ELECTROMAGNETIC AND STRUCTURAL CONSIDERATIONS IN TARGET SUPPORT DESIGN

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ABSTRACT

This paper will address low RCS target mounting systems. Structural and electromagnetic aspects will be considered. The 4:1 vs the 7:1 ratio ogival shell pylons will be evaluated with consideration given to structural integrity, electromagnetic scattering, and positioner size. Measured and analytic data will be used in these evaluations.

KEYWORDS: PYLON, TARGET MOUNTING, OGIVE RATIO, TERMINATIONS, MEASUREMENT

INTRODUCTION

When designing either an indoor or outdoor radar cross section measurement facility there are several components which must be properly selected to obtain optimum performance of the system as a whole. For an indoor range these components include the chamber and absorber, the compact range reflector/feed system, the target mounting system, and of course the radar. Key components of an outdoor system are the construction and environment of the range, the radar feed system and the target mounting system.

If the assumption is made that a facility has an ideal reflector, radar, and absorber layout the selection of a practical high performance target mounting system is critical. Otherwise range performance may be unnecessarily limited by the target mounting system. The word "practical" is important since there are many different approaches to supporting and positioning lower level targets. For this discussion a practical target mounting system is defined as a system which:

1) Has low radar return over a broad frequency range.

2) Is structurally stable.

3) Can adjust and report target position very accurately.

4) And can be used with a broad range of target sizes and shapes.

There will always be some targets for which a specialized support system is required, but a majority of targets can be accommodated with a standard positioning system.

APPROACHES TO TARGET MOUNTING

Various types of target mounting systems have been used over the years. Foam columns have been built in several configurations such as cylindrical, fluted (for frequency tuning), diamond shaped, tear drop shape, cone shaped, and many others. There are certainly some definite advantages as well as disadvantages to this classical approach. The foam column has significant weight capacity vs background level limitations. Measurements of large targets with low RCS are definitely background limited using foam columns. Another drawback is that conical cuts are not practical.

Another commonly used system is an arrangement of strings which are individually manipulated to position the target smoothly. This system is not very practical for large, heavy targets. With this approach some models have to be reinforced in several places to provide structurally sound attachment points for the strings. Additionally, accurate position data is difficult to obtain. Some work is being done with these systems to improve accuracy and model stability, but at this time they are fairly complex and unreliable.

The most practical approach in current use is the metal ogival column. This system usually includes a through shaft drive or an azimuth-over-elevation positioner at the top for target positioning. This approach is normally a good compromise between the return introduced into the measurement by the positioning system and the stability and position accuracy which can be obtained.

PYLON DESIGN CONSIDERATIONS

Regardless which mounting system is used, the idea is to minimize the background or backscatter from the target zone when the target is not present. While minimizing this unwanted return is the main objective, the practical aspects of target handling, stability and structural integrity must also be considered. In order to interface to the largest variety of targets it is beneficial to minimize the size of the rotator and the column itself. The rotator size is usually limited by the elevation and azimuth torques which it must deliver. The rotator size is also dictated by the width of the pylon column to which it must attach. The dimensions of the column are dictated by the load capacity and the stiffness required for accurate data.

Operating loads experienced by support columns are the vertical and horizontal forces created by the target, and bending moments generated when the target is not precisely balanced at the center of attachment. Because of its shape, an ogive has a weak and a strong axis in bending. The bending stresses caused by moments about the weak axis of the column are typically the driving factor in its design.

Figure 1 shows an ogive in cross section. If dimension "A" is held constant, minimizing dimension "B" would do two things. It would reduce the radar cross section of the shape, and it would reduce its ability to carry load. Many ogival columns have been built in many different ratios but the most common seem to be the ratios 4:1 and 7:1. If two pylons are built with the same "A" dimension, one a 4:1 and the other a 7:1, the 7:1 pylon will definitely have the lower radar cross section. If, however, one builds two pylons which are capable of supporting the same side bending moments, the increase in size required will make the return of a 7:1 ogive almost identical to a 4:1. Figure 2 shows how the "A" and "B" dimensions change as the ratio is varied for a pylon whose bending moment capacity is held constant.

The expected radar returns of two pylons with equivalent bending moment capacities are shown in Figures 3 through 6. Pylon ratios of 4:1 and 7:1 were compared. The returns were obtained by modeling the two pylons with horizontal and vertical polarizations using a_backscatter signature modeling technique. The results obtained for the 4:1 pylon were compared against actual measured data for a 4:1 pylon measured in Scientific Atlanta's compact range facility. The figures show that the radar cross section of these two pylons should be very similar.

The selection of the most practical ogive ratio is also affected by the pylon's interface to the rotator. In order to provide a low cross section interface, the pylon has to fit inside the rotator diameter through the rotator's full elevation travel. As the pylon ratio increases, dimension "A" of the pylon has to be increased to maintain the same capacities. Since this dimension influences the diameter of the rotator which would mount on the pylon, the size of the rotator will typically be larger with a larger ratio. Scientific-Atlanta selected the 4:1 ogive as the best compromise between structural integrity and electromagnetic backscatter for the design of its standard line of pylons.

DETERMINING THE PYLON BACKSCATTER

Background level is typically defined as the return from the measurement environment without the target. This background determines the target level that can be measured without extraneous signal level interference. Background is a difficult quantity to measure in the case of a pylon, because the un-terminated end of the pylon has a much higher return than the ogival column will have when properly terminated. There is a need, then, for a standard target (or termination) that will have a lower radar cross section than the pylon itself. To accomplish this, Scientific-Atlanta contracted Ohio State Electromagnetic Science Lab to design and build a pylon termination. The termination was designed to be used with any of Scientific Atlanta standard product rotators. This particular design has an additional advantage in that the low backscatter and flat top allow it to be used as a ground plane for antenna or other special measurements.

The termination is 3 meters long and weighs approximately 100 lbs. The surface has a flat region on the top and bottom. The top has a flush mounted access plate approximately 1 meter long with a perimeter radius of .9 meters. The access plate is secured with flush head screws. There are three symmetrically positioned lifting points for termination installation. The bottom flat region accommodates a rotator (see figure 7).

Preliminary data obtained by both Ohio State and Scientific Atlanta indicates the body can be used down to a frequency of 2 GHz. Measurements were made by taking data of full azimuth cuts in several elevation angles. The best results were obtained with an elevation angle of +2 degrees (see figure 8). The data was expanded in a +/- 2 degree azimuth area around the nose to show better definition. From this information it appears that the termination/pylon combination has a background level of approximately -55 dBsm at 10 GHz in the horizontal polarization (figure 9). This data is in agreement with the data calculated using the modeling technique. Figure 10 shows the same data at vertical polarization, and again, is in good agreement with the theoretical model of the pylon. Agreement of these separate data are important because it increases the confidence level of the comparison between the 4:1 and 7:1 backgrounds.

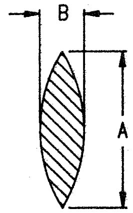

FIGURE 1

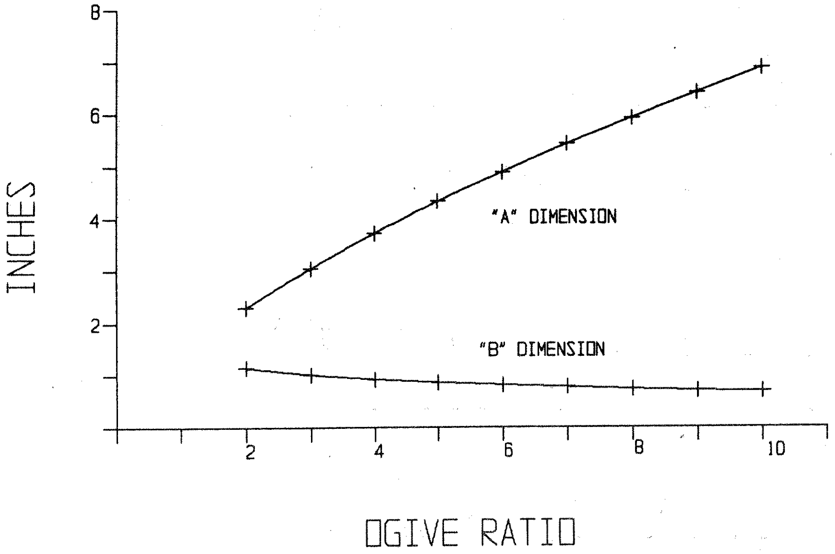

FIGURE 2

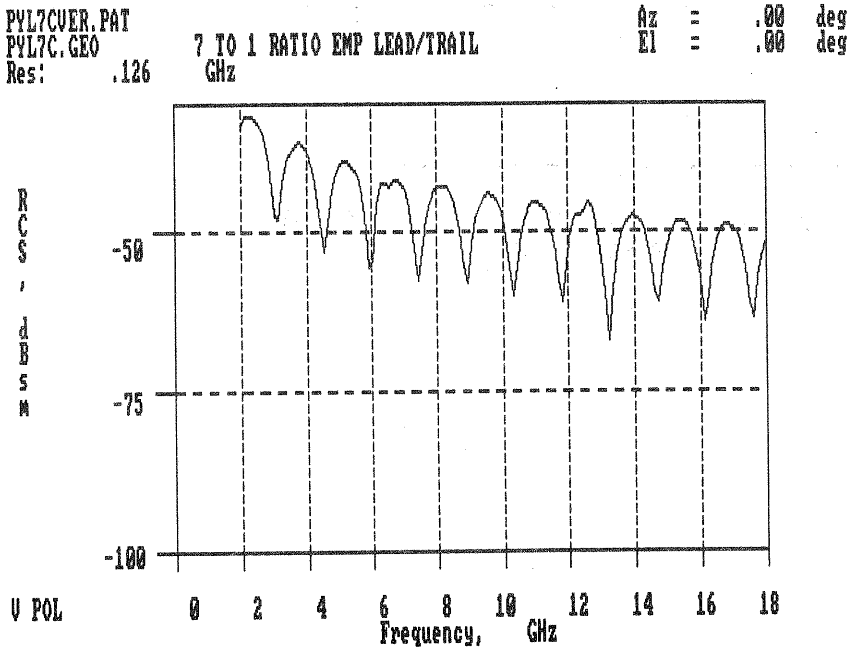

FIGURE 3

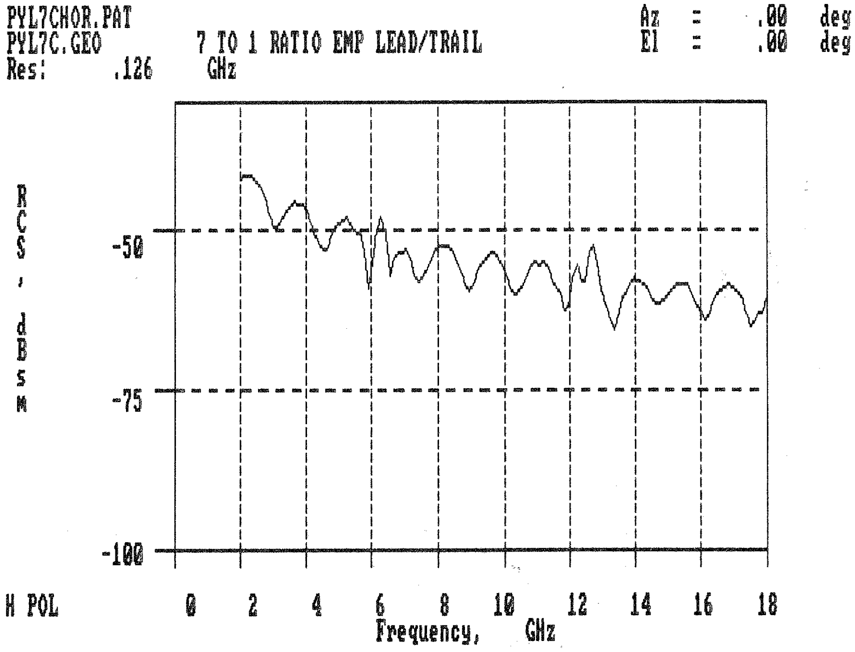

FIGURE 4

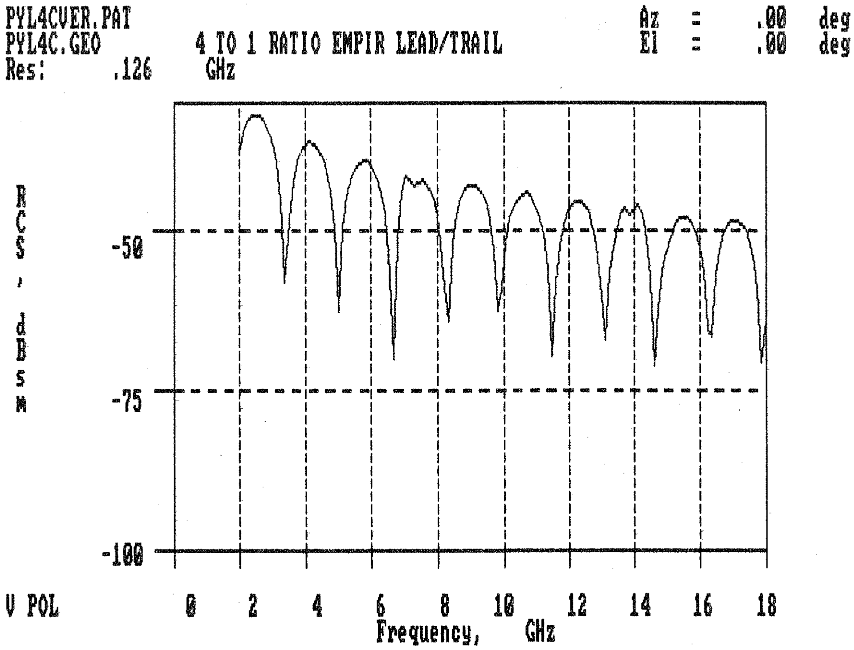

FIGURE 5

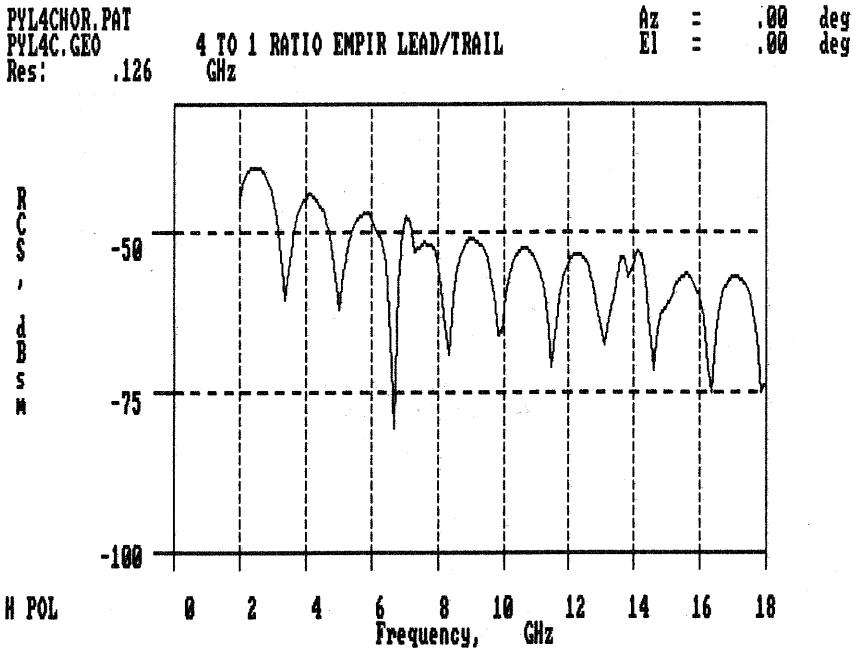

FIGURE 6

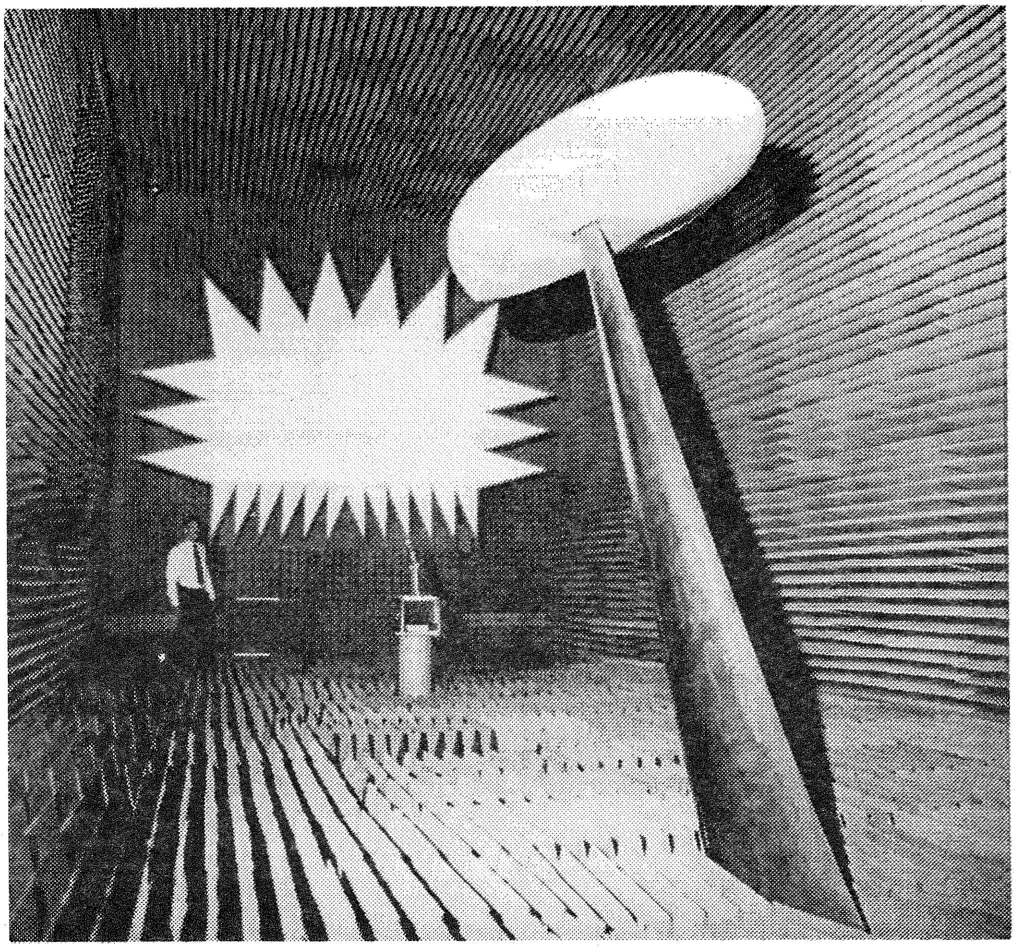

FIGURE 7

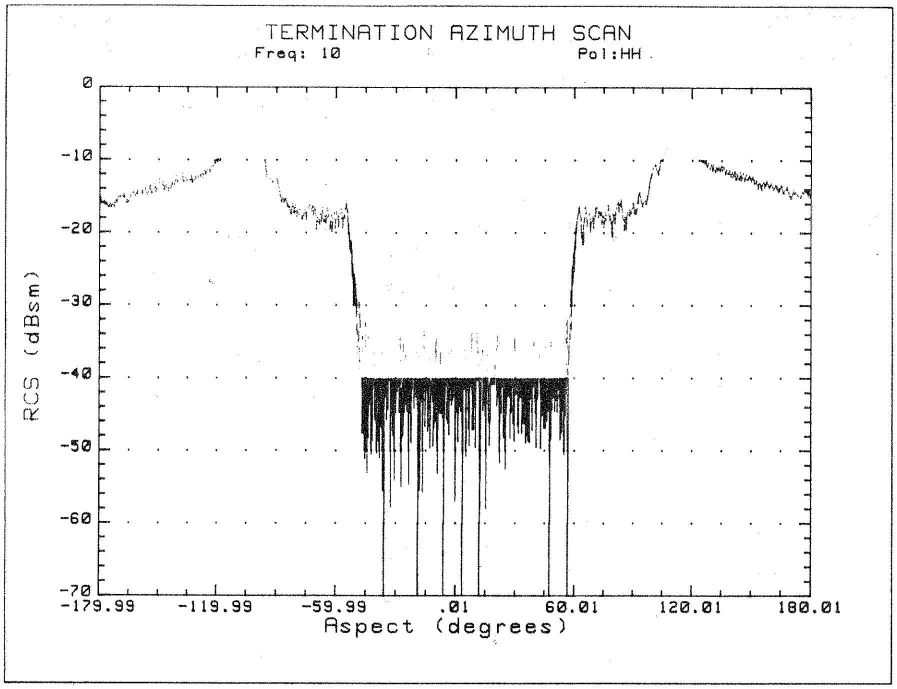

FIGURE 8

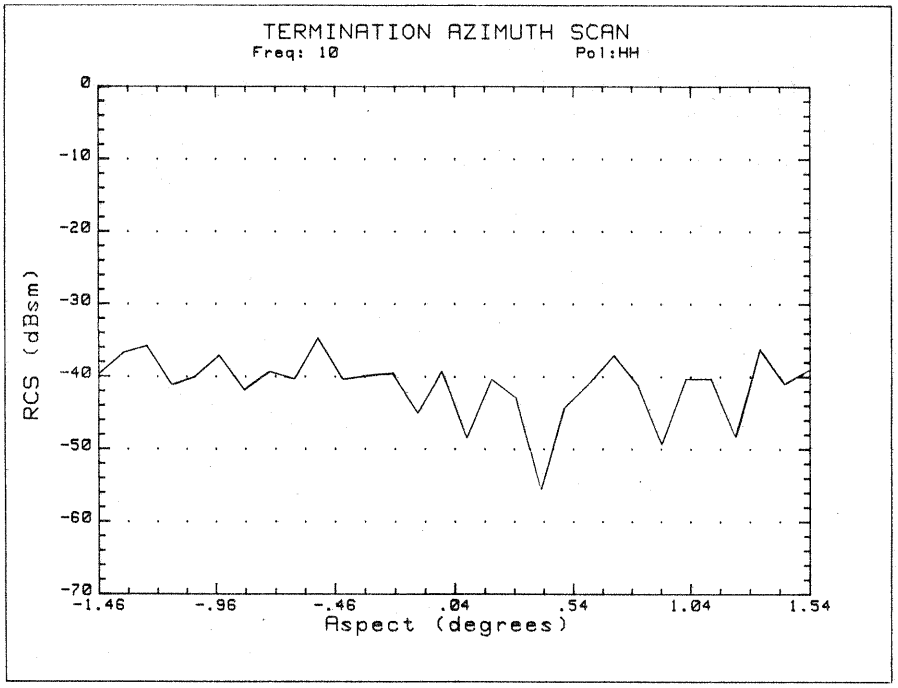

FIGURE 9

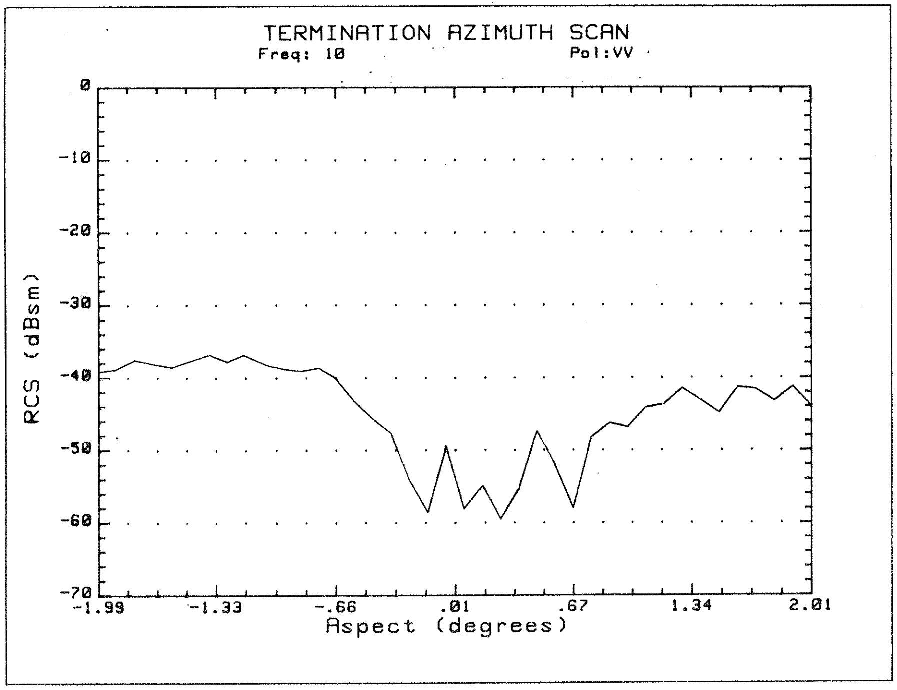
TERMINATION AZIMUTH SCAN
Freq: 10
Pol:VV
RCS (dBsm)
0
-10
-20
-30
-40
-50
-60
-70
-1.99
-1.33
-.66
.01
.67
1.34
2.01
Aspect (degrees)

FIGURE 10

NOTES