SIDELOBE REQUIREMENTS FOR THE MICROWAVE LANDING SYSTEM

Alfred R. Lopez
Wheeler Laboratory, Hazeltine Corporation, Greenlawn, NY 11740

I. INTRODUCTION - The Microwave Landing System (MLS) is the next generation instrument landing system scheduled to replace the existing VHF/UHF ILS. The process of developing and adopting MLS Standards and Recommended Practices (SARPs) by the International Civil Aviation Organization (ICAO) is near completion. The principal antenna type utilized in MLS is the electronically scanned linear antenna. For electronically scanned antennas the concepts of static and dynamic sidelobes are not new. The MLS sidelobe requirements, however, cannot be adequately specified within the context of static and dynamic sidelobes; what is needed is a concept called "effective" sidelobes. This sidelobe characterization is found in the draft ICAO SARPs guidance material [1]; it provides the means for a cost/performance optimization of antenna designs with respect to system accuracy requirements in multipath environments.

II. MLS SIDELOBE REQUIREMENTS - The key element of the Microwave Landing System is a scanning beam antenna which encodes angle by means of the time difference between "TO" and "FRO" scans as shown in Figure 1. This figure also shows a reflecting obstacle which causes a multipath (indirect) signal. Multipath affects the system in two ways: (1) it requires that the receiver processing and logic provide for the acquisition and track of the direct signal in multipath environments, and (2) it causes guidance angle errors by distorting the received beam shapes. This paper is concerned with the guidance errors caused by sidelobe radiation reflected by an obstacle and arriving at the receiver during the reception of the direct beam.

For MLS, the dynamic pattern is defined [2] as the temporal variation of the signal level at the output of the receiver beam-envelope filter, with the receiver stationary and with the beam scanning normally. Figure 2 shows dynamic patterns for direct and multipath signals. The sidelobes of the direct dynamic pattern cannot cause an error since they do not exist during the reception of the main beam. The requirement for the direct dynamic sidelobes is that they be sufficiently low so that the receiver can acquire and track the main beam. In the draft ICAO SARPs [3] it is indicated that "satisfactory performance cannot be assured if dynamic sidelobes persist at levels above -10dB."

CH1672-5/81/0000-000203$00.75

It is the multipath dynamic sidelobes, existing during the reception of the direct beam, that can cause guidance angle errors. This region, shown in the spatial-temporal diagram of Figure 2, is called the effective sidelobe region. The peak dynamic sidelobe in the effective sidelobe region cannot be used to accurately bound the error; this error can only be quantified in terms of the effective sidelobe level. Figure 3 shows three cases where the peak dynamic sidelobe level is the same, however, the beam distortions are such that the resulting errors range from zero to the product of the peak sidelobe level multiplied by the beamwidth.

III. <u>EFFECTIVE SIDELOBE LEVEL</u> - The peak multipath error, $\delta\theta$, caused by the worst case phasing condition between the direct and multipath signals is given by [1]:

$$\delta\theta = \rho_R \, \rho_{MA} \, \rho_{ESL} \, \theta_{BW}$$

where ρ_R is the obstacle reflection coefficient (the ratio of the multipath signal to the direct signal with an omni-directional antenna replacing the scanning beam antenna), ρ_{MA} is the motion averaging factor (When the angle of arrival between the direct and multipath signals at the receiver is large, a short-wavelength standing-wave pattern exists along the flight path which causes a rapid cyclic variation of the multipath error. This effect is utilized to reduce the error by averaging several angle measurements.), and <u>ρ_{ESL} is the effective sidelobe level, the ratio of the worst-case error divided by the beamwidth for a standard multipath signal of $\rho_R = \rho_{MA} = 1$</u>. θ_{BW} is the antenna beamwidth.

Effective sidelobes provide a direct means for relating a specific antenna design to the system error caused by sidelobe radiation. Effective sidelobes can be measured on an antenna range. [4] [5].

A static pattern is the usual antenna pattern. For MLS it is the spatial variation of the radiated signal level with the antenna beam pointing in a fixed direction. The peak static sidelobe level in the effective sidelobe region cannot accurately bound the guidance error. This level can be substantially higher than the peak dynamic sidelobe since it is not filtered. Consequently, a sidelobe specification based on a peak static sidelobe level could result in a greater level of overdesign than for a peak dynamic sidelobe specification.

IV. <u>SUMMARY</u> - For the Microwave Landing System, peak static and dynamic sidelobes cannot accurately bound the error caused by multipath signals from sidelobe radiation. Effective sidelobes, by definition, is the ratio of error to beamwidth for a standard multipath signal. The effective sidelobe characterization can be used to predict actual performance in multipath environments. It can also be used to compare the performance potential of alternative antenna systems; 1^{o} and 2^{o} beamwidth systems are equivalent with respect to errors caused by sidelobe radiation, if the 2^{o} system has effective sidelobes that are 6 dB lower than the 1^{o} system. Effective sidelobes can be measured on an antenna range.

REFERENCES

[1] ICAO, Eighth Meeting of the All Weather Operations Panel Montreal 11-21 March 1980, Agenda Item 1, AN-WP/5099 Appendix C.
[2] FAA "Microwave Landing System (MLS) Signal Format and System Level Functional Requirements" Engineering Requirement 700-08C, p. 68, May 1980.
[3] ICAO, MLS Working Group Meeting, Rio de Janeiro 22 Sept. - 3 Oct. 1980, "Recommended Revisions to Angle and Data SARPs and Guidance Material", Attach. 2.
[4] J.E. Evans, et al. "MLS Multipath Studies, Phase 3 Final Report, Volume II: Development and Validation of Model for MLS Techniques", Lincoln Lab Report No. FAA-RD-79-21, Appendix F, Feb. 1980.
[5] A.R. Lopez, "Effective Sidelobe Level - A Means for Relating Sidelobe Radiation to its Potential to Cause Multipath Error" Hazeltine Memo 4942-80-RL5018; Jan. 22, 1980.

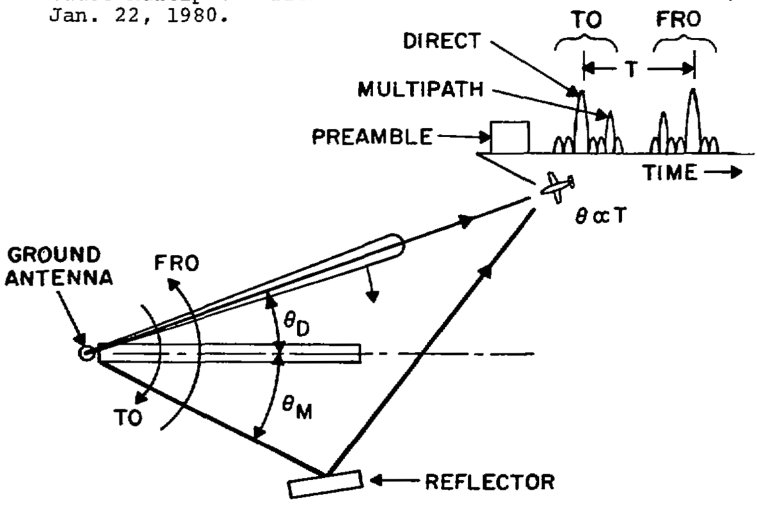

FIGURE 1. MLS RECEIVED WAVEFORM

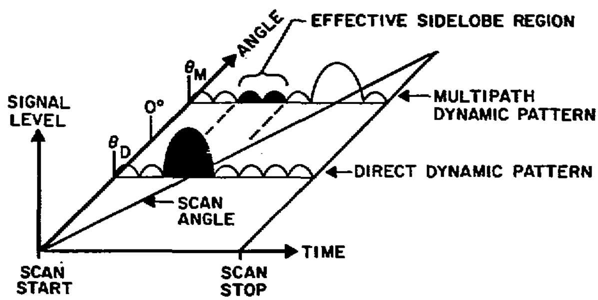

FIGURE 2. DIRECT AND MULTIPATH DYNAMIC PATTERNS

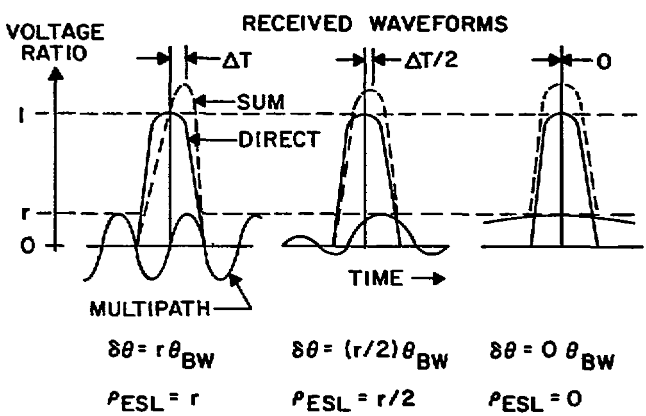

FIGURE 3

ERRORS CAUSED BY DYNAMIC SIDELOBES OF EQUAL PEAK LEVEL