2026/05/21

2026/071/SUPDT-R/41

All KCASR Stockholders and Users

Subject.: ***Notice of Proposed Amendment's (NPA) No. 2026-10 to Kuwait Civil Aviation Safety Regulations KCASR 10 – AERONAUTICAL TELECOMMUNICATIONS – VOL I Rev 04.***

Dear Sir,

Purpose:

The purpose of this NPA is to announce to the KCASR users the intention of the Civil Aviation Authority to amend ***KCASR 10 – AERONAUTICAL TELECOMMUNICATIONS – VOL I*** (issue 4) to comply with ICAO standers and recommended practices up to amendment (95).

Action Required:

All users of KCASR are required to refer to the CAA/ASD website (https://kcasr.dgca.gov.kw) for reviewing the NPA and mail or email (safety@dgca.gov.kw) their comments by 17/Sep/2026 using the attached NPA Response Sheet Forms No. 1500 or using NPA comments & feedback form on the website. If we do not receive your response by this date, it will be assumed that you do not have any comments on the proposal.

If required, the CAA/Aviation Safety Department personnel are available to answer your questions on the interpretation and intended implementation of the proposed amendments.

This is for your information and distribution to the concerned parties.

Yours Sincerely,

President of Civil Aviation

Abdullah F. Alrajhi
Acting / Deputy Director General
for Aviation Safety, Air Transport & Aviation Security

CC: Director General of Civil Aviation.
Dy. Dir. Gen. Kuwait. Intel. Airport Affairs.
Dy. Dir. Gen. for Air Navigation Services Affairs.
Safety Management Coordination Center (SMCC).
Head of Technical Office.
Civil Aviation Security Department.
Aviation Safety Director.
Air Transport Director.
Legal Department

EM
19.5

Notes on the presentation of the Amendment
Notice Of Proposed Amendment
(NPA)

The text of the amendment is arranged to show deleted text in Red Color and with a line through it, new text to be inserted is in Blue color as shown below:

~~Text to be deleted is in Red and shown with a line through it.~~	**Text to be deleted**
New text to be inserted is in Blue Color.	**New text to be inserted**
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. . . Indicates that remaining text is unchanged in front or following the reflected amendment.	**Text is unchanged**

Notice Of Safety Regulation Amendment
(NPA, NSRA and Revisions)

Side bar indicates that text is changed or added.

NPA RESPONSE FORM

NPA 2026-10

Please add your comments on the proposal by ticking [✓] the appropriate box below.

Any additional constructive comments, suggested amendments or alternative action will be welcome and may be provided on this response sheet or by separate correspondence.

☐ No comments on the proposal.

☐ Comments on the proposal. (Please provide explanatory comment).

Name:	Organization:
Address/Contact No:	
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Signature:	Date:

Kuwait Civil Aviation Safety Regulations

KCASR 10 – AERONAUTICAL TELECOMMUNICATIONS

VOLUME - I

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Amendment Record

Amendment No	Date of Issue	Remarks
1	Jun 2018	NPA 2018-12 (Up to ICAO amendment 91) and Part Rename
2	Aug 2020	Based on NPA 2020-11 Updated to ICAO Annex 10 – Vol I (Amendment 92)
3	Sep 2023	Updated to ICAO Annex 10 – Vol I (Amendment 93)
4	Oct 2025	Based on NPA 2025-04 Updated to ICAO Annex 10 – Vol I (Amendment 94)
5	Oct 2026	Based on NPA 2026-10 Updated to ICAO Annex 10 – Vol I (Amendment 95)

CHAPTER 1. DEFINITIONS

Note 1.- *All references to "Radio Regulations" are to the Radio Regulations published by the International Telecommunication Union (ITU). Radio Regulations are amended from time to time by the decisions embodied in the Final Acts of World Radiocommunication Conferences held normally every two to three years. Further information on the ITU processes as they relate to aeronautical radio system frequency use is contained in the* Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including statement of approved ICAO policies *(Doc 9718).*

Note 2*.- KCASR 10, Volume I includes Standards and Recommended Practices for certain forms of equipment for air navigation aids. While the DGCA will determine the necessity for specific installations in accordance with the conditions prescribed in the relevant Standard or Recommended Practice, review of the need for specific installation and the formulation of ICAO opinion and recommendations to Contracting States concerned is carried out periodically by Council, ordinarily on the basis of recommendations of Regional Air Navigation Meetings (Doc 8144* - Directives to Regional Air Navigation Meetings and Rules of Procedure for their Conduct).

Note 3*.- The terminology used in this Regulation to refer to instrument approach operations is based on a previous version of the KCASR 6 classification of instrument approach and landing operations. It can be mapped to the KCASR 6 definitions as follows:*

Performance requirements in support of instrument approach operations

KCASR 10 system performance		*KCASR* 6 method - Approach operation category
Non-precision approach (NPA)		2D-Type A (1)
Approach with vertical guidance (APV)		3D-Type A (2)
	Category I, DH equal to or greater than	3D-Type A (3)
	75 m (250 ft)	
	Category I, DH equal to or greater than	3D-Type B — CAT I (3)
Precision approach (PA)	60 m (200 ft) and less than 75 m (250 ft)	
	Category II	3D-Type B — CAT II
	Category III	3D-Type B — CAT III

(1) Without vertical guidance.
(2) With barometric or SBAS vertical guidance.
(3) With ILS, MLS, GBAS or SBAS vertical guidance.

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

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

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

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

Effective acceptance bandwidth. The range of frequencies with respect to the assigned

procedure or in a designated airspace.

Note.-*Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity~~, availability~~ and functionality needed for the proposed operation in the context of a particular airspace concept. Availability of a global navigation satellite system signal in space and/or some other navigation aid infrastructure is considered within the airspace concept in order to enable the navigation application.*

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

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

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

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

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

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

o) Back azimuth antenna offset shall represent the minimum distance between the back azimuth antenna phase centre and a vertical plane containing the runway centre line.

p) Back azimuth to MLS datum point distance shall represent the minimum distance between the back azimuth antenna and the vertical plane perpendicular to the runway centre line which contains the MLS datum point.

q) Back azimuth alignment with runway centre line shall represent the minimum angle between the zero-degree back azimuth and the runway centre line.

r) *Back azimuth antenna coordinate system shall represent the coordinate system (planar or conical) of the angle data transmitted* by the back azimuth antenna.

Note.- Although the above Standard has been developed to provide for alternate coordinate systems, the planar coordinate system is not implemented and it is not intended for future implementation.

s) *Back azimuth antenna height* shall represent the vertical location of the antenna phase centre with *respect* to the MLS datum point.

Note.- It is intended that no additional auxiliary data A words be defined.

3.11.4.8.3.2 Auxiliary data B content. Auxiliary data B words shall be defined as specified in Appendix A, Tables A-11 and A-13.

3.11.4.8.3.2.1 *Microwave landing system/area navigation (MLS~~/RNAV~~) procedure data.* Where required, auxiliary data words B1 through B39 shall be used to transmit data to support MLS/RNAV procedures. It shall be permissible to divide this procedure data into two separate databases: one for transmission in the approach azimuth sector, the other for transmission in the back azimuth sector. Data for each procedure shall be transmitted in the database for the coverage sector in which the procedure commences. Missed approach procedure data shall be included in the database containing the associated approach procedure.

3.11.4.8.3.2.2 Procedure database structure. Where used, each procedure database shall be constructed as follows:

a) a map/CRC word shall identify the size of the database, the number of procedures defined, and the cyclic redundancy check (CRC) code for validation of the database;

b) procedure descriptor words shall identify all named approach and departure procedures within the database; and

c) way-point data words shall define the location and sequence of way-points for the procedures.

Note.- The structure and coding of auxiliary B words B1 through B39 are defined in Appendix A, Tables A-14 through A-17. Guidance material concerning the coding of MLS/RNAV procedures is given in Attachment G.

3.11.4.9 *System accuracy.* The accuracy standards specified herein shall be met on a 95 percent probability basis unless otherwise stated.

Note 1.- The overall error limits include errors from all causes such as those from airborne equipment, ground equipment, and propagation effects.

Note 2.- It is intended that the error limits are to be applied over a flight path interval that includes the approach reference datum or back azimuth reference datum. Information on the interpretation of MLS errors and the measurement of these errors over an interval appropriate for flight inspection is provided in Attachment G, 2.5.2.

flown) waypoint of the associated missed approach procedure.

Table A-14. MLS/area navigation~~RNAV~~ procedure database structure

(see 3.11.4.8.3.2)

Database	Word	Data content
Approach azimuth	B1	Approach azimuth map/CRC word
	B2	Procedure 1 descriptor word
	. . .	. . .
	. . .	. . .
	B(M+1)	Procedure “M” descriptor word (see Note 1)
	B(M+2) to B(a)	Waypoint data words
	B(a+1) to B(b–1)	Not used.
Back azimuth (see Note 2)	B(b)	Procedure 1 descriptor word
	. . .	. . .
	. . .	. . .
	B(b+N–1)	Procedure “N” descriptor word (see Note 1)
	B(b+N) to B(38)	Waypoint data words
	B39	Back azimuth map/CRC word

NOTES.—

1. Parameter “M” represents the number of named approach and departure procedures which commence within the approach azimuth coverage sector. Parameter “N” represents the number of named approach and departure procedures azimuth coverage sector. Parameter “N” represents the number of named approach and departure procedures
2. A facility without a back azimuth database may employ all words up to B39 for the approach azimuth database.

Table A-15. Auxiliary data B words B1 through B39

(see 3.11.4.8.3.2)

Word	Data content	Type of data	Maximum time (seconds)	Bits used	Range of values	Bit numbers
Approach azimuth map/CRC word						
B1	PREAMBLE	digital	2.5	12		I_1 to I_{12}
	Address			8		I_{13} to I_{20}
	Number of approach azimuth procedure descriptors			4	0 to 15	I_{21} to I_{24}
	Last approach azimuth database word			6	see Note 2	I_{25} to I_{30}
	Approach azimuth CRC code			32	see Note 3	I_{31} to I_{62}
	Word B42 transmitted			1	see Note 4	I_{63}
	Word A4 transmitted			1	see Note 4	I_{64}
	Word B43 transmitted			1	see Note 4	I_{65}
	Spare			4	see Note 12	I_{66} to I_{69}
	PARITY			7	see Note 13	I_{70} to I_{76}

$P_{i1} = P_{i2} = 0.5 \times 10–9$

$P_{p1} = P_{p2} = 2 \times 10–6$

Note.— These figures are from Attachment G, Table G-15, Level 4 and assume exposure times of 30 and 15 seconds, and MTBOs of 4000 and 2000 hours for the azimuth and elevation elements respectively.

$P_s = 1.0$

Note.— Since there is no guided discontinued approach/missed approach procedure using secondary guidance, the probability of an accident during the procedure is taken to be 1.

$P_x = 1.0$

Note.— It is assumed in this example that in a Category III operation the pilot is unable to intervene in the event of an integrity failure in the ground system. The risk reduction factor is therefore equal to 1.

$P_u = 2.5 \times 10\text{-}4$

Note.— The pilot risk reduction factor is estimated at 1 in 4 000 based on a study of accidents to aircraft conducting approaches to land using ground guidance systems. This is the risk reduction factor assumed due to pilot intervention following a continuity of service failure.

Therefore:

$P_i = 1 \times 10–9$

$P_p = 4 \times 10–6$

$P_d = 2.5 \times 10–4$

$P_c = 4 \times 10–6 \times 2.5 \times 10–4 = 1 \times 10–9$

$P_b = 1 \times 10–9 \times 1$

and:

calculated $P_a = 2 \times 10–9$.

3.2 There is therefore a margin of $1 \times 10–9$ on the generic requirement.

4. Application of the risk tree to an MLS/~~RNAV~~ area navigation approach in an obstacle rich environment (Figure A-3).

4.1 In this case there are three navigation elements (i.e. azimuth, elevation and DME/P) and all are assumed to meet the integrity and COS requirements for Level 4 azimuth equipment; i.e integrity = $1 – 0.5 \times 10–9$ and MTBO = 4 000 hours.

$P_{i1} = P_{i2} = P_{i3} = 0.5 \times 10–9$

$P_x = 1.0$

Note.- It is assumed that the pilot is unable to intervene in the event of an integrity failure in the ground system.

$P_{p1} = P_{p2} = P_{p3} = 4 \times 10^{-6}$

Note.— This assumes an obstacle exposure time (OET) of 60 seconds, and an MTBO of 4 000 for all ground elements

4.2 In the case of an MLS/RNAV procedure in an obstacle rich environment, it is assumed that secondary guidance will be essential to execute a safe discontinued approach/missed approach procedure during the period of exposure to the obstacles.

$P_{s1} = 7.5 \times 10^{-5}$

Note.— This is the probability of a COS failure of the secondary guidance ground equipment. It is assumed here that the secondary guidance system has a MTBO of 1 000 hours and that the exposure time is 270 seconds. The exposure time to a failure of the secondary guidance is dependent on the point in the procedure at which the availability of secondary guidance is confirmed. Assuming that this would be prior to the commencement of the MLS/ area navigation procedure, and that the pilot would not be required to reconfirm the availability of secondary guidance before commencing the critical obstacle rich part of the procedure, the exposure time could be several minutes.

$P_{s2} = 5 \times 10^{-5}$

Note.— This is the integrity required by the secondary guidance system.

Therefore:

$P_I = 1.5 \times 10^{-9}$

$P_b = 1.5 \times 10^{-9}$

$P_p = 12 \times 10^{-6}$

$P_s = 7.5 \times 10^{-5} + 5 \times 10^{-5} = 1.25 \times 10^{-4}$

$P_d = 1.25 \times 10^{-4}$

$P_c = 12 \times 10^{-6} \times 1.25 \times 10^{-4} = 1.5 \times 10^{-9}$

And

calculated $P_a = 3 \times 10^{-9}$, as required.

Note.— For obstacle exposure times greater than 60 seconds, it will be necessary to either increase the MTBOs of the primary guidance or to increase the risk reduction factor due to the secondary guidance. For example, if the exposure time is increased to 90 seconds, the MTBOs of the primary guidance must be increased to 6 000 hours or the MTBO of the secondary guidance increased to 2 250 hours. There are clearly trade-offs between the reliability of the primary guidance, the exposure time, and the reliability and integrity of the secondary guidance. The risk tree method can be used to examine individual MLS/area navigation procedures and determine the appropriate reliability and integrity requirements for the primary and secondary guidance.

reply frequency of one DME matches the interrogation frequency of a second DME, the two transponders should be separated by a distance greater than the radio horizon distance between them. The radio horizon distance is calculated taking into account the elevations of the two transponder antennas.

7.1.10 *Special considerations for DME/P associated with ILS*

7.1.10.1 For those runways where it is intended to install DME associated with ILS and where early MLS/~~RNAV~~ area navigation operations are planned, installation of DME/P is preferred.

7.1.10.2 When it is intended to use the DME/P ranging information throughout the terminal area, interrogation pulse pairs with the correct spacing and nominal frequency must trigger the transponder if the peak power density at the trans-ponder antenna is at least minus 93 dBW/m^2. This sensitivity level is based on the values contained in Chapter 3, 3.5.4.2.3.1 and it is applied to DME/P IA mode, where at this level DME/P IA mode is intended to comply with DME/N reply efficiency and at least DME/N accuracy.

7.1.11 *Considerations for the universal access transceiver (UAT*)

7.1.11.1 Frequency planning criteria to ensure compatibility between DME and the UAT are contained in Part II of the *Manual on the Universal Access Transceiver (UAT)* (Doc 9861).

7.2 Guidance material concerning DME/N only

7.2.1 Coverage of DME/N

7.2.1.1 Whether a particular installation can provide the required frequency, protected coverage volume can be determined by using Figure C-20. The propagation loss for paths without obstructions uses the IF-77 propagation model.

7.2.1.2 Whenever a DME that provides coverage using either a directional or bi-directional DME antenna, the antenna pattern in azimuth and elevation has to be taken into account to achieve the full benefit of the reduced separation requirements outside the antennas main lobe. The actual radiation patterns of the antennas depend on a number of factors, including height of the antenna phase centre, height of the DME counterpoise above ground level (AGL), terrain surface roughness, terrain form, site elevation above mean sea level (MSL), and conductivity of ground and counterpoise. For coverage under difficult terrain and siting conditions, it may be necessary to make appropriate increases in the equivalent isotropically radiated power (EIRP). Conversely, practical experience has shown, that under favourable siting conditions, and under the less pessimistic conditions often found in actual service, satisfactory system operation is achieved with a lower EIRP. However, to account for lowest EIRP in notches between the lobes of the real elevation antenna pattern, the values in Figure C-20 are recommended.

Note.— Further guidance may be found in the Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including statement of approved ICAO policies (*Doc 9718, Vol II).*

7.2.1.3 When providing coverage to support performance-based navigation as described in the Performance-based Navigation (PBN) Manual (Doc 9613) and in 7.2.3, the following should be considered:

a) although aircraft approved for PBN based on DME are able to tune to a DME up to a range of 160 NM, automatic DME station tuning by aircraft generally favours more nearby stations. Thus, in airspace volumes served by many DME/N facilities, these facilities may not be used by many aircraft at extended range. Therefore, in such areas served by many DMEs

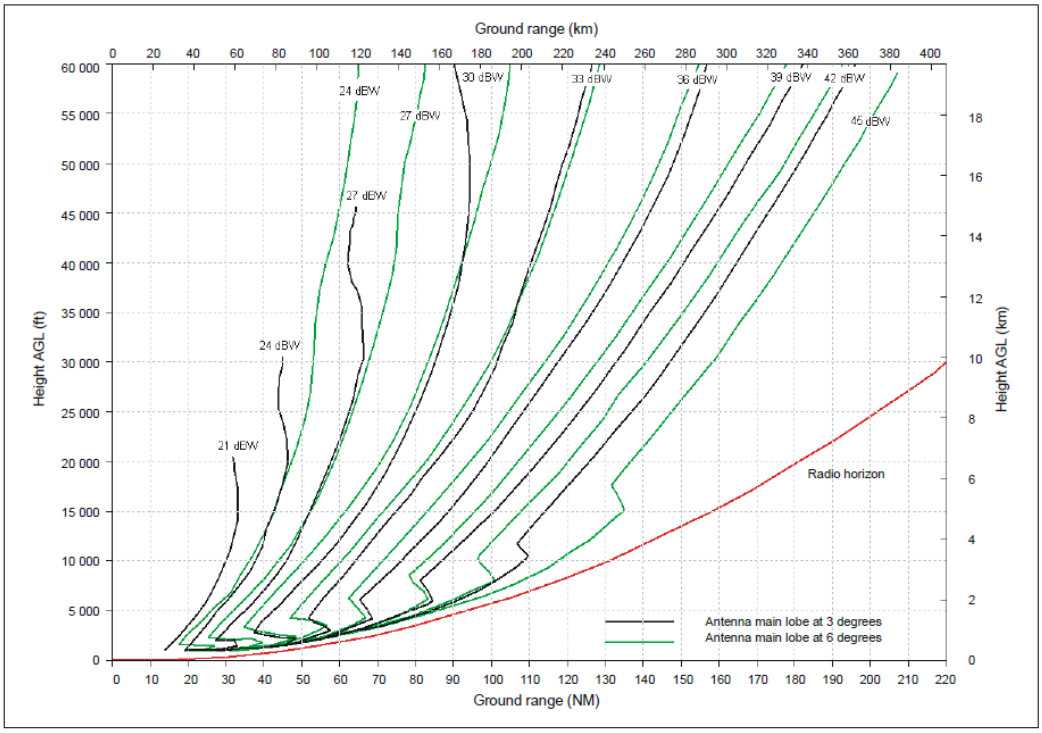


Figure C-20. Necessary EIRP to achieve a power density of –89 dBW/m^2 as a function of height above and distance from the DME

Note 1.- The curves are based on the IF-77 propagation model with a 4/3 Earth radius which has been confirmed by measurements.

Note 2.- The radio horizon in Figure C-20 is for a DME antenna located 5 m (17 ft) AGL over flat terrain. Terrain shielding will reduce the achievable range.

Note 3.- If the antenna is located significantly higher than the assumed reference antenna, the radio horizon and power density will increase.

7.2.3 *DME-DME ~~RNAV~~ area navigation*

7.2.3.1 There is an increasing use of DME to support area navigation ~~(RNAV)~~ operations. Although the use of DME to support ~~RNAV~~ area navigation operations does not impose any additional technical requirements on the DME system, it does raise some additional issues compared with the traditional use of DME with VOR to support conventional operations. These are examined briefly below.

7.2.3.2 DME/DME positioning is based on the aircraft area navigation~~RNAV~~ system triangulating position from multiple DME ranges from DME facility locations in the aircraft database. The resulting accuracy of the position solution depends on the range to the DMEs and their relative geometry. Some additional measures are therefore necessary to ensure that the DME infrastructure is adequate to support the area navigation~~RNAV~~ operation, i.e. that sufficient DMEs are available and that their location provides adequate geometry to meet the accuracy requirements. For approach and departure procedures, it is also necessary to confirm that there

is adequate signal strength and that there are no false locks or unlocks due to multipath. When ensuring there are sufficient DMEs, it is also important to identify any critical DMEs (i.e. those which must be operational for the necessary performance to be assured).

7.2.3.3 Errors in published DME facility locations will result in area navigation~~RNAV~~ position errors. It is therefore important that DME positions are correctly surveyed and that adequate procedures are in place to ensure that the location data are correctly published. For DME facilities collocated with VOR, the DME position should be separately surveyed and published if the separation distance exceeds 30 m (100 ft).

Note.— *Specifications concerning data quality and publication of DME location information are contained in PANS-AIM (Doc 10066), Appendix 1.*

7.2.3.4 When using DME to support area navigation~~RNAV~~, scanning DME aircraft receivers usually do not check the DME identification. As a consequence, removing the identification of a DME during tests and maintenance operations does not guarantee that the signals will not be used operationally. Maintenance actions that may provide misleading information should be minimized.

Note 1.— *Further guidance on flight inspection of DME-DME ~~RNAV~~ area navigation procedures is given in Doc 8071.*

Note 2.— *Further guidance on navigation infrastructure assessment to support ~~RNAV~~ area navigation procedures is given in* EUROCONTROL-GUID-0114 *(available at http://www.eurocontrol.int/eatm /public/standard_page/ gr_lib.html) and on the performance-based navigation (PBN) page of the ICAO website at http://www.icao.int/pbn.*

7.3 Guidance material concerning DME/P only

7.3.1 *DME/P system description*

7.3.1.1 The DME/P is an integral element of the microwave landing system described in Chapter 3, 3.11. The DME/P signal format defines two operating modes, initial approach (IA) and final approach (FA). The IA mode is compatible and interoperable with DME/N and is designed to provide improved accuracies for the initial stages of approach and landing. The FA mode provides substantially improved accuracy in the final approach area. Both modes are combined into a single DME/P ground facility and the system characteristics are such that DME/N and DME/P functions can be combined in a single interrogator. The IA and FA modes are identified by pulse codes which are specified in Chapter 3, 3.5.4.4. In the MLS approach sector, the DME/P coverage is at least 41 km (22 NM) from the ground transponder. It is intended that the interrogator does not operate in the FA mode at ranges greater than 13 km (7 NM) from the transponder site, although the transition from the IA mode may begin at 15 km (8 NM) from the transponder. These figures were selected on the assumption that the transponder is installed beyond the stop end of the runway at a distance of approximately 3600 m (2 NM) from the threshold.

7.3.1.2 A major potential cause of accuracy degradation encountered in the final phases of the approach and landing operation is multipath (signal reflection) interference. DME/P FA mode minimizes these effects by using wideband signal processing of pulses having fast rise time leading edges, and by measuring the time of arrival at a low point on the received pulse where it has not been significantly corrupted by multipath. This is in contrast to the slower rise time

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

1. DEFINITIONS

***Bi-binary*.** Bi-binary is known as “Manchester Encoding”. It is sometimes referred to as “Differential Manchester Encoding”. Using this system, it is the transition of the edge that determines the bit.

***Chip*.** A single digital bit of the output of a pseudo-random bit sequence.

***Gold code*.** A class of unique codes used by GPS, which exhibit bounded cross-correlation and off-peak auto-correlation values.

***Selective availability (SA)*.** A set of techniques for denying the full accuracy and selecting the level of positioning, velocity and time accuracy of GPS available to users of the standard positioning service signal.

Note.— GPS SA was discontinued at midnight on 1 May 2000.

2. GENERAL

Standards and Recommended Practices for GNSS contain provisions for the elements identified in Chapter 3, 3.7.2.2. Additional implementation guidance is provided in the *Global Navigation Satellite System (GNSS) Manual* (Doc 9849).

Note.— Except where specifically annotated, GBAS guidance material applies to GRAS.

3. NAVIGATION SYSTEM PERFORMANCE REQUIREMENTS

3.1 Introduction

3.1.1 Navigation system performance requirements are defined in the *Performance-based Navigation (PBN) Manual* (Doc 9613) for a single aircraft and for the total system which includes the signal-in-space, the airborne equipment and the ability of the aircraft to fly the desired trajectory. These total system requirements were used as a starting point to derive GNSS signal-in-space performance requirements. In the case of GNSS, degraded configurations which may affect multiple aircraft are to be considered. Therefore, certain signal-in-space performance requirements are more stringent to take into account multiple aircraft use of the system.

3.1.2 Two types of approach and landing operations with vertical guidance (APV), APV-I and APV-II, use vertical guidance relative to a glide path, but the facility or navigation system may not satisfy all of the requirements associated with precision approach. These operations combine the lateral performance equal to that of a Facility Performance Category I localizer with different levels of vertical guidance. Both APV-I and APV-II provide access benefits relative to a non-precision approach, and the service that is provided depends on the operational requirements and the SBAS infrastructure. APV-I and APV-II exceed the requirements (lateral and vertical) for current ~~RNAV~~ area navigation approaches using barometric altimetry, and the relevant on-board equipment will therefore be suitable for the conduct of barometric VNAV APV and ~~RNAV~~ area navigation non-precision approaches.

3.2 Accuracy

7. GROUND-BASED AUGMENTATION SYSTEM (GBAS) AND GROUND-BASED REGIONAL AUGMENTATION SYSTEM (GRAS)

Note.— In this section, except where specifically annotated, reference to approach with vertical guidance (APV) means APV-I and APV-II.

7.1 System description

7.1.1 GBAS consists of ground and aircraft elements. A GBAS ground subsystem typically includes a single active VDB transmitter and broadcast antenna, referred to as a broadcast station, and multiple reference receivers. A GBAS ground subsystem may include multiple VDB transmitters and antennas that share a single common GBAS identification (GBAS ID) and frequency as well as broadcast identical data. The GBAS ground subsystem can support all the aircraft subsystems within its service volumecoverage providing the aircraft with approach data, corrections and integrity information for GNSS satellites in view. GBAS ground and aircraft elements are classified according to the types of service they support (as defined in section 7.1.2).

7.1.2 GBAS systems may provide two types of services: approach services and the GBAS positioning service. The approach service provides deviation guidance for FASs within the operational approach service volume coverage-area. The GBAS positioning service provides horizontal position information to support ~~RNAV~~ area navigation operations within the positioning service area volume. The two types of services are also distinguished by different performance requirements associated with the particular operations supported (see Table 3.7.2.4-1) including different integrity requirements as discussed in 7.5.1.

7.1.2.1 GBAS approach services are further differentiated into multiple types referred to as GBAS approach service types (GAST). A GAST is defined as the matched set of airborne and ground performance and functional requirements that are intended to be used in concert in order to provide approach guidance with quantifiable performance. Four types of approach service, GAST A, GAST B, GAST C and GAST D are currently defined. GAST A, B and C are intended to support typical APV I, APV II and Category I operations, respectively. GAST D has been introduced to support landing and guided take-off operations in lower visibility conditions including Category III operations. Note that provisions for a separate service type to support Category II operations, but not Category I nor Category III, have not been made. Since equipment supporting GAST D will function the same when supporting Category II minima as when supporting Category III minima, GAST D provides one means of supporting Category II operations. Category II operations may potentially be supported using GAST C in conjunction with an appropriate aeroplane level integration. A relevant analogy is the authorization in at least one State of lower than Category I minima based on guidance from a facility performance Category I ILS used in conjunction with a head-up display (HUD). Requirements for the approval of Category II operations using GBAS will be defined by the airworthiness and operational approval authorities within States.

7.1.2.1.1 A GBAS ground subsystem may support multiple service types simultaneously. There are two types of ground subsystems, those that support multiple types of approach service and those that do not. Equipment designed in compliance with earlier versions of these SARPs

the scanning beam and DPSK signals and considering other power margins such as the available aircraft antenna gain, propagation losses, coverage losses at wide angles and rain losses which can be, at least partially, discounted in the runway region (see Table G-1).

2.6.3 *Multipath relative power density*

2.6.3.1 Fixed or mobile obstacles around the MLS ground transmitting antennas may create reflections which are known as multipath. The reflections are affecting all MLS transmissions (DPSK, angle guidance signals, out-of-coverage indication signals and clearance pulses). Relative levels between the direct guidance signal (coding the correct guidance signal) and the reflected signals are used by the MLS angular receiver to acquire and track the correct signals. These relative levels therefore have to be within given and known tolerances to allow correct receiver performances. The MOPS for MLS Airborne Receiving Equipment, EUROCAE ED-36B document, contains the MLS receivers' minimum operational performance specifications ensuring correct performances against the multipath environment, as specified in Chapter 3, 3.11.4.10.3

2.6.3.2 The four-decibel minimum ratio in Chapter 3, 3.11.4.10.3.1 and 3.11.4.10.3.3, guarantees a valid acquisition by the receiver. Lower ratios may delay signal acquisition or create false acquisition and tracking of multipath signals.

2.6.3.3 The maximum one-second duration in Chapter 3, 3.11.4.10.3.1 and 3.11.4.10.3.3, will ensure that the correct guidance information will continue to be output by the receiver without alert and will therefore not cause loss of service. This duration has to be assessed using approaching aircraft minimum ground speed.

2.6.3.4 Accuracy requirements will limit the level and duration of azimuth multipath coding angles within a narrow sector around centreline (i.e. +/-4°) as the scanning beam shape depicted in Chapter 3, 3.11.5.2.1.3, will be affected. The periodic ground and flight checks will show whether the error contribution from static multipath is compatible with the accuracy requirements. Critical and sensitive areas protection procedures will ensure that dynamic multipath error contribution will not degrade the overall accuracy beyond accuracy requirements.

2.6.3.5 For elevation guidance, signal-in-space degradation by multipath at lower height is not anticipated.

2.6.4 *Airborne power budget*

2.6.4.1 Table G-2 provides an example of an airborne power budget used in developing the power density standards.

2.7 Data applications

2.7.1 *Basic data.* The basic data defined in Chapter 3, 3.11.4.8.2.1 are provided to enable airborne receivers to process scanning beam information for various ground equipment configurations and to adjust outputs so they are meaningful to the pilot or airborne system. Data functions are also used to provide additional information (e.g. station identification and equipment status) to the pilot or airborne system.

2.7.2 *Auxiliary data*

2.7.2.1 The auxiliary data defined in Chapter 3, 3.11.4.8.3.1 and 3.11.4.8.3.2 are provided to digitally uplink the following types of information:

a) *Data describing ground equipment siting geometry.* These are transmitted in words A1-A4 and in some of the words B40-B54.

b) *Data to support MLS/~~RNAV~~ area navigation operations.* These are transmitted in words B1-B39.

c) *Operational information data.* These are transmitted in words B55-B64.

2.7.2.2 The rates of transmission of auxiliary data words are based on the following criteria:

a) Data that are required to be decoded within six seconds upon entering the MLS coverage volume should be transmitted with a maximum time between transmissions of 1 second (see 7.3.3.1.1).

b) Data that are required for an intended operation but are not required to be decoded within six seconds should be transmitted with a maximum time between transmissions of 2 seconds. This rate will allow the generation of a warning upon loss of data within 6 seconds.

c) Operational information data should be transmitted with a maximum time between transmissions of 10 seconds. This will allow the generation of a warning upon loss of data within 30 seconds.

2.7.3 *Application of MLS/~~RNAV~~ area navigation data words B1 through B39*

2.7.3.1 The data contained in auxiliary data words B1-B39 are designed to allow MLS/~~RNAV~~ area navigation operations to be supported utilizing only the data contained within the MLS data words. In order to support computed centre line approaches to both the primary and secondary runways, curved approaches and departures, and missed approaches, these data include information on procedure type (approach or departure), procedure name, runway and way-points.

2.7.3.2 The data transmitted by approach azimuth and back azimuth are segregated. This means, for example, that each will have a separate cyclic redundancy check (CRC) and be decoded independently by the airborne equipment. Data for a given MLS/~~RNAV~~ area navigation procedure are transmitted in the coverage where the procedure begins. Normally this means that approach and missed approach data would be transmitted by approach azimuth and departure data would be transmitted by back azimuth equipment. However, way-points belonging to approaches, missed approaches or departures could be transmitted in either the azimuth or the back azimuth coverage. For example, a departure may be initiated in approach azimuth coverage, therefore that data would be transmitted by approach azimuth. If the procedure begins in a common coverage region the associated data can be transmitted in only one region, except where otherwise dictated by operational requirements.

2.7.3.3 The procedures are defined by a series of way-points. The way-points are specified in a

This data item indicates whether the next segment of the procedure is straight or curved, whether the current way-point is the last one defined for the procedure, and whether to link the procedure to a missed approach or a shared portion of another procedure identified by a missed approach index or next way-point index. It also indicates whether a data field for threshold crossing height or virtual azimuth to way-point distance is appended to the way-point definition.

2.7.3.9.1 Some typical applications of the identifiers in Appendix A, Table A-17 are listed below. This list is not all inclusive:

a) identifiers 0 and 1 are used when the next way-point in the procedure is not a shared way-point, or is a shared way-point coded for the first time;

b) identifiers 2 and 3 are used to refer to the next way-points in the procedure that are already coded and shared with another procedure. The coding of these way-points is not repeated but the index allows the connection of the procedure to the shared way-points of the other procedure;

c) identifiers 4 and 5 are used in the next-to-last way-point for procedures ending or beginning on the primary runway. The last way-point is the threshold. For this way-point only, the threshold crossing height is specified since the exact location of the threshold with respect to the MLS datum is given in the auxiliary A words. Identifier 4 is used when the MLS/~~RNAV~~ area navigation missed approach guidance is not required, and identifier 5 is used when a “missed approach index” follows;

d) identifiers 6 and 7 are used for the final way-point of any procedure except as noted in c) above. For the primary runway these identifiers are used if there is a need to fully specify the X, Y and Z coordinates of the last way-point. These identifiers are also used for secondary runways and helipads. Identifier 6 is used when no missed approach is following and identifier 7 when a missed approach follows; and

e) identifiers 5 and 7 do not apply to missed approaches and departures.

2.7.3.10 Following the convention for other MLS basic and auxiliary data, all digital data encoded in the database are transmitted with the least significant bit first and the sign bit is transmitted as the most significant bit, with a ONE indicating a negative value. It is noted that the auxiliary data word addresses used to indicate the last approach azimuth database word and the first back azimuth database word are transmitted with the most significant bit first.

2.7.4 *Example application of MLS/~~RNAV~~ area navigation data words*

2.7.4.1 The following paragraphs provide an example of the data assignment process for MLS/~~RNAV~~ area navigation data words contained in auxiliary data words B1-B39. A sample set of approach and departure procedures is provided and the process by which the various way-points and associated procedure characteristics are interpreted and formatted for transmission is described.

2.7.4.2 Table G-3 depicts a set of sample approach, missed approach, and departure procedures for two hypothetical runways. Table G-4 contains way-point data for the sample procedures indicated in Table G-3 and illustrated in Figure G-15.

2.7.4.3 Prior to inserting the procedures data into the structure of B1-B39, the characteristics of the MLS/~~RNAV~~ area navigation data must be understood in order to optimally use the available number of data words. In the data set of Tables G-3 and G-4, the following specific characteristics can be noted: procedures KASEL and NELSO share the same way-points No. 1 (WP 1) and No. 2 (WP 2); procedures KASEL and NELSO link to a missed approach procedure; procedure SEMOR is a secondary runway approach; procedure LAWSO is a departure procedure and will be transmitted in back azimuth coverage; all way-points outside of the precision final approach fix (PFAF) will not require the Z coordinate to be transmitted; the Y coordinate will not have to be transmitted for several way-points that are located on the extended primary runway centre line.

2.7.4.4 Data word B1 specified in Appendix A, Table A-15, defines the structure of the MLS/~~RNAV~~ area navigation data to be transmitted in the approach azimuth coverage sector. This word also contains the approach azimuth CRC code. The number of procedures to be transmitted in the approach azimuth sector is 3. This can be determined from Table G-3. The data word address with the last approach azimuth MLS/~~RNAV~~ area navigation data word is determined after the complete set is inserted into the format. In this case, the address of the last word is B11. The CRC code is calculated as described in Note 3 to Table A-15. Words B42 and B43 are not transmitted so that the relevant bits are set to ZERO. Word A4 is transmitted so that the relevant bit is set to ONE. The coding for data word B1 is shown in Table G-5.

2.7.4.5 Data word B39 specified in Appendix A, Table A-15 defines the structure of the MLS/~~RNAV~~ area navigation data to be transmitted in the back azimuth coverage sector. This word also contains the back azimuth CRC code. The number of procedures to be transmitted in the back azimuth sector is 1. The data word address with the first back azimuth MLS/~~RNAV~~ area navigation data word is determined after the complete set is inserted into the format. In this case the address of the first word is B36. The CRC code is calculated as described in Note 3 to Table A-15. Word B43 is not transmitted so that bit is set to ZERO. The back azimuth map/CRC indicator bit is set to ONE to indicate that this is a map/CRC word. The coding for data word B39 is shown in Table G-5.

2.7.4.6 Procedure descriptor words specified in Appendix A, Table A-15 are defined for all approach and departure procedures. Missed approach procedures are linked to approach procedures in the data format and hence do not require a procedure descriptor. Procedure descriptor words for the sample data set are shown in Table G-6. It is noted that the procedure descriptor data words cannot be fully defined until the completion of the actual assignment of the way-point data due to the need for a “first way-point index” associated with each procedure. This item is the first way-point for the procedure sequence. The index is generated as indicated in 2.7.3.6. It is noted that the “validity indicator” of a procedure name (see Table G-4) is the version number of the procedure and is a value from 1 to 9.

2.7.4.7 The way-point data assignment process is in accordance with Appendix A, Tables A-15, 16 and 17. Table G-7 represents the assignment of the sample data set. The preambles, addresses and parity bits have been left out of the table. Starting with the data word immediately after the approach procedure descriptor words, the first way-point of the first procedure is assigned. For the sample data set, it means that data word B5 is the first word with way-point data. The next step is to insert the data into the appropriate format. The

f) the length of line AD is taken from Table G-12C or G-12D with information on the height of point F; and

g) the area to be protected is bounded by the polygon ABCD.

4.3.7.3.2 Typically, the areas of polygon ABCD in Figure G -26 within at least the first 300 m (1000 ft) or 600 m (2000 ft) of the azimuth antenna are to be designated, respectively, as a critical area where B-727 or B-747 size aircraft are operating. The balance of the region is designated as a sensitive area. Where possible, the azimuth antenna is to be offset to the runway side away from that of active taxiways. At facilities where the azimuth antenna is set back less than 300 m (1000 ft) or located ahead of the runway stop end, a detailed analysis and consideration of the airport layout may support reductions of the area to be protected.

4.3.7.4 Critical and sensitive areas for MLS/~~RNAV~~ area navigation procedures. For MLS/~~RNAV~~ area navigation approach procedures, the critical and sensitive areas will require expansion to protect against in-beam multipath in the sectors used. These expanded areas protect approach procedures which are not possible with ILS. The length of the area to be protected depends on the operational minimum height surface selected from Table G-13. Information for determining the area to be protected is given in Figure G-27. For a wide range of profiles, simulation indicated that, where B-727 size aircraft are operating, adequate protection would be afforded if the first 300 m (1000 ft) of the protected area is designated as a critical area and the remainder as a sensitive area. For B-747 size aircraft, the corresponding length is 600 m (2000 ft). For higher approach profiles, the length derived from Table G-13 or an equation therein may be less than these values; in this case the entire expanded area is to be designated as a critical area. Increased flexibility may be obtained by performing an analysis considering the specific approach profile and airport environment.

4.3.8 *Elevation.* The elevation critical area to be protected results from the critical volume shown in Figure G-24. Normally no sensitive area is defined for the elevation antenna. As the lower surface of the critical volume normally is well above ground level, aircraft may hold near the elevation antenna as long as the lower boundary of the critical volume is not penetrated.

4.3.8.1 For normal siting of a 1.0 degree beamwidth elevation antenna and flat ground, the fuselage of most aircraft types will fit under the profile lower surface of the critical volume of Figure G-24.

4.3.8.2 For a 1.5 degree beamwidth elevation antenna, limited penetration of the profile lower surface of the critical volume of Figure G-24 by an aircraft fuselage may be tolerated by defining the lower part of the critical volume between 1.5 degrees and 1.7 beamwidth below the minimum glide path as sensitive volume. At sites performing well within tolerance, aircraft may hold in front of the antenna provided:

a) the separation angle between the glide path and the top of the aircraft fuselage is at least 1.5 degrees;

b) the aircraft tail fin does not penetrate the lower surface of the critical volume; and

c) the fuselage is at right angle to the centre line.

4.3.8.3 For MLS/~~RNAV~~ area navigation approach procedures, the plan view of the elevation critical area will require expansion to ensure the elevation signal quality along the nominal approach track (Figure G-28). These expanded areas protect approach procedures which are not possible with ILS. The characteristics of the profile view (Figure G-24) remain unchanged, noting that the lower boundary is referenced to the nominal approach track. This guidance material covers a wide range of profiles. Increased flexibility may be obtained by performing an analysis considering the specific approach profile and airport environment.

5. Operational considerations on siting of DME ground equipment

5.1 The DME equipment should, whenever possible, provide indicated zero range to the pilot at the touchdown point in order to satisfy current operational requirements.

5.1.1 When DME/P is installed with the MLS, indicated zero range referenced to the MLS datum point may be obtained by airborne equipment utilizing coordinate information from the MLS data. DME zero range should be referenced to the DME/P site.

6. Interrelationship of ground equipment monitor and control actions

6.1 The interrelationship of monitor and control actions is considered necessary to ensure that aircraft do not receive incomplete guidance which could jeopardize safety, but at the same time continue to receive valid guidance which may safely be utilized in the event of certain functions ceasing to radiate.

Note.- The interrelationship of ground equipment monitor and control actions is presented in Table G-14.

7. Airborne equipment

7.1 General

7.1.1 The airborne equipment parameters and tolerances included in this section are intended to enable an interpretation of the Standards contained in Chapter 3, 3.11 and include allowances, where appropriate, for:

a) variation of the ground equipment parameters within the limits defined in Chapter 3, 3.11;

b) aircraft manoeuvres, speeds and attitudes normally encountered within the coverage volume.

Note 1.- The airborne equipment includes the aircraft antenna(s), the airborne receiver, the pilot interface equipment and the necessary interconnections.

Note 2.- Detailed "Minimum Performance Specifications" for MLS avionics have been compiled and coordinated by the European Organization for Civil Aviation Electronics (EUROCAE) and RTCA Inc. ICAO periodically provides to Contracting States current lists of the publications of these organizations in accordance with Recommendations 3/18(a) and 6/7(a) of the Seventh Air Navigation Conference.

7.1.2 *Function decoding*

7.1.2.1 The airborne equipment is to be capable of decoding and processing the approach azimuth, high rate approach azimuth, back azimuth, and approach elevation functions, and data required for the intended operation.

7.1.2.2 In addition, the receiver utilizes techniques to prevent function processing resulting from the presence of function preambles embedded within the data fields of basic and auxiliary data words and scanning beam side lobe radiation. One technique to accomplish this is to decode all function preambles. Following the decode of a preamble, the detection and decoding of all function preambles is then disabled for a period of time corresponding to the length of the function.

7.1.2.3 Range information is decoded independently.

7.1.3 The receiver decodes the full range of angles permitted by the signal format for each function. The guidance angle is determined by measuring the time interval between the received envelopes of the TO and FRO scans. The decoded angle is related to this time interval by the equation given in Chapter 3, 3.11.4.5.

7.1.4 The receiver is capable of normal processing of each radiated function without regard to the position of the function in the transmitted sequences.

7.1.5 If the MLS approach azimuth and back azimuth information is presented on the selector and/or flight instruments, it is to be displayed in magnetic degrees. Receivers in the automatic mode display the relevant information transmitted by the ground station as part of the basic data word 4.

7.1.6 The receiver has the capability for both manual and automatic selection of approach track, elevation angle and back azimuth radial when provided. When in automatic mode, the selection is made as follows.

7.1.6.1 *Approach azimuth* - select the angular reciprocal of the approach azimuth magnetic orientation in basic data word 4.

7.1.6.2 *Elevation angle* - select the minimum glide path in basic data word 2.

7.1.6.3 *Back azimuth* - select the angle of the back azimuth magnetic orientation in basic data word 4.

Note.— The receiver indicates when deviation is referenced to the back azimuth signal.

7.1.7 The MLS airborne receiver system must have an integrity compatible with the overall integrity of MLS which is at least $1 - 1 \times 10^{-7}$ in any one landing.

7.1.8 For airborne equipment used in MLS/~~RNAV~~ area navigation operations the capability is to be provided to unambiguously display the procedure selected.

7.2 Radio frequency response

7.2.1 *Acceptance bandwidth*

7.2.1.1 The receiver should meet acquisition and performance requirements when the received signal frequency is offset by up to plus or minus 12 kHz from the normal channel centre frequency. This figure considers possible ground transmitter offsets of plus or minus 10 kHz and Doppler shifts of plus or minus 2 kHz. The receiver should decode all functions independently of the different frequency offsets of one function relative to another.

7.2.2 *Selectivity*

7.3.2.3 The aircraft should be on the runway centre line or on the selected azimuth angle at 60 m (200 ft) and the receiver has to be in tracking mode. Below that height, the receiver should keep tracking the approach azimuth or high rate approach azimuth signal as far as this signal is coding an angle within a narrow sector centred on the runway centre line or on the selected azimuth angle even if other signals are up to 10 dB higher than the tracked signal.

7.3.3 *Data functions*

7.3.3.1 *Data acquisition.* Performance in the airborne acquisition of data provided on either the basic or auxiliary data function is broken into two items: the time allowed to acquire the data and the probability of an undetected error in the acquired data.

7.3.3.1.1 At the minimum signal power density, the time to acquire basic data word 2 which is transmitted at a rate of 6.25 Hz does not exceed two seconds on a 95 per cent probability basis. The time to acquire data that are transmitted at a rate of 1 Hz does not exceed 6 seconds on a 95 per cent probability basis.

7.3.3.1.2 In the acquisition process, the receiver decodes the appropriate data words and applies certain tests to ensure that the probability of undetected errors does not exceed 1×10^{-6} at the minimum signal power density for those data requiring this level of integrity. The recommended performance specifications for undetected errors may require additional airborne processing of the data beyond simple decoding. For example, these may be achieved by processing multiple samples of the same data words.

7.3.3.1.3 If the receiver does not acquire data required for the intended operation, a suitable warning is to be provided.

7.3.3.1.4 At the minimum signal power density the time to acquire all data words required to support MLS/ ~~RNAV~~ area navigation operations (auxiliary data words B1-B41, A1/B42, A2, A3, A4/B43 and basic data word 6) must not exceed 20 seconds on a 95 per cent probability basis. The MLS/~~RNAV~~ area navigation equipment has to ensure that the probability of undetected errors for this block of data does not exceed 0.5×10^{-9}. This performance assumes a 2 dB improvement in signal to noise. This may be achieved through reduced cable loss, margin or improved receiver sensitivity (see the airborne power budget given in Table G-2). Additionally, with signal levels above this, the acquisition time is intended to be less than 20 seconds.

7.3.3.2 *Data validation.* After acquisition of data, the receiver repeatedly confirms that the data being received are the same as the acquired data. The receiver decodes several consecutive and identical data different from that previously acquired before taking action to accept the new decoded data.

7.3.3.2.1 For data required to support MLS/~~RNAV~~ area navigation operations, the airborne equipment applies the cyclic redundancy check (CRC) to the data to ensure sufficient integrity has been achieved. Data that continue to be received continue to be validated. The MLS/RNAV equipment does not accept a new block of data to be used until it is validated with the CRC.

7.3.3.3 *Data loss.* Within 6 seconds after the loss of basic data or auxiliary data that is transmitted with a maximum interval of 2 seconds or less, the receiver provides a suitable warning and removes the existing data. Within 30 seconds after the loss of auxiliary data other than that

referred to above, the receiver provides a suitable warning.

7.3.3.3.1 For data required to support MLS/~~RNAV~~ area navigation operations, the airborne equipment does not remove existing data following validation except under the conditions described in 7.3.3.2.1. An MLS/~~RNAV~~ area navigation data block that has been validated by the CRC is not removed until a new data block has been received with a different ground equipment identification in basic data word 6, a new MLS channel is selected, or power is removed. Additionally the data block is not removed when transitioning to back azimuth coverage.

7.3.4 *Multipath performance*

7.3.4.1 Where the radiated signal power density is high enough to cause the airborne equipment thermal noise contribution to be insignificant, the following specifications should apply for scalloping frequencies between 0.05 Hz and 999 Hz.

7.3.4.1.1 *In-beam multipath.* Multipath signals coded less than two beamwidths from the direct signal and with amplitudes of 3 dB or more below the direct signal should not degrade the angle guidance accuracy output by more than plus or minus 0.5 beamwidth (peak error). The receiver should not lose track when such conditions occur.

7.3.4.1.2 *Out-of-beam multipath.* Multipath signals coded 2 beamwidths or more from the direct signal and with amplitudes of 3 dB or more below the direct signal should not degrade the angle guidance accuracy by more than plus or minus 0.02 beamwidth. For azimuth signals, and within a narrow sector around the centre line or around the selected azimuth angle, multipath signals with amplitudes of up to 10 dB above the direct signal and not distorting the direct beam shape as specified in Chapter 3, 3.11.5.2.1.3, should not degrade the angle guidance accuracy by more than plus or minus 0.02 beamwidth. The receiver should not lose track when such conditions occur.

7.3.5 *Clearance*

7.3.5.1 The airborne equipment should provide clearance guidance information whenever the antenna is in the presence of a valid clearance guidance signal.

7.3.5.2 When the decoded angle indication is outside the proportional guidance sector defined in Appendix A, Table A-7, the MLS guidance signal should be interpreted as clearance guidance.

7.3.5.3 When clearance pulses are transmitted, the receiver shall be able to process the range of pulse envelope shapes that may appear in the transition between clearance and scanning beam signals. A particular pulse envelope is dependent on the receiver position, scanning antenna beamwidth, and the relative phase and amplitude ratios of the clearance and scanning beam signals as shown in Figure G-8. The receiver is also required to process rapid changes of indicated angle of the order of 1.5 degrees (peak amplitude) when outside the proportional guidance limits.

7.3.5.4 In receivers with the capability to select or display azimuth angle guidance information greater than plus or minus 10 degrees, the proportional coverage limits in basic data must be decoded and used to preclude use of erroneous guidance.

7.4 Control and output

represents the point to which the azimuth guidance along the runway conforms to the signal characteristics specified in Chapter 3, 3.11 (format: XX:YY/ZZ/E). If the guidance signal along the runway does not conform to the above-mentioned characteristics, then a dash (—) is used in the format.

d) *Reliability of the guidance signal.* The character 1, 2, 3 or 4 indicates the level of integrity and continuity of service of the guidance signal (Table G-15). The character A, which is placed after the Level 3 or 4 designation, indicates that the elevation and DME/P objectives are equivalent to the azimuth objectives in accordance with Note 6 of Table G-15 (format: XX:YY/ZZ/E/4).

Note 1.- Where DME is not required for the intended MLS operations, there is no need to include DME/P reliability in MLS classification.

Note 2- Where an improved elevation and/or DME/P reliability is required according to Note 6 of Table G-15 for the intended MLS/~~RNAV~~ area navigation operations, the improved elevation and/or DME/P reliability is to be included in the MLS classification.

12.3.1 Any degradation of the signal below Annex 10 Standards, or below previously published performance, should be promulgated by the appropriate authority (Chapter 2, 2.1.2 and Section 10 above).

12.4 Table G-15 gives continuity of service and integrity objectives for MLS basic and MLS/~~RNAV~~ area navigation operations.

Note.- In relation to specific MLS operations it is intended that the level of integrity and continuity of service would typically be associated as follows:

1) Level 2 is the performance objective for MLS equipment used to support low visibility operations when guidance for position information in the landing phase is supplemented by visual cues. This level is a recommended objective for equipment supporting Category I operations;

2) Level 3 is the performance objective for MLS equipment used to support operations which place a high degree of reliance on MLS guidance for positioning through touchdown. This level is a required objective for equipment supporting Category II and IIIA operations; and

3) Level 4 is the performance objective for MLS equipment used to support operations which place a high degree of reliance on MLS guidance throughout touchdown and roll-out. This level basically relates to the needs of the full range of Category III operations.

12.5 The following example of MLS facility classification:

denotes a system with:

a) a proportional guidance sector of 40 degrees left and 30 degrees right of the zero-degree azimuth;

b) vertical guidance down to 50 ft above threshold;

c) roll-out guidance to MLS point E; and

d) integrity and continuity of service Level 4 with elevation and DME/P objectives

equivalent to azimuth.

13. Computed centre line approaches

13.1 General

13.1.1 Computed centre line approaches considered below are based on a computed path along a runway centre line where the azimuth antenna is not sited on the extended runway centre line. The simplest form of a computed centre line approach is one in which the nominal track is parallel to the zero-degree azimuth. In order to conduct MLS/~~RNAV~~ area navigation operation, a greater capability than that available in the basic MLS receiver is required.

13.1.2 Computed centre line approaches to the MLS primary runway are conducted to the runway whose relationship to the MLS ground equipment is identified in the auxiliary data words.

13.1.3 When the final segment is contained in the MLS coverage volume, computed centre line approaches can be conducted along a straight final segment on a descent gradient down to the decision height (DH). Computed centre line approaches may result in decision heights that are above decision heights achievable with aligned MLS approaches.

13.2 Computed centre line approach error budget

13.2.1 RTCA (RTCA/DO-198) has described a total system error budget for MLS area navigation ~~(RNAV)~~ equipment. This error budget includes contributions due to:

a) ground system performance;

b) airborne sensor performance;

c) ground system geometry effects;

d) MLS/~~RNAV~~ area navigation computer computational error; and

e) flight technical error (FTE).

13.2.2 The composite of the above errors with the exclusion of FTE is referred to as total position error. Within 3.7 km (2 NM) of the MLS approach reference datum the permissible total lateral position error for MLS/~~RNAV~~ area navigation equipment at a position 60 m (200 ft) above the MLS datum point on a 3-degree elevation angle and a runway length of 3000 m (10000 ft), is 15 m (50 ft) (see the note below). Similarly, the permissible total vertical position error is 3.7 m (12 ft) at the same position. A portion of the total position error budget has been reserved for the MLS/~~RNAV~~ area navigation computer performance (computational error). Within 3.7 km (2 NM) of the MLS approach reference datum, the portion of the error budget reserved for computational error is ±0.6 m (2 ft) both laterally and vertically. The results presented in 13.5 are dependent on meeting this computational accuracy requirement.

13.2.3 Using root sum square methodology the permissible total lateral position error, exclusive of MLS/~~RNAV~~ area navigation computer performance, is slightly less than ±15 m (50 ft). Similarly, the permissible total vertical position error, exclusive of computational error is slightly less than ±3.7 m (12 ft). Hence, the combined error due to ground system performance, airborne sensor performance and ground system geometry effects is not

expected to exceed ±15 m (50 ft) laterally and 3.7 m (12 ft) vertically at the described location. Using this information and assumptions about ground and airborne sensor performance, the maximum permissible azimuth and elevation antenna offsets (geometry effects) from the runway centre line can be obtained.

~~1.1~~ 13.2.4 The CMN does not exceed ±7.3 m (24 ft) laterally and ±1.9 m (6.3 ft) vertically, or the linear equivalent of ±0.1 degree, whichever is less. The linear values are based on nominal antenna sitings (azimuth antenna to threshold distance of 3300 m (11000 ft) and datum point to threshold distance of 230 m (760 ft)), with a 3-degree elevation angle. Within 3.7 km (2 NM) of the MLS approach reference datum, the portion of the CMN budget reserved for computational error is 1.1 m (3.5 ft) laterally and 0.6 m (2.0 ft) vertically.

Note.— All errors represent 95 percentile errors.

13.3 Siting and accuracy considerations

13.3.1 Theoretical and operational analysis has shown that several factors will impact the amount of azimuth antenna lateral offset that can be permitted and still obtain lateral and vertical position accuracy identified in 13.2.

13.3.2 *Distance between azimuth and elevation antennas*

13.3.2.1 For a given azimuth antenna offset, a short azimuth to elevation distance results in relatively large azimuth angles at positions near the approach reference datum. As a result, the error contribution from the DME is large, and the lateral accuracy may degrade unacceptably. At a runway where a large azimuth antenna offset and a short azimuth to elevation distance exist, use of DME/P rather than DME/N may be required to achieve the required lateral accuracy.

13.3.3 *Azimuth accuracy*

13.3.3.1 The azimuth antenna offset limits presented in 13.5 are based on the ±6 m (20 ft) azimuth path following error accuracy specification (see Chapter 3, 3.11.4.9.4). The recommended ±4 m (13.5 ft) azimuth accuracy specification would permit larger azimuth antenna offsets and still obtain required computed position accuracy at DH. Azimuth angle accuracy is assumed to degrade in accordance with Chapter 3, 3.11.4.9.

13.3.4 *DME accuracy*

13.3.4.1 Smaller errors in position determination result when DME/P equipment is used and the final approach segment is contained within 9.3 km (5 NM) of the MLS approach reference datum. There are two DME/P final approach mode accuracy standards in this region. Resulting azimuth antenna offset values when using DME/P as presented in 13.5, are based on final approach mode Standard 1 accuracy. Larger azimuth antenna offset values may be permissible if DME/P equipment meeting final approach mode Standard 2 accuracy is used. DME/P final approach mode Standard 1 ranging accuracy is assumed to degrade in accordance with Chapter 3, 3.5.3.1.3.4 and Table B. DME/N is assumed to degrade in accordance with Chapter 3, 3.5.3.1.3.2.

13.3.5 *Use of elevation information in the lateral position computation*

13.3.5.1 Generally, lateral position computation that excludes elevation information will be sufficient for computed centre line approaches to the primary runway. If elevation information is not used in lateral computation, the lateral error increases. This error increases with azimuth angle, height and decreasing range. Permissible azimuth antenna offsets presented in 13.5 are reduced if elevation information is not used in the lateral computation. Elevation angle accuracy is assumed to degrade in accordance with Chapter 3, 3.11.4.9.

13.4 Equipment considerations

13.4.1 Performance of airborne sensors, MLS ground equipment and MLS/~~RNAV~~ area navigation avionics implementation influence the range of application of computed centre line approaches. Information presented in 13.5 is based on the following equipment considerations.

13.4.2 *Airborne sensors*

13.4.2.1 It is assumed the receiver will decode all auxiliary data words required for MLS computed centre line approaches unless the information contained in the data words is available from other avionics sources with the same accuracy and integrity as required for auxiliary data. Digital MLS angle data and range data are needed for computing lateral and vertical position. Angle data quantization is 0.01 degrees. Range quantization is 2.0 m (0.001 NM).

13.4.3 ~~*RNAV*~~ *Area navigation computations*

13.4.3.1 No assumption is made about where the ~~RNAV~~ area navigation position computations are made. A portion of the computed centre line approach error budget has been reserved for computation error. This permits flexible algorithm implementation.

13.4.4 *Permissible azimuth antenna offset calculation techniques*

13.4.4.1 RTCA (RTCA/DO-198, Appendix D) has identified several different position determination algorithms. Different algorithms can handle different ground equipment configurations. The algorithm designed to handle any ground equipment geometry is the RTCA case 12 algorithm. Permissible antenna offset values were obtained using Monte Carlo simulation techniques. The results were also obtained using a direct analytical method. The analytical method uses geo-metric transformations of the maximum MLS angle and range errors to determine system performance. The Monte Carlo technique through the emulation of an MLS/~~RNAV~~ area navigation system is a statistical method used to determine system performance.

13.4.4.2 *Possible restriction in position determination.* Depending on ground equipment geometry a region of possible multiple solutions to the position determination algorithm may exist. This region of multiple solutions is dependent on the locations of the elevation antenna and DME transponder relative to the runway and computed approach path. The most pronounced effect occurs when the DME transponder lies in the region between the approach path DH point and the elevation antenna. The position ambiguities can be resolved when the DME transponder is located behind the elevation antenna when viewed from the approach direction. When the DME transponder is located in front of the elevation antenna it may not be possible to resolve the position ambiguity.

critical software for these functions will have to be designed, developed, documented and evaluated.

13.6.2.2 The necessary algorithms are relatively simple and do not pose any certification difficulty. However, experience with flight management system (FMS) computers indicates that it would be difficult to certify a safety-critical function implemented within an existing FMS. Current FMS architectures are not partitioned to allow separate certification of different functions to different levels of criticality and the size and complexity of an FMS precludes safety-critical certification of the entire FMS computer. Consequently, alternatives to FMS implementation can be considered for computed centre line capability intended for low visibility applications (e.g. incorporation within the autopilot or within the MLS receiver). These alternatives would provide output guidance with the same output characteristics as a normal straight-in approach.

13.6.3 *Ground system performance*

13.6.3.1 Based on the implementation assumed in 13.3.5, elevation guidance would be used in exactly the same manner as for basic MLS approaches. Consequently, the elevation ground equipment integrity and continuity of service objectives would remain unchanged from those already given in Table G-15. For lateral guidance, the integrity and continuity of service objectives given in Table G-15 for azimuth would apply to the azimuth and DME combined, resulting in objectives for both that are more stringent than those needed for basic MLS operations. However, a low visibility computed centre line operation to a 30 m (100 ft) DH may be achieved by the use of ground equipment meeting the level 4 objectives contained in Table G-15.

13.6.4 *Accuracy*

13.6.4.1 MLS/~~RNAV~~ area navigation will support computed paths to Category I decision heights for the primary runway given siting limitations as identified in Figure G-30. In addition, under certain conditions MLS/RNAV may provide sufficient accuracy to support Category II and III approaches. In order to accomplish this, the airborne implementation is as stated in 13.6.1.2.

13.6.4.2 The error budgets for Category II and III procedures are the following. For Category III, the lateral accuracy requirements are the same as the MLS approach azimuth accuracies specified at the approach reference datum. These requirements are ±6 m (20 ft) for PFE and ±3.2 m (10.5 ft) for CMN (Chapter 3, 3.11.4.9.4). For Category II the lateral requirements are obtained by splaying the allowed Category III values from the approach reference datum out to the Category II decision height of 30 m (100 ft). The equations used to compute these values (in metres) are:

1400 m runway spacing and +200 m threshold stagger.

14. Application of Table G-15 service level objectives for MLS/~~RNAV~~ area navigation operations

14.1 MLS/~~RNAV~~ area navigation procedures discussed below can be conducted with ground equipment meeting integrity and continuity of service objectives identified in Table G-15. Many of these operations may be accomplished with MLS ground equipment meeting Level 2 objectives only. Further a majority of the procedures may not require positive guidance during the discontinued approach/missed approach procedure. Where procedural means cannot provide the required obstacle clearance along an unguided discontinued approach/missed approach, some form of secondary guidance will be required. The accuracy requirements of the secondary guidance system will be determined by the nature of the obstacle-rich environment.

14.1.1 In those rare cases where an MLS/RNAV procedure is in an obstacle-rich environment, the calculated obstacle exposure time (OET) may require a higher level of equipment type than that required for landing.

14.1.2 *Determination of critical segments*

14.1.2.1 The following terms are used to determine the length of the critical segments of an MLS/~~RNAV~~ area navigation procedure.

Obstacle-rich environment. An environment where it is not possible to construct an unguided discontinued approach/missed approach using procedural means. Secondary guidance will be required to achieve a climb to minimum sector altitude.

Critical segment. A segment where an unguided discontinued approach/missed approach would expose the aircraft to an obstacle.

Obstacle exposure time (OET). The time interval required to fly the critical segment of an MLS/RNAV procedure. This time is used to establish the required level of service of the non-aircraft guidance equipment.

14.1.2.2 In order to determine OET the following procedure can be followed (see Figure G-34):

a) determine if there is an obstacle-rich environment by aligning the unguided discontinued approach/missed approach surface with any potential heading that may be used during an unguided discontinued approach/missed approach from the MLS/~~RNAV~~ area navigation procedure;

b) determine whether there is a procedural means for avoiding the obstacle without the need for secondary guidance; and

c) determine the OET as the period of time during which the obstacle is within the unguided discontinued approach/ missed approach surface, while there is no procedural means for avoiding the obstacle.

14.2 Computed centre line operations

14.2.1 When conducted to the primary runway, these operations require the airborne system to

Table G-1. System power budget

(±40° azimuth coverage: 0–20° vertical coverage: 37 km (20 NM) range)

Power budget items (Note 1)	Approach azimuth function					Elevation function			Back azimuth function			
	DPSK	Clearance	Angle BW 1°	Angle BW 2°	Angle BW 3° (Note 2)	DPSK	Angle BW 1°	Angle BW 2°	DPSK	Angle BW 1°	Angle BW 2°	Angle BW 3°
Signal required at aircraft (dBm)	–95.0	–93.5	–91.2	–85.2	–81.7	–95.0	–93.5	–90.0	–95.0	–93.5	–88.2	–84.7
Propagation loss (dB) (Notes 3, 4)	139.0	139.0	139.0	139.0	139.0	138.1	138.1	138.1	133.9	133.9	133.9	133.9
Probabilistic losses (dB):												
a) Polarization	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
b) Rain	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	1.3	1.3	1.3	1.3
c) Atmospheric	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
d) Horizontal multipath	3.0	3.0	0.5	0.5	0.5	3.0	–	–	3.0	0.5	0.5	0.5
e) Vertical multipath	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	2.0	2.0
Root – sum – square (RSS) total a) through e) (dB)	4.3	4.3	3.1	3.1	3.1	4.3	2.5	2.5	3.9	2.5	2.5	2.5
Horizontal and vertical pattern loss (dB)	–	1.0	2.0	2.0	2.0	–	6.0	6.0	–	2.0	2.0	2.0
Monitor margin (dB)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Antenna gain (dB) (Note 5)	–	–13.3	–23.0	–20.0	–18.0	–	–20.8	–17.8	–	–23.0	–20.0	–18.0
Net power gain at coverage extremes (dB)	–7.3	–	–	–	–	–7.3	–	–	–7.3	–	–	–
Required transmitter power (dBm)	42.5	39.0	31.4	40.4	41.1	41.6	33.8	40.3	37.1	23.4	31.7	37.2
Example 20 watt transmitter (dBm)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Transmitter power margin (dB)	0.5	4.0	11.6	2.6	1.9	1.4	9.2	2.7	5.9	19.6	11.3	5.8

NOTES.—

1. Losses and antenna gains are representative values.
2. High data rate for 3° azimuth beamwidth will reduce required transmitter power by 4.8 dB.
3. Distance to azimuth antenna taken as 41.7 km (22.5 NM).
4. Distance to back azimuth antenna taken as 23.1 km (12.5 nautical miles).
5. The required transmitter power can be reduced by using higher efficiency antennas.

Table G-2. Airborne power budget

Power budget items	DPSK	Clearance	Approach azimuth function Angle BW 1°	2°	3°	3° (Note 1)	Elevation function Angle BW 1°	2°	Back azimuth function Angle BW 1°	2°	3°
IF SNR (dB) required for:											
a) 72% decode rate	5.0	—	—	—	—	—	—	—	—	—	—
b) 0.1° CMN (Note 2)	—	—	8.8	14.8	18.3	13.5	—	10.0	—	11.8	15.3
c) Acquisition	—	6.5	—	—	—	—	6.5	—	6.5	—	—
Noise power in 150 kHz IF bandwidth (dBm)	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0
Signal power required at IF (dBm)	–117.0	–115.5	–113.2	–107.2	–103.7	–108.5	–115.5	–112.0	–115.5	–110.2	–106.7
Noise figure (dB)	11	11	11	11	11	11	11	11	11	11	11
Cable loss (Note 3) (dB)	5	5	5	5	5	5	5	5	5	5	5
Airborne antenna gain (dBi)	0	0	0	0	0	0	0	0	0	0	0
Margin (dB)	6	6	6	6	6	6	6	6	6	6	6
Signal required at aircraft (dBm)	–95.0	–93.5	–91.2	–85.2	–81.7	–86.5	–93.5	–90.0	–93.5	–88.2	–84.7

Notes.—
1. High rate approach azimuth function.
2. 0.2° CMN for the back azimuth function.
3. Provides for either front or rear antenna cable losses in typical installations. Additional losses (up to 11 dB) may be accommodated by air carrier class avionics.

Table G-3. Sample area navigation procedures for MLS installation on Runway 23R
(see Figure G-15)

Procedure name	Procedure type	Runway	Missed approach	Number of way-points	AAZ or BAZ
KASEL-1-A	Approach	23R	Yes	4	AAZ
NELSO-1-B	Approach	23R	Yes	3	AAZ
N/A	Missed approach	23R	N/A	2	AAZ
SEMOR-1-C	Approach	26 (Note)	No	2	AAZ
LAWSO-6-D	Departure	23R	N/A	3	BAZ

Note.— Runway 26 is a secondary runway. The virtual azimuth to way-point distance is 3 000 m.

Table G-2. Airborne power budget

Power budget items	DPSK	Clearance	Approach azimuth function Angle BW 1°	2°	3°	3° (Note 1)	Elevation function Angle BW 1°	2°	Back azimuth function Angle BW 1°	2°	3°
IF SNR (dB) required for:											
a) 72% decode rate	5.0	—	—	—	—	—	—	—	—	—	—
b) 0.1° CMN (Note 2)	—	—	8.8	14.8	18.3	13.5	—	10.0	—	11.8	15.3
c) Acquisition	—	6.5	—	—	—	—	6.5	—	6.5	—	—
Noise power in 150 kHz IF bandwidth (dBm)	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0	–122.0
Signal power required at IF (dBm)	–117.0	–115.5	–113.2	–107.2	–103.7	–108.5	–115.5	–112.0	–115.5	–110.2	–106.7
Noise figure (dB)	11	11	11	11	11	11	11	11	11	11	11
Cable loss (Note 3) (dB)	5	5	5	5	5	5	5	5	5	5	5
Airborne antenna gain (dBi)	0	0	0	0	0	0	0	0	0	0	0
Margin (dB)	6	6	6	6	6	6	6	6	6	6	6
Signal required at aircraft (dBm)	–95.0	–93.5	–91.2	–85.2	–81.7	–86.5	–93.5	–90.0	–93.5	–88.2	–84.7

NOTES.—

1. High rate approach azimuth function.
2. 0.2° CMN for the back azimuth function.
3. Provides for either front or rear antenna cable losses in typical installations. Additional losses (up to 11 dB) may be accommodated by air carrier class avionics.

Table G-3. Sample RNAV procedures for MLS installation on Runway 23R
(see Figure G-15)

Procedure name	Procedure type	Runway	Missed approach	Number of way-points	AAZ or BAZ
KASEL-1-A	Approach	23R	Yes	4	AAZ
NELSO-1-B	Approach	23R	Yes	3	AAZ
N/A	Missed approach	23R	N/A	2	AAZ
SEMOR-1-C	Approach	26 (Note)	No	2	AAZ
LAWSO-6-D	Departure	23R	N/A	3	BAZ

Note.— Runway 26 is a secondary runway. The virtual azimuth to way-point distance is 3 000 m.

Table G-4. Sample way-point information for MLS/area navigation procedures

Basic indicator	Validity indicator	Route indicator	Way-point number	X (metres)	Y (metres)	Z (metres)	Notes
KASEL	1	A	4	8 200	–9 094	N/A	No Z
			3	9 954	–5 336	789	PFAF
			2	6 556	0	344	No Z, No Y
			1	259	0	16.8 (Note)	Threshold
NELSO	1	B	3	9 742	6 499	819	PFAF
			2	6 556	0	344	Shared with KASEL
			1	259	0	16.8 (Note)	Shared with KASEL
N/A (missed approach)	N/A	N/A	2	–7 408	0	N/A	No Z, No Y
			1	0	0	N/A	No Z, No Y
SEMOR	1	C	2	5 567	–5 276	346	PFAF
			1	159	–2 401	16	Threshold
LAWSO	6	D	3	–8 018	3 057	N/A	No Z
			2	–4 964	0	N/A	No Z, No Y
			1	0	0	N/A	No Z, No Y

Note.— This value is the threshold crossing height, referenced to ground level at threshold. The height of the threshold with respect to the MLS datum point is given in auxiliary word A2.

Table G-4. Sample way-point information for MLS/RNAV procedures

Basic indicator	Validity indicator	Route indicator	Way-point number	X (metres)	Y (metres)	Z (metres)	Notes
KASEL	1	A	4	8 200	–9 094	N/A	No Z
			3	9 954	–5 336	789	PFAF
			2	6 556	0	344	No Z, No Y
			1	259	0	16.8 (Note)	Threshold
NELSO	1	B	3	9 742	6 499	819	PFAF
			2	6 556	0	344	Shared with KASEL
			1	259	0	16.8 (Note)	Shared with KASEL
N/A (missed approach)	N/A	N/A	2	–7 408	0	N/A	No Z, No Y
			1	0	0	N/A	No Z, No Y
SEMOR	1	C	2	5 567	–5 276	346	PFAF
			1	159	–2 401	16	Threshold
LAWSO	6	D	3	–8 018	3 057	N/A	No Z
			2	–4 964	0	N/A	No Z, No Y
			1	0	0	N/A	No Z, No Y

Note.— This value is the threshold crossing height, referenced to ground level at threshold. The height of the threshold with respect to the MLS datum point is given in auxiliary word A2.

Table G-6. Example of procedure descriptor word assignments

Data item	Bit numbers	Procedure descriptor data words							
		KASEL B2		NELSO B3		SEMOR B4		LAWSO B36	
		Value	Coded	Value	Coded	Value	Coded	Value	Coded
Basic indicator (first character)	I_{21}-I_{25}	K	11010	N	01110	S	11001	L	00110
Second character	I_{26}-I_{30}	A	10000	E	10100	E	10100	A	10000
Third character	I_{31}-I_{35}	S	11001	L	00110	M	10110	W	11101
Fourth character	I_{36}-I_{40}	E	10100	S	11001	O	11110	S	11001
Fifth character	I_{41}-I_{45}	L	00110	O	11110	R	01001	O	11110
Validity indicator	I_{46}-I_{49}	1	1000	1	1000	1	1000	6	0110
Route indicator	I_{50}-I_{54}	A	10000	B	01000	C	11000	D	00100
Runway number	I_{55}-I_{60}	23	111010	23	111010	26	010110	23	111010
Runway letter	I_{61}-I_{62}	R	10	R	10	–	00	R	10
Procedure type	I_{63}	APP	0	APP	0	APP	0	DEP	1
First way-point index	I_{64}-I_{69}	1	100000	4	001000	5	101000	1	100000

Note.— Bit coding is indicated with the lower bit number on the left.

Table G-7. Example of way-point assignments for MLS/area navigation approach procedures

Procedure name	Data word	Bit numbers	Data item	Value	Value	WP Index
KASEL	B5	I_{21-35}	WP 4 – X coordinate	8 200 m	110000010011000	1
		I_{36}	Y coordinate follows	Yes	1	
		I_{37-51}	WP 4 – Y coordinate	–9 094 m	000001111011001	
		I_{52}	Z coordinate follows	No	0	
		I_{53-55}	Next segment/field identifier	straight = 0	000	
		I_{56-69}	WP 3 – X coordinate (first 14 bits)	9 954 m	00001100111100	2
	B6	I_{21}	WP 3 – X coordinate (last bit)		0	
		I_{22}	Y coordinate follows	Yes	1	
		I_{23-37}	WP 3 – Y coordinate	–5 336 m	001001000001001	
		I_{38}	Z coordinate follows	Yes	1	
		I_{39-51}	WP 3 – Z coordinate	789 m	1001111011000	
		I_{52-54}	Next segment field/identifier	curved = 1	100	
		I_{55-69}	WP 2 – X coordinate	6 556 m	100000000101000	3
	B7	I_{21}	Y coordinate follows	No	0	
		I_{22}	Z coordinate follows	Yes	1	
		I_{23-35}	WP 2 – Z coordinate	344 m	0011110110000	
		I_{36-38}	Next segment/field identifier	5	101	
		I_{39-44}	Threshold way-point height	16.8 m	010001	
		I_{45-50}	Missed approach index	7	111000	
NELSO		I_{51-65}	WP 3 – X coordinate	9 742 m	101110110111000	4
		I_{66}	Y coordinate follows	Yes	1	
		I_{67-69}	WP 3 – Y coordinate (first 3 bits)	6 499 m	110	
	B8	I_{21-32}	WP 3 – Y coordinate (last 12 bits)		101111001000	
		I_{33}	Z coordinate follows	Yes	1	
		I_{34-46}	WP 3 – Z coordinate	819 m	1110100111000	
		I_{47-49}	Next segment/field identifier	shared = 3	110	
		I_{50-55}	Next way-point index	3	110000	
SEMOR		I_{56-69}	WP 2 – X coordinate (first 14 bits)	5 567 m	11111110000100	5
	B9	I_{21}	WP 2 – X coordinate (last bit)		0	
		I_{22}	Y coordinate follows	Yes	1	
		I_{23-37}	WP 2 – Y coordinate	–5 276 m	101100000001001	
		I_{38}	Z coordinate follows	Yes	1	
		I_{39-51}	WP 2 – Z coordinate	346 m	0111110110000	
		I_{52-54}	Next segment/field identifier	straight = 0	000	
		I_{55-69}	WP 1 – X coordinate	159 m	011111000000000	6

Procedure name	Data word	Bit numbers	Data item	Value	Value	WP Index
	B10	I_{21}	Y coordinate follows	Yes	1	
		I_{22-36}	WP 1 – Y coordinate	–2 401 m	010101011100001	
		I_{37}	Z coordinate follows	Yes	1	
		I_{38-50}	WP 1 – Z coordinate	16 m	0010111000000	
		I_{51-53}	Next segment/field identifier	6	011	
		I_{54-59}	Virtual azimuth distance	3 000 m	011110	
Missed Approach		I_{60-69}	WP 2 – X coordinate (first 10 bits)	–7 408 m	0111001011	7
	B11	I_{21-25}	WP 2 – X coordinate (last 5 bits)		01001	
		I_{26}	Y coordinate follows	No	0	
		I_{27}	Z coordinate follows	No	0	
		I_{28-30}	Next segment/field identifier	straight = 0	000	
		I_{31-45}	WP 1 – X coordinate	0	000000000000000	8
		I_{46}	Y coordinate follows	No	0	
		I_{47}	Z coordinate follows	No	0	
		I_{48-50}	Next segment/field identifier	6	011	
		I_{51-69}	Spare	zeros	000...000	

Note.— Bit coding is indicated with the lower bit number on the left.

Table G-7. Example of way-point assignments for MLS/RNAV approach procedures

Procedure name	Data word	Bit numbers	Data item	Value	Value	WP Index
KASEL	B5	I_{21-35}	WP 4 – X coordinate	8 200 m	110000010011000	1
		I_{36}	Y coordinate follows	Yes	1	
		I_{37-51}	WP 4 – Y coordinate	–9 094 m	000001111011001	
		I_{52}	Z coordinate follows	No	0	
		I_{53-55}	Next segment/field identifier	straight = 0	000	
		I_{56-69}	WP 3 – X coordinate (first 14 bits)	9 954 m	00001100111100	2
	B6	I_{21}	WP 3 – X coordinate (last bit)		0	
		I_{22}	Y coordinate follows	Yes	1	
		I_{23-37}	WP 3 – Y coordinate	–5 336 m	001001000001001	
		I_{38}	Z coordinate follows	Yes	1	
		I_{39-51}	WP 3 – Z coordinate	789 m	1001111011000	
		I_{52-54}	Next segment field/identifier	curved = 1	100	
		I_{55-69}	WP 2 – X coordinate	6 556 m	100000000101000	3
	B7	I_{21}	Y coordinate follows	No	0	
		I_{22}	Z coordinate follows	Yes	1	
		I_{23-35}	WP 2 – Z coordinate	344 m	0011110110000	
		I_{36-38}	Next segment/field identifier	5	101	
		I_{39-44}	Threshold way-point height	16.8 m	010001	
		I_{45-50}	Missed approach index	7	111000	
NELSO		I_{51-65}	WP 3 – X coordinate	9 742 m	101110110111000	4
		I_{66}	Y coordinate follows	Yes	1	
		I_{67-69}	WP 3 – Y coordinate (first 3 bits)	6 499 m	110	
	B8	I_{21-32}	WP 3 – Y coordinate (last 12 bits)		101111001000	
		I_{33}	Z coordinate follows	Yes	1	
		I_{34-46}	WP 3 – Z coordinate	819 m	1110100111000	
		I_{47-49}	Next segment/field identifier	shared = 3	110	
		I_{50-55}	Next way-point index	3	110000	
SEMOR		I_{56-69}	WP 2 – X coordinate (first 14 bits)	5 567 m	11111110000100	5
	B9	I_{21}	WP 2 – X coordinate (last bit)		0	
		I_{22}	Y coordinate follows	Yes	1	
		I_{23-37}	WP 2 – Y coordinate	–5 276 m	101100000001001	
		I_{38}	Z coordinate follows	Yes	1	
		I_{39-51}	WP 2 – Z coordinate	346 m	0111110110000	
		I_{52-54}	Next segment/field identifier	straight = 0	000	
		I_{55-69}	WP 1 – X coordinate	159 m	011111000000000	6
	B10	I_{21}	Y coordinate follows	Yes	1	
		I_{22-36}	WP 1 – Y coordinate	–2 401 m	010101011100001	
		I_{37}	Z coordinate follows	Yes	1	

Procedure name	Data word	Bit numbers	Data item	Value	Value	WP Index
		I_{38-50}	WP 1 – Z coordinate	16 m	0010111000000	
		I_{51-53}	Next segment/field identifier	6	011	
		I_{54-59}	Virtual azimuth distance	3 000 m	011110	
Missed Approach		I_{60-69}	WP 2 – X coordinate (first 10 bits)	–7 408 m	0111001011	7
	B11	I_{21-25}	WP 2 – X coordinate (last 5 bits)		01001	
		I_{26}	Y coordinate follows	No	0	
		I_{27}	Z coordinate follows	No	0	
		I_{28-30}	Next segment/field identifier	straight = 0	000	
		I_{31-45}	WP 1 – X coordinate	0	000000000000000	8
		I_{46}	Y coordinate follows	No	0	
		I_{47}	Z coordinate follows	No	0	
		I_{48-50}	Next segment/field identifier	6	011	
		I_{51-69}	Spare	zeros	000...000	

Note.— Bit coding is indicated with the lower bit number on the left.

Table G-8. Example MLS/area navigation departure way-point assignments

Procedure name	Data word	Bit numbers	Data item	Value	Coding	WP Index
LAWSO	B37	I_{21-35}	WP 3 – X coordinate	–8 018 m	001111000011001	1
		I_{36}	Y coordinate follows	Yes	1	
		I_{37-51}	WP 3 – Y coordinate	3 057 m	010101010010000	
		I_{52}	Z coordinate follows	No	0	
		I_{53-55}	Next segment/field identifier	curved = 1	100	
		I_{56-69}	WP 2 – X coordinate (first 14 bits)	–4 964 m	11001001111000	2
	B38	I_{21}	WP 2 – X coordinate (last bit)		1	
		I_{22}	Y coordinate follows	No	0	
		I_{23}	Z coordinate follows	No	0	
		I_{24-26}	Next segment/field identifier	straight = 0	000	
		I_{27-41}	WP 1 – X coordinate	0	000000000000000	3
		I_{42}	Y coordinate follows	No	0	
		I_{43}	Z coordinate follows	No	0	
		I_{44-46}	Next segment/field identifier	Last WP = 6	011	
		I_{47-69}	Spare	zeros	000...000	

Note.— Bit coding is indicated with the lower bit number on the left.

Table G-8. Example MLS/RNAV departure way-point assignments

Procedure name	Data word	Bit numbers	Data item	Value	Coding	WP Index
LAWSO	B37	I_{21-35}	WP 3 – X coordinate	–8 018 m	001111000011001	1
		I_{36}	Y coordinate follows	Yes	1	
		I_{37-51}	WP 3 – Y coordinate	3 057 m	010101010010000	
		I_{52}	Z coordinate follows	No	0	
		I_{53-55}	Next segment/field identifier	curved = 1	100	
		I_{56-69}	WP 2 – X coordinate (first 14 bits)	–4 964 m	11001001111000	2
	B38	I_{21}	WP 2 – X coordinate (last bit)		1	
		I_{22}	Y coordinate follows	No	0	
		I_{23}	Z coordinate follows	No	0	
		I_{24-26}	Next segment/field identifier	straight = 0	000	
		I_{27-41}	WP 1 – X coordinate	0	000000000000000	3
		I_{42}	Y coordinate follows	No	0	
		I_{43}	Z coordinate follows	No	0	
		I_{44-46}	Next segment/field identifier	Last WP = 6	011	
		I_{47-69}	Spare	zeros	000...000	

Note.— Bit coding is indicated with the lower bit number on the left.

Procedure name	Data word	Bit numbers	Data item	Value	Value	WP Index
Missed Approach		I_{38-50}	WP 1 – Z coordinate	16 m	0010111000000	
		I_{51-53}	Next segment/field identifier	6	011	
		I_{54-59}	Virtual azimuth distance	3 000 m	011110	
		I_{60-69}	WP 2 – X coordinate (first 10 bits)	–7 408 m	0111001011	7
	B11	I_{21-25}	WP 2 – X coordinate (last 5 bits)		01001	
		I_{26}	Y coordinate follows	No	0	
		I_{27}	Z coordinate follows	No	0	
		I_{28-30}	Next segment/field identifier	straight = 0	000	
		I_{31-45}	WP 1 – X coordinate	0	000000000000000	8
		I_{46}	Y coordinate follows	No	0	
		I_{47}	Z coordinate follows	No	0	
		I_{48-50}	Next segment/field identifier	6	011	
		I_{51-69}	Spare	zeros	000...000	

Note.— Bit coding is indicated with the lower bit number on the left.

Table G-9. Example of complete MLS/area navigation database

	Bit position															
	1	2			3		4			5		6			7	
Word	3456	7890	1234	5678	9012	3456	7890	1234	5678	9012	3456	7890	1234	5678	9012	3456
A1	0000	0111	0011	0010	0101	1101	1001	1000	0010	0110	0010	0100	0000	0000	0000	0100
A2	0000	1010	0011	0010	0111	0000	0010	0111	1001	1000	0000	0000	0110	0000	0001	1010
A3	0000	1101	0011	0010	0001	0111	0110	0110	0011	0000	0100	0110	0111	0000	0111	1101
A4	0001	0011	0011	0010	0111	0000	0010	0000	0000	0000	0001	0000	0000	0000	0110	1000
B1	0000	0111	1100	0010	1100	0111	0100	0011	1111	0000	0001	1001	0001	0000	0010	0111
B2	0000	1010	1101	0100	0011	0011	0100	0011	0100	0100	0011	1010	1001	0000	0111	1001
B3	0000	1101	0111	0101	0000	1101	1001	1111	0100	0010	0011	1010	1000	0100	0000	1101
B4	0001	0011	1100	1101	0010	1101	1110	0100	1100	0110	0001	0110	0001	0100	0011	1110
B5	0001	0100	1100	0001	0011	0001	0000	0111	1011	0010	0000	0001	1001	1110	0000	0001
B6	0001	1001	0100	1001	0000	0100	1110	0111	1011	0001	0010	0000	0001	0100	0011	0000
B7	0001	1110	0100	1111	0110	0001	0101	0001	1110	0010	1110	1101	1100	0111	0110	1001
B8	0010	0010	1011	1100	1000	1111	0100	1110	0011	0110	0001	1111	1100	0010	0000	0011
B9	0010	0101	0110	1100	0000	0100	1101	1111	0110	0000	0001	1111	0000	0000	0101	0110
B10	0010	1000	1010	1010	1110	0001	1001	0111	0000	0001	1011	1100	1110	0101	1110	0100
B11	0010	1111	0100	1000	0000	0000	0000	0000	0000	1100	0000	0000	0000	0000	0110	0100
B36	1001	0001	0011	0100	0011	1011	1001	1111	0011	0001	0011	1010	1011	0000	0010	0101
B37	1001	0110	0011	1100	0011	0011	0101	0101	0010	0000	1001	1001	0011	1100	0100	0000
B38	1001	1011	1000	0000	0000	0000	0000	0000	1100	0000	0000	0000	0000	0000	0001	1101
B39	1001	1100	1000	1001	0010	1011	0010	0001	1000	1011	1111	0010	0000	0000	1010	1001
B40	1010	0000	0111	0011	0110	0110	0110	1000	0101	0110	0101	0010	0010	1010	0110	1001
B41	1010	0111	1100	0000	0000	0110	1101	1001	0111	0000	0000	0000	0000	0000	0001	1111
B44	1011	0011	1110	1010	0101	1000	0100	1010	0000	1110	1110	1000	1000	0000	0001	1011
B45	1011	0100	1111	1001	0000	0000	0000	1101	0010	0100	0000	0000	0010	1111	0000	0011
BDW6	0011	0011	1000	1000	0011											

Note.— Preamble bits I_1 to I_{12} are not shown.

Table G-9. Example of complete MLS/RNAV database

	Bit position															
	1	2			3		4			5		6			7	
Word	3456	7890	1234	5678	9012	3456	7890	1234	5678	9012	3456	7890	1234	5678	9012	3456
A1	0000	0111	0011	0010	0101	1101	1001	1000	0010	0110	0010	0100	0000	0000	0000	0100
A2	0000	1010	0011	0010	0111	0000	0010	0111	1001	1000	0000	0000	0110	0000	0001	1010
A3	0000	1101	0011	0010	0001	0111	0110	0110	0011	0000	0100	0110	0111	0000	0111	1101
A4	0001	0011	0011	0010	0111	0000	0010	0000	0000	0000	0001	0000	0000	0000	0110	1000
B1	0000	0111	1100	0010	1100	0111	0100	0011	1111	0000	0001	1001	0001	0000	0010	0111
B2	0000	1010	1101	0100	0011	0011	0100	0011	0100	0100	0011	1010	1001	0000	0111	1001
B3	0000	1101	0111	0101	0000	1101	1001	1111	0100	0010	0011	1010	1000	0100	0000	1101
B4	0001	0011	1100	1101	0010	1101	1110	0100	1100	0110	0001	0110	0001	0100	0011	1110
B5	0001	0100	1100	0001	0011	0001	0000	0111	1011	0010	0000	0001	1001	1110	0000	0001
B6	0001	1001	0100	1001	0000	0100	1110	0111	1011	0001	0010	0000	0001	0100	0011	0000
B7	0001	1110	0100	1111	0110	0001	0101	0001	1110	0010	1110	1101	1100	0111	0110	1001
B8	0010	0010	1011	1100	1000	1111	0100	1110	0011	0110	0001	1111	1100	0010	0000	0011
B9	0010	0101	0110	1100	0000	0100	1101	1111	0110	0000	0001	1111	0000	0000	0101	0110
B10	0010	1000	1010	1010	1110	0001	1001	0111	0000	0001	1011	1100	1110	0101	1110	0100
B11	0010	1111	0100	1000	0000	0000	0000	0000	0000	1100	0000	0000	0000	0000	0110	0100
B36	1001	0001	0011	0100	0011	1011	1001	1111	0011	0001	0011	1010	1011	0000	0010	0101
B37	1001	0110	0011	1100	0011	0011	0101	0101	0010	0000	1001	1001	0011	1100	0100	0000
B38	1001	1011	1000	0000	0000	0000	0000	0000	1100	0000	0000	0000	0000	0000	0001	1101
B39	1001	1100	1000	1001	0010	1011	0010	0001	1000	1011	1111	0010	0000	0000	1010	1001
B40	1010	0000	0111	0011	0110	0110	0110	1000	0101	0110	0101	0010	0010	1010	0110	1001
B41	1010	0111	1100	0000	0000	0110	1101	1001	0111	0000	0000	0000	0000	0000	0001	1111
B44	1011	0011	1110	1010	0101	1000	0100	1010	0000	1110	1110	1000	1000	0000	0001	1011
B45	1011	0100	1111	1001	0000	0000	0000	1101	0010	0100	0000	0000	0010	1111	0000	0011
BDW6	0011	0011	1000	1000	0011											

Note.— Preamble bits I_1 to I_{12} are not shown.

Table G-12D. Typical azimuth sensitive area lengths (computed centre line approach, see 4.3.7.2, complex sites)
(distances are in metres (feet); values in both units have been rounded)

Azimuth to threshold distance	2.0° beamwidth					1.0° beamwidth		
	1 830 (6 000)	2 140 (7 000)	2 440 (8 000)	2 750 (9 000)	3 050 (10 000)	3 350 (11 000)	3 660 (12 000)	3 960 (13 000)
B-727, complex site								
Height: 300 (1 000)	300 (1 000)	300 (1 000)	300 (1 000)	300 (1 000)	300 (1 000)	300 (1 000)	300 (1 000)	300 (1 000)
300 (1 000)	300 (1 000)	300 (1 000)	330 (1 100)	460 (1 500)	550 (1 800)	490 (1 600)	520 (1 700)	550 (1 800)
300 (1 000)	300 (1 000)	330 (1 100)	330 (1 100)	490 (1 600)	550 (1 800)	580 (1 900)	610 (2 000)	730 (2 400)
330 (1 100)	330 (1 100)	330 (1 100)	490 (1 600)	550 (1 800)	670 (2 200)	700 (2 300)	790 (2 600)	880 (2 900)
330 (1 100)	330 (1 100)	550 (1 800)	640 (2 100)	730 (2 400)	1 010 (3 300)	940 (3 100)	1 040 (3 400)	1 160 (3 800)
640 (2 100)	640 (2 100)	790 (2 600)	940 (3 100)	1 070 (3 500)	1 250 (4 100)	1 250 (4 100)	1 280 (4 200)	1 430 (4 700)
B-747, clean site								
300 (1 000)	430 (1 400)	460 (1 500)	490 (1 600)	520 (1 700)	670 (2 200)	550 (1 800)	580 (1 900)	610 (2 000)
75 (250)	670 (2 200)	760 (2 500)	820 (2 700)	880 (2 900)	1 010 (3 300)	980 (3 200)	1 070 (3 500)	1 130 (3 700)
60 (200)	730 (2 400)	820 (2 700)	920 (3 000)	1 010 (3 300)	1 130 (3 700)	1 040 (3 400)	1 070 (3 500)	1 220 (4 000)
45 (150)	820 (2 700)	880 (2 900)	980 (3 200)	1 100 (3 600)	1 220 (4 000)	1 100 (3 600)	1 190 (3 900)	1 430 (4 700)
30 (100)	920 (3 000)	1 010 (3 300)	1 130 (3 700)	1 280 (4 200)	1 430 (4 700)	1 580 (5 200)	1 770 (5 800)	1 950 (6 400)
15 (50)	1 100 (3 600)	1 370 (4 500)	1 620 (5 300)	1 830 (6 000)	2 130 (7 000)	2 230 (7 300)	2 350 (7 700)	2 380 (7 800)

Table G-12E. Typical azimuth sensitive area semi-width to protect roll-out guidance (see 4.3.7)
(distances are in metres (feet))

Azimuth to threshold distance	2.0°beamwidth					1.0°beamwidth		
	1 830 (6 000)	2 140 (7 000)	2 440 (8 000)	2 750 (9 000)	3 050 (10 000)	3 350 (11 000)	3 660 (12 000)	3 960 (13 000)
Clean/complex site	38 (123)	48 (157)	59 (193)	70 (230)	83 (271)	54 (177)	62 (202)	69 (227)

Table G-13. Minimum height surface angle and related protected coverage volume lengths for MLS/area navigation approach procedures

Protected coverage volume length L[m(ft)] PCH = 2.0 m	Minimum height surface angle (degrees), θ	
	B-727	B-747
300 (1 000)	1.81	3.49
450 (1 500)	1.23	2.36
600 (2 000)	0.95	1.79
750 (2 500)	0.77	1.44
900 (3 000)	N/A	1.21

The following equation can be used to determine the minimum height surface angle (Θ) in respect to an azimuth antenna phase centre for arbitrary protected coverage volume length "L".

$$\theta = \tan^{-1}\left[\frac{\mathrm{TFH} + \frac{\sqrt{\lambda(\mathrm{L})}}{4} - \mathrm{PCH}}{\mathrm{L}}\right]$$

where:

TFH = tail fin height;
PCH = phase centre height of MLS antenna;
λ = MLS wave length.

Note.— TFH equals 10.4 m for B-727 and 19.3 m for B-747, and λ is 0.06 m. PCH and L must be in metres if TFH and λ are in metres.

Table G-13. Minimum height surface angle and related protected coverage volume lengths for MLS/RNAV approach procedures

Protected coverage volume length L[m(ft)] PCH = 2.0 m	Minimum height surface angle (degrees), θ	
	B-727	B-747
300 (1 000)	1.81	3.49
450 (1 500)	1.23	2.36
600 (2 000)	0.95	1.79
750 (2 500)	0.77	1.44
900 (3 000)	N/A	1.21

The following equation can be used to determine the minimum height surface angle (Θ) in respect to an azimuth antenna phase centre for arbitrary protected coverage volume length "L".

$$\theta = \tan^{-1}\left[\frac{\mathrm{TFH} + \frac{\sqrt{\lambda(\mathrm{L})}}{4} - \mathrm{PCH}}{\mathrm{L}}\right]$$

where:

TFH = tail fin height;
PCH = phase centre height of MLS antenna;
λ = MLS wave length.

Note.— TFH equals 10.4 m for B-727 and 19.3 m for B-747, and λ is 0.06 m. PCH and L must be in metres if TFH and λ are in metres.

Table G-14. Interrelationship of ground equipment monitor and control action

Subsystem failure	Resultant action						
	Approach azimuth	Approach elevation	Back azimuth	Basic data radiated into approach azimuth coverage	Basic data radiated into back azimuth coverage	Auxiliary data	DME/N or DME/P
Approach azimuth	*	*		+		+	
Approach elevation		*					
Back azimuth			*		+		
Basic data radiated into approach azimuth coverage	*	*		*		+	
Basic data radiated into back azimuth coverage			*		*		
Auxiliary data	+	+		+		*	
DME/N or DME/P							*

* Indicates radiation should cease.
\+ Indicates radiation may continue when operationally required.

Table G-15. Continuity of service and integrity objectives for MLS basic and MLS/area navigation operations

Level	Azimuth or elevation			DME/P (Note 6)		
	Integrity in any one landing	Continuity of service	MTBO (hours)	Integrity in any one landing (Note 4)	Continuity of service	MTBO (hours)
1	Not demonstrated, but designed to meet the Level 2 requirements (Note 3)					
2	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000
3	$1 - 0.5 \times 10^{-9}$	$1 - 2 \times 10^{-6}$ (15 s)	2 000	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000
4 (Note 5)	$1 - 0.5 \times 10^{-9}$	$1 - 2 \times 10^{-6}$ (30 s Az) (15 s El) (Note 6)	4 000 Az 2 000 El (Note 6)	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000

Notes.—

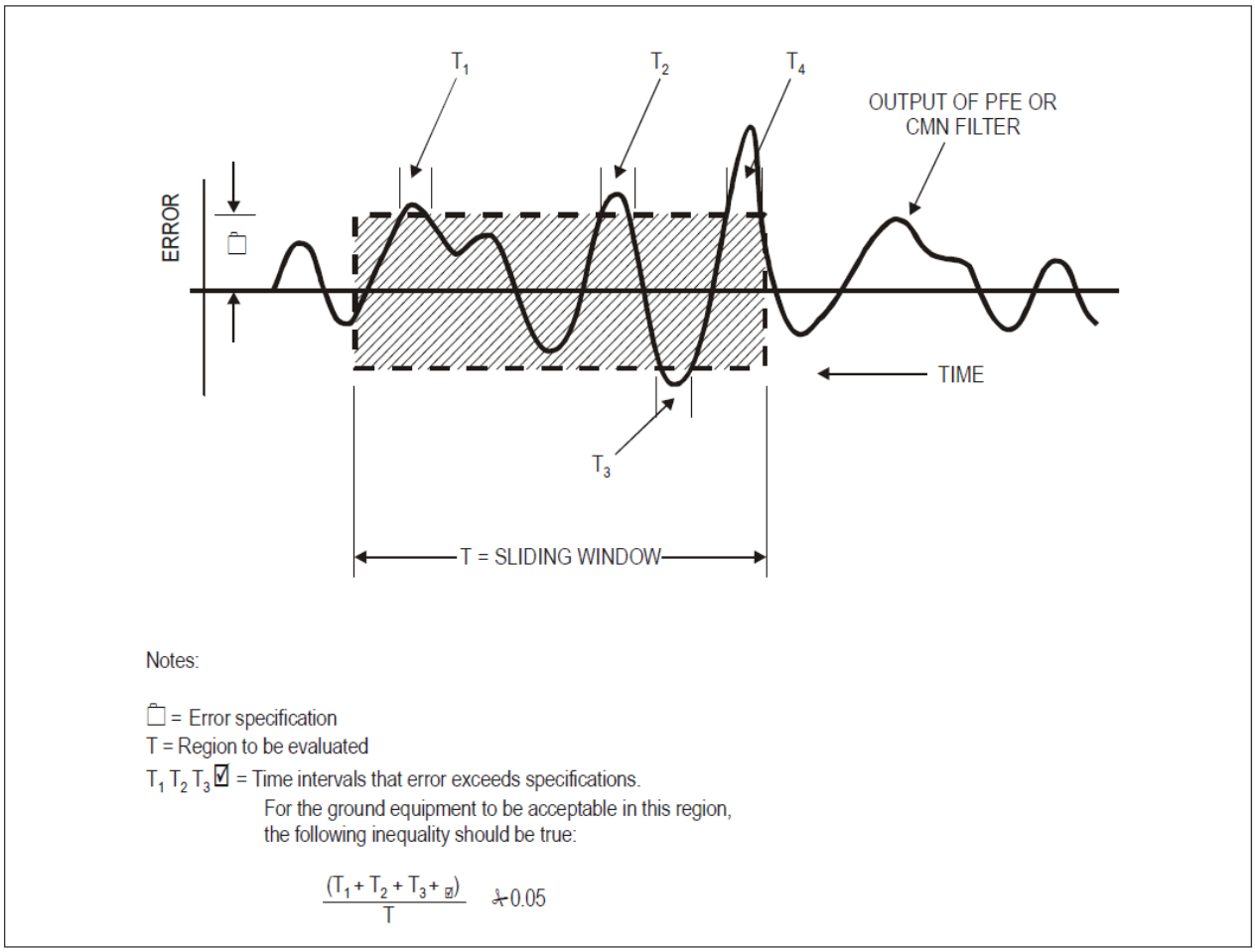
1. Data word continuity of service and integrity are included in the specified values of the angle function for each level of service.
2. Back azimuth is not required for basic operations.
3. It is intended that all equipments meet at least Level 2 requirements.
4. If DME/N is used with MLS the figures may be reduced to $1 - 1 \times 10–5$.
5. The Level 4 exposure times are based on experience with ILS and are consistent with existing operational capabilities. As experience is gained with MLS, and enhanced operational capabilities are proposed, it may be necessary to adjust these values.
6. MLS/area navigation procedures may require the Level 3 and 4 integrity, continuity of service and MTBO objectives of the elevation, DME/P and, if used, back azimuth to be equivalent to the approach azimuth equipment.

Table G-15. Continuity of service and integrity objectives for MLS basic and MLS/RNAV operations

Level	Azimuth or elevation			DME/P (Note 6)		
	Integrity in any one landing	Continuity of service	MTBO (hours)	Integrity in any one landing (Note 4)	Continuity of service	MTBO (hours)
1	Not demonstrated, but designed to meet the Level 2 requirements (Note 3)					
2	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000
3	$1 - 0.5 \times 10^{-9}$	$1 - 2 \times 10^{-6}$ (15 s)	2 000	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000
4 (Note 5)	$1 - 0.5 \times 10^{-9}$	$1 - 2 \times 10^{-6}$ (30 s Az) (15 s El) (Note 6)	4 000 Az 2 000 El (Note 6)	$1 - 1 \times 10^{-7}$	$1 - 4 \times 10^{-6}$ (15 s)	1 000

Notes.—

1. Data word continuity of service and integrity are included in the specified values of the angle function for each level of service.
2. Back azimuth is not required for basic operations.
3. It is intended that all equipments meet at least Level 2 requirements.
4. If DME/N is used with MLS the figures may be reduced to $1 - 1 \times 10^{-5}$.
5. The Level 4 exposure times are based on experience with ILS and are consistent with existing operational capabilities. As experience is gained with MLS, and enhanced operational capabilities are proposed, it may be necessary to adjust these values.
6. MLS/RNAV procedures may require the Level 3 and 4 integrity, continuity of service and MTBO objectives of the elevation, DME/P and, if used, back azimuth to be equivalent to the approach azimuth equipment.



Notes:

□ = Error specification
T = Region to be evaluated
$T_1\ T_2\ T_3$ ☑ = Time intervals that error exceeds specifications.
For the ground equipment to be acceptable in this region, the following inequality should be true:

$$\frac{(T_1 + T_2 + T_3 + \square)}{T} \leq 0.05$$

Figure G-12. MLS measurement methodology

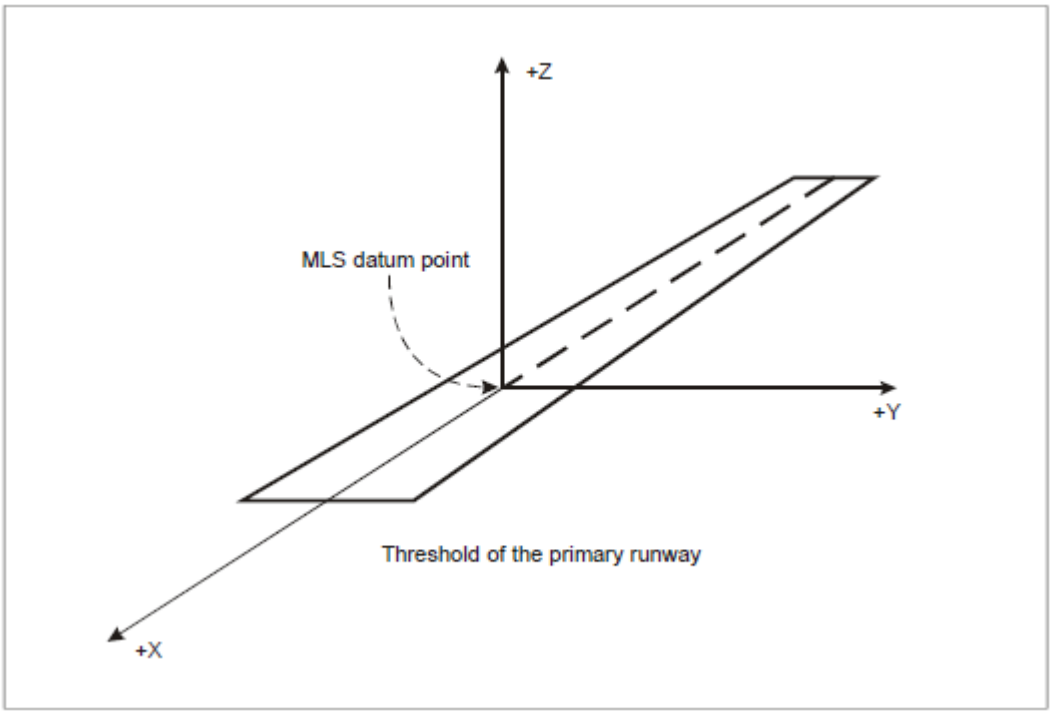


Figure G-13. MLS/area navigation way-point coordinate system

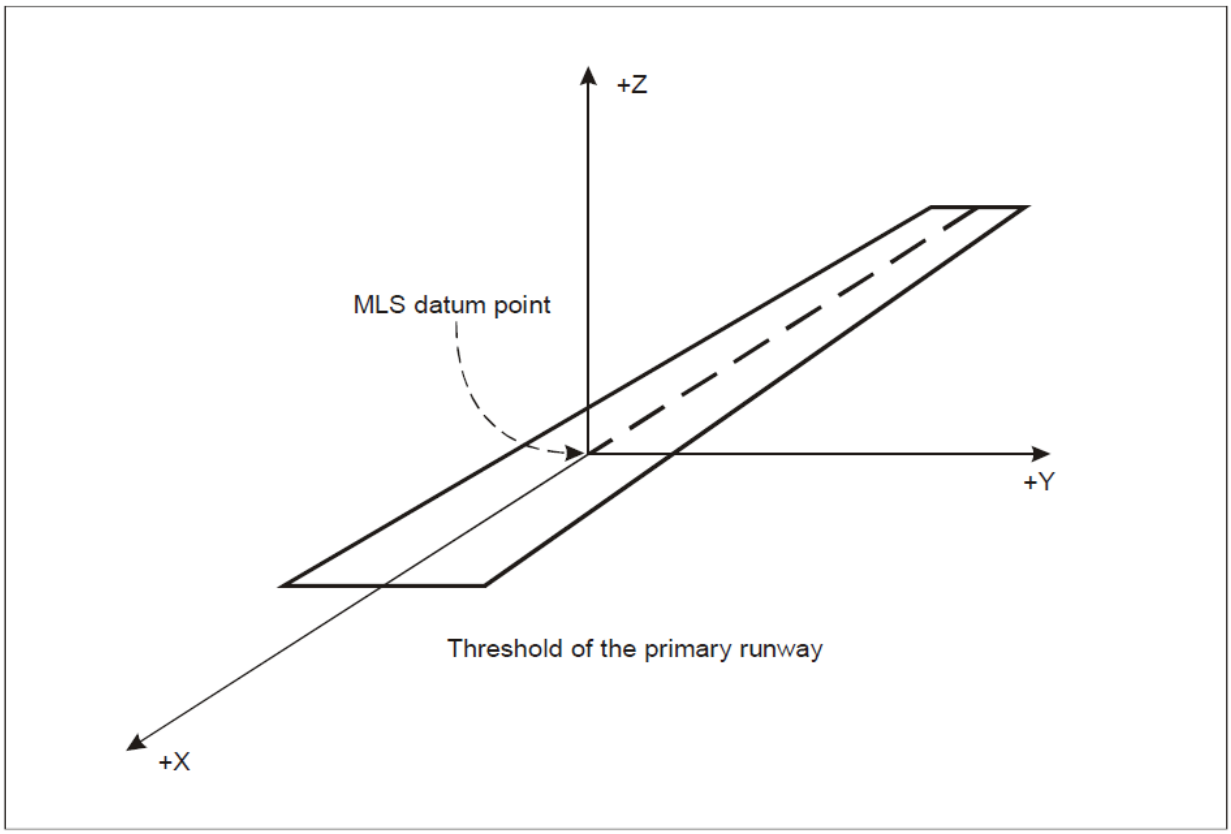


Figure G-13. MLS/RNAV way-point coordinate system

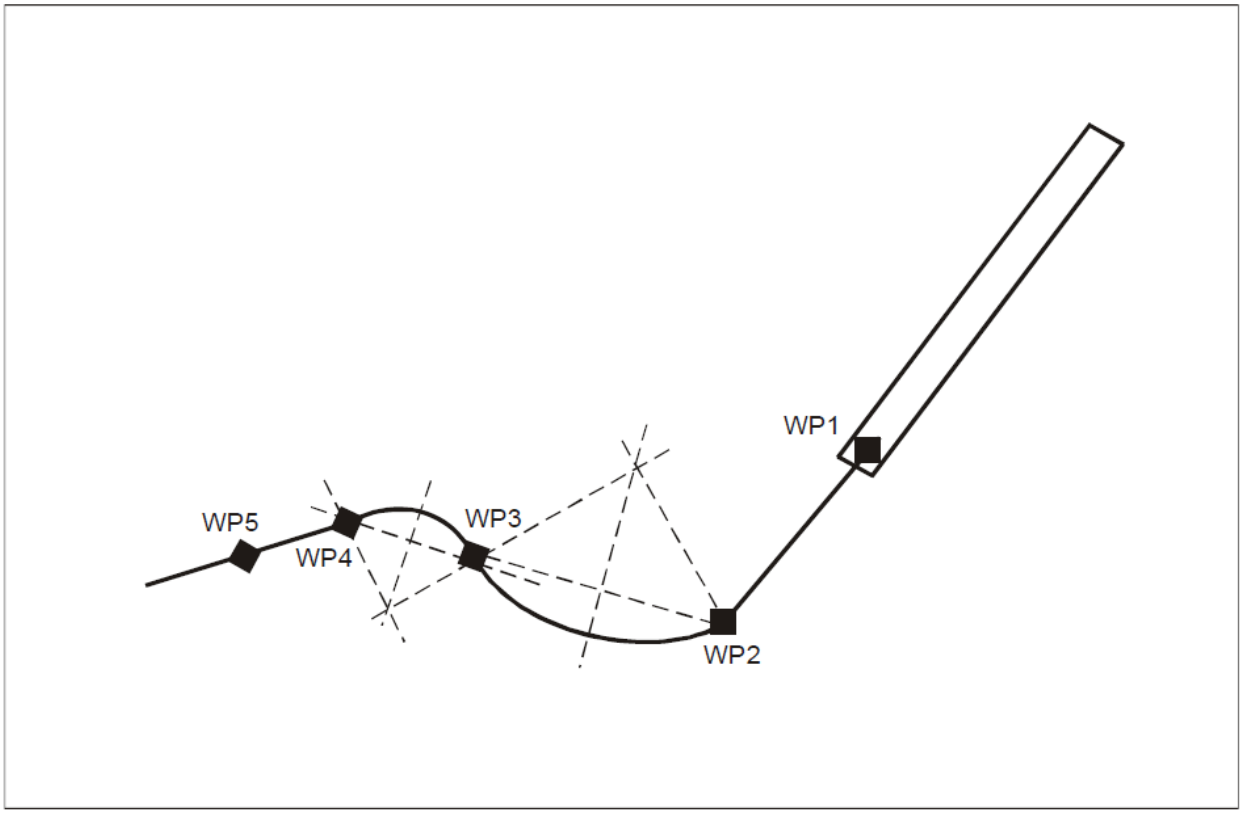


Figure G-14. Definition of curved segments

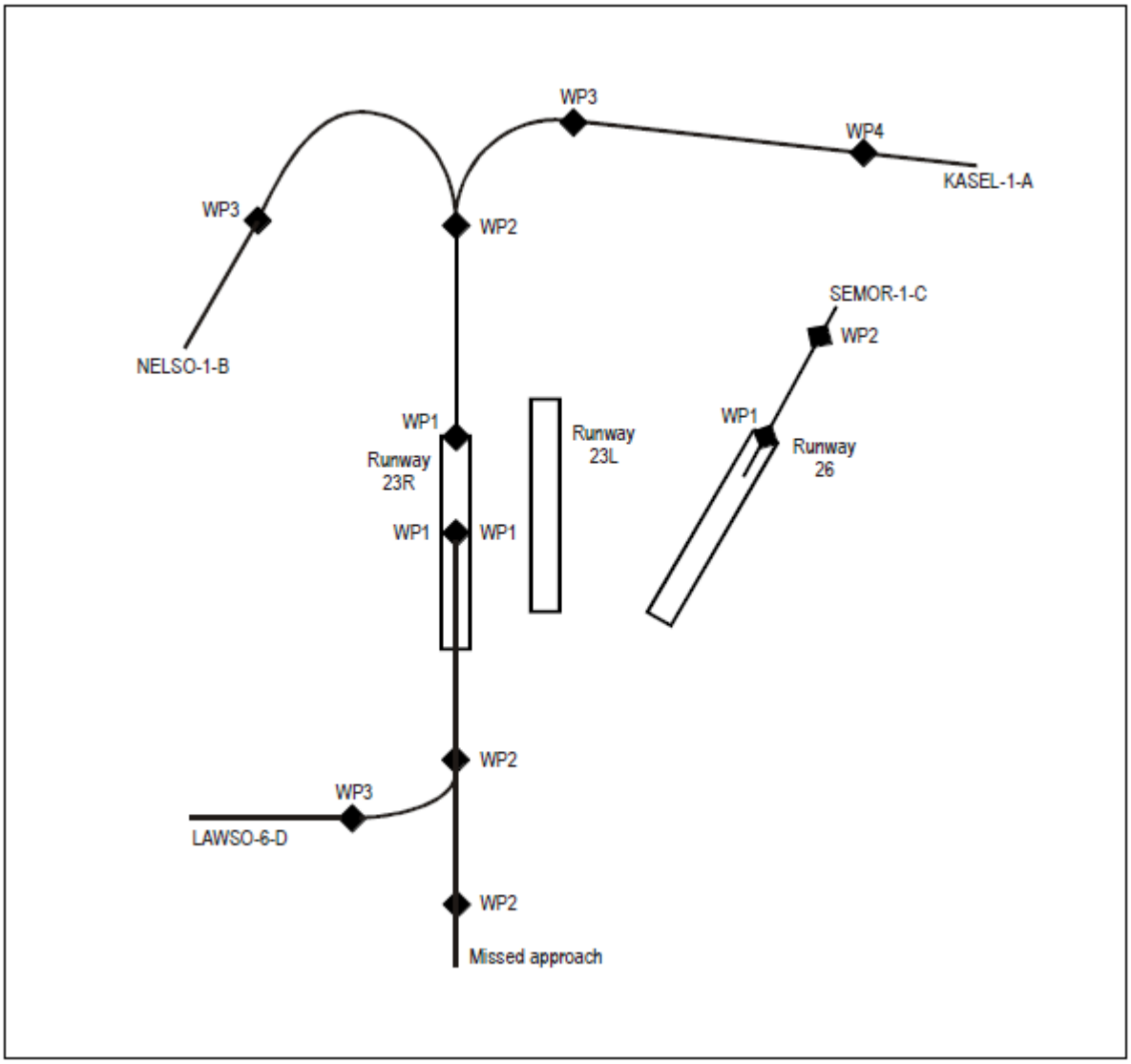


Figure G-15. Diagram of sample MLS/area navigation procedures

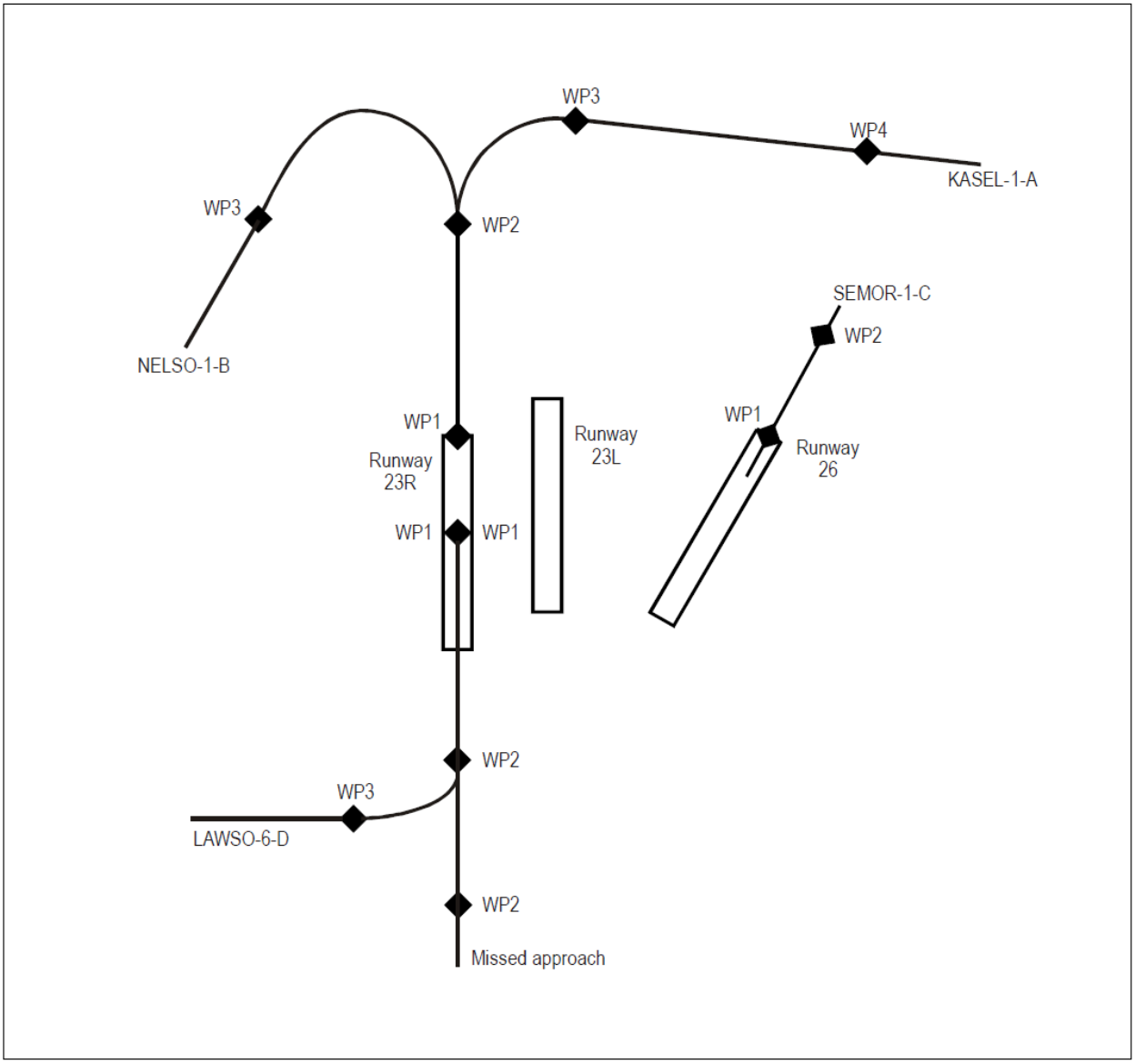


Figure G-15. Diagram of sample MLS/RNAV procedures

3. CONSIDERATIONS

3.1 Operational considerations

The following considerations are based on the assumption that the operational requirements are defined, that the required resources are committed, and that the required effort is applied. In particular, changes in radio navigation facility provision require associated efforts in airspace planning, procedure design, consideration of regulatory aspects and broad consultation with impacted airspace users.

3.2 NDB-related considerations

3.2.1 NDBs serve no role in PBN operations except as a means for position cross-checking and general situational awareness. These minor roles should not lead to the requirement to retain NDB facilities.

3.2.2 Except where no other alternative is available due to constraints in user fleet, financial, terrain or safety limitations:

a) the use of NDBs as en-route navigation aids or terminal area markers is generally obsolete;

b) NDBs used to support SID/STAR should be replaced by ~~RNAV~~ area navigation waypoints;

c) NDBs used as locators to assist in ILS intercept operations should be replaced by ~~RNAV~~ area navigation waypoints;

d) the use of NDB to support missed approach operations should be discouraged except where local safety cases require a non-GNSS missed approach capability; and

e) NDBs used as a non-precision approach aid should be withdrawn, taking the opportunity offered by the implementation of Assembly Resolution 37-11.

3.3 VOR related considerations

3.3.1 The only PBN navigation specification enabled by VOR, provided a co-located DME is present, is RNAV 5. Provision of RNAV 5 based on VOR/DME is subject to significant limitations, since integrated multi-sensor navigation makes very little use of VOR/DME, in some cases limiting the range of use to 25 NM. Also, only very few aircraft operators have a certified RNAV 5 capability which is based only on VOR/DME. Consequently, the use of VOR/DME to provide PBN services is discouraged. The only exception to this could be to support RNAV 5 routes at or near the bottom of en-route airspace (above minimum sector altitude, MSA) where achieving DME/DME coverage is challenging.

3.3.2 In principle, to enable cost savings, VOR facilities should be withdrawn in the context of an overall PBN plan. No new stand-alone VOR facilities (e.g. at new locations) should be implemented. However, VORs may be retained to serve the following residual operational purposes:

a) as a reversionary navigation capability (for example, for general aviation operations in order to assist in avoiding airspace infringements);

b) to provide navigation, cross-checking and situational awareness, especially for terminal area operations (pilot MSA awareness, avoiding premature automatic flight control system arming for ILS intercept, aircraft operational contingency procedures, such as engine failure on take-off, missed approaches, if required by local safety cases), in particular in areas where low altitude DME/DME coverage is limited;

c) for VOR/DME inertial updating where DME/DME updating is not available;

d) for non-precision approaches, as long as users are not equipped for RNP approaches and if no other suitable means of precision approach is available;

e) for conventional SID/STAR to serve non-PBN-capable aircraft;

f) as required to support the operations of State aircraft; and

g) to support procedural separation (as detailed in Doc 4444).

3.3.3 In order to provide DME-based ~~RNAV~~ area navigation capabilities, those locations which are retained for VOR should normally also be equipped with a co-located DME.

3.3.4 It is expected that adherence to the above principles should enable a decrease of the current number of facilities by 50 per cent or more in areas which support high densities of traffic. To achieve such results, States should develop a rationalization plan, taking into account the service age, all uses and operational roles of their facilities. This normally requires significant coordination with airspace users. The rationalization plan should be an integral part of the PBN implementation plan. Experience has shown that the associated project effort amounts to less expense than the replacement and refurbishment of a single VOR facility. The rationalization planning for VOR is also an important input into the evolution planning for DME.

3.4 DME-related considerations

3.4.1 DME/DME fully supports PBN operations based on the RNAV 1, RNAV 2 and RNAV 5 navigation specifications. Consequently, DME/DME (for equipped aircraft) is the most suitable current terrestrial PBN capability. DME/DME provides a fully redundant capability to GNSS for ~~RNAV~~ area navigation applications, and a suitable reversionary capability for RNP applications requiring an accuracy performance of ±1 NM (95 per cent) laterally, where supported by an adequate DME infrastructure.

Note.- While some aircraft are certified to provide RNP based on DME/DME, the ability of DME to provide RNP on a general basis is currently under investigation.

3.4.2 States are encouraged to plan the evolution of their DME infrastructure by considering the following:

a) Where a terrestrial navigation reversion capability is required, a DME network capable of supporting DME/DME navigation should be provided, where possible;

b) the DME network design should consider cost-savings opportunities whenever possible, such as the withdrawal from a site if an associated VOR is removed, or the possibility to efficiently set up new DME stand-alone sites where other ANSP CNS assets are located;