AN MLS SIMULATION FACILITY

by

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Abstract

A Microwave Landing System (MLS) simulation facility is described that generates direct and multipath C-band signals suitable for evaluating an airborne receiver. Test scenarios and data reduction are accomplished by a PDP 11/10 computer. Typical test results are presented. Some future applications are considered.

The MLS Simulation Facility was developed at Calspan ATC in support of the Federal Aviation Administration Microwave Landing System (MLS) development.[1,2,3] This simulator is primarily used to evaluate and multipath effects on MLS signals. Multipath errors are difficult to evaluate in flight tests because of the many variables in the airport environment. The facility is also used to evaluate low signal level performance, interference susceptibility of MLS signals, and signal format parameters and to develop processing algorithms for MLS receivers.

The microwave landing system uses a TO-FRO scanning beam for azimuth guidance and a DOWN-UP scanning beam for elevation guidance as illustrated in Figure 1. Angle decoding is done in the aircraft receiver by measuring the time interval between the two beam passages. A time multiplexed signal format, shown in Figure 2, provides the angle guidance, function identity, receiver synchronization and data.

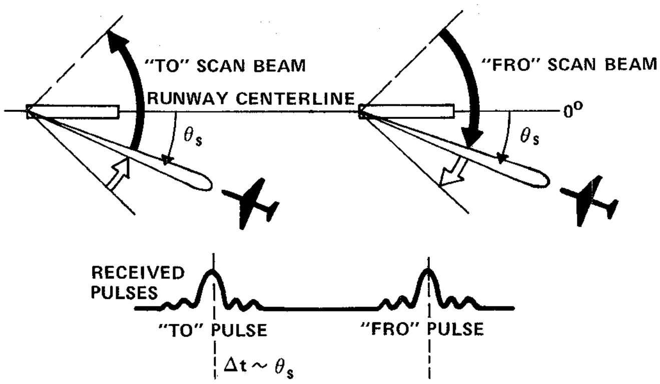

Figure 1 PRINCIPLE OF TRSB ANGLE MEASUREMENT

The MLS simulator provides an output waveshape equivalent to that received in the aircraft from the TO-FRO or DOWN-UP scanning beam antenna. In addition, as shown in Figure 3, the multipath from a single reflecting surface is simulated. Block diagrams of the MLS simulator are shown in Figures 4 and 5. The simulated MLS signal (at C-band) is connected directly to the test receiver signal input terminal. Simulator variable parameters are controlled by a digital computer for each scan. The computer performs data analysis of the receiver signal outputs.

In the MLS simulation the beam shapes are generated by counters that address PROM's (Programmable Read Only Memories). Beamwidth is controlled by selecting the clock frequency for the PROM address counters. The PROM outputs drive double-balanced mixers to the desired signal shape by means of digital-to-analog converters. The multipath beams include first and second sidelobes on each side. The RF phase of the first sidelobe is shifted 180° from the main beam and second sidelobe by inverting the drive to the double-balanced mixer beam shaper. PROM's have been programmed for -20, -25, and -30 dB sidelobes (both equal). This beam generation is directed by a digital word from the computer which thus sets the angles (TO-FRO beam separation time) for both the direct and multipath beams. Figure 6 shows oscilloscope pictures of the simulated signals as they appear in a receiver log video output.

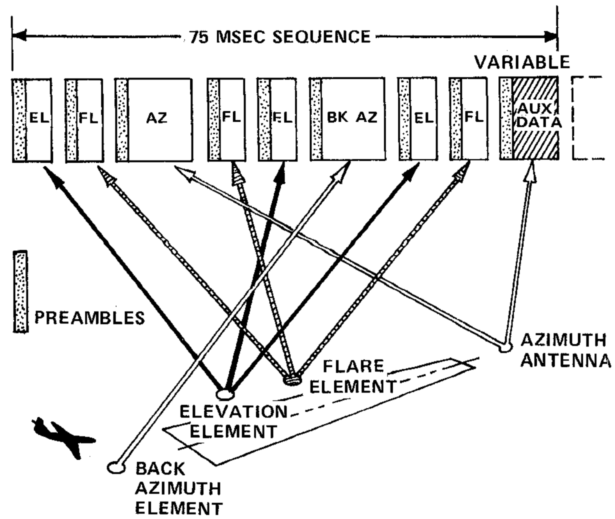

Figure 2 TIME MULTIPLEXED SIGNAL FORMAT

The multipath beams are further controlled by the computer to offset the carrier frequency (scalloping frequency difference) to represent the doppler shift on the multipath signal as illustrated in Figure 7, and to set the multipath amplitude. These changes are made between scans as desired. The direct beam and multipath beam are then summed and the composite signal is translated to C-band for application to the receiver. Provision for synchronization and for function identification DPSK transmissions are made in the simulator.

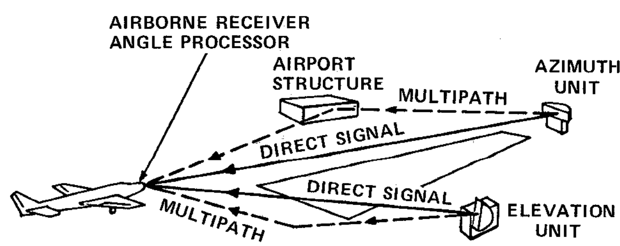

Figure 3 MLS SIMULATOR CAPABILITIES

The receiver under test produces an indicated output angle that is made available to the control computer by the interface unit. A normal test consists of 5 seconds with direct signal only, up to 20 seconds of multipath, and 2 seconds of direct signal. The indicated angle is stored in the computer and also provided to the chart recorder for a visual indication of test progress. Following the

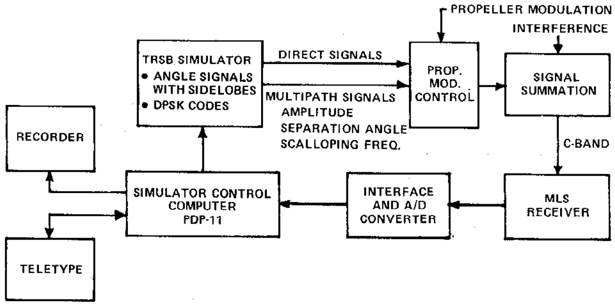

Figure 4 MICROWAVE LANDING SYSTEM SIMULATION FACILITY

end of the test, the stored data may be filtered by a 10-radian/second low-pass filter or by an α, β filter with variable parameters, as well by other digital filters (representing aircraft path following, control motion, and control rate). In each case, the mean shift in angle (from the 5 seconds before multipath application) and the standard deviation of angle during the multipath are computed. The filtered outputs are also available for chart recording.

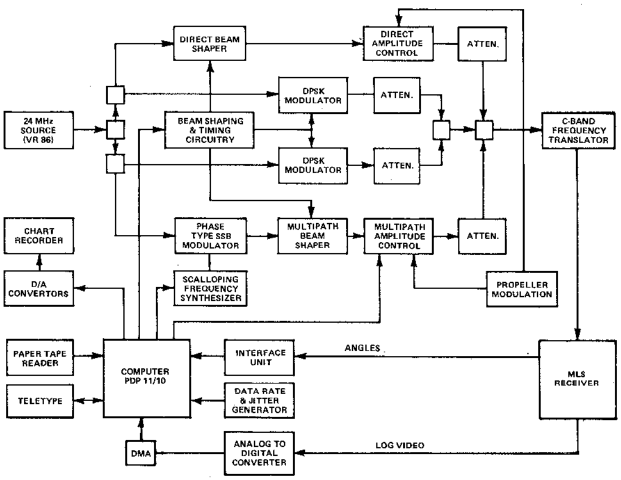

Figure 5 FUNCTIONAL DIAGRAM OF MLS SIMULATOR

This hardware simulation facility has been used extensively in the development and evaluation of MLS receivers. MLS signals with the same characteristics as those received at the aircraft antenna for many approach situations and multipath environments can be generated in this facility. Signals are fed directly into the receiver antenna terminals. The receiver and processing algorithms can be debugged and evaluated with a limited number of laboratory tests so that developmental flight test hours are minimized.

Simulations were started in 1972 to assist the Federal Aviation Administration in evaluating the various systems proposed for the MLS program. These

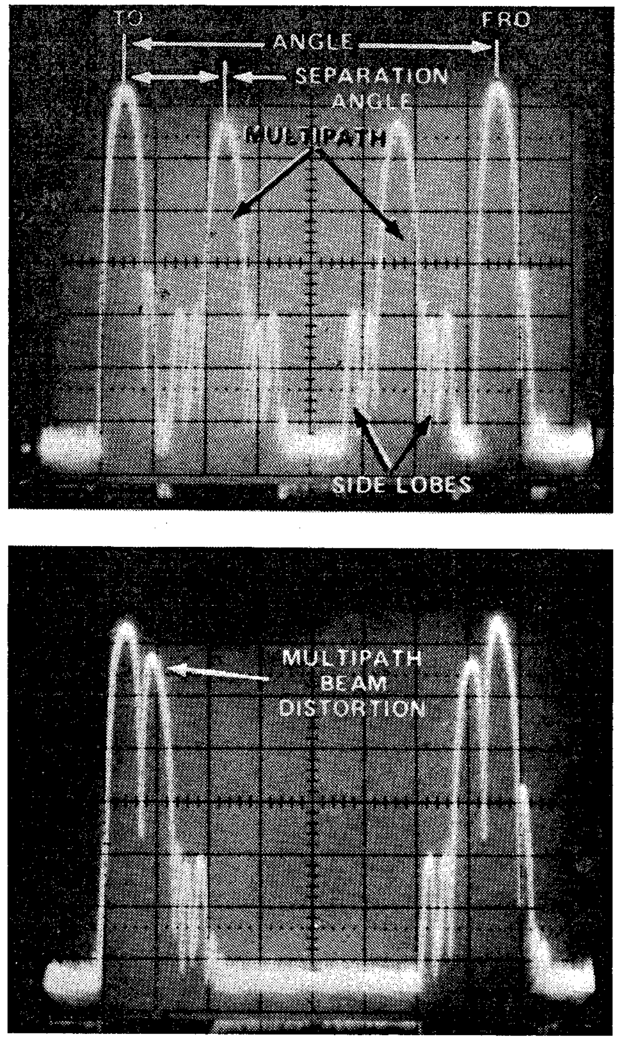

Figure 6 SIMULATED DIRECT AND MULTIPATH BEAMS

simulation facilities have been modified and upgraded to represent the time reference scanning beam system selected as the international standard system to replace ILS.

The U.S. developed MLS receivers have been evaluated in the Calspan MLS facility. These include the receivers used in the final system tests for the ICAO evaluations. Performance tests have also been run on a low-cost receiver under development for general aviation. A large data base has been generated for the MLS receiver performance characteristics using a number of different processing algorithms. Receiver performance characteristics measured with the simulator have been used to verify computer models of MLS receivers.[4] Performance data taken with the actual receivers do have a good correlation with performance measured in flight tests.

A multimode processor was developed for the FAA to demonstrate processing techniques other than the dwell gate processor used in the receivers for ICAO flight tests. The algorithms and software were developed using the PDP-11 computer with the MLS simulator. A field test version of the multimode processor was implemented with an LSI-11 microprocessor. The multimode processor can process azimuth or elevation data, with up to four different algorithms, in real time. Tests with this processor have shown that flight test performance can be predicted from simulation data.

A typical scenario for an aircraft on final approach that passes through a region of multipath affecting the elevation guidance signal is shown in Figure 8. The parameters of the multipath signal are programmed in the computer for generating the time history of the interfering signal experienced by the approaching aircraft. Error signals for two different processing algorithms are shown in Figure 8.

The simulation techniques developed for this facility have been used also in the design of MLS test sets. The simulation facility at Calspan ATC can be easily modified for conducting the wide variety of tests that will be required to certify a receiver design for operational use.

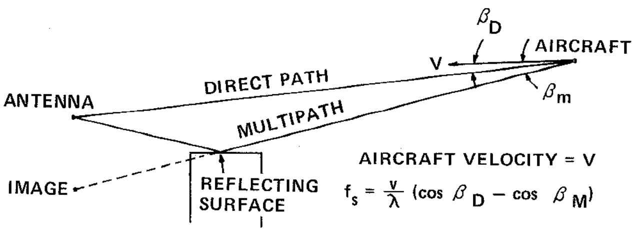

Figure 7 SCALLOPING FREQUENCY (f_s)

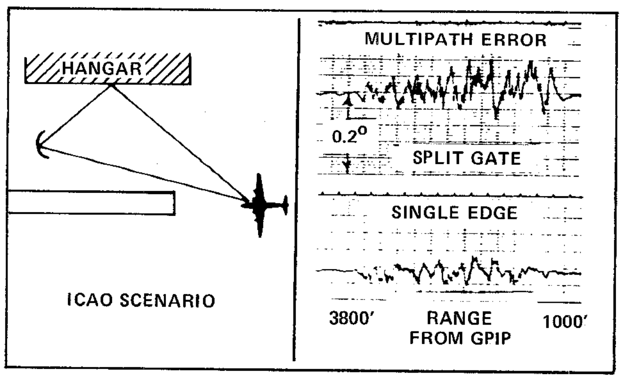

Figure 8 A TYPICAL MULTIPATH SCENARIO

References

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