (490 ft) in any hour shall not exceed 10^{-5}.

6.3.7.3.4.2.1.3 The probability of unscheduled outages of the ranging function from an SBAS satellite in any hour shall not exceed 10^{-3}.

6.3.7.3.4.2.1.4 The range rate error shall not exceed 2 m (6.6 ft) per second.

6.3.7.3.4.2.1.5 The range acceleration error shall not exceed 0.019 m (0.06 ft) per second-squared.

6.3.7.3.4.3 *Service area*. The SBAS service area shall be a defined area within an SBAS coverage area where SBAS meets the requirements of 6.3.7.2.4 and supports the corresponding approved operations.

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

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

6.3.7.3.4.4 *RF characteristics*

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

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

Note.— After 2005, when the upper GLONASS frequencies are vacated, another type of SBAS may be introduced using some of these frequencies.

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

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

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

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

6.3.7.3.4.5 *SBAS network time (SNT)*. The difference between SNT and GPS time shall not exceed 50 nanoseconds.

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

a) SBAS satellite time of transmission;

b) SBAS satellite position;

c) corrected satellite time for all satellites;

d) corrected satellite position for all satellites;

e) ionospheric propagation delay effects;

f) user position integrity;

g) time transfer to UTC; and

h) service level status.

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

6.3.7.3.5 *Ground-based augmentation system (GBAS) and ground-based regional augmentation system (GRAS)*

Note 1.— Except where specifically annotated, GBAS Standards and Recommended Practices apply to GBAS and GRAS.

Note 2.— Except where specifically annotated, reference to approach with vertical guidance (APV) means APV-I and APV-II.

6.3.7.3.5.1 *Performance*. GBAS combined with one or more of the other GNSS elements and a fault-free GNSS receiver shall meet the requirements for system accuracy, continuity, availability and integrity for the intended operation as stated in 6.3.7.2.4.

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

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

a) provide locally relevant pseudo-range corrections;

b) provide GBAS-related data;

c) provide final approach segment data when supporting precision approach;

d) provide predicted ranging source availability data; and

e) provide integrity monitoring for GNSS ranging sources.

Note.— Additional GBAS SARPs will be developed to provide ground-based ranging function.

6.3.7.3.5.3 *Coverage*

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

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

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

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

6.3.7.3.5.3.1.1 For Category I precision approach, the data broadcast as specified in 6.3.7.3.5.4 shall extend down to 3.7 m (12 ft) above the runway surface.

6.3.7.3.5.3.1.2 The data broadcast shall be omnidirectional when required to support the intended applications.

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

6.3.7.3.5.3.2 *GBAS positioning service.* The GBAS positioning service area shall be that area where the data broadcast can be received and the positioning service meets the requirements of 6.3.7.2.4 and supports the corresponding approved operations.

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

6.3.7.3.5.4 *Data broadcast characteristics*

Note.— RF characteristics are specified in Appendix B, 6.3.6.2.

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

Note 1.— Guidance material on VOR/GBAS frequency assignments and geographical separation criteria is given in Attachment D, 7.2.1.

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

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

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

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

6.3.7.3.5.4.4 *Data broadcast RF field strength and polarization*

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

6.3.7.3.5.4.4.1 *GBAS/H*

6.3.7.3.5.4.4.1.1 A horizontally polarized signal shall be broadcast.

6.3.7.3.5.4.4.1.2 The effective radiated power (ERP) shall provide for a horizontally polarized signal with a minimum field strength of 215 microvolts per metre (–99 dBW/m^2) and a maximum field strength of 0.350 volts per metre (–35 dBW/m^2) within the GBAS coverage volume. The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst. The RF phase offset between the HPOL and any VPOL components shall be such that the minimum signal power defined in Appendix B, 3.6.8.2.2.3 is achieved for HPOL users throughout the coverage volume.

6.3.7.3.5.4.4.2 *GBAS/E*

6.3.7.3.5.4.4.2.1 An elliptically polarized signal shall be broadcast whenever practical.

6.3.7.3.5.4.4.2.2 When an elliptically polarized signal is broadcast, the horizontally polarized component shall meet the requirements in 6. 3.7.3.5.4.4.1.2, and the effective radiated power (ERP) shall provide for a vertically polarized signal with a minimum field strength of 136 microvolts per metre (–103 dBW/m^2) and a maximum field strength of 0.221 volts per metre (–39 dBW/m^2) within the GBAS coverage volume. The field strength shall be measured as an average over the period of the synchronization and ambiguity resolution field of the burst. The RF phase offset between the HPOL and VPOL components, shall be such that the minimum signal power defined in Appendix B, 3.6.8.2.2.3 is achieved for HPOL and VPOL users throughout the coverage volume.

Note.— The minimum and maximum field strengths in 6.3.7.3.5.4.4.1.2 and 6.3.7.3.5.4.4.2.2 are consistent with a minimum receiver sensitivity of –87 dBm and minimum distance of 200 m (660 ft) from the transmitter antenna for a coverage range of 43 km (23 NM).

6.3.7.3.5.4.5 *Power transmitted in adjacent channel*s. The amount of power during transmission under all operating conditions when measured over a 25 kHz bandwidth centred on the ith adjacent channel shall not exceed the values shown in Table 6.3.7.3.5-1 (located at the end of section 6.3.7).

6.3.7.3.5.4.6 *Unwanted emissions.* Unwanted emissions, including spurious and out-of-band emissions, shall be compliant with the levels shown in Table 6.3.7.3.5-2 (located at the end of section 6.3.7). The total power in any VDB harmonic or discrete signal shall not be greater than –53 dBm.

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

a) pseudo-range corrections, reference time and integrity data;

b) GBAS-related data;

c) final approach segment data when supporting precision approach; and

d) predicted ranging source availability data.

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

6.3.7.3.6 *Aircraft GNSS receiver*

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

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6.3.7.6 Status monitoring and NOTAM

6.3.7.6.1 Changes in the current and projected status of GNSS space and ground elements that may have an impact on user performance or operational approvals shall be reported to relevant air traffic service units.

Note 1.— Additional information is provided in Attachment D, 9.

Note 2.— To assess the operational impact of changes in status, a service prediction tool may be required.

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APPENDIX B. TECHNICAL SPECIFICATIONS FOR THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

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3.2 Global navigation satellite system (GLONASS) channel of standard accuracy (CSA) (L1)

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3.2.5 COORDINATE SYSTEM

3.2.5.1 PZ-90 (*Parameters of common terrestrial ellipsoid and gravitational field of the earth 1990*). The GLONASS broadcast ephemeris shall describe a position of transmitting antenna phase centre of a given satellite in the PZ-90 earth-centred earth-fixed reference frame.

3.2.5.2 *Conversion between PZ-90 and WGS-84.* The following conversion parameters shall be used to obtain position coordinates in WGS-84 from position coordinates in PZ-90 (Version 2):

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{WGS-84} = \begin{bmatrix} -0.36 \\ +0.08 \\ +0.18 \end{bmatrix} + \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{PZ-90}$$

Note.— X, Y and Z are expressed in metres.

3.2.5.2.1 The conversion error shall not exceed 0.1 metres (1 sigma) along each coordinate axis.

ATTACHMENT C. INFORMATION AND MATERIAL FOR GUIDANCE IN THE APPLICATION OF THE STANDARDS AND RECOMMENDED PRACTICES FOR ILS, VOR, PAR, 75 MHz MARKER BEACONS (EN-ROUTE), NDB AND DME

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2. Material concerning ILS installations

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2.1.10 *Reducing localizer bends and areas with insufficient difference in depth of modulation (DDM)*

2.1.10.1 *Introduction.* Owing to site effects at certain locations, it is not always possible to produce with simple standard ILS installations localizer courses that are sufficiently free from troublesome bends or irregularities. If this is the case, it is highly preferable to use two radio frequency carriers to provide the standard coverage and signal characteristics. Additional guidance on two radio frequency carrier coverage is provided in 2.7. If standard coverage requirements still cannot be met, reducing radiation in the direction of objects and accepting an increase of the lower vertical coverage boundaries as permitted in CAR-ANS 6.3, 6.3.1.3.3.1 may be employed.

2.1.10.2 *Reducing standard localizer coverage.* When using the coverage reduction option defined in 3.1.3.3.1, care needs to be taken to ensure that the reduced coverage volume is consistent with the minimum altitudes published for the instrument approach procedure. Additionally, normal vectoring operations should not be terminated and a clearance to intercept the localizer should not be issued until within the promulgated coverage area. This is sometimes referred to as the operational service volume.

2.1.10.2.1 *Operational considerations from an air traffic management perspective.* Instrument approach procedures must be designed to take into account any reduction in localizer coverage permitted by the Standard in CAR-ANS 6.3, 6.3.1.3.3.1. This can be done either by ensuring that the procedure remains within localizer coverage or by providing alternative means to navigate. Consequently, a significant portion (2 NM minimum) of the initial segment must be within localizer coverage. Localizer coverage needs to be available sufficiently in advance of the area where controllers usually give the approach or intercept clearance to permit pilots to verify the Morse code identification (IDENT).

2.1.10.2.2 *Operational considerations from a pilot/aircraft perspective.* For aircraft equipped with automatic flight control systems (AFCS), localizer coverage needs to be available prior to the activation of the AFCS intercept mode (manual or automatic flight) with sufficient advance to permit checking the IDENT signal. When flying manually or when using an AFCS, pilots normally check the IDENT of the ILS facility and then wait to arm the mode enabling localizer intercept turn initiation and capture until after receiving the approach or intercept clearance. Ideally, additional aids (if included in the approach procedure) should permit a determination of the relationship between the aircraft position and the localizer front course line by the pilot.

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2.5 Diagrams (Figures C-6 to C-12 illustrate certain of the Standards contained in CAR-ANS 6.3)

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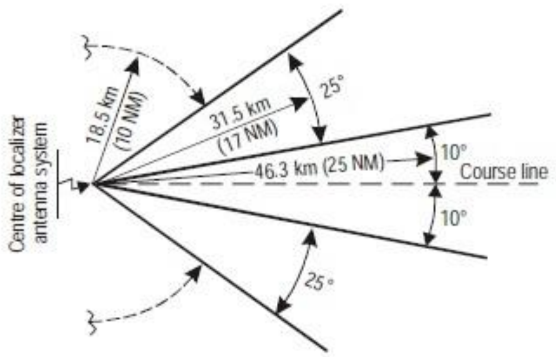
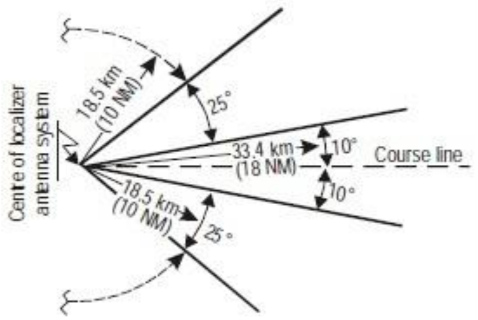


When topographical features dictate or operational requirements and alternative navigation facilities permit, the following coverage may be provided:



Note.— If coverage as prescribed in CAR-ANS 6.3, 6.3.1.3.3.1 *is required outside the plus or minus 35-degree sector, this is provided to 18.5 km (10 NM), as indicated by the broken arc above.*

Figure C-7A. Localizer coverage with respect to azimuth

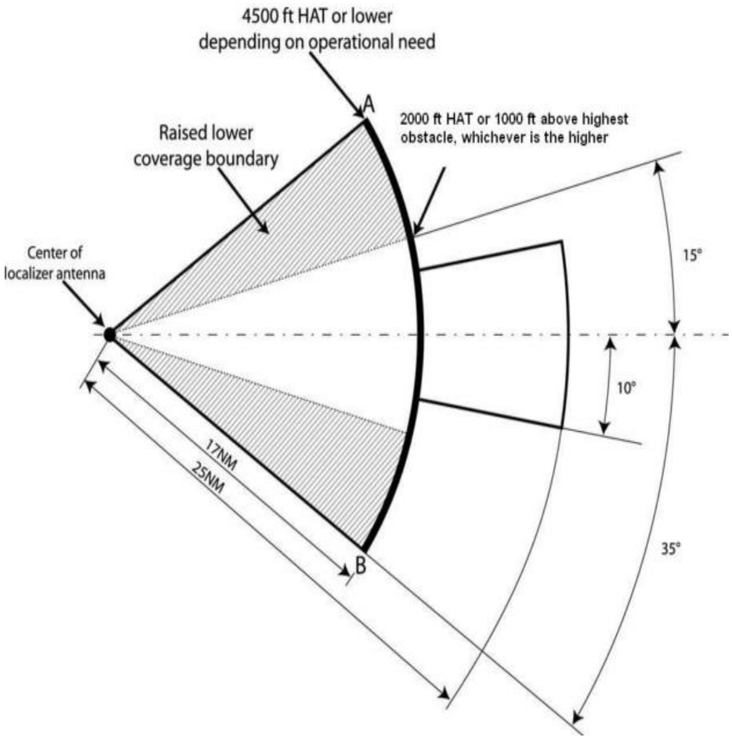


Figure C-7B. Reduced localizer coverage with respect to azimuth

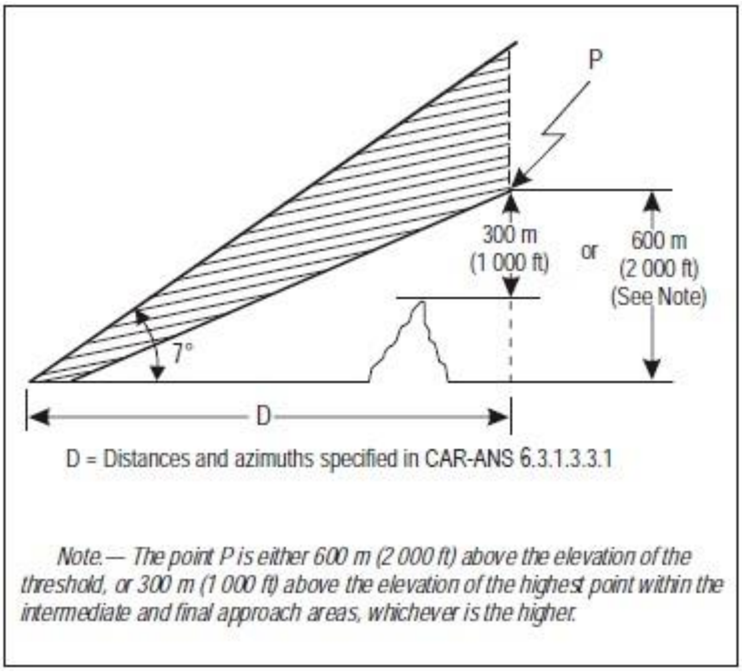


Figure C-8A. Localizer coverage with respect to elevation

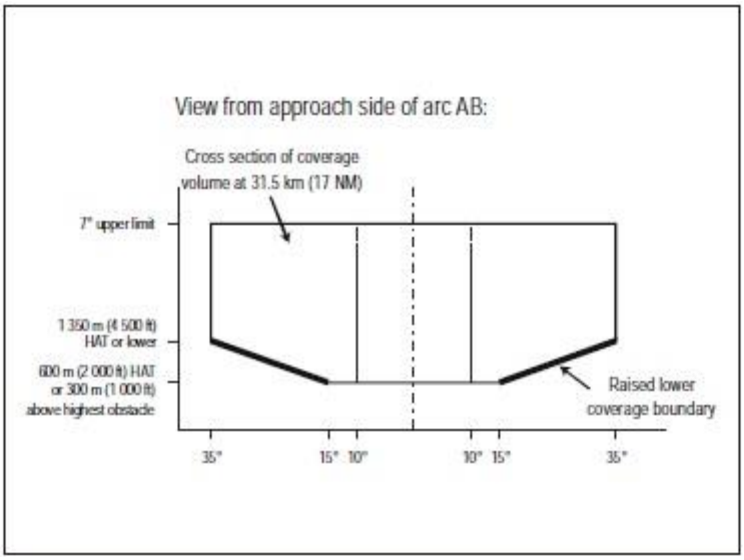


Figure C-8B. Reduced localizer coverage with respect to elevation

ATTACHMENT D. INFORMATION AND MATERIAL FOR GUIDANCE IN THE APPLICATION OF THE GNSS STANDARDS AND RECOMMENDED PRACTICES

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3.2 Accuracy

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3.2.7 A range of vertical accuracy values is specified for Category I precision approach operations which bounds the different values that may support an equivalent operation to ILS. A number of values have been derived by different groups, using different interpretations of the ILS standards. The lowest value from these derivations was adopted as a conservative value for GNSS; this is the minimum value given for the range. Because this value is conservative, and because GNSS error characteristics are different from ILS, it may be possible to achieve Category I operations using larger values of accuracy and alert limits within the range. The larger values would result in increased availability for the operation. The maximum value in the range has been proposed as a suitable value, subject to validation.

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3.3 Integrity and time-to-alert

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3.3.5 For APV and precision approach operations, integrity requirements for GNSS signal-in-space requirements of CAR-ANS 6.3, Table 6.3.7.2.4-1, were selected to be consistent with ILS requirements.

3.3.6 Alert limits for typical operations are provided in Note 2 to Table 6.3.7.2.4-1. A range of alert limits is specified for precision approach operations, reflecting potential differences in system design that may affect the operation. In ILS, monitor thresholds for key signal parameters are standardized, and the monitors themselves have very low measurement noise on the parameter that is being monitored. With differential GNSS, some system monitors have comparably large measurement uncertainty whose impact must be considered on the intended operation. In all cases, the effect of the alert limit is to restrict the satellite-user geometry to one where the monitor performance (typically in the pseudorange domain) is acceptable when translated into the position domain.

3.3.7 The smallest precision approach vertical alert limit (VAL) value (10 m) was derived based on the monitor performance of ILS as it could affect the glideslope at a nominal decision altitude of 200 ft above the runway threshold. By applying this alert limit, the GNSS error under faulted conditions can be directly compared to ILS error under faulted conditions, such that the GNSS errors are less than or equal to ILS errors. For those fault conditions with comparably large monitor noise in GNSS, this results in monitor thresholds that are more stringent than ILS.

3.3.8 The largest precision approach vertical alert limit value (35 m) was derived to ensure obstacle clearance equivalent to ILS for those error conditions which can be modelled as a bias during the final approach, taking into account that the aircraft decision altitude is independently derived from barometric pressure. An assessment has been conducted of the worst-case effect of a latent bias error equal to the alert limit of 35 m, concluding that adequate obstacle clearance protection is provided on the approach and missed approach (considering the decision altitude would be reached early or late, using an independent barometric altimeter). It is important to recognize that this assessment only addressed obstacle clearance and is limited to those error conditions which can be modelled as bias errors. Analysis has shown 35 m bias high and low conditions can be tolerated up to the approach speed category (category A through D) glide path angle limits in ICAO Doc 8168 without impinging on the ILS obstacle clearance surfaces.

3.3.9 Since the analysis of a 35 m VAL is limited in scope, a system-level safety analysis should be completed before using any value greater than 10 m for a specific system design. The safety analysis should consider obstacle clearance criteria and risk of collision due to navigation error, and the risk of unsafe landing due to navigation error, given the system design characteristics and operational environment (such as the type of aircraft conducting the approach and the supporting airport infrastructure). With respect to the collision risk, it is sufficient to confirm that the assumptions identified in 3.3.8 are valid for the use of a 35 m VAL. With respect to an unsafe landing, the principal mitigation for a navigation error is pilot intervention during the visual segment. Limited operational trials, in conjunction with operational expertise, have indicated that navigation errors of less than 15 m consistently result in acceptable touchdown performance. For errors larger than 15 m, there can be a significant increase in the flight crew workload and potentially a significant reduction in the safety margin, particularly for errors that shift the point where the aircraft reaches the decision altitude closer to the runway threshold where the flight crew may attempt to land with an unusually high rate of descent. The hazard severity of this event is major (see Doc 9859, Safety Management Manual). One acceptable means to manage the risks in the visual segment is for the system to comply with the following criteria:

a) the fault-free accuracy is equivalent to ILS. This includes system 95 per cent vertical NSE less than 4 m, and fault-free system vertical NSE exceeding 10 m with a probability less than 10^{-7} for each location where the operation is to be approved. This assessment is performed over all environmental and operational conditions under which the service is declared available;

b) under system failure conditions, the system design is such that the probability of an error greater than 15 m is lower than 10^{-5}, so that the likelihood of occurrence is remote. The fault conditions to be taken into account are the ones affecting either the core constellations or the GNSS augmentation under considerations or the GNSS augmentation under consideration. This probability is to be understood as the combination of the occurrence probability of a given failure with the probability of detection for applicable monitor(s). Typically, the probability of a single fault is large enough that a monitor is required to satisfy this condition.

3.3.10 For GBAS, technical provision has been made to broadcast the alert limit to aircraft. GBAS standards require the alert limit of 10 m. For SBAS, technical provisions have been made to specify the alert limit through an updateable database (see Attachment C).

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4.2 GLONASS

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4.2.2 *Accuracy*. Accuracy is measured with a representative receiver and a measurement interval of 24 hours for any point within the coverage area. The positioning and timing accuracy are for the signal-in space (SIS) only and do not include such error sources as: ionosphere, troposphere, interference, receiver noise or multipath. The accuracy is derived based on the worst two of 24 satellites being removed from the constellation and a 6-metre constellation RMS SIS user range error (URE).

4.2.3 *Range domain accuracy*. Range domain accuracy is conditioned by the satellite indicating a healthy status and transmitting standard accuracy code and does not account for satellite failures outside of the normal operating characteristics. Range domain accuracy limits can be exceeded during satellite failures or anomalies while uploading data to the satellite. Exceeding the range error limit constitutes a major service failure as described in 4.2.6. The range rate error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. The range acceleration error limit is the maximum for any satellite measured over any 3-second interval for any point within the coverage area. The root-mean-square range error accuracy is the average of the RMS URE of all satellites over any 24-hour interval for any point within the coverage area. Under nominal conditions, all satellites are maintained to the same standards, so it is appropriate for availability modelling purposes to assume that all satellites have a 6-metre RMS SIS URE. The standards are restricted to range domain errors allocated to space and control segments.

4.2.4 *Availability.* Availability is the percentage of time over any 24-hour interval that the predicted 95 per cent positioning error (due to space and control segment errors) is less than its threshold, for any point within the coverage area. It is based on a 12-metre horizontal 95 per cent threshold and a 25-metre vertical 95 per cent threshold, using a representative receiver and operating within the coverage area over any 24-hour interval. The service availability assumes the worst combination of two satellites out of service.

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4.2.6 *Major service failure.* A major service failure is defined as a condition over a time interval during which a healthy GLONASS satellite's ranging signal error (excluding atmospheric and receiver errors) exceeds the range error limit of 18 m (as defined in CAR-ANS Part 6, 6.3.7.3.2.1.3 a)) and/or failures in radio frequency characteristics of the CSA ranging signal, navigation message structure or navigation message contents that deteriorate the CSA receiver's ranging signal reception or processing capabilities.

EFFECTIVITY CLAUSE:

This amendment shall be added to the PCAR-ANS Part 6 and shall take effect immediately and shall supersede any other memoranda, regulations, and directives in conflict with this provision after compliance with the requisite single newspaper publication and a copy was filed with the U.P. Law Center – Office of the National Administrative register.

So ordered. Signed this 24 day of NOV 2016, CAAP, Pasay City.

CAPT. JIM C. SYDIONGCO