



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

MIMIMUM OPERATIONAL PERFORMANCE SPECIFICATION FOR MICROWAVE LANDING SYSTEM (MLS) AIRBORNE RECEIVING EQUIPMENT

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ED-36B

October 2007

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FOREWORD

1. This document, prepared by EUROCAE Working Group 28 "MLS" Task Force was accepted by the Council of EUROCAE on 22 October 2007.
2. EUROCAE is an international non-profit making organisation. Membership is open to European users and manufacturers of equipment for aeronautics, trade associations, national civil aviation administrations and, under certain conditions, non-European Members. Its work programme is directed to the study of technical problems facing users and manufacturers of equipment for aeronautics and all related topics. It aims to contribute at national and international levels to the solution of such problems.
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4. This document supersedes the Minimum Operational Performance Specification for MLS Airborne Receiving Equipment (ED-36A February 1995)
5. EUROCAE performance specifications are recommendations only. EUROCAE is not an official body of the European Governments; its recommendations are valid as statements of official policy only when adopted by a particular government or conference of governments.
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- NOTE:** *The following related documents are also published by EUROCAE:*
- *ED-57 MPS for distance measuring equipment (DME/N and DME/P) (ground equipment) - December 1986.*
 - *ED-54 MOPR for distance measuring equipment interrogators (DME/N and DME/P) operating in the frequency range 960 - 1215 MHZ (airborne equipment) - January 1987.*
 - *ED-53A MOPS for microwave landing system (MLS) (ground equipment) - December 1989.*

CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

- 1.1.1 The Minimum Operational Performance Specifications herein are designed to ensure that airborne receiving equipment approved as complying with them will be compatible with the ICAO Annex 10 Standards and Recommended Practices in respect of Microwave Landing System (MLS) including the November 2007 ICAO Navigation System Panel proposed MLS amendments. The minimum operational role for all receivers shall be that of Cat. I ILS replacement.

NOTE 1: *It is anticipated that these proposed amendments will be published by ICAO in the Amendment 84 of ICAO Annex 10 in November 2009.*

- 1.1.2 Mandatory clauses are denoted by “shall”.

- 1.1.3 Environmental test requirements have been specified in respect of the parameters which may be particularly susceptible to the effects of environment. Although this document provides a single minimum performance specification for receivers, several alternative environmental categories, as specified in EUROCAE ED-14D/RTCA DO-160D may exist, those applicable to the conditions over which the equipment is declared to operate shall be applicable.

- 1.1.4 Demonstration of compliance with certain of the requirements of this specification may involve somewhat complex test procedures, e.g. where a scalloping of input signal is required. Suitable test procedures in respect of these requirements have been formulated and are included in Chapter 5. Alternative procedures providing equivalent integrity may be used.

- 1.1.5 The airborne antenna(s) coverage provided is assumed to be adequate for the operational requirements envisaged.

In this Specification, it is assumed that no multipath robustness is provided by the airborne antenna system.

- 1.1.6 This document provides minimum operational performance specifications for the airborne portion of the microwave landing system. Should the MLS functions be incorporated into multi-function equipment with other facilities, the requirements of this specification must be met whilst operating as an MLS receiver.

- 1.1.7 This minimum specification does not require the provision of guidance information decoded from the MLS ground back azimuth antenna. The receiver must be capable of providing all guidance and data information as specified in this document whether or not MLS back azimuth is provided in the ground installation.

- 1.1.8 Guidance contained in the following documents should be considered in conjunction with this specification:

- EUROCAE ED-53A note 1- MOPS for Microwave Landing System (MLS) (ground equipment)

NOTE 1: *The ED-53A document is under review by the Task Force and an updated version is anticipated when ED 36B is published.*

- EUROCAE ED-54 - MOPR for Airborne Distance Measuring Equipment
- EUROCAE ED-14D/RTCA DO-160D - Environmental Conditions and Test Procedures for Airborne Equipment
- RTCA DO-177 - Minimum Operational Performance Standard for Microwave Landing System (MLS) Airborne Receiving Equipment (including changes 1 and 2).

- RTCA DO-189 - Minimum Operational Performance Standard for Airborne Distance Measuring Equipment (DME)
- EUROCAE ED-12B/RTCA DO-178B - Software Considerations in Airborne Systems and Equipment Certification.
- EUROCAE ED -80/ RTCA DO -254 - Design Assurance Guidance for Airborne Electronic Hardware.

1.2 OPERATIONAL APPLICATIONS

1.2.1 General

MLS is a system which can provide signals for guidance, control and display for terminal area operations, including the approach, landing, ground roll, missed approach and departure phases. Outputs indicating the magnitude and sense of deviations from a preset azimuth and elevation angle can be used by conventional autopilot and display systems to support conventional 'ILS' like approaches. Outputs may also be provided which give the aircraft angular position relative to the selected MLS azimuth and elevation references. These data, together with range information from an appropriate DME, can be used by Flight Management Systems, RNAV systems, dedicated MLS coupler units or the MLS receiver itself (e.g. to allow offset azimuth approach). Such systems will enable exploitation of the coverage area of the MLS system to support complex approach and departure procedures. They will be capable of controlling the aircraft trajectory automatically and of providing data for advanced displays which will support the monitoring of the aircraft's progress through the airspace or, if desired and operationally acceptable, enable such approaches to be flown manually.

Typical applications are described in the following paragraphs. However, it should be noted that these examples are primarily presented to indicate the range of possible applications of the MLS, including both the ground and airborne elements, which may be encountered. It is not intended that the minimum receiver specified in this document shall be capable of all the following applications.

1.2.2 Small Airport Applications

Aircraft types using small airports include executive business jets, commuter and STOL (Short Take Off and Landing) aircraft, helicopters and private owners' single or multiengine aircraft. The range of possible MLS approach paths available will encompass the operational requirements of all these aircraft types.

For the present, it is assumed that the MLS final approach path will be flown, as normal, down the extended runway centre line. However, several options may be available for the initial approach path and possibly for any intermediate approach path.

The range of available options will depend upon the capability of the airborne equipment and the availability, or otherwise, of suitable DME ground installations.

There may be a need to execute approaches along a datum offset from the MLS boresight to compensate for offset ground antennas, for terrain avoidance or other operational requirements. For non-precision offset approaches it may be possible to utilise unprocessed deviation information; however for most operations a system providing, in conjunction with DME, position computation and guidance will be required. For precision approaches of this nature, DME/P may be required.

Other facilities may be needed for the execution of some approach procedures such as an ability to operate using supplementary navigation aids (e.g. Multi-DME) for part of the initial approach.

1.2.3 Medium and High Density Terminal Applications

A wide MLS proportional guidance coverage sector will most probably be used in medium and high density terminal areas.

Operators with minimum equipment will use straight-in approach paths. Curved paths, segmented paths including paths between MLS defined way points may be used by aircraft, fitted with a Flight Management System (FMS), Area-Navigation (RNAV) or dedicated MLS coupler unit. Approach paths comprising two or more glide path angles may be used for either terrain avoidance or noise reduction purposes.

1.2.4 Missed Approach and Departure Applications

MLS signals may be used to provide missed approach or departure guidance in azimuth for obstruction clearance, noise abatement, or Air Traffic Control procedures.

The missed approach or departure path may be the continuation of the runway centre line, selected or designated MLS azimuth, segmented straight line paths or curved paths using MLS defined waypoints.

In these applications the receiver must decode the back azimuth signal, providing an output signal that will indicate deviation from the selected azimuth reference. In addition, provision must be made for switching from approach to back azimuth signal providing the necessary scaling and sense changes. Positive indications of functions that are in use must be available to the aircrew.

Where antenna polar diagrams or operational requirements necessitate, switching between front and rear looking antennas shall be provided.

1.2.5 Automatic Landing and Rollout Guidance

MLS signals may be used by aircraft equipped for automatic landing and rollout. Other sensor data (such as radar altimeter inputs) will still be required for the flare-out and landing. After touch down, the MLS azimuth signals may be used to provide precision guidance along the runway during the rollout.

1.2.6 Special Operational Applications

In some cases approaches may be made to non-instrumented runways that are within the proportional coverage of MLS instrumented runways by using offset azimuth angles with curved or segmented paths between MLS defined waypoints. For such operations additional computation may be needed to enable the use of MLS guidance information. This technique may be used for approaches to STOL runways and airport helicopter landing areas.

MLS azimuth and elevation guidance may be used to provide approach capability to helipads, remote areas, offshore oil rigs and moving platforms such as ships. In addition, MLS portable transmitters may be established at emergency sites.

Typically collocated azimuth and elevation systems will be used to provide a straight-in approach. Approach glide path angles utilised will depend on aircraft characteristics and environment.

1.3 TECHNICAL DESCRIPTION OF MLS

The microwave landing system provides positional information in three dimensions by means of angular and range data. In addition a ground to air datalink is provided. The angular data is provided in both horizontal (approach and back azimuth) and vertical (elevation) planes. These functions are described below.

1.3.1 Angle information

The ground-based equipment transmits time encoded information signals within the promulgated coverage sector, operating on one of 200 channels within the frequency range 5 031.0 MHz to 5 090.7 MHz.

The angle information is derived within the receiver by measuring the time difference between a 'TO' pulse and a 'FRO' pulse of a narrow beamwidth fanshaped scanning beam. This information may be provided in either planar or conical co-ordinates. The receiver is not expected to provide any co-ordinate conversion.

NOTE: *The planar co-ordinate system is not implemented and is not intended for future implementation.*

The signal format is time multiplexed providing information in sequence, on a vertically polarised single carrier channel for all functions, including a ground-air data link. Each function is uniquely labelled by a preceding Function Identity (FI) transmission thereby enabling a random order of function transmission. All data transmissions including that of function identification use carrier bi-phase Differential Phase Shift Keying (DPSK) as modulation.

The airborne equipment receives the FI preamble which it decodes to determine the information function that is about to be transmitted. The "TO" and "FRO" pulses produced by the scanning beam are then detected and the angular information derived. Certain acquisition/validation checks are made on the angle data to ensure the integrity of the output information.

1.3.2 Range Information

The range information for MLS is normally provided by Distance Measuring Equipment (DME), operating on one of 200 channels between 960 and 1215 MHz. Each of the 200 DME channels is uniquely paired to one of the 200 MLS channels.

The Basic MLS configuration as defined by ICAO requires only the use of conventional DME (DME/N). Precision DME (DME/P) is required where more precise ranging information throughout the azimuth coverage sector is necessary. Only where operational requirements do not necessitate such precision may DME/N be used.

The DME/P uses an interrogate/transpond signal format which is interoperable with conventional DME (DME/N) during the initial approach (IA) phase. When suitable airborne interrogators are used, DME/P gives enhanced range accuracy and integrity over conventional DME.

The DME/P ground station range extends to at least 22 Nautical Miles (NM) and will work in the final approach (FA) mode for ranges up to 7 NM. The change from IA to FA mode is determined by the airborne interrogator changing its interrogation mode. The enhanced accuracy and improved multipath immunity is achieved in part by changes to the transmitted pulse rise time, and by wide band processing techniques in conjunction with low level threshold timing techniques. The specifications for the airborne DME interrogator are contained in EUROCAE ED-54 and RTCA DO-189. EUROCAE ED-57 provides the specification for the ground DME transponder.

1.4 AIRBORNE SYSTEM

Figure 1-1 illustrates the processes involved in a typical airborne MLS installation. A minimum installation may use only a single antenna thereby eliminating the requirement for the antenna switch. The need for additional antennas will depend upon the polar diagram of the antenna and/or the proposed aircraft operations and when provided the antenna select switch will be realised within the MLS receiver. The switching logic will normally be provided within the receiver but may be determined externally for operational reasons.

When long cable runs are involved it may be necessary to provide additional amplification.

The remaining functions shown in [Figure 1-1](#) illustrate the functions typically required of the airborne receiver.

1.5 MLS SIGNAL CHARACTERISTICS

This chapter provides information on the nature of the MLS signal characteristics. It is derived from the ICAO Annex 10 signal in space characteristics and also takes into account propagation loss, together with signal multipath and reception effects. This therefore provides a definition of the characteristics of the received signal within MLS coverage, which shall be used in the design of the MLS receiver and against which it shall be tested.

1.6 SIGNAL FREQUENCY

ICAO Annex 10 designates the frequency associated with each of the 200 channels for MLS operations. A transmitter tolerance of up to ± 10 kHz is allowed which, when combined with possible doppler shifts of up to ± 2 kHz resulting from aircraft motion, implies a total tolerance of ± 12 kHz on the nominal frequency (see [Figure 3-1](#)).

The ICAO plan for current channels is given in Appendice B. In the future, additional channels may be defined in the 5091-5150 MHz frequency band.

1.7 FUNCTION RATES

When provided, the MLS functions are repeated at the rates given in [Table 1-1](#).

1.8 FUNCTION SEQUENCES

As each function contains a function identity it can occur in any position in the Time Division Multiplexed (TDM) sequence. (The exception is Back Azimuth which must be preceded by Basic Data Word 2).

The timing interval between repetitive transmission of any function will be varied to provide protection from synchronous interference. Examples of sequences which have demonstrated protection are illustrated in ICAO Annex 10, Attachment G to Part 1, [Figures G3 A, B and C](#).

1.9 FUNCTION ORGANISATION

The different functions are organised as follows:

1.9.1 Angle

The angle function sequence consists of a preamble, sector signals and time slots for the "TO" and "FRO" scans as indicated in [Figure 1-2](#).

1.9.2 Basic Data

Basic data function is organised as 32 bit words consisting of a function preamble (12 bits), data content (18 bits) and parity (2 bits). The timing for the basic data function is given in [Table 1-5](#).

1.9.3 Auxiliary Data

Auxiliary data function is organised as 76 bit words consisting of function preamble (12 bits), address (8 bits), data content (49 bits) and parity (7 bits). The timing for the Auxiliary data function is given in [Table 1-6](#). The address bits are to be set according to [Table 1-7](#).

1.10 TRANSMITTED SIGNAL CHARACTERISTICS

1.10.1 Differential Phase Shift Keying (DPSK)

Data contained in the signal is encoded in DPSK with the following characteristics:

- A "0" is represented by a 0 (± 10) degree phase shift and a "1" is represented by a 180 (± 10) degree phase shift.
- Bit rate is 15 625 bits/second.
- Bit duration is 64 microseconds.
- No amplitude modulation will be applied to the transmitted signal during the phase transition.
- The transition time will not exceed 10 microseconds.
- The phase will advance or retard monotonically through the phase transition region.

1.10.2 Preamble

Each function is preceded by a preamble signal, which consists of a radio frequency carrier acquisition period, a receiver reference time code and a function identification code.

The preamble timing is given in [Table 1-8](#).

1.10.2.1 Preamble Carrier Acquisition Period

All preambles begin with carrier acquisition transmissions of unmodulated carrier which have a duration of 832 microseconds (13 bits).

1.10.2.2 Receiver Reference Time

All preambles contain the receiver reference time code 11101 in bits I_1 to I_5 (known as the Barker code). The time of the phase transition midpoint from I_4 to I_5 shall be the receiver reference time.

1.10.2.3 Function Identification

A code for function identification follows the reference time (Barker) code. This code consists of five information bits (bits I_6 to I_{10}) plus two parity bits (bits I_{11} and I_{12}) as listed in [Table 1-9](#).

1.10.3 Sector Signals

1.10.3.1 Ground Equipment Identification

NOTE: The code bit (I_{13}) in the time slot previously allocated for the alternate (Morse code) ground equipment identification following the azimuth preamble is fixed in the "ZERO" state.

1.10.3.2 Airborne Antenna Selection Signal

A six bit, zero-phase DPSK signal is transmitted, on azimuth functions only, starting 576 microseconds and ending 960 microseconds after the receiver reference time.

1.10.3.3 Azimuth Out-of-Coverage Indication (OCI)

Where provided, right, left and rear azimuth OCI pulses are transmitted 1 216 microseconds, 1 088 microseconds and 960 microseconds respectively after the receiver reference time. Each pulse is at least 100 microseconds in duration measured at the half amplitude points. The rise and fall times are less than 10 microseconds.

Such pulses are:

- Greater than any guidance signal in the out of coverage sector.
- At least 5 dB less than the appropriate clearance level in the clearance sector.
- At least 5 dB less than the guidance signal in the proportional coverage region.

NOTE: *The time slot allocated to OCI may be sub-divided into two pulses of at least 50 microseconds with rise and fall times of less than 10 microseconds.*

1.10.3.4 Elevation OCI

Where provided the elevation OCI pulse is transmitted 640 microseconds after the receiver reference time and the duration is at least 100 microseconds measured at the half amplitude points. The rise and fall times are less than 10 microseconds.

Such pulses are at least 5 dB less than any guidance signal within the guidance sector and greater than any guidance signal in the out of coverage indication sector.

NOTE: *The time slot allocated to OCI may be sub-divided into two pulses of at least 50 microseconds with rise and fall times of less than 10 microseconds.*

1.10.4 Angle Guidance Parameters

Angle guidance information is encoded by the amount of time between the centres of the received "TO" and "FRO" scanning beam main lobes.

The following angle to time relationship applies.

$$\theta = (T_o - t) \frac{V}{2}$$

where

$\theta =$	Azimuth or elevation guidance angle in degrees
$t =$	Time separation in microseconds between "TO" and "FRO" beam centre
$T_o =$	Time separation in microseconds between "TO" and "FRO" beam centres corresponding to zero degrees.
$V =$	Scan velocity, in degrees per microsecond.

T_o and V together with the maximum scan angle range are given in [Table 1-10](#).

The "TO" and "FRO" scan transmissions shall be symmetrically disposed about the mid-scan point listed in each of [Table 1-2](#) to [Table 1-4](#). The mid-scan point and the centre of the time interval between the TO and FRO scan transmissions shall coincide with a tolerance of ± 10 microseconds.

The standard scanning beam shape is defined in [Figure 1-3](#). The transmitted beamwidth ranges from 0.5 to 4 degrees for azimuth guidance signals and 0.5 to 2.5 degrees for elevation.

1.10.5 Azimuth Clearance Guidance

When the promulgated proportional azimuth coverage is less than ± 40 degrees, clearance guidance information will be provided in one of the two ways indicated below:

- By transmitting pulses in a "TO"/"FRO" format adjacent to the stop/start times of the scanning beam signal, as shown in [Figure 1-4](#).

The fly right clearance pulse represents positive angles and the fly left clearance pulse represents negative angles. The duration of each clearance

pulse is 50 ± 5 microseconds. The transmitter switching time between clearance pulses and the scanning beam transmissions will not exceed 10 microseconds. The rise time at the edge of the clearance pulse not adjacent to the scanning beam will be less than 10 microseconds.

The signal in space characteristics of the clearance guidance pulses are as follows:

- in the fly right clearance sector, the fly right clearance guidance will exceed the scanning beam sidelobes and all other guidance and OCI signal by at least 5 dB;
- in the fly left clearance sector, the fly left clearance guidance will exceed the scanning beam sidelobes and all other guidance and OCI signals by at least 5 dB;
- within the proportional guidance sector, the clearance guidance signals will be at least 5 dB below the scanning beam main lobe.

NOTE: *If this type of Clearance is used, bit I29 of Basic Data Word 1 will be set to '0'.*

- b. By continuing the scan beyond the designated proportional coverage sector, to at least ± 40 degrees.

NOTE: *If this type of Clearance is used, bit I29 of Basic Data Word 1 will be set to '1'.*

1.10.6 Data Function

The MLS signal format provides for the transmission of basic and auxiliary data.

1.10.6.1 Basic Data Structure and Timing

The basic data content, maximum interval between transmissions of the same word and organisation of the words are as specified in [Table 1-11](#). Data containing digital information shall be transmitted with the least significant bit first and the smallest binary number shall represent the lower range limit with increments in binary steps to the upper absolute range limit specified.

Example: For basic Data Word 3 with 2 degree azimuth and 0.5 degree elevation beamwidth and 3000 m DME distance the data word is:

- Preamble bits I_1 to I_{12} 111011010000
- Contents bits I_{13} to I_{32} 11000000001111000010

NOTE: *The minimum value quoted under "range of values" will be coded as 00...0*

1.10.6.2 Basic Data Contents

The data items are specified as follows:

- a. Approach azimuth antenna to threshold distance is the minimum distance between the approach azimuth antenna phase centre to the vertical plane perpendicular to the centre line which contains the runway threshold.
- b. Approach azimuth proportional coverage limit represents the limit of the sector in which proportional approach azimuth guidance is transmitted.
- c. Clearance signal type indicates the method of providing the azimuth clearance signal.
- d. Minimum glide path represents the lowest angle of descent along the zero-degree azimuth.
- e. Back azimuth status represents the operational status of the back azimuth equipment.

- f. DME status represents the operational status of the DME equipment.
- g. Approach azimuth status represents the operational status of the approach azimuth equipment.
- h. Approach elevation status represents the operational status of the approach elevation equipment.
- i. Beamwidth is the antenna beamwidth for the function concerned measured at the -3 dB points and defined in angular units on the boresight in the plane of coverage.
- j. DME distance represents the minimum distance between the DME antenna phase centre and the vertical plane perpendicular to the runway centre line which contains the MLS datum point.
- k. Approach azimuth magnetic orientation represents the angle measured in the horizontal plane clockwise from Magnetic North to the zero-degree approach azimuth guidance radial, originating from the approach azimuth antenna. The vertex of the measured angle shall be the approach azimuth antenna phase centre.
- l. Back azimuth magnetic orientation represents the angle measured in the horizontal plane clockwise from Magnetic North to the zero-degree back azimuth guidance radial, originating from the back azimuth antenna. The vertex of the measured angle shall be the back azimuth antenna phase centre.
- m. Back azimuth proportional coverage limit represents the limit of the sector in which proportional back azimuth guidance is transmitted.
- n. MLS ground equipment identification represents the last three characters of the system identification. The characters shall be encoded in accordance with International Telegraph Alphabet No. 5 using b1 through b6 (see [Table 1-13](#)).

NOTE: *b₇ of this code may be reconstructed in the airborne receiver by taking the complement of b₆.*

1.10.6.3 Auxiliary Data Organisation and Timing

The contents, maximum interval between transmissions of the same word and organisation are specified in [Table 1-12](#). Two auxiliary data word formats are provided, one for digital data and one for alphanumeric character data.

Data containing digital information is transmitted with the least significant bit first. Alphanumeric data characters are encoded in accordance with International Alphabet No.5 using seven information bits, plus one even parity bit added to each character. Alphanumeric data are transmitted in the order in which they are to be read. The serial transmission of a character shall be with the lower order bit transmitted first and the parity bit transmitted last.

NOTE 1: *The presently defined auxiliary data A contents are specified below, auxiliary data B contents are reserved for future use and auxiliary data C contents are reserved for national use.*

NOTE 2: *Words A1 to A4 contain essential data and will be transmitted by all ground stations.*

1.10.6.4 Auxiliary Data A Content

The data items are defined as follows:

- a. Approach azimuth antenna offset represents the minimum distance between the approach azimuth antenna phase centre and a vertical plane containing the runway centre line.
- b. Approach azimuth antenna to MLS datum point distance represents the minimum distance between the approach azimuth antenna phase centre and

the vertical plane perpendicular to the runway centre line which contains the MLS datum point.

- c. Approach azimuth alignment with runway centre line represents the minimum angle between the zero-degree approach azimuth guidance radial and the runway centre line.
- d. Approach azimuth antenna co-ordinate system represents the co-ordinate system (planar or conical) of the angle data transmitted by the approach azimuth antenna.
- e. Approach azimuth antenna height represents the vertical location of the antenna phase centre with respect to the MLS datum point.
- f. Approach elevation antenna offset represents the minimum distance between the elevation antenna phase centre and a vertical plane containing the runway centre line.
- g. MLS datum point to threshold distance represents the distance measured along the runway centre line from the MLS datum point to the runway threshold.
- h. Approach elevation antenna height represents the height of the elevation antenna phase centre relative to the height of the MLS datum point.
- i. MLS datum point elevation represents the datum point elevation relative to mean sea level (MSL).
- j. Runway threshold height represents the vertical location of the intersection of the runway threshold and centreline with respect to the MLS datum point.
- k. DME offset represents the minimum distance between the DME antenna phase centre and a vertical plane containing the runway centre line.
- l. DME to MLS datum point distance represents the minimum distance between the DME antenna phase centre and the vertical plane perpendicular to the runway centre line which contains the MLS datum point.
- m. DME antenna height represents the vertical location of the antenna phase centre with respect to the MLS datum point.
- n. Runway stop-end distance represents the distance along centreline between the runway stop-end and the MLS datum point.
- o. Back azimuth antenna offset represents the minimum distance between the back azimuth antenna phase centre and a vertical plane containing the runway centre line.
- p. Back azimuth antenna to MLS datum point distance represents 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 represents the minimum angle between the zero-degree back azimuth guidance radial and the runway centre line.
- r. Back azimuth antenna co-ordinate system represents the co-ordinate system (planar and conical) of the angle data transmitted by the back azimuth antenna.
- s. Back azimuth antenna height represents the vertical location of the antenna phase centre with respect to the MLS datum point.

1.11

INTERRUPTION OF TRANSMITTED SIGNALS

Based on ICAO Annex 10 specifications, the maximum period during which erroneous guidance information is radiated, including period(s) of zero radiation, will not exceed one second and the maximum zero radiation will be less than 500 milliseconds. Therefore, the transmitted signal from Azimuth or/and Elevation ground systems may be absent for up to 500 milliseconds.

1.12 PROPAGATION EFFECTS

1.12.1 Amplitude Variation

Because of signal propagation effects amplitude variation may occur both between functions (due to, for example, the differences in relative distance between the aircraft and the ground antennas) and between components of function (due to, for example, different ground antenna gain and patterns). These differences must be accommodated by the receiver within the accuracy requirements given in Chapter 3.

1.12.1.1 Power Density

For each function, the preamble signal power density at the airborne antenna may vary between -89.5 dBW/m^2 and -14.5 dBW/m^2 whilst within the coverage of the appropriate function.

1.12.1.2 Relative Amplitudes of Functions

Whilst within the coverage volume of two or more functions a difference of preamble signal power density of up to 75 dB may be experienced.

1.12.1.3 Relative Amplitudes of Components of Functions in absence of multipath

In the following tables the lower scanning beam power results from the ICAO power budget allowance whereby beamwidth reductions permit lower transmitter power whilst maintaining accuracy. The higher power differences result from a constant transmitter power for all elements of a function.

a. within proportional coverage

The relative amplitudes between the different components of one function, referenced to the Preamble may vary over an amplitude range as follows:

- Data : 0 dB
- Scanning Beam : - 5 dB to + 15 dB
- Pulsed Clearance (if any) : at least 5 dB below
scanning beam level
- O.C.I. (if any) : at least 5 dB below
scanning beam level
- Scanning beam sidelobes : at least 25 dB below
scanning beam level

NOTE 1: *Because of differences in ground equipment data and scanning beam antenna patterns and variations in multipath propagation effects, the scanning beam relative amplitude may vary outside the above range.*

NOTE 2: *The receiver is required to operate in accordance with the requirements of chapter 3 when both the DPSK and scanning beam signal power levels exceed the minimum levels specified in [Table 3-1](#).*

b. within clearance region (in case of pulsed clearance)

The relative amplitudes between the different components of one function, referenced to the Preamble may vary over an amplitude range as follows:

- Data : 0 dB
- Scanning Beam : at least 5 dB below
applicable clearance level
- Left or right clearance : 1.5 dB to + 5 dB
: as applicable

- Non applicable clearance : at least 5 dB below
applicable clearance level
- O.C.I. (if any) : at least 5 dB below
applicable clearance level
- Side lobes : at least 5 dB below
applicable clearance level

c. within clearance region (in case of scanned clearance)

The relative amplitudes between the different components of one function, referenced to the Preamble may vary over an amplitude range as follows:

- Data : 0 dB
- Scanning Beam : - 5 dB to + 15 dB
- O.C.I. (if any) : at least 5 dB below
scanning beam level
- Scanning beam sidelobes : at least 25 dB below
scanning beam level

d. within out of coverage region

The appropriate OCI shall be at least 5 dB greater than any other MLS signal in this region.

1.12.2 Multipath environment

Both in beam and out of beam multipath are anticipated.

Scanning beam Out of beam multi-path with relative level up to 10 dB above the direct signals may be encountered during the final approach, landing, rollout and take-off phases of flight (below 200 ft) due to strong reflection of the azimuth scanning beam on large surfaces and structures in the vicinity of the runway. During these phases, the reflected signals are coding angles corresponding to the position of the reflecting surfaces relative to runway centreline.

The duration of such reception is airport geometry and aircraft speed dependent but may affect a significant portion of the runway length.

Above 200 ft, multi-path signal may be received with a relative level up to 4dB below the direct signal level. At these altitudes and during very short periods of time, multi-path signal with level above the direct signal level may be received.

Out of Beam multi-path signals do not distort the direct signal beam shape as presented in Figure 1.3.

During Low Visibility operations, when sensitive areas are protected, In-Beam multipath will be constrained to a level at which the PFE and CMN requirements can be met during final approach (i.e. below 200 ft), landing and roll-out.

Where OCI are not implemented, some valid signals coding angles within the proportional or clearance region may be received in the Out of Coverage region. Operational procedures design will protect the users from this false guidance reception.

The multipath levels and associated performance are given in paragraph 3.9.3.

Rationales for the above levels and durations may be found in Appendix D.

1.12.3 Periodic interruption of signal

The signal may be periodically interrupted by for example, propeller modulation. A practical model for this being a square wave modulation having a 12 dB attenuation, a duty cycle of 15% and a repetition rate between 10 and 100 pulses per second.

1.13 DEFINITIONS

The following terms are defined for the purpose of this document.

Differential Phase Shift Keying (DPSK)

Phase shift keying is a modulation technique in which information is transmitted by means of defined phase shifts of the carrier. In DPSK the information is transmitted by the difference in phase of successive bits of the carrier. In this system a binary "0" is represented by a 0 degree phase shift and binary "1" by a 180 degree phase shift.

Preamble

Preamble comprises a period of unmodulated carrier frequency (which can be used to phase lock an oscillator), a synchronisation code and a Function Identity (FI) code.

Approach Azimuth and Back Azimuth Signals

The approach azimuth and back azimuth signals comprise a preamble transmission followed by sector signals and a "TO"/"FRO" scanning beam transmission which is symmetrical about the midscan time.

Elevation Signals

The elevation signal comprises a preamble transmission followed by a "TO"/"FRO" scanning beam transmission which is symmetrical about the midscan time.

Data Signals

Data functions are transmitted from the sector antenna in addition to the angle scan functions. Each data word has a preamble which allows its function to be recognised and processed.

The data functions are subdivided into Basic and Auxiliary data. Basic data consists of 32 bit words providing information associated directly with the operation of the landing guidance system. Auxiliary data, transmitted in addition to the basic data, consists of 76 bit words that provide ground equipment information for use in refining airborne position calculation and other supplementary information.

Clearance Signals

Clearance signals are transmitted into the volume of airspace, inside the coverage sector, within which the azimuth guidance information provided is not proportional to the angular displacement of the aircraft. When decoded these signals provide constant left or right indication of the aircraft position with respect to the proportional guidance sector.

Out of Coverage Indication (OCI)

Out of coverage signals can be transmitted into regions outside the intended coverage sector of a particular angle function. These are used by the receiver to ensure that the guidance signal is flagged when the receiver is outside the promulgated coverage sector.

Deviation Sensitivity

The Deviation Sensitivity defines the relationship between the analogue output value and the difference between the preset angle demand and the received angle.

Reference Time

The reference time is the midpoint of the last phase transition in the receiver synchronisation code 11101 (bits I_1 to I_5) contained in every preamble transmission.

Midpoint Time

The measured time interval between the reference time and the midpoint between the received scanned “TO” and “FRO” pulses.

Midscan Point

The measured time at the centre of the pause between the end of the “TO” scan and the start of the “FRO” scan as defined by the ICAO MLS signal format.

Scan Velocity

The constant angular velocity at which the scanning beam is swept across the coverage volume.

Zero Degree Time

The time interval between “TO” and “FRO” pulses which represents an angle of zero degrees.

Control Motion Noise (CMN)

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

Path Following Error (PFE)

The PFE is defined as those components of the MLS guidance error which could cause aircraft displacement from the desired course and/or glidepath.

Path Following Noise (PFN)

That portion of the guidance signal error which could cause aircraft displacement from the mean course line or mean glide path as appropriate.

1.14**ABBREVIATIONS**

AMP	Amplifier
ATC	Air Traffic Control
ATT	Antenna To Threshold Distance
CW	Continuous Wave
DC	Direct Current
DME	Distance Measuring Equipment
FA	Final Approach
FI	Function Identity
FMS	Flight Management System
FSD	Full Scale Deflection
IA	Initial Approach
ICAO	International Civil Aviation Organisation
IF	Intermediate Frequency
ITU	International Telecommunications Union
MSB	Most Significant Bit
MSL	Mean Sea Level
MTBF	Mean Time Between Failures
NM	Nautical Mile
RF	Radio Frequency

RNAV	Area Navigation
SNR	Signal-To-Noise-Ratio
STOL	Short Take Off And Landing
TDM	Time Division Multiplexed
VSWR	Voltage Standing Wave Ratio

TABLE 1-1 : MLS FUNCTION RATES

Function	Average Rate (Hz) measured over any 10 second period
Approach azimuth guidance (Note 1)	$13 \pm 0,5$
High rate approach azimuth guidance (Note 1)	$39 \pm 1,5$
Back azimuth guidance (Note 2)	$6,5 \pm 0,25$
Approach elevation guidance	$39 \pm 1,5$
Basic data	see Table 1-11
Auxiliary data	see Table 1-12

NOTE 1: *Alternative azimuth guidance rates. The higher rate will provide improved accuracy but can only be used if sufficient time is available within the signal format used. For European operation the high rate will normally be provided.*

NOTE 2: *Back azimuth may not always be provided.*

TABLE 1-2 : APPROACH AZIMUTH FUNCTION TIMING

EVENT	15.625 kHz Clock pulse (number)	Time Slot begins at (milliseconds)
Preamble	0	0
Morse code	25	1.600
Antenna select	26	1.664
Rear OCI	32	2.048
Left OCI	34	2.176
Right OCI	36	2.304
" TO "test	38	2.432
" TO " scan (Note)	40	2.560
Pause		8.760
Midscan point		9.060
" FRO " scan (Note)		9.360
" FRO " test		15.560
End function (airborne)		15.688
End Guard time (ground)		15.900

NOTE: *The actual commencement and completion of the "TO" and the "FRO" scan transmissions are dependent on the amount of proportional guidance provided. The time slots provided will accommodate a maximum scan of plus or minus 62.0 degrees. Scan timing will be compatible with accuracy requirements.*

TABLE 1-3 : HIGH RATE APPROACH AZIMUTH AND BACK AZIMUTH FUNCTION TIMING

EVENT	15.625 kHz Clock pulse (number)	Time Slot begins at (milliseconds)
Preamble	0	0
Morse code	25	1.600
Antenna select	26	1.664
Rear OCI	32	2.048
Left OCI	34	2.176
Right OCI	36	2.304
“ TO ” test	38	2.432
“ TO ” scan (Note)	40	2.560
Pause		6.760
Midscan point		7.060
“ FRO ” scan (Note)		7.360
“ FRO ” test		11.560
End function (airborne)		11.688
End Guard time (ground)		11.900

NOTE: *The actual commencement and completion of the "TO" and the "FRO" scan transmissions are dependent on the amount of proportional guidance provided. The time slots provided will accommodate a maximum scan of plus or minus 42.0 degrees. Scan timing will be compatible with accuracy requirements.*

TABLE 1-4 : APPROACH ELEVATION FUNCTION TIMING

EVENT	15.625 kHz Clock pulse (number)	Time Slot begins at (milliseconds)
Preamble	0	0
Processor pause	25	1.600
OCI	27	1.728
" TO "scan (Note)	29	1.856
Pause		3.406
Midscan point		3.606
" FRO " scan (Note)		3.806
End function (airborne)		5.356
End Guard time (ground)		5.600

NOTE: *The actual commencement and completion of the "TO" and the "FRO" scan transmissions are dependent on the amount of proportional guidance provided. The time slots provided will accommodate a maximum scan of - 1.5 degrees to + 29.5 degrees. Scan timing shall be compatible with accuracy requirements.*

TABLE 1-5 : BASIC DATA FUNCTION TIMING

EVENT	15.625 kHz Clock pulse (number)	Time Slot begins at (milliseconds)
Preamble	0	0
Data transmission (Bits I_{13} - I_{30})	25	1.600
Parity transmission (Bits I_{31} - I_{32})	43	2.752
End function (airborne)	45	2.880
End Guard time (ground)		3.100

TABLE 1-6 : AUXILIARY DATA FUNCTION TIMING

EVENT	15.625 kHz Clock pulse (number)	Time Slot begins at (milliseconds)
Preamble	0	0
Address transmission (Bits I_{13} - I_{20})	25	1.600
Data transmission Bits I_{21} - I_{69})	33	2.112
Parity transmission (Bits I_{70} - I_{76})	82	5.248
End function (airborne)	89	5.696
End Guard time (ground)		5.900

TABLE 1-7 : AUXILIARY DATA WORDS ADDRESS CODES

No.	I_{13}	I_{14}	I_{15}	I_{16}	I_{17}	I_{18}	I_{19}	I_{20}	No.	I_{13}	I_{14}	I_{15}	I_{16}	I_{17}	I_{18}	I_{19}	I_{20}
1	0	0	0	0	0	1	1	1	33	1	0	0	0	0	1	0	1
2	0	0	0	0	1	0	1	0	34	1	0	0	0	1	0	0	0
3	0	0	0	0	1	1	0	1	35	1	0	0	0	1	1	1	1
4	0	0	0	1	0	0	1	1	36	1	0	0	1	0	0	0	1
5	0	0	0	1	0	1	0	0	37	1	0	0	1	0	1	1	0
6	0	0	0	1	1	0	0	1	38	1	0	0	1	1	0	1	1
7	0	0	0	1	1	1	0	0	39	1	0	0	1	1	1	0	0
8	0	0	1	0	0	0	1	0	40	1	0	1	0	0	0	0	0
9	0	0	1	0	0	1	0	1	41	1	0	1	0	0	1	1	1
10	0	0	1	0	1	0	0	0	42	1	0	1	0	1	0	1	0
11	0	0	1	0	1	1	1	1	43	1	0	1	0	1	1	0	1
12	0	0	1	1	0	0	0	1	44	1	0	1	1	0	0	1	1
13	0	0	1	1	0	1	1	0	45	1	0	1	1	0	1	0	0
14	0	0	1	1	1	0	1	1	46	1	0	1	1	1	0	0	1
15	0	0	1	1	1	1	0	0	47	1	0	1	1	1	1	1	0
16	0	1	0	0	0	0	1	1	48	1	1	0	0	0	0	0	1
17	0	1	0	0	0	1	0	0	49	1	1	0	0	0	1	1	0
18	0	1	0	0	1	0	0	1	50	1	1	0	0	1	0	1	1
19	0	1	0	0	1	1	0	0	51	1	1	0	0	1	1	0	0
20	0	1	0	1	0	0	0	0	52	1	1	0	1	0	0	1	0
21	0	1	0	1	0	1	1	1	53	1	1	0	1	0	1	0	1
22	0	1	0	1	1	0	1	0	54	1	1	0	1	1	0	0	0
23	0	1	0	1	1	1	0	1	55	1	1	0	1	1	1	1	1
24	0	1	1	0	0	0	0	1	56	1	1	1	0	0	0	1	1
25	0	1	1	0	0	1	1	0	57	1	1	1	0	0	1	0	0
26	0	1	1	0	1	0	1	1	58	1	1	1	0	1	0	0	1
27	0	1	1	0	1	1	0	0	59	1	1	1	0	1	1	1	0
28	0	1	1	1	0	0	1	0	60	1	1	1	1	0	0	0	0
29	0	1	1	1	0	1	0	1	61	1	1	1	1	0	1	1	1
30	0	1	1	1	1	0	0	0	62	1	1	1	1	1	0	1	0
31	0	1	1	1	1	1	1	1	63	1	1	1	1	1	1	0	1
32	1	0	0	0	0	0	1	0	64	0	0	0	0	0	0	0	0

NOTE: Parity bits I_{19} and I_{20} are chosen to satisfy the equations:

$$I_{13} + I_{14} + I_{15} + I_{16} + I_{17} + I_{18} + I_{19} = \text{EVEN}$$

$$I_{14} + I_{16} + I_{18} + I_{20} = \text{EVEN}$$

TABLE 1-8 : PREAMBLE TIMING

EVENT	15.625 kHz Clock pulse (number)	Time Slot begins at (milliseconds)
Carrier acquisition (CW transmission)	0	0
Receiver reference time code		
$I_1 = 1$	13	0.832
$I_2 = 1$	14	0.896
$I_3 = 1$	15	0.960
$I_4 = 0$	16	1.024
$I_5 = 1$	17	1.088 (Note 2)
Function identification		
I_6	18	1.152
I_7	19	1.216
I_8	20	1.280
I_9	21	1.344
I_{10}	22	1.408
I_{11}	23	1.472
I_{12}	24	1.536
End preamble		1.600

NOTE 1: *This table applies to all functions.*

NOTE 2: *Reference time for receiver synchronisation for all function timing.*

TABLE 1-9 : FUNCTION IDENTIFICATION CODES

Functional Element	Bit Number						
	I ₆	I ₇	I ₈	I ₉	I ₁₀	I ₁₁	I ₁₂
Approach azimuth	0	0	1	1	0	0	1
High rate approach azimuth	0	0	1	0	1	0	0
Approach elevation	1	1	0	0	0	0	1
Back azimuth	1	0	0	1	0	0	1
Basic data 1	0	1	0	1	0	0	0
Basic data 2	0	1	1	1	1	0	0
Basic data 3	1	0	1	0	0	0	0
Basic data 4	1	0	0	0	1	0	0
Basic data 5	1	1	0	1	1	0	0
Basic data 6	0	0	0	1	1	0	1
Auxiliary data A	1	1	1	0	0	1	0
Auxiliary data B	1	0	1	0	1	1	1
Auxiliary data C	1	1	1	1	0	0	0

NOTE: Parity bits I₁₁ and I₁₂ are chosen to satisfy the equation:

$$I_6 + I_7 + I_8 + I_9 + I_{10} + I_{11} + = \text{EVEN}$$

$$I_6 + I_8 + I_{10} + I_{12} + = \text{EVEN}$$

TABLE 1-10 : SCAN TIMING CONSTANTS

FUNCTION	MAXIMUM ANGLE SCAN RANGE (degrees)	ZERO DEGREE TIME (T ₀) (μs)	V (degree/μs)	MIDSCAN POINT TIME (T _m) (μs)
Low Rate Azimuth	-62 to +62 degrees	6 800	0.020	7 972
Elevation	-1.5 to +29.5 degrees	3 350	0.020	2 518
Back Azimuth	-42 to +42 degrees	4 800	-0.020	5 972
High Rate Azimuth	-42 to +42 degrees	4 800	0.020	5 972

TABLE 1-11 : BASIC DATA

Word	Data content	Maximum time between transmissions (seconds)	Bits used	Range of values	Least significant bit	Bit number
1	Preamble	1.0	12	(see Note 9)	100 m	1-12
	Approach azimuth antenna to threshold distance		6	0 to 6 300 m		13-18
	Approach azimuth proportional coverage negative limit		5	0 to 60 degrees		19-23
	Approach azimuth proportional coverage positive limit		5	0 to 60 degrees		24-28
	Clearance signal type		1	(see Note 8)		29
	Spare		1			30
	Parity		2	(see Note 1)		31-32
2	Preamble	0.16	12	(see Note 9)	0.1 degrees	1-12
	Minimum glide-path		7	2 to 14.7 degrees		13-19
	Back azimuth status		1	(see Note 2)		20
	DME status		2	(see Note 6)		21-22
	Approach azimuth status		1	(see Note 2)		23
	Approach elevation status		1	(see Note 2)		24
	Spare		6	(see Note 3)		25-30
	Parity		2	(see Note 1)		31-32

TABLE 1-11 : BASIC DATA (CONT'D)

Word	Data content	Maximum time between transmissions (seconds)	Bits used	Range of values	Least significant bit	Bit number
3	Preamble	1.0	12	(see Note 9)		1-12
	Approach azimuth beamwidth		3	0.5 to 4 degrees (see note 7)	0.5 degrees	13-15
	Approach elevation beamwidth		3	0.5 to 2.5 degrees (see note 7)	0.5 degrees	16-18
	DME distance		9	0 m to 6 387.5 m	12.5 m	19-27
	Spare		3			28-30
	Parity		2	(see Note 1)		31-32
4	Preamble	1.0	12	(see Notes 4 and 9)		1-12
	Approach azimuth magnetic orientation		9	0 to 359 degrees	1 degree	13-21
	Back azimuth magnetic orientation		9	0 to 359 degrees	1 degree	22-30
	Parity		2	(see Note 1)		31-32