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METAL SPACE FRAME RADOME

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OTTAWA

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ABSTRACT

A full-scale mock-up of a 55-foot metal-space-frame radome designed at Lincoln Laboratory has been tested over an AN/FPS-6 antenna. This radome employs a random geometry and, as was expected, very few scatter side lobes were located — the largest being 33 db below the main beam. Two other side lobes at -40 db were also located.

Transmission tests indicated a one-way reduction in field strength of 7% to 8.5% — an average of 0.7 db.

The VSWR of the antenna alone was 1.04, while with the radome in front of the antenna the VSWR varied from 1.01 to 1.07, depending on the antenna-radome orientation.

The maximum vertical boresight error at 2800 mc/s was measured to be 0.15 milliradian. A similar test made with a modified AN/FPS-6 antenna operating at 6000 mc/s showed a boresight error of 0.18 milliradian. However, it is probable that a smaller error would be observed with a properly designed antenna.

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METAL SPACE FRAME RADOME

- W. Lavrench -

INTRODUCTION

When CW-396A radomes were installed over AN/FPS-6 radar antennas, severe ground clutter occurred at some of the sites. It has since been shown [1] that this ground clutter is caused by energy scattered by the many parallel equidistant flanges on the CW-396A radome panels.

The CW-396A radome is an early design and is based on the icosahedron, each triangle of which is subdivided into 36 essentially equilateral triangles. This procedure results in a simple design with a minimum number of different types of panels; however, the resultant parallel flanges act as a diffraction grating and produce several sets of side lobes which account for the excessive ground clutter. Since many of these side lobes lie below the main beam, ground clutter exists even when the beam is well elevated.

At the time that the CW-396A radomes were being installed over the AN/FPS-6 radar antennas, a metal-space-frame (MSF) radome with a more random geometry was under development at Lincoln Laboratory. Scale model tests at Lincoln Laboratory [2] indicated that the radome would be suitable for use over the above antennas. The prototype radome was subsequently installed by Rome Air Development Center at one of the sites and its performance evaluated. First indications were that the performance was not much better than had been the case with the CW-396A radome.

Concurrently with the above, design studies on an MSF radome with a random geometry were under way at the National Research Council. When it became apparent that the Lincoln Laboratory prototype was near completion and that the NRC radome would have no significant advantages, design work was terminated.

It was felt that a greater contribution would be made by subjecting the Lincoln Laboratory design to a full-scale test over an AN/FPS-6 antenna. This decision became all the more important in view of RADC experience with the MSF radome at the operational site.

LINCOLN LABORATORY MSF RADOME

This radome, also based on the icosahedron, has a much more random layout of panels than the CW-396A radome. Each major triangle is subdivided into 40 triangles. A triangular panel consists of three metal edges to which a dielectric membrane is bonded. A cross section of the joint between two panels is shown in Fig. 1. For additional strength, small gusset plates are welded to the corners of the panels.

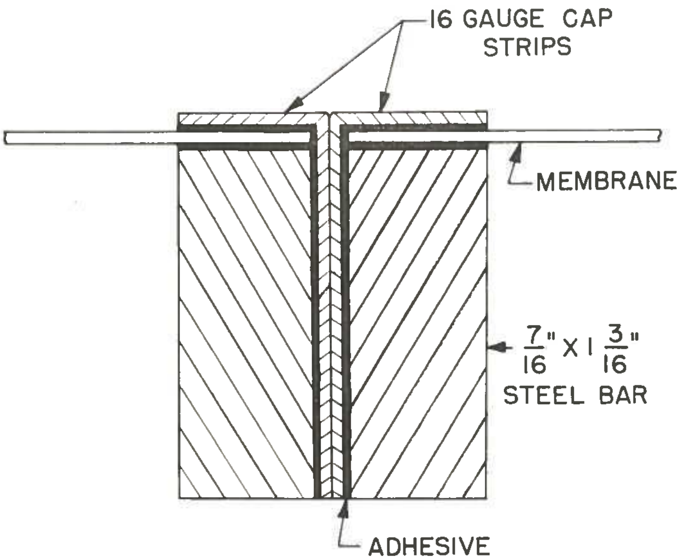

Fig. 1 Cross section of joint between two panels of the Lincoln Laboratory metal-space-frame radome

For the tests at the National Research Council, a simplified design was adopted to duplicate this radome. The membrane was discarded, as its effect on performance is negligible compared with that of the metal struts. The two metal bars at the panel edges were replaced by a single $1\frac{1}{8}" \times 1\frac{1}{8}"$ bar. The ends of the bars were bolted to 6-inch steel disks in which accurately positioned holes had been drilled. These metal disks, at the same time, simulate the gusset plates in the original design. In this manner, one-third of a radome was erected at the radome test site, as shown in Plate I. By rotating the radome test stand, measurements with, and without the radome can be made. The test site used has been described elsewhere [3, 4]. Most of the tests were done with the AN/FPS-6 antenna operating at 2800 mc/s, in order that comparisons could be made with results obtained when the CW-396A radome was tested [1].

Transmission

Rotation of the radome section about the antenna shows a reduction in one-way field strength of 7% to 8.5%. A typical plot of transmission is shown in Fig. 2. The large dips in transmission are caused by the three radome supports.

Radiation Patterns

Many radiation patterns were taken to locate possible scatter side lobes. Nothing extraordinary was found. The largest side lobe located was 33 db below the peak of the main beam. Only one of this size was found. Two side lobes at about -40 db were also located. In view of this somewhat negative result, it is felt that a three-dimensional model of the antenna patterns is unwarranted. Results of tests on the CW-396A radome, on the other hand, did require a three-dimensional model for adequate presentation.

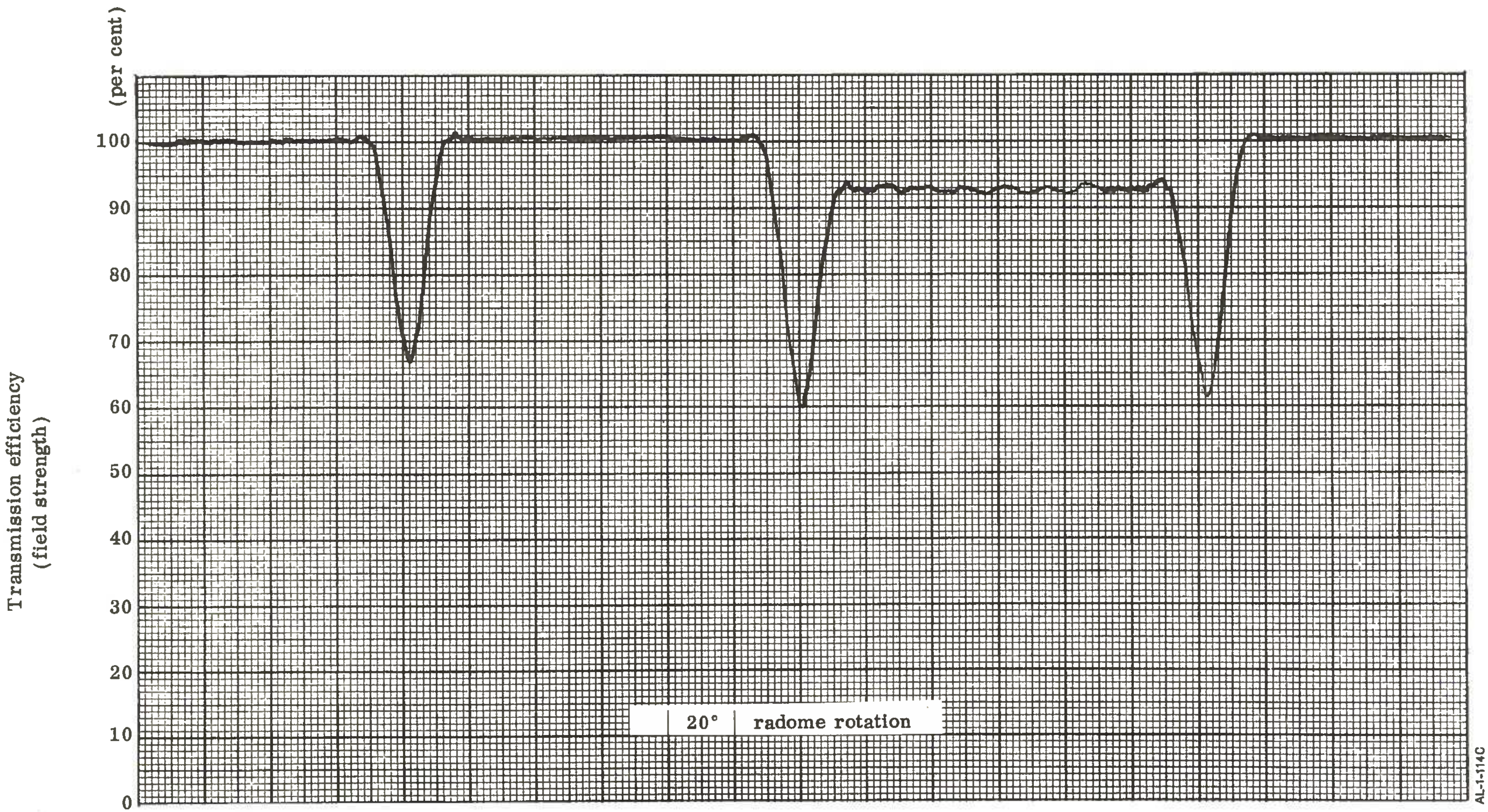

Fig. 2 Variation of transmission efficiency with radome rotation

Reflection Measurements

Reflections from the radome wall were monitored by a directional coupler mounted behind the feed horn. The output of the directional coupler was fed into a recorder as the radome was rotated about the antenna. This test was repeated for antenna elevation angles ranging from 0° to 30°. The VSWR of the antenna alone was 1.04. With the radome in front of the antenna the VSWR varied from 1.01 to 1.07, depending on the antenna-radome orientation.

Boresight Tests

As with the CW-396A radome, boresight tests were carried out by replacing the standard AN/FPS-6 feed horn with a dual horn to simulate an amplitude comparison monopulse system in the vertical plane. A typical boresight plot is shown in Fig. 3. The maximum shift is 0.15 milliradian. The three large shifts are produced by the radome supports.

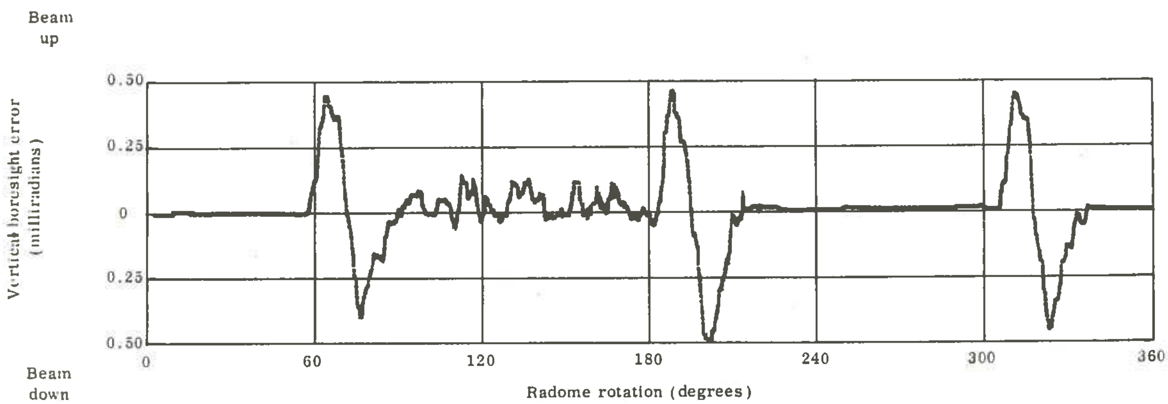

Fig. 3 Variation of vertical boresight error with radome rotation

Additional boresight tests were made at 6000 mc/s with a different set of feed horns. A maximum shift of 0.18 milliradian was measured. Admittedly the antenna as used in this test is rather makeshift, consequently this result is suspect. It is believed that a properly designed 6000 mc/s antenna would undergo a boresight shift smaller than that measured in this instance.

SUMMARY

The electrical characteristics of the MSF radome, as measured at the National Research Council on a full-scale mock-up check closely with results obtained at Lincoln Laboratory on a scale model.

The MSF radome is either equal or superior to the CW-396A radome in all of the properties that were checked (Table I). In particular, the MSF random geometry almost entirely avoids generation of scatter side lobes.

For comparison the properties of the two radomes are tabulated below.

TABLE I

COMPARISON OF CW-396A RADOME AND METAL-SPACE-FRAME RADOME

		CW-396A	LINCOLN LAB. MSF
TRANSMISSION LOSS		1.0 db	0.7 db
VSWR	without radome	1.08	1.04
	with radome	1.04 - 1.10	1.01 - 1.07
SCATTER SIDE LOBES		many, largest at -22 db	very few, largest at -33 db
BORESIGHT ERROR (maximum)	2800 mc/s	0.23 milliradian	0.15 milliradian
	6000 mc/s	not measured	0.18 milliradian

References

1. Lavrench, W., "Results of Tests on the AN/FPS-6 Antenna under the CW-396A Radome", NRC Report ERB-585, May 1961
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3. Lavrench, W., "Electrical Performance of Rigid Ground Radomes", IRE Trans., AP-8: 548, 1960
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PLATE I — NRC MOCK-UP OF LINCOLN LABORATORY METAL-SPACE-FRAME RADOME