This document contains portions of DO-177, including Change 1 and Change 2. Change 1 and Change 2 are NOT integrated into the text, so users need to do that.

This includes only section 2, 2.1, and 2.2, plus the appendix on receiver testing, which explains some of the details about executive monitor parameters (which are also aircraft measurements).

2.0 AIRBORNE MICROWAVE LANDING SYSTEM EQUIPMENT REQUIREMENTS

2.1 General Requirements

2.1.1 Airworthiness

The design and manufacture must provide for installation so as not to impair the airworthiness of the aircraft.

2.1.2 Intended Function

All equipment must perform its intended function(s), as defined by the manufacturer, and its proper use must not create a hazard to other users of the National Aviation System.

2.1.3 Federal Communications Commission Rules

All equipment must comply with the applicable rules of the Federal Communications Commission.

2.1.4 Fire Protection

Except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials used shall be self-extinguishing.

NOTE: A possible means of showing compliance is contained in Federal Aviation Regulations, Part 25, Appendix F.

2.1.5 Rating of Components

The equipment shall not incorporate in its design a component of such rating that, when the equipment is operated throughout the range of specified environmental tests, the rating established by the manufacturer of the component is exceeded.

2.1.6 Operation of Controls

The design of the equipment shall be such that the controls intended for use during flight cannot be operated in any position, combination or sequence which would result in a condition be detrimental to the reliability of the equipment or operation of the aircraft.

2.1.7 Accessibility of Controls

Controls which are not normally adjusted in flight shall not be readily available to flight personnel.

2.1.8 Effects of Test

The design of the equipment shall be such that the application of the specified tests would not result in any discernible condition which would be detrimental to the reliability of the equipment manufactured in accordance with such design.

2.1.9 Equipment Performance

Certain of the minimum performance standards specified in Subsection 2.2 are required to be demonstrated under environmental conditions, as specified in Subsection 2.3. The required environmental tests are limited to those specified; however, the equipment shall be designed to meet the performance standards of Subsection 2.2 under all conditions within the specified envelopes defined by the environmental categories declared by the manufacturer. (See RTCA/DO-160A for explanation of categories.)

2.1.10 Specific Equipment Requirements

2.1.10.1 Angle Guidance Decoding

The design of the equipment shall be such that the angle guidance information is decoded by measuring the time interval between the centers of the received envelopes of the "TO" and "FRO" scanning beam main lobes.

2.1.10.2 Beam Envelope Filtering

The design of the equipment shall be such that the beam envelope shall be filtered. The bandwidth of the filter process shall not exceed 26 kHz.

NOTE: This amount of filtering will assure that the errors stated in Table 2-1 will not be exceeded in the presence of stepping beam noise on the scanning beam which is characteristic of digitally controlled beam scanning processes.

2.1.11 Equipment Configuration

It is the intention of this document to permit manufacturers to establish interface standards between the antenna, navigation display, control unit and receiver-processor unit

	VISUAL		BASIC ELECTRICAL		ELECTRICAL A		ELECTRICAL B	
	AZ	EL	AZ	EL	AZ	EL	AZ	EL
PATH FOLLOWING ERROR WITHOUT MULTIPATH	N/A	N/A	0.12°	0.05°	0.06°	0.03°	0.017°	0.017°
CONTROL MOTION NOISE WITHOUT MULTIPATH	N/A	N/A	0.05°	0.035°	0.03°	0.02°	0.015°	0.01°
RESOLUTION	N/A	N/A	0.03°	0.03°	0.02°	0.02°	0.01°	0.01°
CENTERING ERROR	0.12°	0.05°	N/A	N/A	N/A	N/A	N/A	N/A

NOTE 1: The Visual and Basic Electrical outputs are comparable to ILS Class C, Electrical A is comparable to ILS Class E and the Electrical B output accuracy is the same as stated in Annex 10 of the ICAO Convention.

NOTE 2: The specific Table values are based on the following conditions:

a. RF Singal Level −20 to −70 dBm.
b. Scanning Beamwidth −0.5 to 3 degrees.
c. No periodic signal interruptions.

NOTE 3: N/A means not applicable.

Table 2-1. ANGLE GUIDANCE OUTPUT CHARACTERISTICS

and obtaining regulatory approval of these components of the total system. It is the intention of this document to allow interchangeability of system components thus defined. For example, equipment may be designed to have several passive antenna configurations available to meet the needs of various aircraft. The manufacturer should be allowed to establish an antenna interface standard and receive approval of the various antenna designs without performing tests for each antenna design.

2.2 Equipment Performance - Standard Conditions

This subsection specifies the performance requirements for all equipment angle output signals. Four guidance outputs are specified: Visual, basic electrical output, electrical guidance output A and electrical guidance output B. The equipment shall provide at least one of these outputs. Unless otherwise specified, these requirements shall be met using standard test signals as described in Appendix C.

NOTE: An alternative to visual or electrical guidance outputs could be the use of fiber optics technology.

2.2.1 Accuracy Without Multipath

Unless otherwise specified, the equipment shall provide guidance without associated warnings under the service conditions given in paragraphs 2.2.1.1 through 2.2.1.5. The path following and centering errors shall not exceed the limits given in Table 2-1. The control motion noise, with a 95% probability, shall not exceed the limits given in Table 2-1.

2.2.1.1 RF Signal Level Variations

The equipment shall provide guidance data on all MLS channel frequencies over a range of signal variations from -20 dBm to -95 dBm from the antenna (from 50 dB above to 25 dB below the standard test signal level.) From -70 dBm to -95 dBm, the path following error and centering errors may degrade linearly to 2 times the value specified in Table 2-1.

The control motion noise may degrade linearly to the following values:

RF Signal Level (dBm)	Control Motion Noise Az/El (Deg)
-87	0.075/0.04
-95	0.2/0.08

Airborne equipment providing electrical outputs A and B shall limit azimuth control motion noise errors to less than 0.04 degrees for a 1.0 degree azimuth antenna beamwidth and for RF signal levels above -87 dBm. The visual output noise error shall not exceed ±10% of the full scale indication. The equipment must process a function independently of the amplitude of other functions.

NOTE: This requirement presumes a 0 dB antenna gain over the required coverage sector when on a straight-in approach. Any cable loss or difference of nominal antenna gain, for which approval of the receiver is desired, should be taken into account.

2.2.1.2 In the Presence of an Interfering Signal

The equipment shall meet the interference requirements of paragraphs 2.2.1.2.1 and 2.2.1.2.2. The interference frequency shall be at any one of the 200 discrete MLS channels other than the equipment operating frequency. In addition, the interference frequency shall be offset 12 kHz from its normal value towards the equipment operating frequency. ?

NOTE 1: The 12 kHz offset includes 10 kHz of ground transmitter tolerance and 2 kHz for doppler shift.

NOTE 2: The requirements of this paragraph are intended to include any effects of image frequency response.

2.2.1.2.1 In-Band Interference Without Desired Signal

The equipment shall generate a warning signal in the absence of an MLS signal at the equipment operating frequency and in the presence of an interfering signal at -62 dBm or less and within 1.2 MHz of the equipment operating frequency. The equipment shall also generate a warning signal when the interference level is -40 dBm or less and the frequency is more than 1.2 MHz from the equipment operating frequency. ?

2.2.1.2.2 Interference With Desired Signal

The equipment shall output guidance data meeting the requirements of paragraph 2.2.1.1 in the presence ~~of a standard~~ test ~~signal at the equipment operating frequency and~~ with an interfering signal at -62 dBm or less, which is within 1.2 MHz of the equipment operating frequency. When the interference level is -40 dBm or less and the frequency is more than 1.2 MHz from the equipment operating frequency, the equipment shall also output guidance data meeting the requirements of paragraph 2.2.1.1.

2.2.1.2.3 Out-of-Band Interference

The equipment shall output guidance data meeting the requirements of paragraph 2.2.1.1 ~~when a standard test signal is applied~~ in the presence of an out-of-band interference signal of the following characteristics.

a. From 5000 MHz to 5250 MHz excluding the band from 5030 MHz to 5091.7 MHz; -55 dBm CW.

b. From 50 kHz to 5000 MHz and from 5250 MHz to 12.4 GHz; -20 dBm CW.

c. The C-Band weather radar band from 5350 MHz to 5470 MHz; 0 dBm pulses 2.5 microseconds long at 400 pulses per second.

NOTE 1: Special consideration may be appropriate for MLS equipment intended for installation in aircraft equipped with C-Band weather radar.

NOTE 2: It is anticipated that MLS equipment design will likely contain protection to safeguard against damage or subsequent degradation of performance caused by signals existing in the environment in which MLS equipment will be operating.

2.2.1.3 Variation in Scanning Beam Width

The equipment shall function over a range of scanning beamwidths from 0.5 to 5.0 degrees for azimuth and 0.5 to 3.0 degrees for elevation.

2.2.1.3.1 Elevation Function

The equipment shall meet the requirements of Table 2-1 for beamwidths of 0.5 to 2.0 degrees. For beamwidths from 2.0 to 3.0 degrees, the accuracy requirements of Table 2-1 may degrade linearly to a factor of 1.5.

2.2.1.3.2 Azimuth Function

The equipment shall meet the requirements of Table 2-1 for beamwidths of 0.5 to 3.0 degrees. For beamwidths from 3.0 to 5.0 degrees, the accuracy of Table 2-1 may degrade linearly to a factor of 1.6.

NOTE: Provision for larger beamwidths allows for beam spreading as the guidance angle increases. Beam spreading may be as much as 1/cos (theta), where theta is the guidance angle being decoded.

2.2.1.4 Periodic Signal Interruption

The equipment shall meet the requirements of paragraph 2.2.1.1 with a degradation not to exceed 10% when a -95 dBm received signal is modulated by a waveform which introduces a 12 dB periodic attenuation as shown in Figure 2-1.

NOTE: Periodic signal interruptions may be caused by propellor/rotor modulation.

2.2.1.5 Proportional Coverage

The angle guidance outputs shall meet the accuracy standards of Table 2-1 over the range of proportional coverage provided by the equipment.

2.2.2 Warnings

The equipment shall produce clearly discernible warnings (e.g. flag) to warn the pilot, and other systems that utilize the MLS signals, of improper or unreliable guidance.

If a flag is used to display the warning visually, it shall be as large as practical, commensurate with the display and shall be plainly visible under all normal flight deck conditions.

2.2.2.1 Warnings Related to Guidance Signals

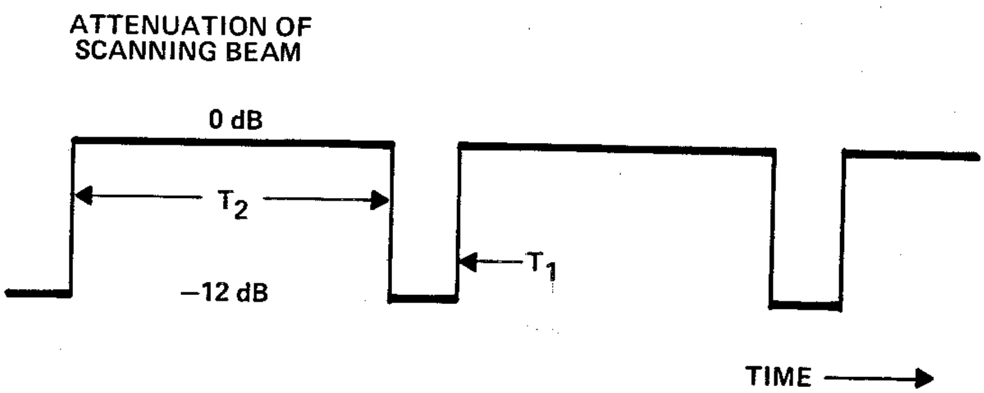
Warnings shall be provided for both the azimuth and elevation functions. These warnings shall be present when primary power is initially applied to the equipment. The warnings shall be removed when the criteria in paragraph 2.2.2.1.1 are satisfied. The warnings shall be generated when the criteria in paragraph 2.2.2.1.3 are satisfied.

Assessment of each sample of the guidance signal is required to permit operation in environments where the reflected signal may exceed the direct signal during limited periods. When the warnings are not present, the requirements of paragraphs 2.2.1 and 2.2.3 shall be met.

NOTE: Warnings are based on the percentage of guidance signal frames meeting the criteria in this subsection over a period of time necessary to ensure positive and stable actions.

2.2.2.1.1 Criteria for Warning Removal

Warnings shall be removed if no equipment failures are detected and if 55% or more of the guidance signal frames satisfy receiver validation criteria and contain a guidance signal exceeding all others by 3 ± 1 dB.



$$\frac{T_1}{T_1 + T_2} = 15\% \quad ; \quad \frac{1}{T_1 + T_2} = 10 \text{ TO } 100 \text{ PULSES PER SECOND}$$

FIGURE 2-1

MODULATION ENVELOPE SIMULATING SIGNAL INTERRUPTION indicator and visual outputs shall be compensated by the azimuth-to-threshold distance code transmitted in Basic Word 1 to provide linear proportional coverage of plus and minus 350 feet $\pm$10% at the runway threshold for azimuth-to-threshold distances between 1000 meters and 6300 meters. For azimuth-to-threshold distances less than 1000 meters, the angular proportional coverage shall be as declared by the manufacturer in the installation instructions.

2.2.6.2 <u>Proportional Azimuth Coverage for Non-Compensated Outputs</u>

Check

For azimuth electrical outputs not intended to drive a deviation indicator, the minimum range of angular proportional coverage shall be plus and minus 6.0 degrees $\pm$ 10%. The output shall vary linearly with angle, independently of the azimuth-to-threshold distance.

2.2.6.3 <u>Azimuth Coverage Outside Receiver Proportional Range</u>

For azimuth scanning beam angles from the limits of proportional coverage provided by the receiver to $\pm$60 degrees, the receiver shall provide the appropriate full scale indication or a code that describes its presence and status.

2.2.6.4 <u>Proportional Elevation Coverage</u>

For visual outputs or for electrical outputs intended to drive an elevation deviation indicator, the full range of angular proportional coverage shall be from 3/4 the reference angle to 5/4 the reference angle within 10%. For outputs not intended to drive a deviation indicator, the minimum range of angular proportional coverage shall be from 3/4 the reference angle to 5/4 the reference angle.

<u>NOTE</u>: 1 For outputs to an autopilot it may be desirable to have proportional guidance from 0 degrees to at least 7.5 degrees.

NOTE: 2

2.2.6.5 <u>Elevation Coverage Outside Receiver Proportional Range</u>

For elevation scanning beam angles outside the range of proportional coverage provided by the receiver and between 0 degrees and at least 28 degrees, the receiver shall provide the appropriate full-scale indication or a code that describes its presence and status.

Internal composition of AZ + EL deviations

2.2.7 Clearance

If the clearance function is being used for guidance, it shall be indicated by a full-scale indication in the appropriate direction or by a code that describes its presence and status.

2.2.8 Station Identification

The equipment shall provide the identification transmitted by by the ground sub-system via an output derived from ~~either~~ Basic Data ~~or a Morse code transmission.~~ When a visual display of station identification is provided, the display shall consist of ~~four~~ at least 3 alphameric characters.

2.2.9 Visual Indicator

The requirements of this paragraph are based on an indicator of the moving pointer type. It is recognized that display devices using other types of indication are possible. When such display devices are provided, the intent of this paragraph shall be met.

If a visual indicator is provided, the following requirements shall be met.

2.2.9.1 Deflection Range

The course deviation pointer shall deflect at least 5/8 inch along its scale when the deviation equals full-scale value.

2.2.9.2 Deflection Direction

When the measured angle is algebraically greater than the reference angle, the deviation pointer shall deflect to the RIGHT (approach azimuth) or DOWN (elevation).

2.2.9.3 Deflection Linearity

Over the deflection range from zero to full scale, the deflection shall be within 10% of being proportional to the course deviation from centerline or within 2.6% of the full-scale value, whichever is greater.

2.2.10 Additional Data

If the manufacturer declares that the equipment has the capability of providing or displaying any information derived from Basic or Auxiliary Data signals, the following shall apply:

NOTE: The criteria for validation are defined in paragraph 1.7.

2.2.2.1.2 Time Delays for Warning Removal

The time elapsed from angle guidance signal application to warning signal removal shall depend on the percentage of transmitted guidance signal frames which meet the criteria of paragraph 2.2.2.1.1 as follows:

Percentage	Time (sec)
55	8 to 12
75	1.6 to 2.4
100	0.8 to 1.2

2.2.2.1.3 Criteria for Warning Signal Generation

Warnings shall be generated if any one of the following criteria are satisfied:

a. When an equipment failure is detected.

b. When there is a loss of the transmitted guidance signal.

c. When 55% or more of the guidance signals are not validated.

d. When at least 55% of the OCI signals exceed the primary signals by 1 dB or more.

e. When an alternate signal exceeds the primary signal by at least 1 dB.

NOTE: For the azimuth function, when the primary guidance produces an output between ±3 degrees, the amplitude ratio requirements in e above may be increased up to 6 dB. $?_0$

2.2.2.1.4 Time Delays for Warning Generation

The time required to produce warnings based on the percentage of signal frames meeting the requirements in paragraph 2.2.2.1.3 shall be as follows:

a. For signal frames meeting the requirements of 2.2.2.1.3.a, less than 1 second.

b. For signal frames meeting the requirements of 2.2.2.1.3.b, 1.0 to 1.4 seconds.

c. For signal frames meeting the requirements of any or all of paragraphs 2.2.2.1.3.c and 2.2.2.1.3.d:

Percentage	Time (sec)
55	8 to 12
75	1.6 to 2.4
100	0.8 to 1.2

d. For signal frames meeting the requirements of paragraph 2.2.2.1.3.e, 10 to 20 seconds or the elapsed time since the last warning removal, whichever is less.

NOTE: When the amplitude ratio mentioned in the note for paragraph 2.2.2.1.3 is increased to 6 dB, the time delay requirement in d above may be reduced to 2 seconds or the elapsed time since the last warning removal, whichever is less.

2.2.2.1.5 Guidance Signal Quality During Warning Generation Delay Times

With associated warnings removed and during the time periods specified in paragraph 2.2.2.1.4, guidance signal outputs being provided shall reflect the most recent guidance input signals without abrupt guidance changes.

2.2.2.1.6 Criteria for Transition Between Proportional and Clearance Guidance

When transitioning between proportional and clearance guidance, the equipment shall output the appropriate clearance indication without issuing a warning signal.

NOTE: The received signal may have the following characteristics in the transition sector that must be accommodated in the design to preclude undesired warning signals.

a. Multiple crossing of a fixed threshold below the beam peak due to noise or interference between the clearance and scanning beam signals.

b. Rapid changes in indicated angle output equal to 1.5 degrees between successive beam measurements.

Change to 2.2.2.3.

2.2.2.1.7 Concurrently Generated Warning Signals

When ~~the above~~ conditions cause an azimuth warning signal generation, the elevation warning signal shall be generated concurrently.

stet

3 sec

2.2.2.2 Warnings Derived From Basic ~~and~~ Auxiliary Data and Aircraft Specific Data.

All data warnings shall be generated within 1 second plus twice the maximum time between transmissions.

2.2.2.3

2.2.2.2.1 Warning Derived From ~~Minimum Selectable~~ Glide Path Data angle selection

A warning signal shall be provided if the selected glide path is below the glide path angle transmitted in Basic Data or if the minimum glide path message has not been decoded.

2.2.2.2.2 Warning Derived From Proportional Coverage Limits

If a proportional guidance output or selectable azimuth angles are provided beyond +10 degrees, a warning signal shall be generated when either of the following conditions are present:

a. The proportional coverage limits are not decoded.

b. The selected angle is beyond the angles indicated by the proportional coverage limits.

2.2.2.2.3 Warning Derived From Runway Length Data

For equipment that provides outputs compensated by runway length, a warning shall be provided if the runway length data word has not been decoded.

2.2.2.2.4 Warning Derived from Magnetic Orientation ~~Approach~~ Azimuth

2.2.2.2.~~4~~ 5 Data Word Parity Check

A warning shall be provided when a data word fails the parity check.

NOTE: It is understood that in the absence of parity, data output is not provided.

2.2.2.

2.2.3 Accuracy in the Presence of Multipath

In the presence of the multipath signals specified below, the equipment shall provide guidance without associated warnings on all channel frequencies.

2.2.3.1 Path Following and Centering Error

The additional path following or centering error introduced by the presence of multipath shall not exceed the limits stated below for a range of signal levels from -20 dBm to -87 dBm and for separation angles between zero and two beamwidths for rates of change in differential phase between direct and multipath signals from 0.05 to 999 Hz.

Multipath (Ratio of multipath to direct signal)	Error (Beamwidth)
-3 dB	0.5
-6 dB	0.3

For separation angles in excess of two beamwidths to the edge of coverage, the error in the absence of multipath side lobes shall not exceed those specified in Table 2-1.

The additional error in the presence of -20 dB side lobes shall not exceed 0.1 beamwidth.

2.2.3.2 Control Motion Noise

The additional control motion noise introduced by the presence of multipath shall not exceed 0.5 beamwidth for -3 dB multipath for separation angles between zero and two beamwidths for rates of change of differential phase between direct and multipath signals from 0.05 to 999 Hz. For separation angles in excess of two beamwidths to the edge of coverage, the additional noise in the presence of -20 dB side lobes shall not exceed 0.1 beamwidth.

NOTE: The total noise is that obtained by combining the additional noise on an RSS basis with the values in Table 2-1.

2.2.4 Resolution

The minimum increment of change of the angle value shall not exceed the limits given in Table 2-1.

2.2.5 Output Response Characteristics

When the azimuth or elevation angle is stepped by 0.2 degree, the visual and basic electrical outputs shall reach 67% of their ultimate values within 2.0 seconds. Electrical outputs A and B shall reach 67% of their ultimate values within 0.12 second. The overshoot shall not exceed 5% for the basic electrical output and 20% for electrical outputs A and B. The specific output filter transfer function shall be declared by the equipment manufacturer.

2.2.6 Coverage

2.2.6.1 Proportional Azimuth Coverage for Compensated Outputs

For azimuth, electrical outputs intended to drive a deviation

a. When signals containing valid Basic or Auxiliary Data (i.e. absence of warnings derived from the parity check) are applied to the receiver at a level of -92 dBm, the output shall be the same as contained in the input within one second plus twice the update interval of the particular data word.

b. The output data format shall be as declared by the manufacturer.

NOTE: The output may be in the form of a visual display or as an electrical signal to other equipment.

2.2.11 Antenna Performance

2.2.11.1 Frequency Bandwidth

The antenna shall operate on any frequency from 5031 MHz to 5090.7 MHz.

2.2.11.2 Voltage Standing Wave Ratio

The voltage standing wave ratio (VSWR) shall not be greater than 2:1 within the frequency bandwidth. The reference transmission line impedance shall be stated by the manufacturer.

2.2.11.3 Polarization

The antenna shall be predominantly vertically polarized.

2.2.11.4 Gain

The antenna minimum and maximum gain and associated maximum allowable transmission line loss shall be stated for the particular receiver design to meet the performance requirements of paragraph 2.2.1.1. The stated maximum and minimum gain shall be measured over the azimuth angle of 140 degrees and over an elevation angle of 35 degrees.

2.2.11.5 Alternate Configuration

For some applications, certain receiver functions (such as RF amplification, pre-selection, and frequency conversion) may be included within the antenna equipment separate and remote from the main receiving equipment and/or multiple antennas may be utilized. In such cases, equivalent performance shall be provided.

2.2.12 High-Rate Azimuth ~~Option~~

~~Unless otherwise specified, when the capability to process high-rate azimuth signals is provided~~, the receiver shall meet the performance requirements with respect to both the normal and high-rate azimuth as stated above for approach azimuth. The high-rate azimuth, ~~when provided~~, shall be in addition to normal azimuth.

The ability to receive both

NOTE: Proposed documentation for MLS ground stations suggest that consideration may be given to the use of high-rate azimuth at some locations in lieu of certain expanded MLS functions and approach azimuth.

2.2.13 Angle Selection

When angle selection is provided, it shall be unmistakable to the person making the selection and shall satisfy the respective requirements of the following paragraphs. When the selected angle is equal to the received angle, the deviation output shall be zero.

X

2.2.13.1 Elevation Reference Angle Selection

X

Elevation reference angle selection will be accomplished by at least one of the following methods:

a. Manually selected, selection range and increments to be declared by the equipment manufacturer.

NOTE: When a preset glide path is provided, a manual override option may be included which when initiated selects the minimum glide path angle on Basic Data.

b. Automatically set to the minimum selectable glide path angle on Basic Data. Where automatic selection of the elevation reference angle is used, the equipment shall output the angle in use.

2.2.13.2 Azimuth Reference Angle Selection

Azimuth reference angle selection will be accomplished by at least one of the following methods:

a. Preset in the equipment at zero degrees.

b. Manually selected, selection range and increments to be declared by the equipment manufacturer. For selected angles greater than ± 10 degrees, the receiver shall decode the azimuth proportional coverage limits on Basic Data and the receiver shall provide a warning if either the selected angle is outside the proportional guidance limits or if the Basic Data proportional coverage limits are not decoded.

2.2.14 RF Channel Selection

A visual display of the channel selected shall be provided and selection shall be made from any one of the frequencies listed in Appendix A. At -95 dBm, the angle receiver guidance outputs shall meet the requirements of paragraph 2.2.1.1 on all channels.

A P P E N D I X   E

MEASUREMENT OF EQUIPMENT ACCURACY

1.0 INTRODUCTION

Equipment accuracy as specified in Subsection 2.2. of this document is in terms of the path following error (PFE) and control motion noise (CMN). These parameters are intended to describe the interaction of the angle guidance signal with the aircraft in terms which can be directly related to aircraft guidance errors and the flight control system design.

The aircraft inertia does not permit it to deviate from the intended path for guidance error frequency components greater than 0.5 rad/sec for azimuth and 1.5 rad/sec for elevation. However, suitable frequency response must be provided for the guidance signal output to avoid eroding the amplitude and phase margins of automatic flight control systems to assure aircraft guidance stability. A 10 rad/sec single pole filter has been found adequate to do this. However, 10 rad/sec components are inputted to the automatic flight control system. Although they do not contribute to a path following error, they can cause vibrations in the control surfaces and the pilot control column as well as inducing attitude variations in the aircraft. These considerations are illustrated in Figure E-1 and form the basis for the definitions of the guidance error components.

The PFE is defined as those components of the MLS guidance error which could cause aircraft displacement from the desired course and/or glide path. These components have a frequency of 0.5 rad/sec or less for azimuth and 1.5 rad/sec or less for elevation.

The CMN is defined as those components of the MLS guidance error which could offset the aircraft attitude angle and cause control surface, wheel and column motions during coupled flight, but which does not cause aircraft displacement from the desired course or glide path. These components lie between 0.3 and 10 rad/sec for azimuth and between 0.5 and 10 rad/sec for elevation.

The basic measurement approach which is followed to evaluate the PFE and CMN errors consists of separating the error components into the appropriate frequency bands by the use of a PFE filter and a CMN filter on the receiver output as shown in Figure E-2. The time required to evaluate the PFE and CMN errors depends primarily on the time constants of the filters and on slowly varying error components such as may be introduced by multipath interference. The methods of measurement are applicable to equipments with electrical analog or digital outputs.

2.0 MEASUREMENT METHODOLOGY

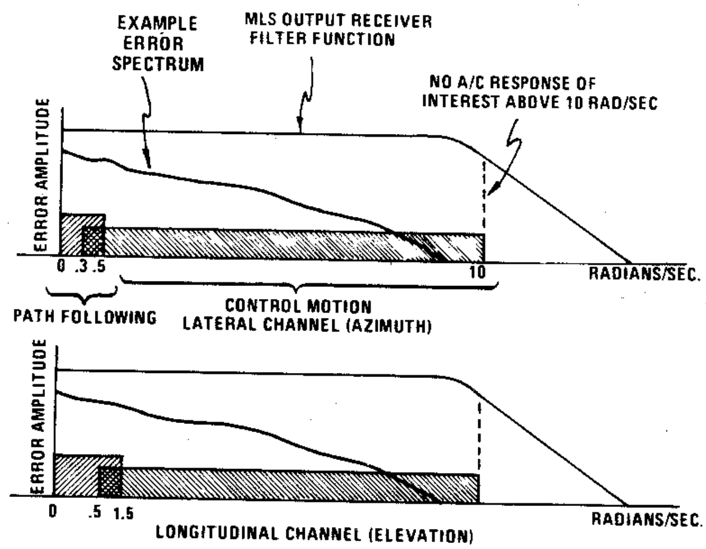
A test set provides the signal to the MLS receiver under test with the appropriate guidance angle as input. The output of the receiver is connected to the PFE and CMN filters as shown in Figure E-2.

The output of the PFE filter is a data stream with a relatively slow variation and with values close to the input angle. The difference between the filter output and the input angle is the PFE. After the equipment has been outputting data with a given input for at least 10 seconds, the PFE must remain within the limits specified for the following 10 seconds without multipath, and for the following 40 seconds with multipath. The initial 10-second period is needed to avoid any transient effects.

The output of the CMN filter is a data stream averaging zero and with more rapid variations than the PFE. After 10 seconds of output with a given input, the following 10 seconds of data without multipath, and the following 40 seconds of data with multipath, is examined for compliance. At least 95% of the values must fall within the specified limits. In the case of analog time history recordings, this condition is considered to be met if the data does not exceed the specified limits more than 5% of the test period.

C H A N G E S

MARCH 26, 1982 & SEPTEMBER 19, 1986



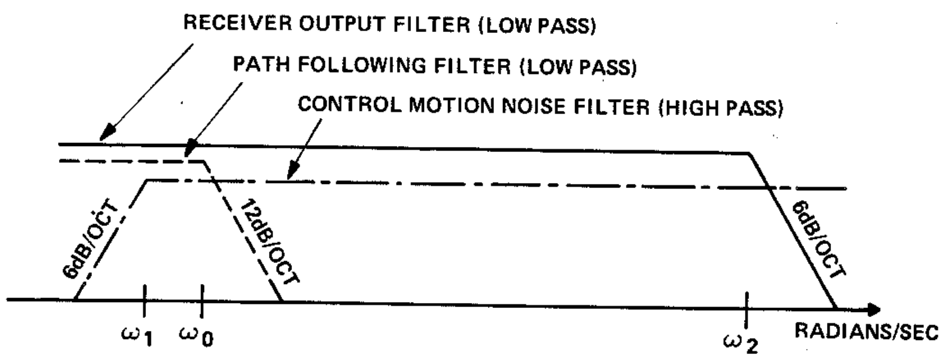
a. The Components of the Error Spectrum

GUIDANCE FUNCTION	CORNER FREQUENCIES (RADIANS/SEC)		
	ω_0	ω_1	ω_2
APPROACH AZIMUTH	0.5	0.3	10
APPROACH ELEVATION	1.5	0.5	10

RECEIVER OUTPUT FILTER $\dfrac{\omega_2}{S+\omega_2}$

PATH FOLLOWING FILTER $\dfrac{\omega_n{}^2}{S^2+2\zeta\omega_n S+\omega_n{}^2}$ $\zeta = 1; \omega_0 = .64\omega_n$

CONTROL MOTION NOISE FILTER $\dfrac{S}{S+\omega_1}$ $S = j\omega$



b. Test Filter Characteristics

Figure E-1. Error Spectrum and Filter Characteristics

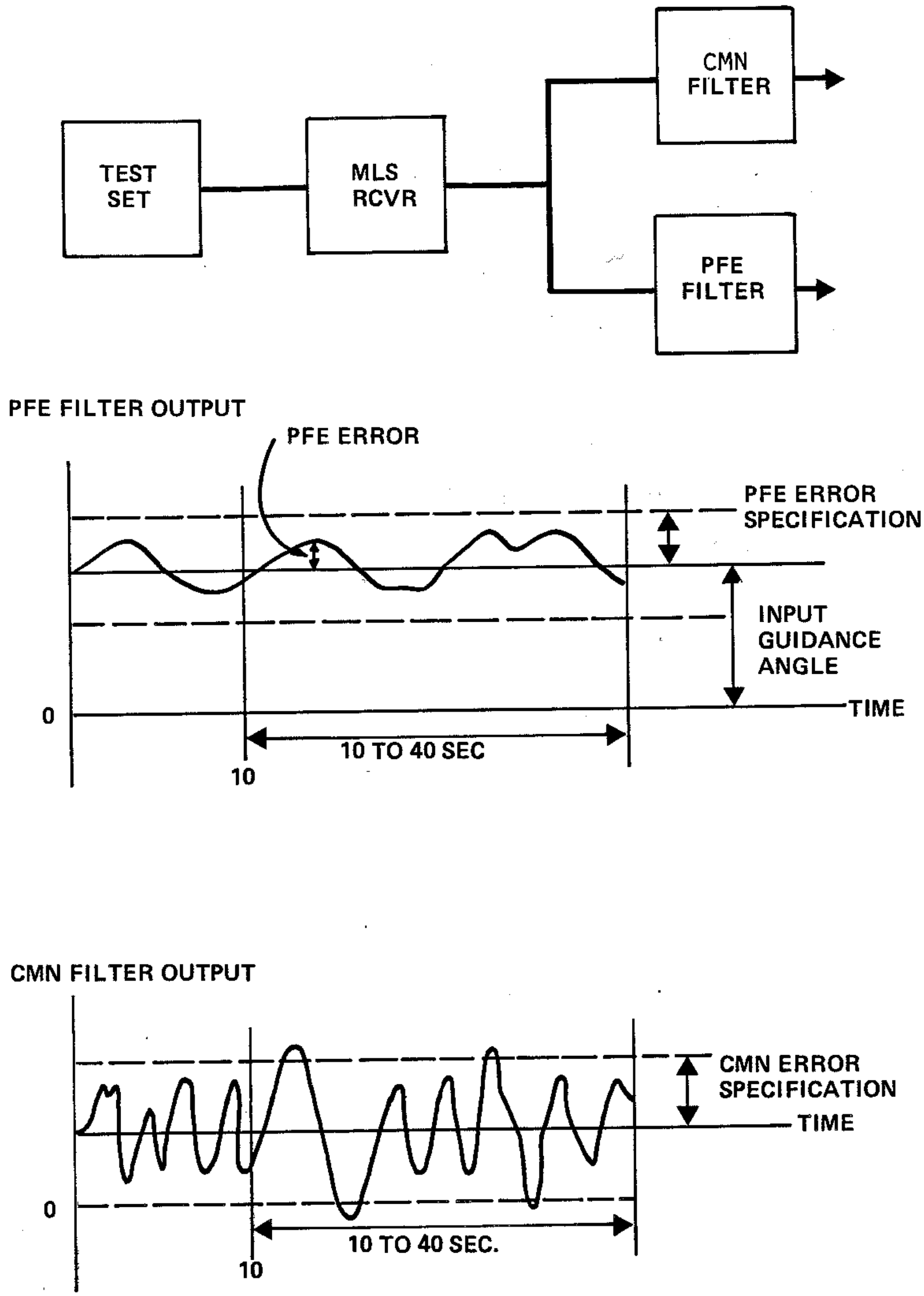


Figure E-2. PFE and CMN Measurements with Filters

Change

March 26, 1982

RADIO TECHNICAL COMMISSION FOR AERONAUTICS
1717 H Street, N. W., Suite 655
Washington, D. C. 20006

CHANGE 1
-to-
RTCA/DO-177

MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR MICROWAVE LANDING SYSTEM (MLS) AIRBORNE RECEIVING EQUIPMENT

Page 14: Delete the subparagraph titled "Validated Guidance Signal" in its entirety and insert the following:

"Validated Guidance Signal - A guidance signal processed by the receiver that satisfies the following criteria:

a. The correct function identification is decoded.

b. The preamble timing signal is decoded.

c. The "TO" and "FRO" scanning beams or left/right clearance signals are present and symmetrically located within 40 microseconds of the midpoint time.

d. The decoded beamwidth is from 12 to 250 microseconds."

Page 15: Paragraph 1.8. Add the following new subparagraph:

"For the purposes of this document, it is assumed that the ground equipment installer will control MLS transmissions such that reflected signals within ± 3 degrees of the runway centerline extended rarely exceed the direct signal."

Page 17: Paragraph 2.1.6. Delete the word "be" in the fourth line.

Page 19: Table 2-1. Replace existing Table 2-1 with the attached new table dated March 1982.

Page 20: Paragraph 2.2.1.1. Add the following as the third paragraph on the bottom of page 20.

"The path following error, centering error and control motion noise limits specified above apply throughout the range of conditions cited in Table 2-1, Note 2 (b), (c) and (d)."

Page 21: Paragraph 2.2.1.2.1. Delete the word "signal" in the first line.

Page 25: Paragraph 2.2.2.1.2. Delete the word "signal" in the second line.

Page 25: Paragraph 2.2.2.1.3. Delete the word "Signal" in the title.

Page 25: Paragraph 2.2.2.1.3 e. Change the words "an alternate" to "a guidance" in the first line.

Page 25: Paragraph 2.2.2.1.3. Delete the NOTE in its entirety.

Page 26: Paragraph 2.2.2.1.4. Delete the NOTE in its entirety.

Page 26: Paragraph 2.2.2.1.7. Replace the existing paragraph with the following:

"Concurrently Generated Warnings

When the above conditions cause an azimuth warning generation, the elevation warning shall be generated concurrently."

Page 27: Paragraph 2.2.2.2.1. Delete the word "signal" in the first line.

Page 27: Paragraph 2.2.2.2.2. Delete the word "signal" in the second line.

Page 28: Paragraph 2.2.5. Delete the text in its entirety and replace with the following:

> "When the azimuth or elevation angle is stepped, the visual and electrical outputs, when used only for visual display, shall reach 67% of their ultimate values within 2.0 seconds. Other electrical outputs shall reach 67% of their ultimate values within 0.12 second and the overshoot shall not exceed 20%. The specific output filter transfer function shall be declared by the equipment manufacturer."

Page 45: Paragraph 2.4.2.1. Under Measurement Procedure, delete the text in Step b. and replace with the following:

> "Set the equipment under test to channel frequency 5061.0 MHz. Adjust the test set RF output to -20 dBm, the elevation beamwidth to 2 degrees and the azimuth beamwidth to 3 degrees."

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CHANGE NO. 2

-TO-

RTCA/DO-177

MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR MICROWAVE LANDING SYSTEM (MLS) AIRBORNE RECEIVING EQUIPMENT

RTCA Paper No. 465-86/EC-980
September 19, 1986

	VISUAL		BASIC ELECTRICAL		ELECTRICAL A		ELECTRICAL B	
	AZ	EL	AZ	EL	AZ	EL	AZ	EL
PATH FOLLOWING ERROR WITHOUT MULTIPATH	N/A	N/A	0.12°	0.05°	0.06°	0.03°	0.017°	0.017°
CONTROL MOTION NOISE WITHOUT MULTIPATH	N/A	N/A	0.05°	0.035°	0.03°	0.02°	0.015°	0.01°
RESOLUTION	N/A	N/A	0.03° OR 1/64 FSD	0.03° OR 1/64 FSD	0.02°	0.02°	0.01°	0.01°
CENTERING ERROR	0.12°	0.05°	N/A	N/A	N/A	N/A	N/A	N/A

NOTE 1: The Visual and Basic Electrical outputs are comparable to ILS Class C, Electrical A is comparable to ILS Class E and the Electrical B output accuracy is the same as stated in Annex 10 of the ICAO Convention.

NOTE 2: The specific Table values are based on the following conditions:

a. RF Signal Level: -20 to -70 dBm
b. Scanning Beamwidth: Azimuth, 0.5 to 3.0 degrees; Elevation, 0.5 to 2 degrees.
c. Data Rates: Azimuth, 13 Hz; Elevation, 39 Hz.
d. No periodic signal interruptions.

NOTE 3: N/A means not applicable.

NOTE 4: The Basic Electrical Resolution shall be at least 0.03 degrees for applications such as autopilots and 1/64 of the full scale deflection (FSD) for visual displays such as CDI and HSI.

Table 2-1. ANGLE GUIDANCE OUTPUT CHARACTERISTICS

(Revised March 1982)

<u>Page 32</u>: Paragraph 2.2.12:
Delete "Option" in the title.
Delete the following portion of the first sentence: "Unless otherwise specified, when the capability to process high-rate azimuth signals is provided,"
Delete the <u>NOTE</u>.

Paragraph 2.2.13:
Add the following new last sentence: "The display of the selected angle shall be the angle about which the receiver is out-putting course deviations."

Paragraph 2.2.13.1, "Elevation Reference Angle Selection":
Replace the text of the entire paragraph including the <u>NOTE</u> with the following:

"Elevation Reference (glide path) angle shall be automatically selected to the minimum glide path angle encoded in Basic Data Word 2. As an option, the glide path may also be manually selected. The range of selection and increments shall be declared by the equipment manufacturer."

Paragraph 2.2.13.2, "Azimuth Reference Angle Selection":
Replace the text of the entire paragraph with the following:

"Approach azimuth reference angle shall be automatically selected to the reciprocal of the approach azimuth magnetic orientation encoded in Basic Data Word 4. As an option, the approach azimuth reference angle may also be manually selected from 0 to 359 degrees, with increments to be declared by the equipment manufacturer."

Add "<u>NOTE</u>: The angular reciprocal of an angle is the sum of 180 degrees and that angle, expressed as a value between 0 and 359 degrees."

<u>Page 51</u>: Paragraph 2.4.2.3, subparagraph h.:
Add "b," between "steps" and "d"

Paragraph 2.4.2.4, subparagraph a.:
Add 2nd sentence "Set the MLS Test Set to the standard test signal."

<u>Page 53</u>: Paragraph 2.4.2.4, subparagraph h.:
Add the following new sentence in front of "Adjust .. etc.":
"Steps h. through l. are tested at -95 dBm only."

After subparagraph l. add the following note:

"<u>NOTE</u>: Varying the signal generator as specified in subparagraph (c) and (e) slowly enough to keep all interference components within the receiver pass band, may take an impractical period of time. Compliance with this paragraph may be accomplished by any other equivalent method."

Wct swept X band radar & close in
around IF frequencies

2x2 5031 show up(?)