FAA William J. Hughes Technical Center, ACB-430

Technical Memorandum

Date: 12/13/2003

To: File

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RE: Antenna Rotation

Background

The FAA has procured five Integrated Multipath Limiting Antennas (IMLAs), four of which are planned to be included in a new LAAS Test Prototype (LTP) installed at the William J. Hughes Technical Center. These IMLA's consist of the dBs-200 14-element dipole array (with double-wall radome) and the dBs-200A cross-V dipole High Zenith Antenna. The antenna serial numbers are 025, 026, 027, 028, and 029. Analysis of data collected using these IMLAs have shown that the bias trend observed is not consistent across all azimuths.

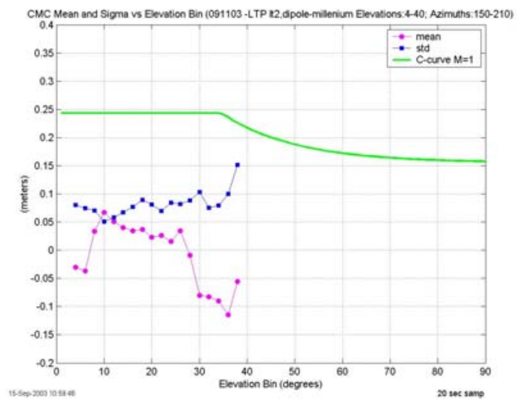
Test Setup

In order to assess the effect of any azimuth-dependent characteristics in the dbS-200, and to attempt to isolate their cause, data was collected as the antenna was rotated in –90-degree increments. At each rotational position, data was collected for a minimum of two 24-hour periods. The serial number for the antenna used is 026, and all data was taken with the antenna at an established LTP site (LT2). The mean and standard deviation versus elevation were plotted for six 60-degree azimuth bins for each day. This test was done twice—once with the dbS-200 inside of a vented double-wall radome with the HZA on top, and once with the antenna bare, with no radome, and with the HZA placed to the side on the ground. Additionally, as an example of the effect of the radome alone on antenna performance, two days of data with the vented double-wall radome on but without the HZA mounted on top were processed with the dbS-200 at its original position.

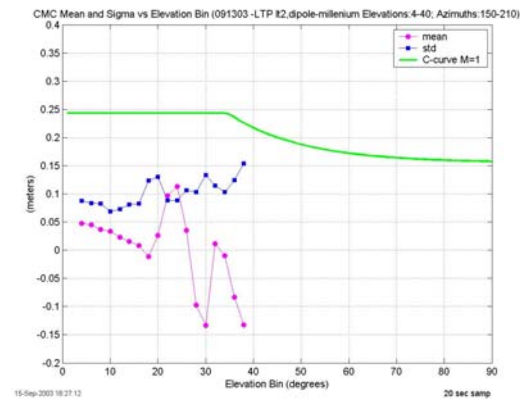
Test Results

The data was first examined at a fixed section of the environment. **Figure 1** shows the performance of the dipole, with the vented double-wall radome and the HZA on top, between azimuths 150 and 210 degrees for each of four rotational positions. The four plots show markedly different trends as the antenna is rotated. This discrepancy in the way four different 60-degree sections of the dbS-200 perform in the same environment indicates that the antenna must not have entirely homogeneous characteristics in all azimuth sectors. One reason for plotting data from the same azimuth sectors is to determine if there are errors present which may be due to environmental factors, such as multipath. These errors would appear similar regardless of the segment of antenna observing them. Analysis of these plots, as well as further analysis of plots of the CMC magnitude versus azimuth and elevation, indicated no presence of such errors. Plots of the five remaining 60-degree azimuth bins show similar disparities in performance as the antenna is rotated.

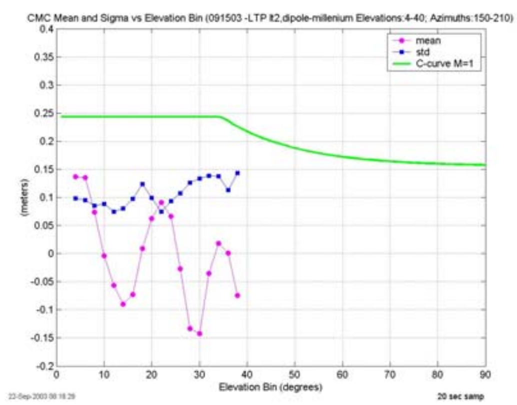
0 degrees rotation



90 degrees rotation CCW



180 degrees rotation



270 degrees rotation CCW

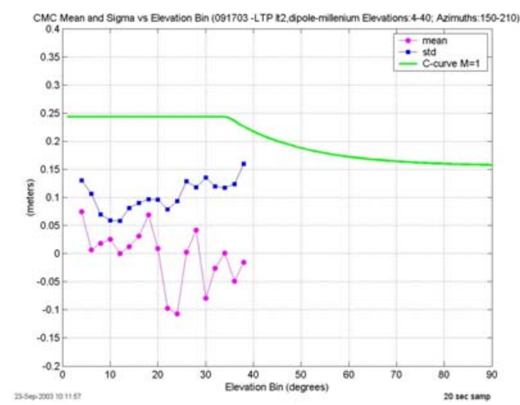


Figure 1: dbS-200 with vented double-wall radome and HZA, data from 150-210 degrees azimuth

Next, the data from a fixed segment of the antenna, as it was rotated through different environments, was considered. **Figure 2** shows the performance of the portion of the antenna that was originally located between 270 and 330 degrees azimuth as it is rotated by 90-degree increments (to 180-240, 90-150, and finally, 0-60 degrees azimuth). The similarities in the trends seen in these four plots are considerable—the most prominent dip in mean occurs at 30-32 degrees elevation, largest peak at 22-24 degrees, etc. This shows that performance within a given azimuth bin can be traced back to the section of antenna that was observing it. Sets of plots for the other five 60-degree portions of the antenna show comparable results.

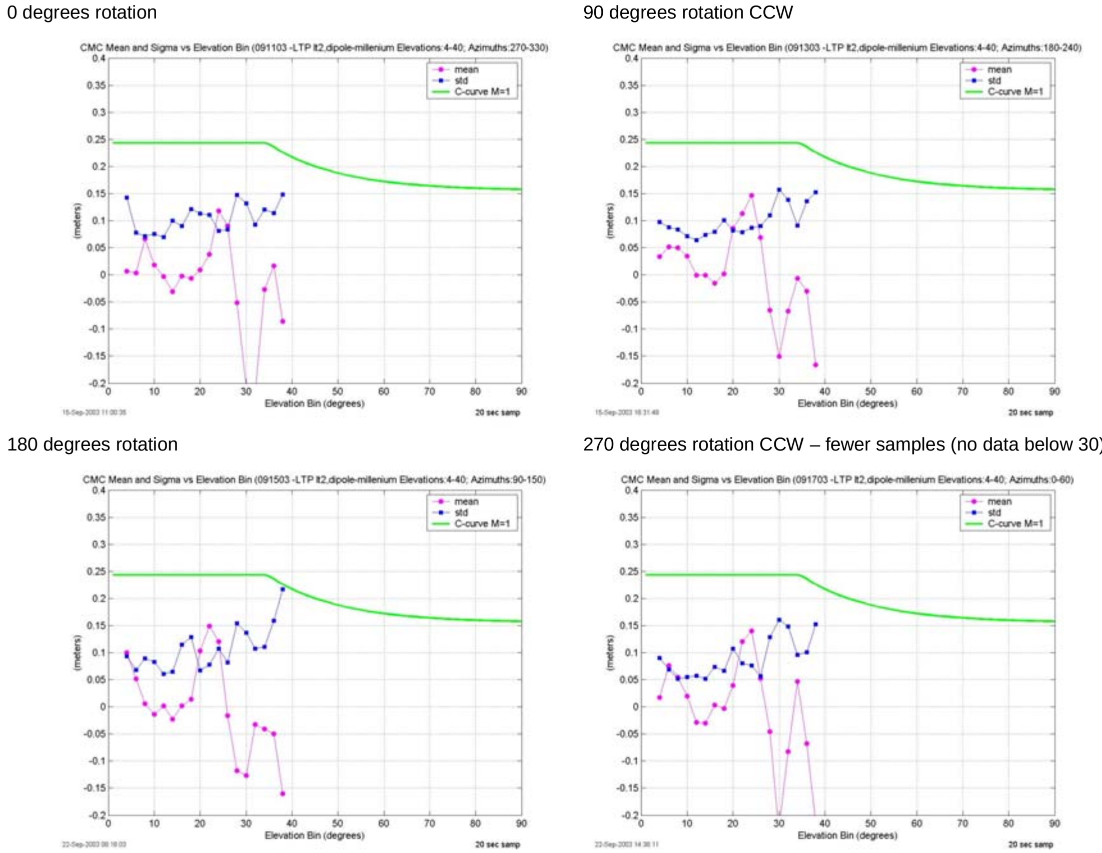


Figure 2: **dbS-200 with vented double-wall radome and HZA, data as observed by antenna sector originally at 270-330 degrees azimuth**

Since previous tests have shown that the radome can affect the overall antenna performance, the four 90-degree rotations were repeated with no radome on. This set of data was collected without the HZA atop the dipole array. The plots shown in **Figure 3** display the trends seen in the 150 to 210 degree azimuth sector as the antenna was rotated. The trends shown here are significantly more similar to one another than those seen in the same azimuth bin with the vented double-wall radome intact (**Figure 1**)--particularly at elevations above 25 degrees. However, there are notable differences between the trends at lower elevations. Mean trends in data from the other five 60-degree azimuth bins show a similar amount of correspondence.

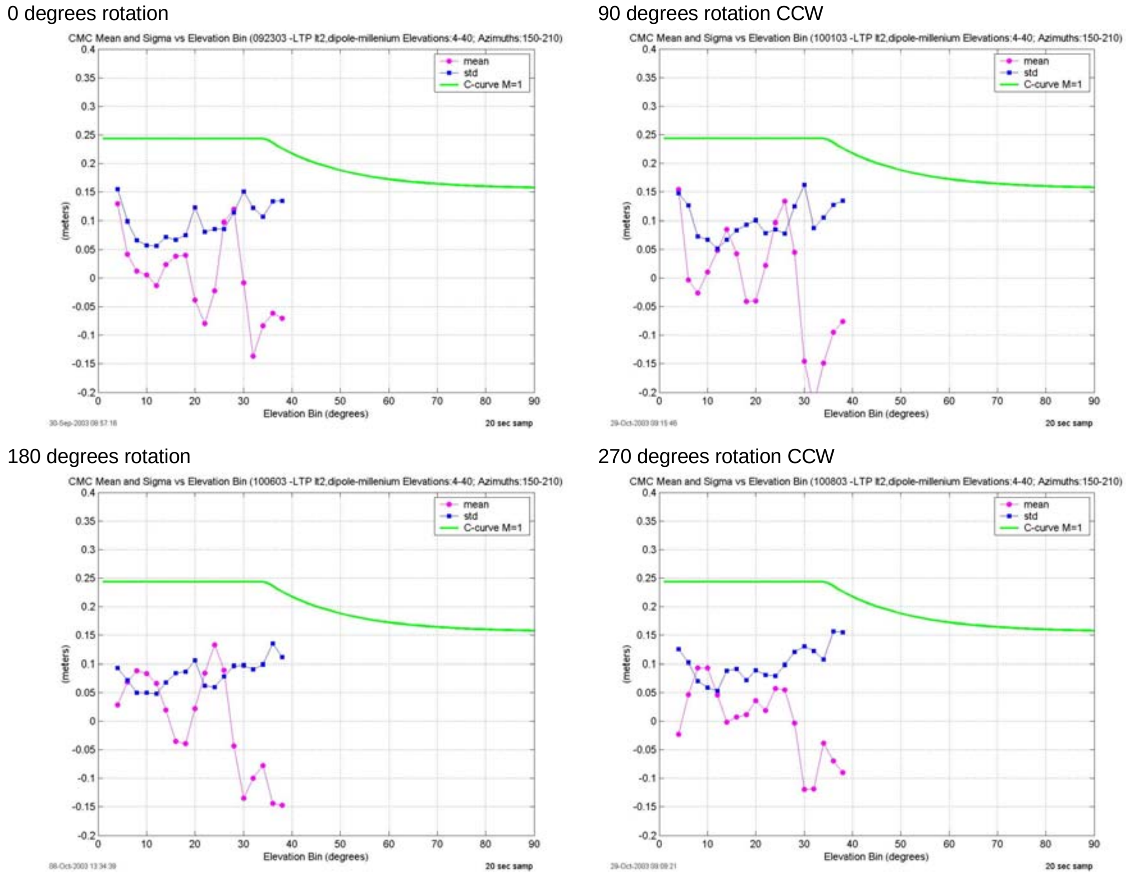


Figure 3: dbS-200 with no radome and no HZA, data from 150-210 degrees azimuth

Figure 4, below, shows performance plots for the section of the dipole, still with no radome and no HZA, which was originally at 270 to 330 degrees azimuth at four positions (270-330, 180-240, 90-150, and 0-60 degrees azimuth). The characteristics of the trends seen in these plots are not as similar to one another as those seen in the case with the radome and HZA in place (as shown in **Figure 2**). In this instance, the highest peak occurs anywhere between 20 and 30 degrees elevation, and the first major dip is seen at 14, 16, or 18 degrees. Much less variability in the location of these points was seen with the vented double-wall radome and HZA present.

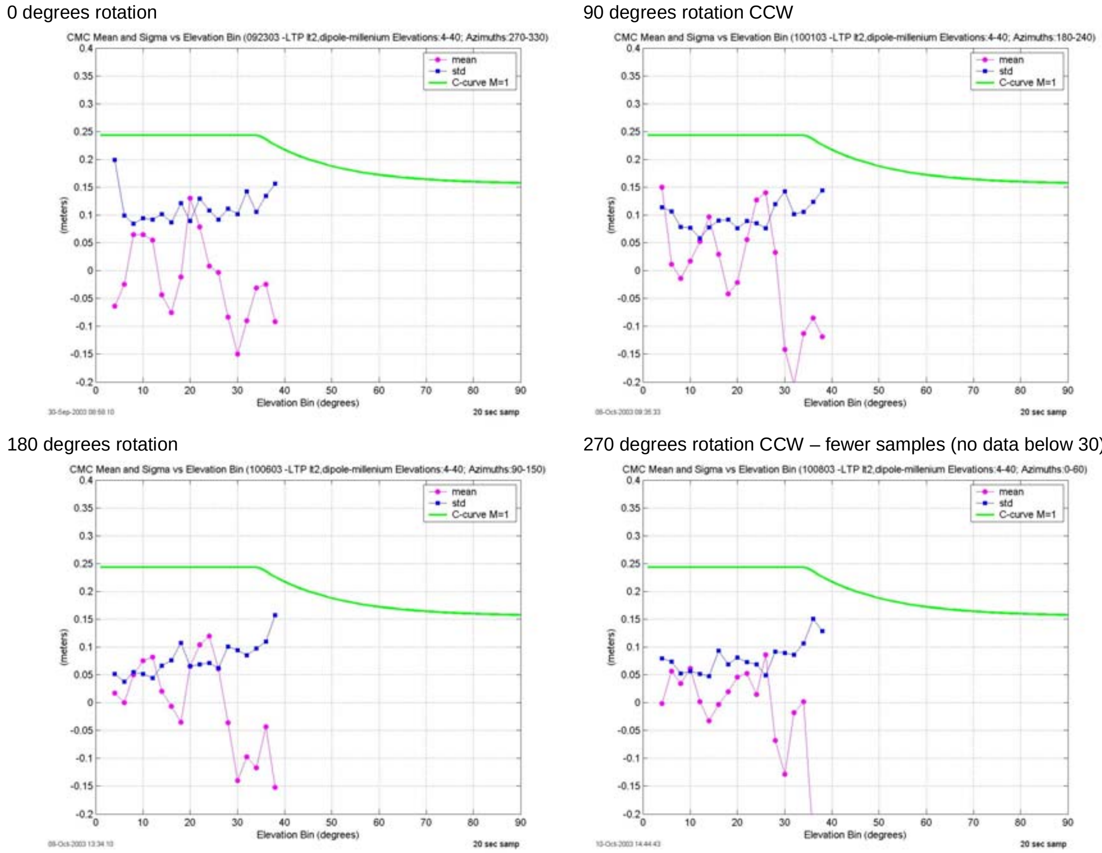


Figure 4: dbS-200 with no radome and no HZA, data as observed by antenna sector originally at 270-330 degrees azimuth

The fact that the data collected with no radome or HZA in place shows significantly less disparity between trends in the 150-210 degree azimuth bin implies that the bare dipole is much more uniform across azimuths than it is with the radome and HZA present. The data showing that the trends from one 60-degree section of antenna do not remain as constant as they did with the radome and HZA present further this point; there appears to be only weak azimuth-dependent characteristics within the antenna core which move along with the rotation of the antenna. This leads to the conclusion that a good deal of the azimuth dependency of the antenna is due to either the presence of the radome, in this case a vented double-wall, the HZA, or a combination thereof.

To further explore this, data from the antenna's original position--before any rotation was made--with the radome on, but the HZA sitting nearby on the ground rather than on top of the dipole, was collected and processed. **Figures 5a**, **5b**, and **5c** show the performance of the antenna between 90 and 150 degrees azimuth with no radome and without the HZA, with the vented double-wall radome and without the HZA, and with the radome and the HZA, respectively. These plots show that adding the vented double-wall radome to the bare dipole core causes significant changes to the antenna performance. Then adding the HZA to the top of the radome-covered dipole further modifies the trend in the mean. Changes such as the ones seen in the Figure 5 plots can be observed in each of the 60-degree azimuth bins.

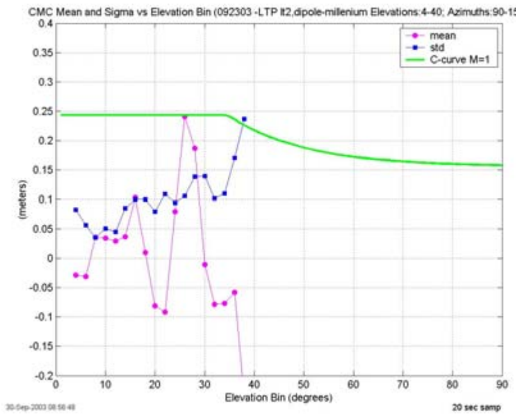


Figure 5a:
dBs-200 with no radome and no HZA, data from 90-150 degrees azimuth

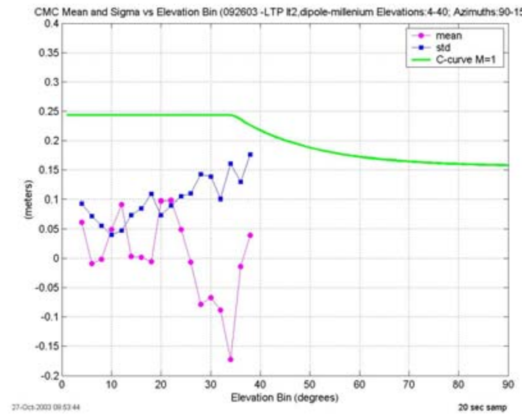


Figure 5b:
dBs-200 with vented double-wall radome and HZA not mounted on top, data from 90-150 degrees azimuth

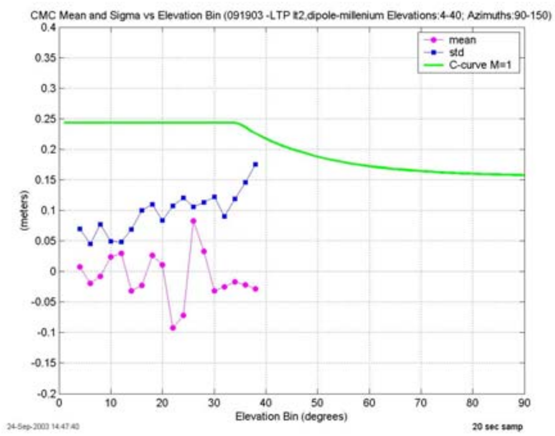


Figure 5c:
dBs-200 with vented double-wall radome and HZA, data from 90-150 degrees azimuth

Summary and Conclusions

Testing was performed to observe possible azimuth dependencies of the bias seen on the dbS-200 antenna. Testing with the dbS-200 housed inside of a vented double-wall radome and with the HZA mounted on top of it show the presence of azimuth-dependent trends far more conclusively than testing with the antenna bare (with no radome at all) and with the HZA placed on the ground. This suggests that a good deal of the variation in performance versus azimuth may arise from the presence of the radome and/or the HZA, rather than from the dbS-200 core itself.

Observations made with the dbS-200 at a constant position with no radome or HZA present, with only the radome, and with the radome and the HZA intact clearly show that both the vented double-wall radome and the HZA both have a very significant effect on the performance of the antenna.