Results of MLS/ILS Comparison Flight Test at the YUMA MCAS, Arizona

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NOTICE

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16. Abstract

A series of flight tests were performed by the Federal Aviation Administration (FAA) Technical Center at the Marine Corps Air Station (MCAS) Yuma, Arizona, to obtain Microwave Landing System (MLS) performance data and to compare the performance of a commissioned Category I Instrument Landing System (ILS) with the performance of a prototype MLS. The Technical Center's test bed MLS was transported to and collocated with the commissioned Category I ILS on runway 21R at the MCAS Yuma. The flight data collected indicate that while both the ILS and MLS met Category I standards, the MLS represented a noticeable improvement in accuracy, signal quality, and flyability.

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EXECUTIVE SUMMARY

A series of flight tests were performed by the Federal Aviation Administration (FAA) Technical Center at the Marine Corps Air Station (MCAS), Yuma, Arizona, to obtain Microwave Landing System (MLS) performance data and to compare the performance of a commissioned Category I Instrument Landing System (ILS) with the performance of a prototype MLS. The Technical Center's test bed MLS was transported to and collocated with the commissioned Category I ILS on runway 21R at the MCAS Yuma. The flight data collected indicate that while both the ILS and MLS met Category I standards, the MLS represented a noticeable improvement in accuracy, signal quality, and flyability.

INTRODUCTION

BACKGROUND.

Project 5 of the Federal Aviation Administration (FAA) Microwave Landing System (MLS) Demonstration and Evaluation Program addresses the comparison of MLS to Instrument Landing System (ILS) performance. The comparison of MLS to ILS focuses on the direct comparison of MLS and ILS data collected simultaneously on tracked approaches made by FAA Technical Center instrumented aircraft using collocated MLS and ILS ground equipment for guidance.

During the month of June 1990, a series of tests were performed at the Marine Corps Air Station (MCAS) Yuma, Arizona, to obtain MLS performance data. The series of MLS tests performed included an operational comparison of the course qualities of a commissioned Category I ILS with a collocated MLS (reference 1) as well as testing to verify proposed ILS/MLS collocation standards (reference 2).

The MLS was sited at Yuma at the request of the Douglas Aircraft Company. The system was provided at their Yuma test site for the purpose of conducting MLS data collection flights using their MD-11. However, since the MLS was collocated with the ILS, the FAA took advantage of the collocation to collect direct ILS/MLS comparison data.

SITE DESCRIPTION.

MCAS Yuma is located approximately 3 miles west of Yuma and is jointly operated by the U.S. Marine Corps and the Yuma City Airport Authority. The airport is a military/commercial aviation airport with very high military traffic volume. The MLS was sited to serve runway 21R for conventional straight-in approaches. Figure 1 shows the airport layout. The MLS and ILS equipment positions are shown in figures 2 and 3.

EQUIPMENT DESCRIPTION

The prototype MLS ground equipment used for these tests was the Bendix-built FAA Technical Center test bed MLS which is comprised of a 2° beamwidth azimuth and a 1.5° beamwidth elevation subsystem. Precision range information was provided by a precision distance measuring equipment (DME/P) system built by the Montek Division of E-Systems, Incorporated. The MLS azimuth subsystem provided 40° of proportional coverage on either side of the system boresight which was aligned with the centerline of runway 21R. The elevation subsystem provided proportional vertical coverage from 1° to 15° above the horizon. Range coverage provided by the DME/P system was omnidirectional to a minimum radius of 20 nautical miles (nmi) from the equipment site. An accurate drawing of the MLS azimuth and elevation subsystems is shown in figure 4.

All of the airborne data were collected using the FAA Technical Center's fully instrumented Convair 580 (CV-580). A Bendix ML-201A MLS receiver was used to collect the MLS data; a Bendix RNA-34AF navigation receiver was used to collect the localizer and glide slope data. Both of these receivers output both analog and digital data. DME ranging data, for reference information only, was collected using an E-Systems DME/P located near the azimuth and localizer. Both analog (strip chart recorder) and digital (Kennedy 9-track recorder) data were collected. The digital data were recorded at the full rate of the MLS subsystems, 13 hertz (Hz) for the azimuth, 39 Hz for the elevation. The analog data were used for real time "quick look" information, while digital data was processed post-flight and is used in this report.

The ground truth or tracking system used for these tests was the FAA Technical Center's Single Point Optical Ranging Tracker (SPORT). The SPORT consisted of a precision theodolite, with drive motors in both the azimuth and elevation axes, which was modified to mount a high resolution video camera equipped with a telephoto lens. The video from the camera was processed in real time to generate an error signal based on tracking the point of greatest contrast in the video image. The system automatically tracked the nosewheel taxi light of the test bed aircraft and was generally employed after sundown to maximize the contrast between the aircraft light and the background sky. Accurate range information was provided by a C-Band ranging system. Overall system accuracy for the SPORT was +/-36 arc seconds (+/-0.0061 degrees) in azimuth and elevation and +/-1.5 meter (4.92 feet) in range. Tracker data were recorded synchronously at a rate of 10 Hz. Each data point consisted of time, theodolite azimuth and elevation angles, and slant range from the tracker to the aircraft. Tracker time was synchronized with aircraft time using a portable IRIG-B time code generator. The tracker was positioned at a known point near the MLS elevation subsystem and tracked all runs from that location.

TEST DESCRIPTION

The localizer was sited, on the runway centerline extended, 1192 feet beyond the stop end of the runway. The MLS azimuth was installed with the phase center of the antenna 188 feet in front of the localizer and was symmetrical about the centerline extended. The DME/P was sited 1186 feet beyond the stop end of the runway 190 feet to the right (as seen by the pilot on an approach) of runway centerline. Figure 2 is a drawing of the localizer, azimuth, and DME/P locations. The glide slope was sited 1162 feet back from threshold and 475 feet to the right of runway centerline. The elevation station was installed to place the front of the antenna 973 feet from threshold 423 feet to the right of centerline. This location was to the runway side of a line from the glide slope antenna to the runway centerline at threshold and provided for coincident threshold crossing heights between the glide slope and elevation systems. Figure 3 shows the locations of the glide slope and elevation antennas.

For the purpose of this report, four MLS/ILS comparison approaches recorded during the Yuma tests were analyzed. The four approaches were all 3.0° glide slope centerline approaches to runway 21R. ILS guidance was used for two of the approaches, and MLS guidance was used for the remaining two approaches.

RESULTS AND ANALYSIS

The data from other tests performed during this and other test series indicate that the collocation of an MLS azimuth with a localizer and an MLS elevation with a glide slope does not affect the quality of the course structure of the ILS (reference 2). Therefore, any differences between the ILS and MLS performance were not caused by collocating the systems. ILS and MLS course error data are normally presented differently due to different specifications for each system. The ILS data, both localizer and glide slope, are raw error (receiver cross pointer minus tracker) and were not filtered. The MLS data used for this report was also unfiltered raw error so that all comparisons in this report are between raw error data.

Figures 5 and 6 are composites of the MLS raw error data from the azimuth and elevation, respectively. These composites contain the four runs used to produce the MLS statistical composites in figure 7. Figures 8 and 9 are composites of the ILS raw error data from the localizer and glide slope, respectively. These composites contain the four runs used to produce the ILS statistical composites in figure 10.

Figures 7 and 10 are graphical representations of the error data from the four approaches. Each figure is a statistical composite of the error data from all four runs pertaining to the MLS azimuth and elevation (figure 7) and the ILS localizer and glide slope (figure 10). The raw error data for each of the MLS and ILS subsystems from each of the four approaches were "binned" at 0.5 nmi intervals from a slant range of 10 nmi to runway threshold. The mean and standard deviation (sigma) was calculated for the data population of each of the bins. These parameters are plotted with the mean of each bin represented by a circle bisected by a vertical line connecting the +/-2 sigma variations, which also represents the 95 percent confidence limits. The applicable ILS Category I tolerance limits (reference 3) are shown as dashed lines in figure 10.

The tolerance limits shown for the MLS azimuth and elevation error plots (figure 7) are the path following error (PFE) limits since no tolerance exists for MLS raw error (reference 4).

Regarding figure 7, the MLS error data, it can be seen that the error data from the MLS azimuth subsystem shows a uniform bias of approximately -0.03° with 2 sigma variations of approximately 0.02° over the 10 nmi range of the tracked data. It should be noted that the distance from the MLS azimuth subsystem to the threshold of runway 21R was 14,303 feet. This distance far exceeds the maximum MLS azimuth to threshold distance of 7,000 feet recommended to allow a 2° beamwidth azimuth to support the system accuracy requirements of FAA-STD-022C (reference 4). However, the recorded angular accuracy of the MLS azimuth subsystem installed at Yuma MCAS represented a linear variation of approximately +/-5 feet at threshold which is well within the accuracy requirement of +/-20 feet. The error data from the MLS elevation subsystem shows a uniform bias of approximately +0.06° with 2 sigma variations of approximately 0.025° over the 10 nmi range of the tracked data.

Figure 10 shows the ILS error data. These data were prepared in the same way as the MLS data to allow a direct comparison. MCAS Yuma is a benign ILS site with no reported signal anomalies and none were observed or recorded in the collected data. The data collection flights were performed during the early evening hours to obtain optimum tracker performance. Because of the time of day, military and commercial aviation traffic to the airport was at minimum and the remaining traffic was accommodated on runways other than 21R. Consequently, none of the ILS localizer data show any evidence of overflight perturbations. The localizer error data show a slightly varying bias of approximately +0.04° with 2 sigma variations of approximately 0.03°. The glide slope error data show a varying bias of approximately 0.10° with 2 sigma variations of approximately 0.05°.

A comparison of the MLS and ILS data shows that even in a benign ILS site, the MLS error data reflects a noticeable improvement over the ILS error data in signal quality, accuracy, and flyability.

CONCLUSIONS

1. The collocation of the Microwave Landing System (MLS) subsystems with the Yuma Instrument Landing System (ILS) localizer and glide slope did not affect the quality of the course structure of the ILS.

2. Even in a benign ILS site, the MLS error data show a noticeable improvement over the ILS error data in signal quality, accuracy, and flyability.

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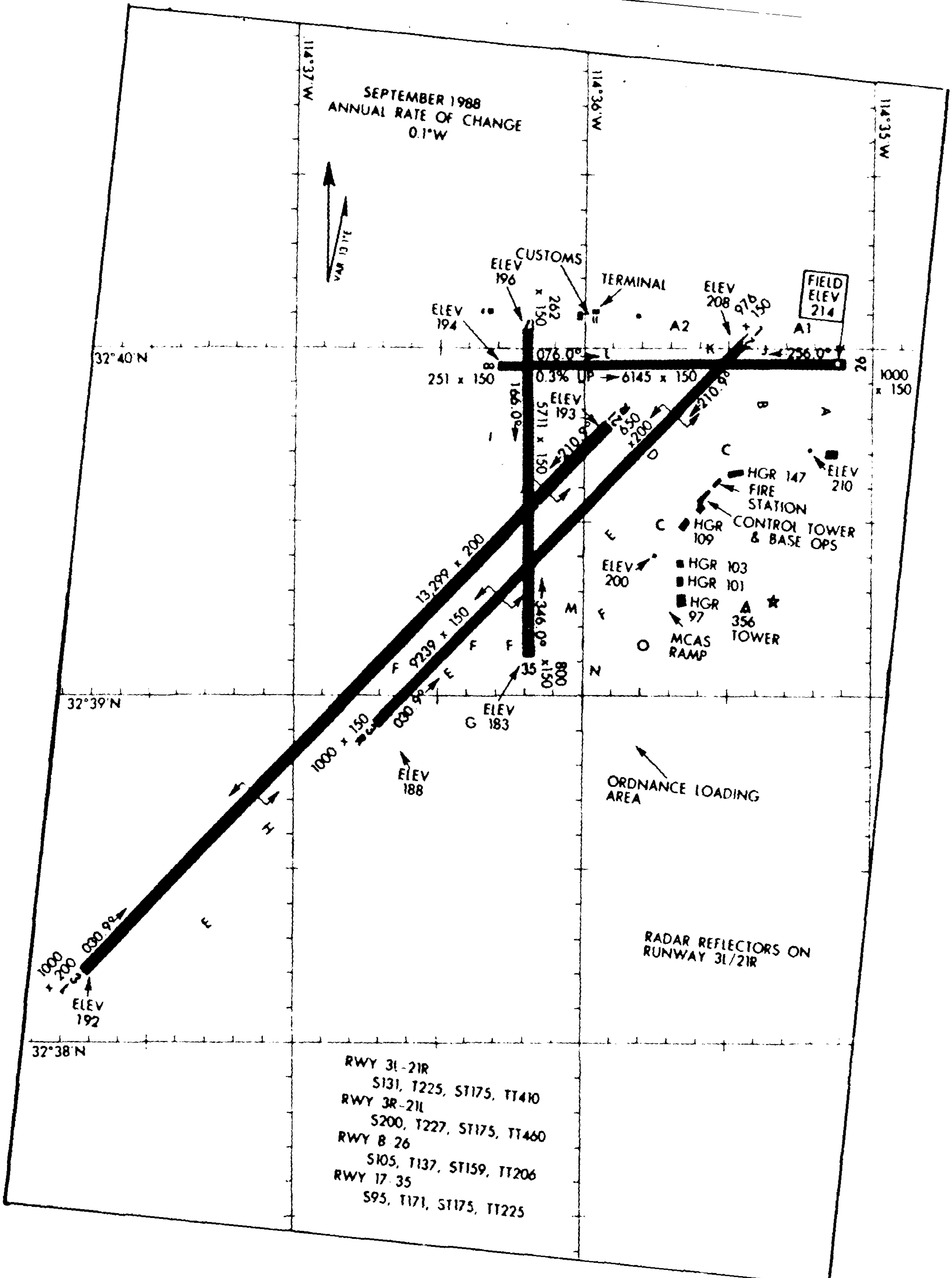


FIGURE 1. YUMA MCAS/YUMA INTERNATIONAL AIRPORT LAYOUT

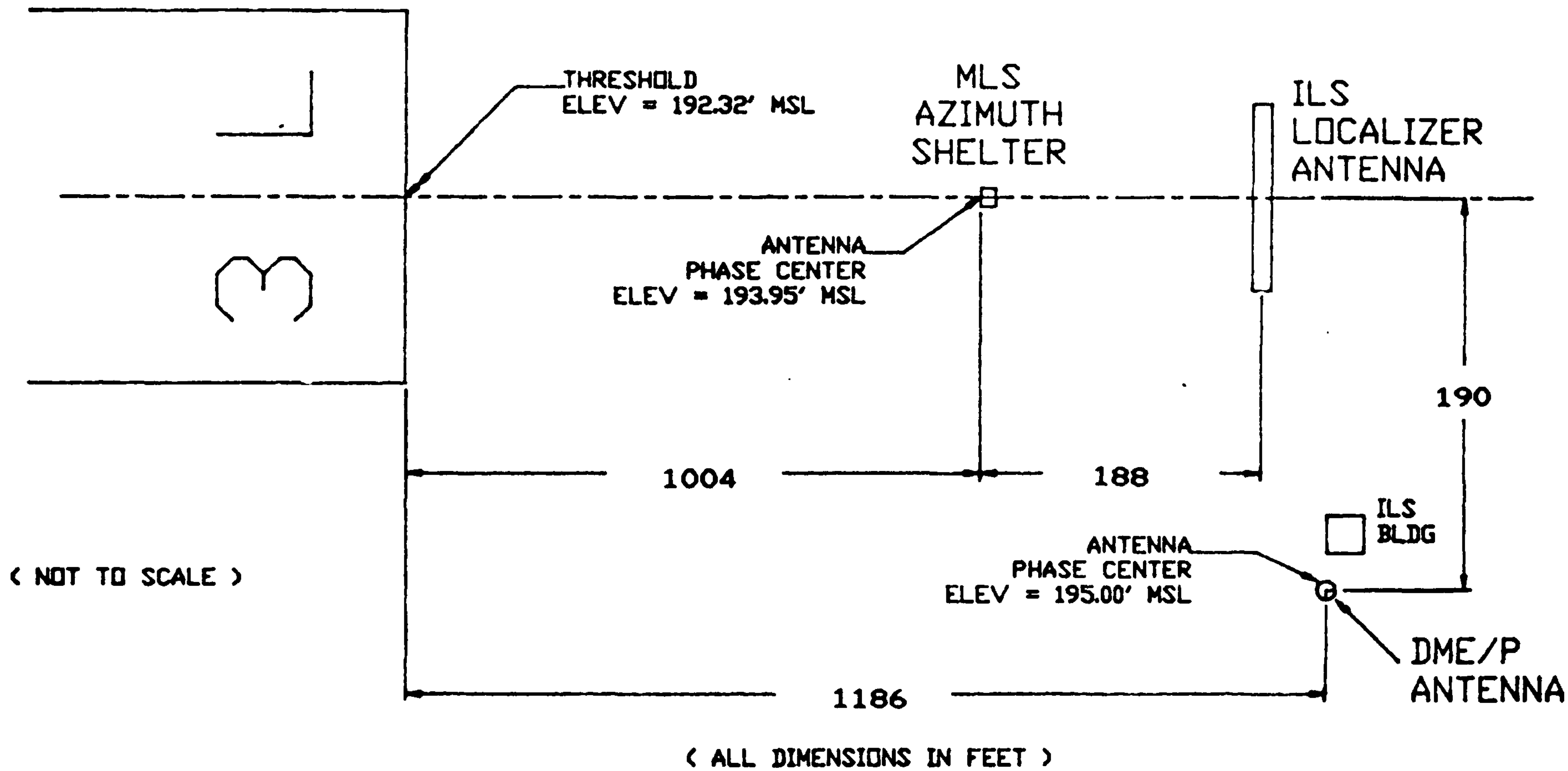


FIGURE 2. COLLOCATED MLS AZIMUTH/ILS LOCALIZER LAYOUT

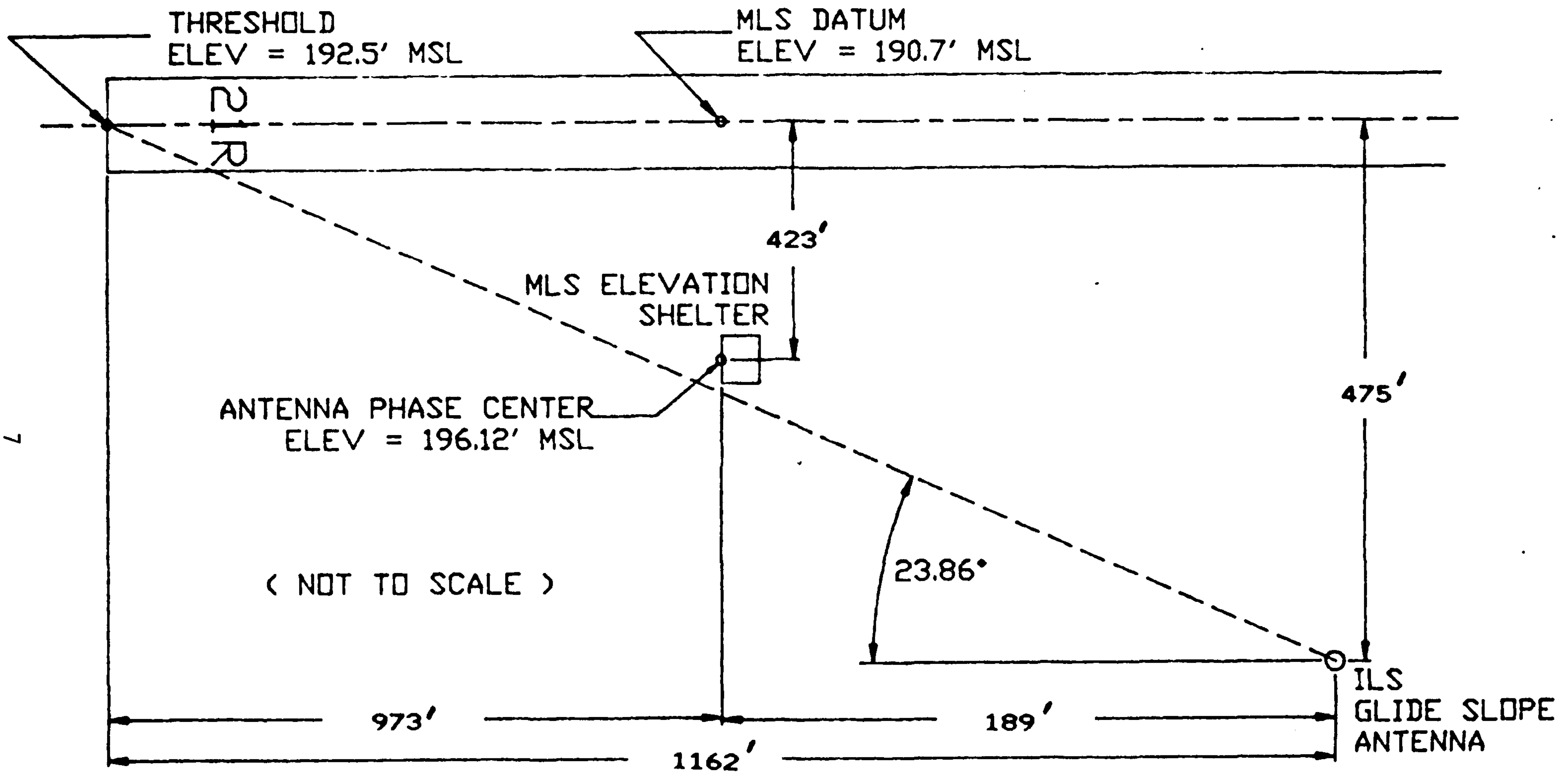
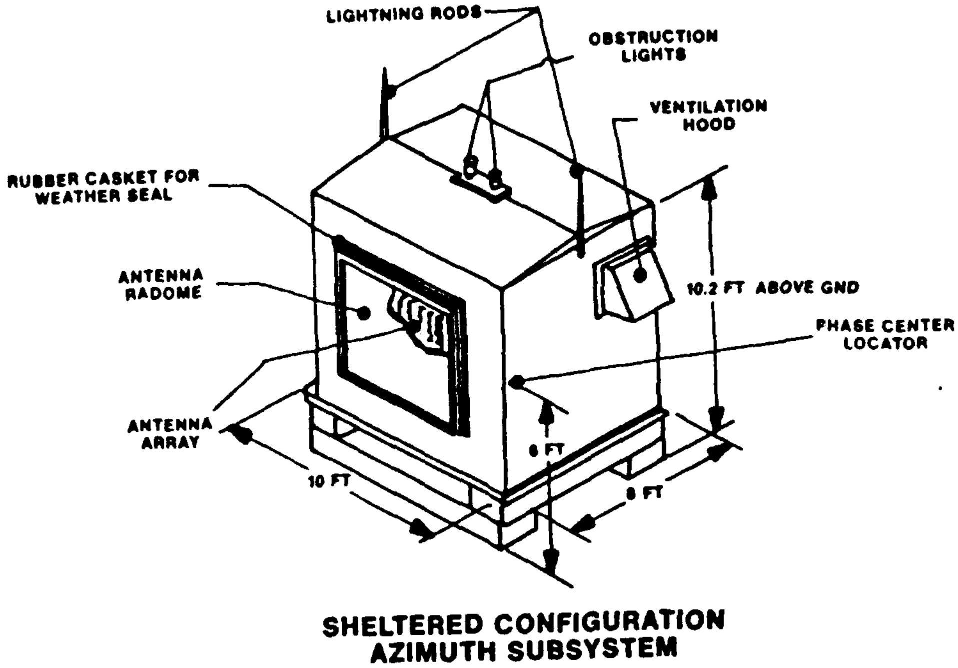


FIGURE 3. COLLOCATED MLS ELEVATION/ILS GLIDESLOPE LAYOUT



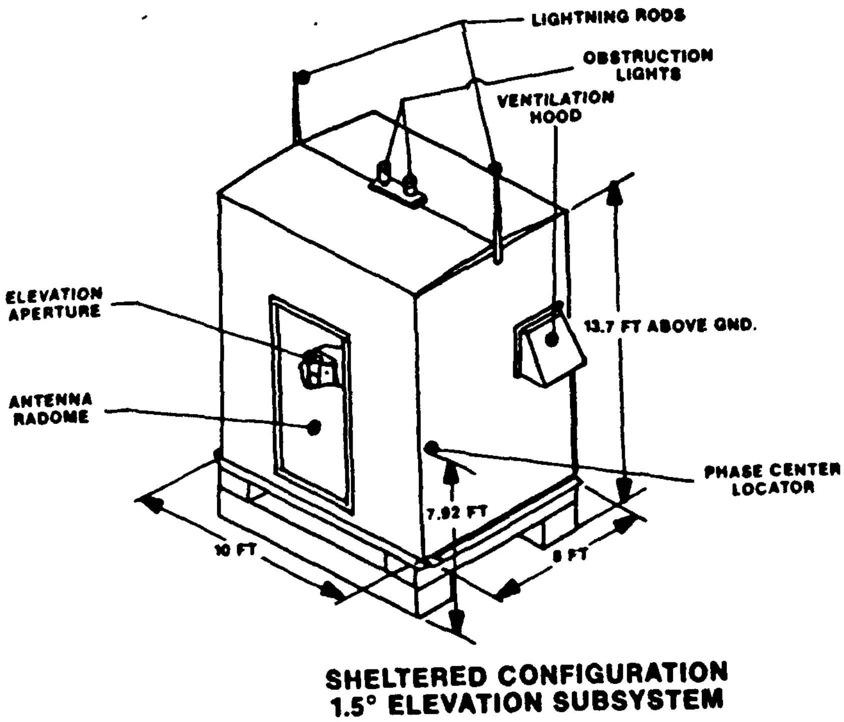


FIGURE 4. DRAWING AND MLS AZIMUTH AND ELEVATION STATIONS

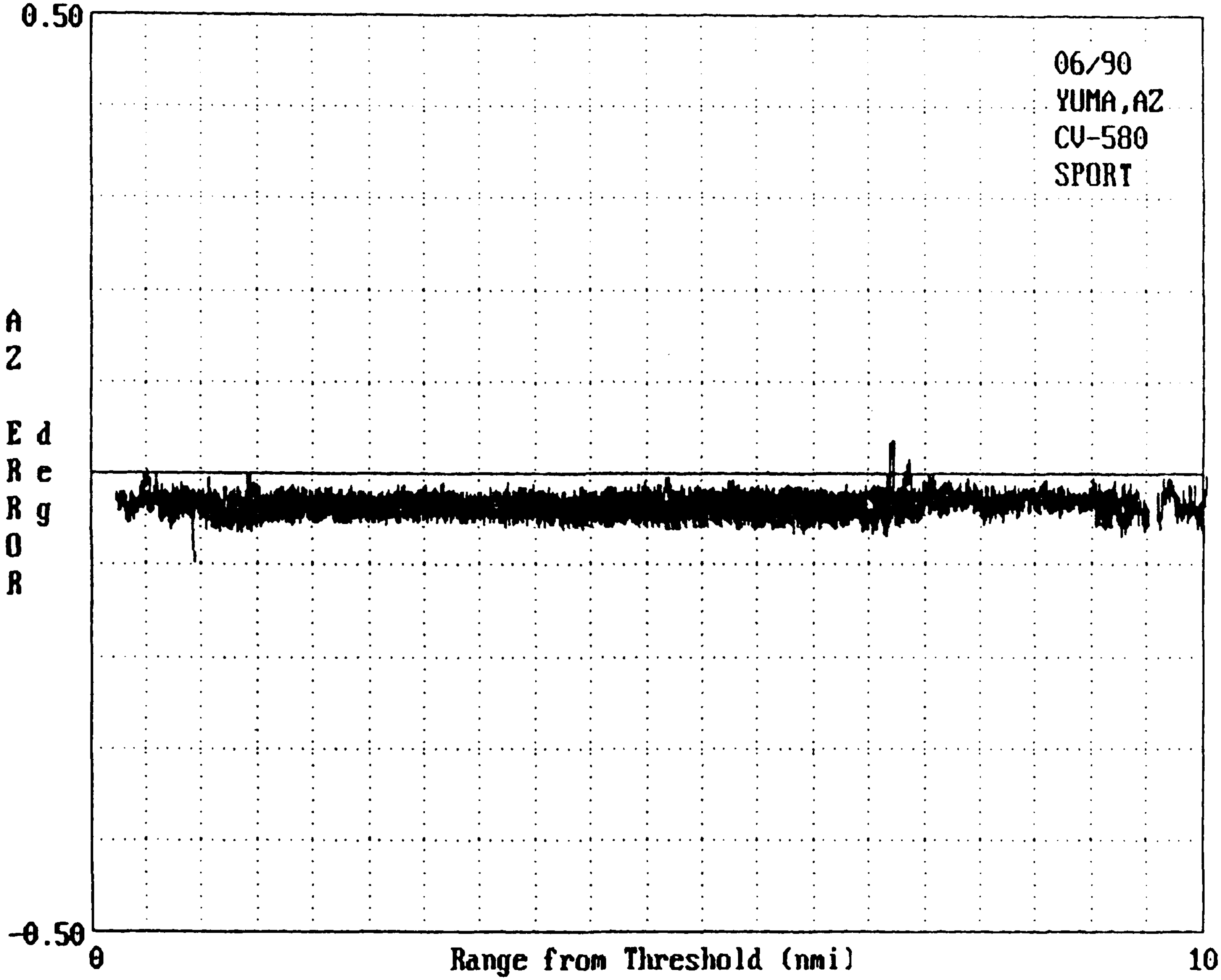


FIGURE 5. COMPOSITE RAW MLS AZIMUTH DATA FROM FOUR APPROACHES

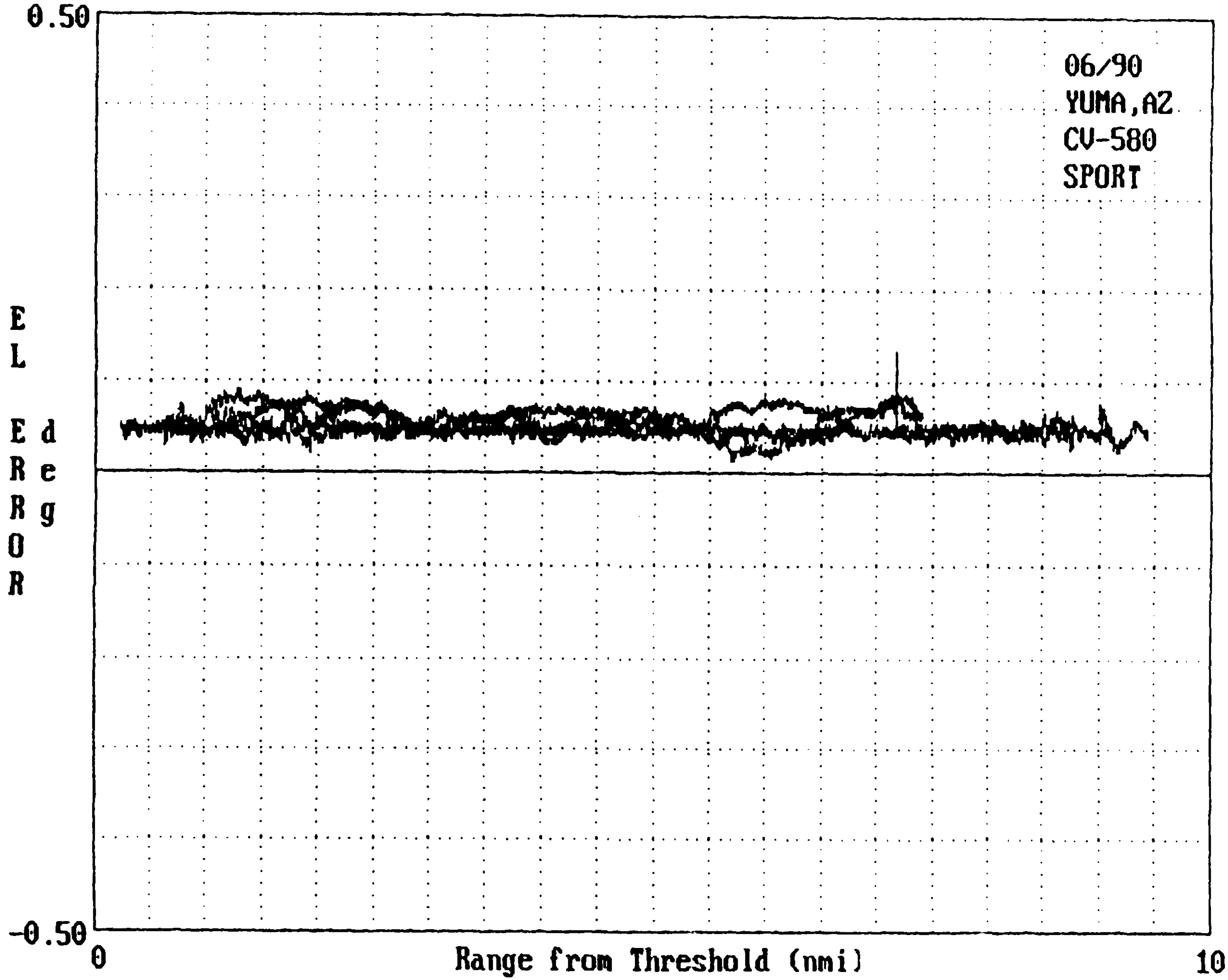
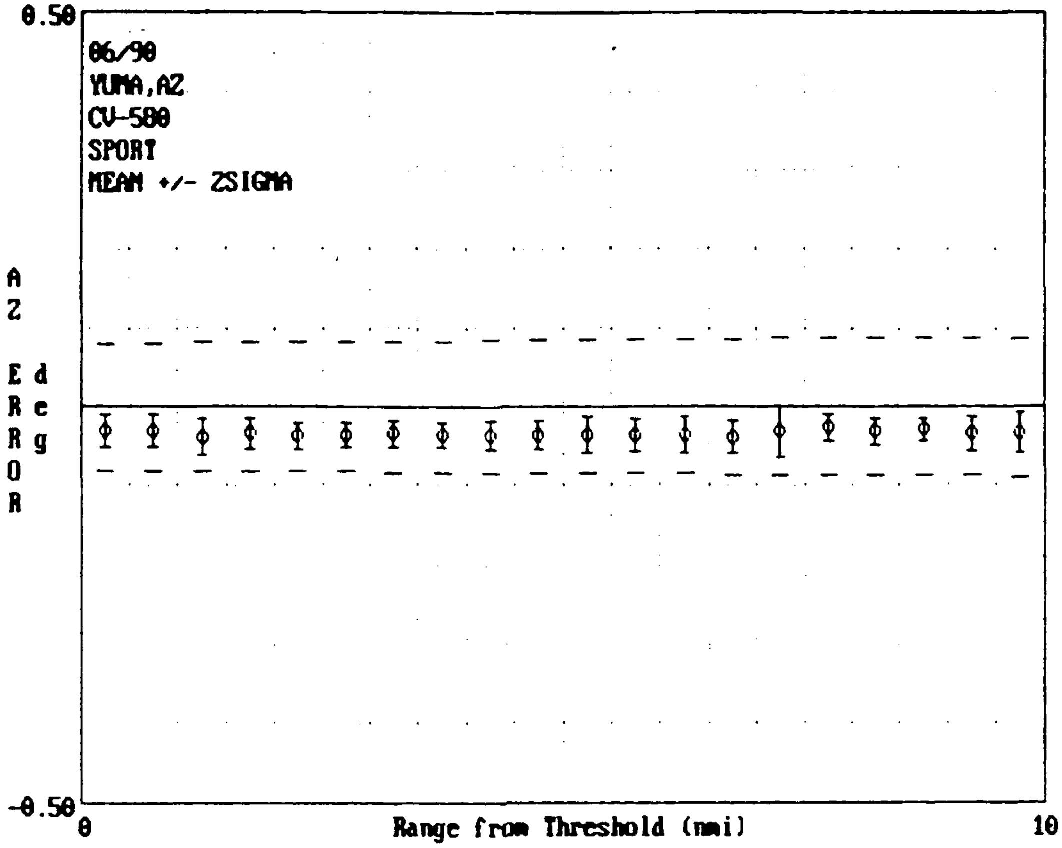


FIGURE 6. COMPOSITE RAW MLS ELEVATION ERROR DATA FROM FOUR APPROACHES



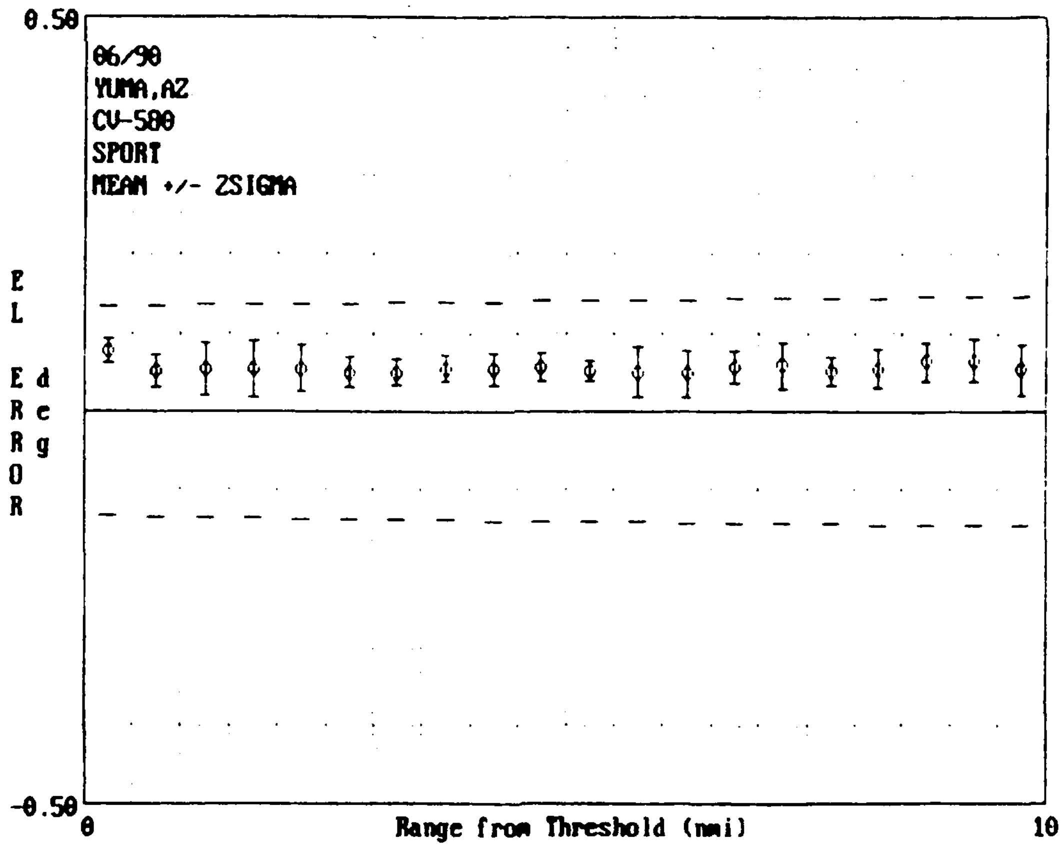


FIGURE 7. STATISTICAL MLS ERROR DATA FROM FOUR APPROACHES

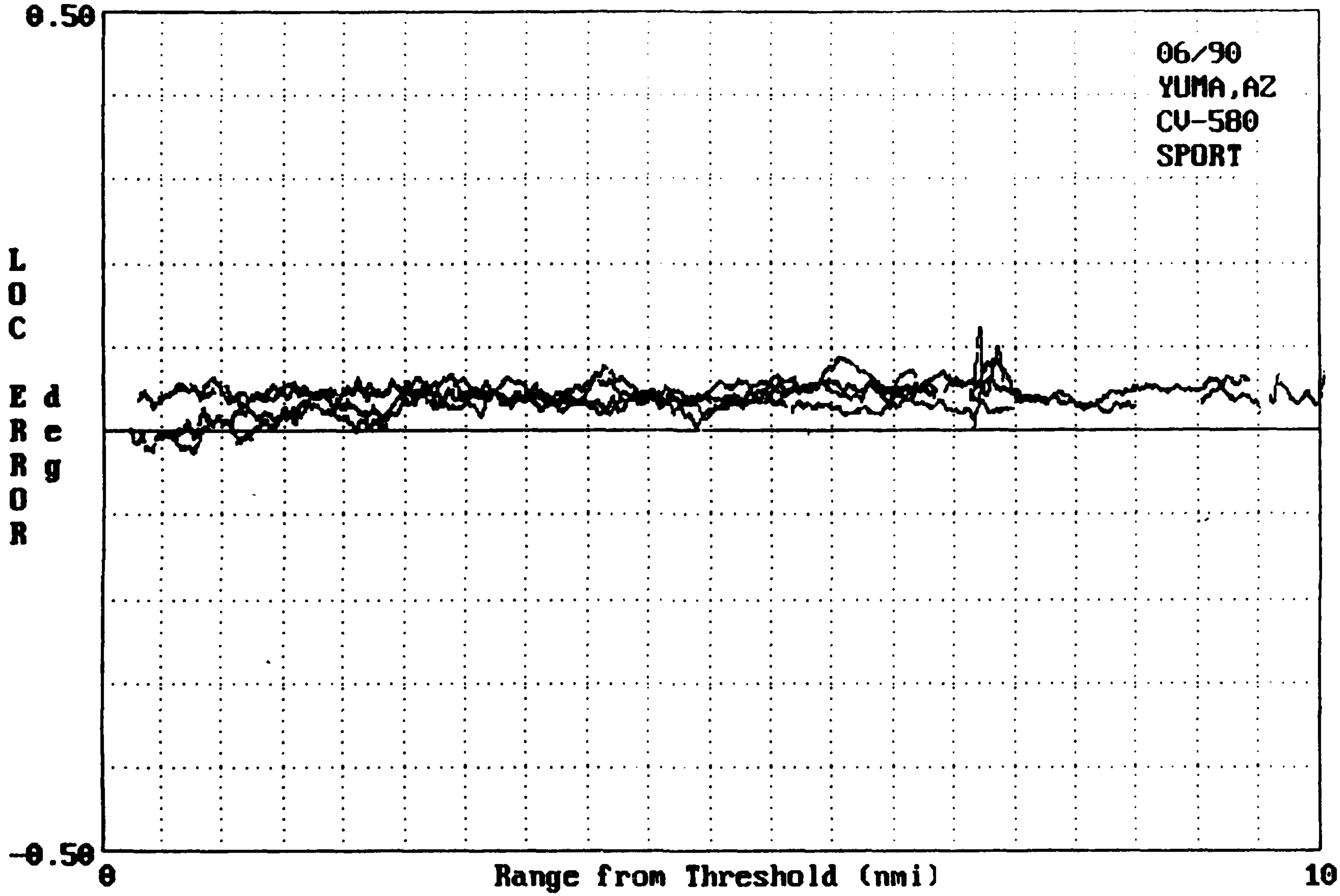


FIGURE 8. COMPOSITE RAW ILS LOCALIZER ERROR DATA FROM FOUR APPROACHES

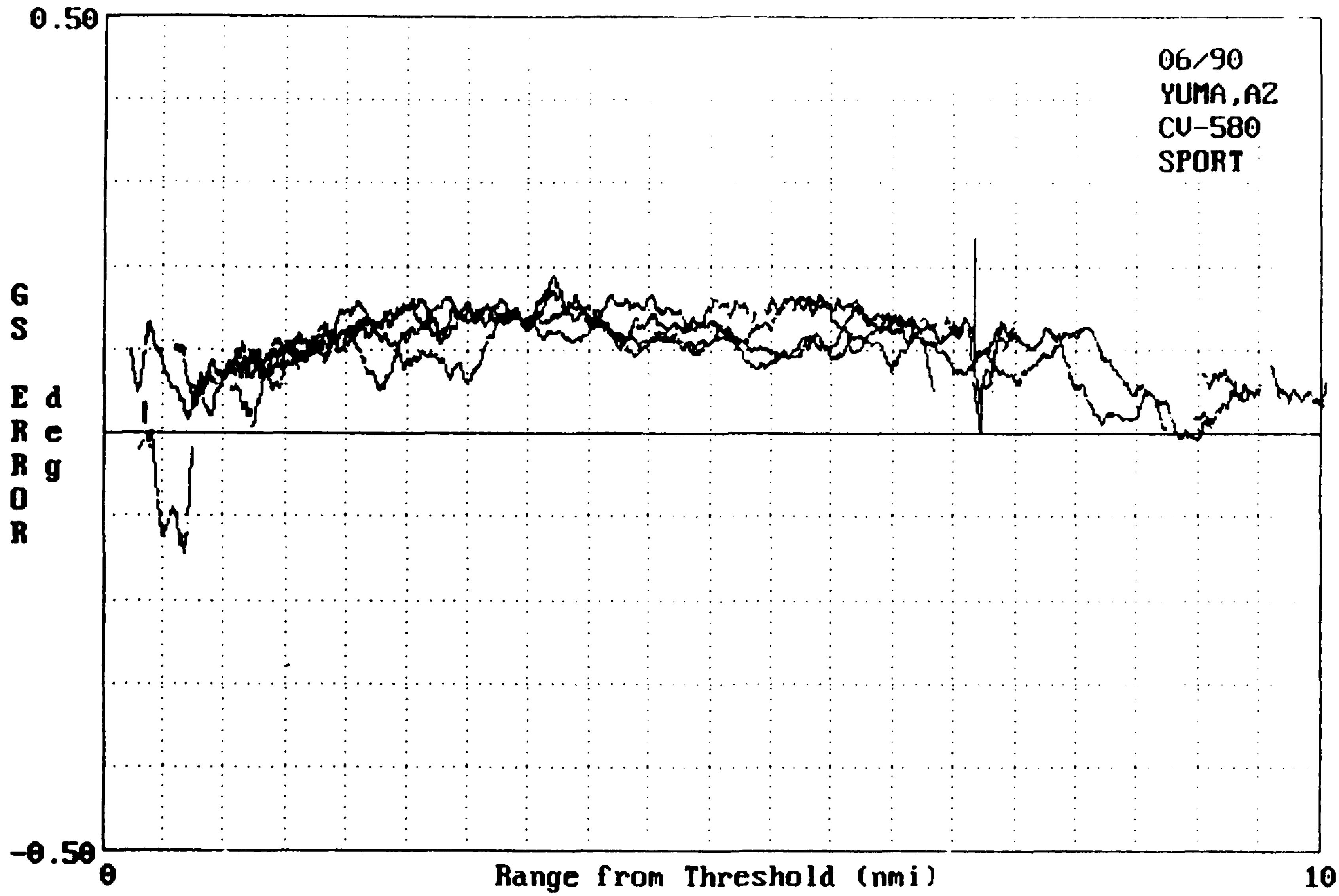
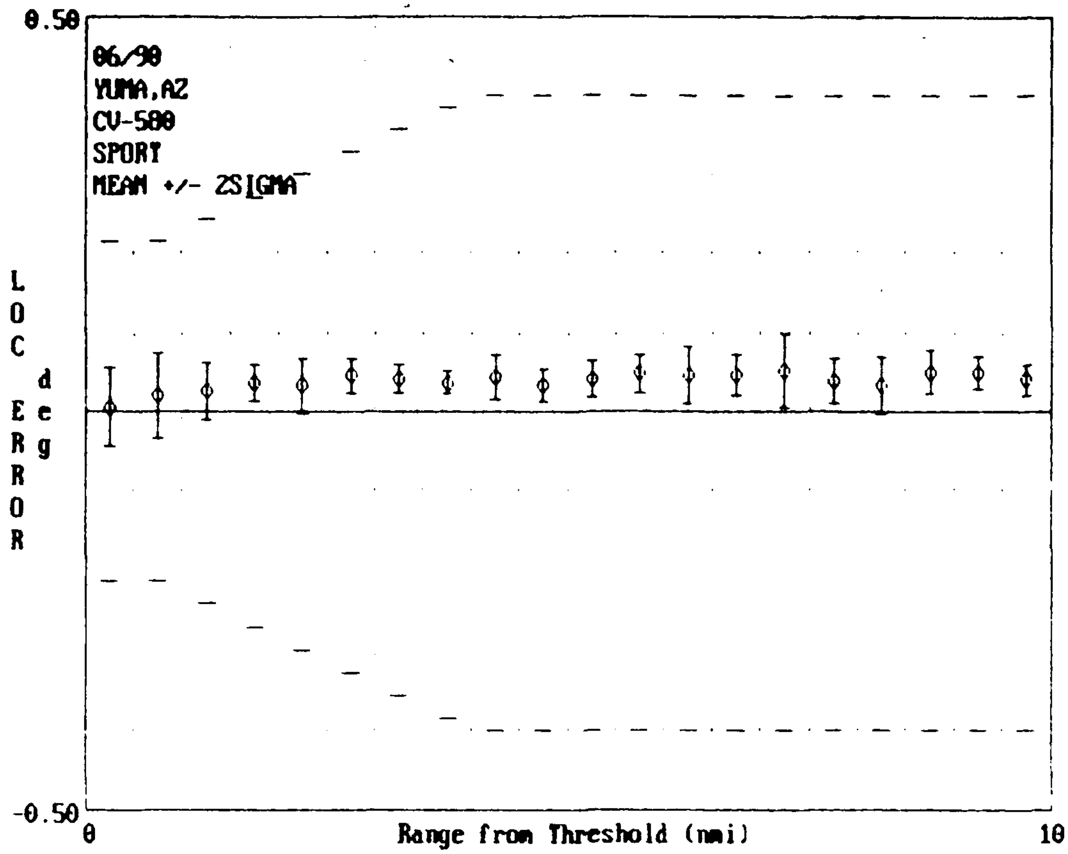


FIGURE 9. COMPOSITE RAW ILS GLIDESLOPE DATA FROM FOUR APPROACHES



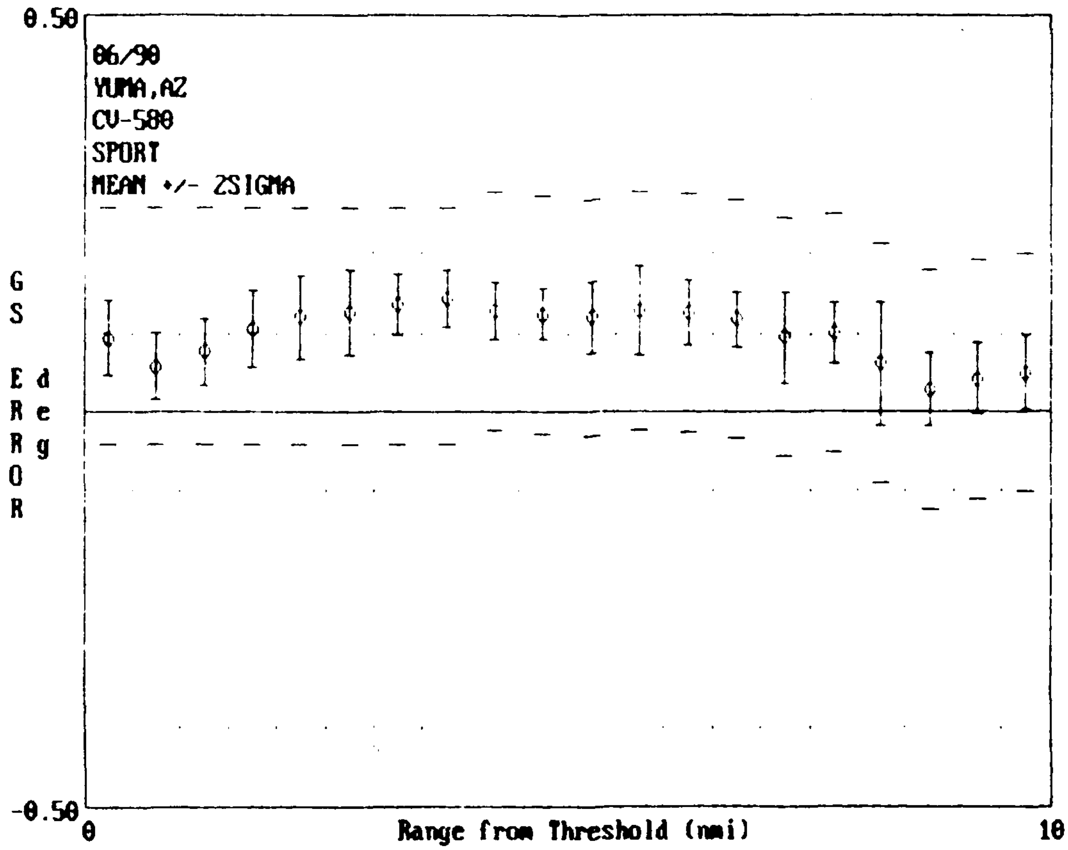


FIGURE 10. STATISTICAL ILS ERROR DATA FROM FOUR APPROACHES

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