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# ANALYSIS OF A MEDIUM SIZE BOR RADOME

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## FINAL TECHNICAL REPORT

August 1992

by

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Syracuse University, Syracuse, New York 13244

Prepared for:

OFFICE OF NAVAL RESEARCH  
800 North Quincy Street  
Arlington, Virginia 22217-5000

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## **Abstract**

A brief summary of a simple moment solution is presented for the problem of analysing a medium size BOR (body of revolution) radome. The radome is excited by a plane wave (receive mode) and we are interested in finding the total far scattered field and the total internal field that is transmitted into the radome. A medium size radome is one which is not much larger than the wavelength of the exciting field. Using a simple spherical dielectric shell as a model, it is shown that one can obtain accurate results with BOR formulation where the necessary computer CPU and storage is much less than those required by arbitrary surface formulation that was used in an earlier report.

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## 1. Introduction

Although exact solutions are available for the problem of electromagnetic transmission through spherical dielectric shells, only approximate solutions exist for shells of arbitrary shape. A ray-optics method is commonly employed by radome engineers. Ray methods provide accurate results for large radomes. However, the method becomes somewhat complicated and less accurate for rapidly curving shells which may have edges or corners. A missile radome is an example of such a shell. At lower frequencies where the radome is small (compared to the wavelength), it can be accurately analysed by using a surface integral formulation. Such a method can be used for surfaces of arbitrary shape, and is summarized in [1]. The details are given in [2] and [3]. Although applicable to arbitrarily shaped small radomes, the method becomes impractical for larger radomes. This limitation is due to enormous need for CPU and computer storage. Fortunately, most radomes are BORs. Hence, one can take advantage of this and extend the surface integral formulation to medium size radomes without running into serious computer limitations. The problem considered here is that of analysing a medium size radome which is a BOR (body of revolution). We are interested in finding the total internal field transmitted into the radome, and the total scattered far field. In this report we present the latter to prove the point of using BOR formulation. This is done by comparing the radar cross section of a spherical radome computed using the BOR formulation with the exact result and results computed using the arbitrary surface formulation.

## **2. Formulation of the problem**

### **2.1 Statement of the problem**

The problem considered here is identical to the problem that was studied in Section 2.1 of [3], except that now we assume the radome to be a BOR. In other words, both the inner and the outer surfaces of the radome can be obtained by rotating a "generating curve" around "the axis" of the radome. Also, here we considered only the receiving mode. Hence the source shown inside the inner surface in Fig.1 of [3] is now assumed to be turned off. All other assumptions are assumed to be the same.

### **2.2 Application of the Surface Equivalence Principle.**

Since the surface equivalence principle does not depend on the shape of the surface involved, all of the statements in Section 2.2 of [3] apply here as well. Hence the integral equations to be solved in the present case are identical to those given by (13)-(16) of [3], even if both the inner and the outer surfaces are assumed to be BOR surfaces.

### 3. Application of the moment method

The set of the integral equations given by (13)-(16) of [3] are solved numerically using MOM (the method of moments) [4]. In applying MOM to BOR surfaces, the generating curve of the surfaces are approximated by linear segments and on each segment two components of both electric and magnetic currents are expanded in a "finite Fourier Series" in circumferential variable, with unknown expansion coefficients. The variation of the currents in the perpendicular direction is assumed to be piecewise linear. The incident field, and the field produced by expansion currents are also expressed in terms of Fourier series. By following this technique, different "modes" are decoupled. The result is solving many small systems of linear set of the equations, instead of one large system. This results in a considerable saving in CPU and storage. The details of the procedure are given in [5] and will not be repeated here. In fact, the whole method that we used here is a combination of those reported in [3] and [5].

#### 4. Results and Conclusions

In trying to prove the efficiency of the present method, we considered a spherical dielectric shell of inner radius 0.2 meters, outer radius 0.3 meters, and dielectric constant of 4.0. The radome is assumed to be excited by a plane wave of wavelength equal to 1.0 meter. Figure 1 shows the radar cross section of this radome computed using the present method. Figure 2 shows the exact result and two numerical results computed by the arbitrary surface formulation. It is clear from these figures that the present method gives more accurate results than the arbitrary surface formulation. It is also clear that the present method is much more efficient. The results obtained by the present method with only 152 unknowns are more accurate than the results of the other method with even 1008 unknowns. To illustrate this point was the main objective of this project.

Other objectives of this project included finding the total internal (hence the bearing error) of the radome with or without the presence of a metallic reflector. Unfortunately we have not yet obtained such specific results. However, once the current distribution is computed, almost all other engineering parameters are easy to obtain. Hence we believe that computation of the internal fields is trivial and can be achieved with a minimal extra effort.

**BOR METHOD (152 UNKNOWN) DIELECTRIC CONST=4.0**  
SPHERICAL SHELL INNER RADUIS=0.2M OUTER=0.3M LAMDA=1M

SCATTERING CROSS SECTION COMPUTED USING BOR FORMULATION

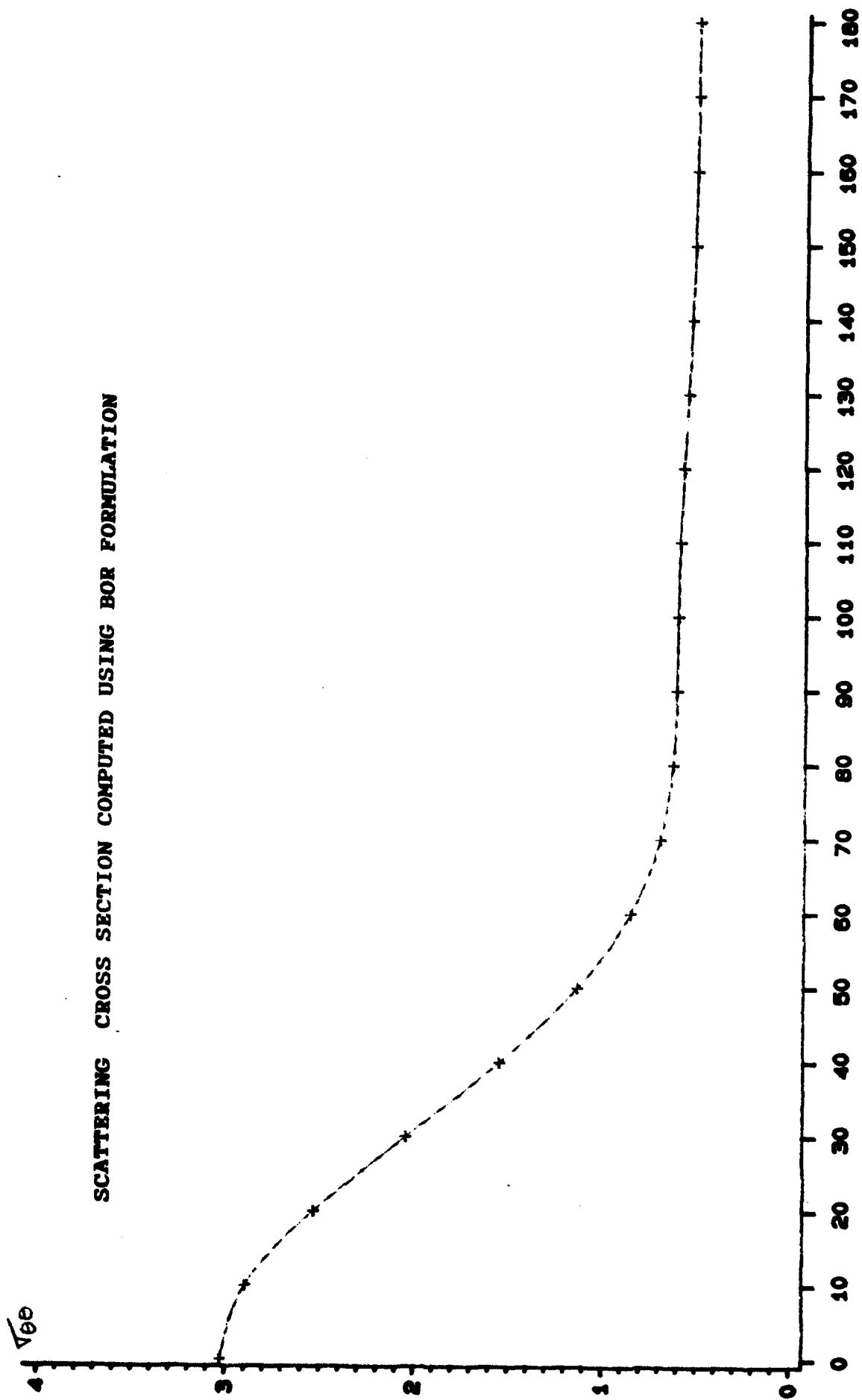


FIGURE 1.

THETA (DEGREES)

Shell ;  $b=0.3 \text{ m}$  ,  $a=0.2 \text{ m}$  ,  $\text{diel. const}=4.0$

Wavelength  $\sim 1.0 \text{ m}$ .

- 1- Exact result.
- 2- 480 unknowns.
- 3- 1008 unknowns.

SCATTERING CROSS SECTION COMPUTED BY ARBITRARY SURFACE  
FORMULATION COMPARED WITH THE EXACT RESULTS.

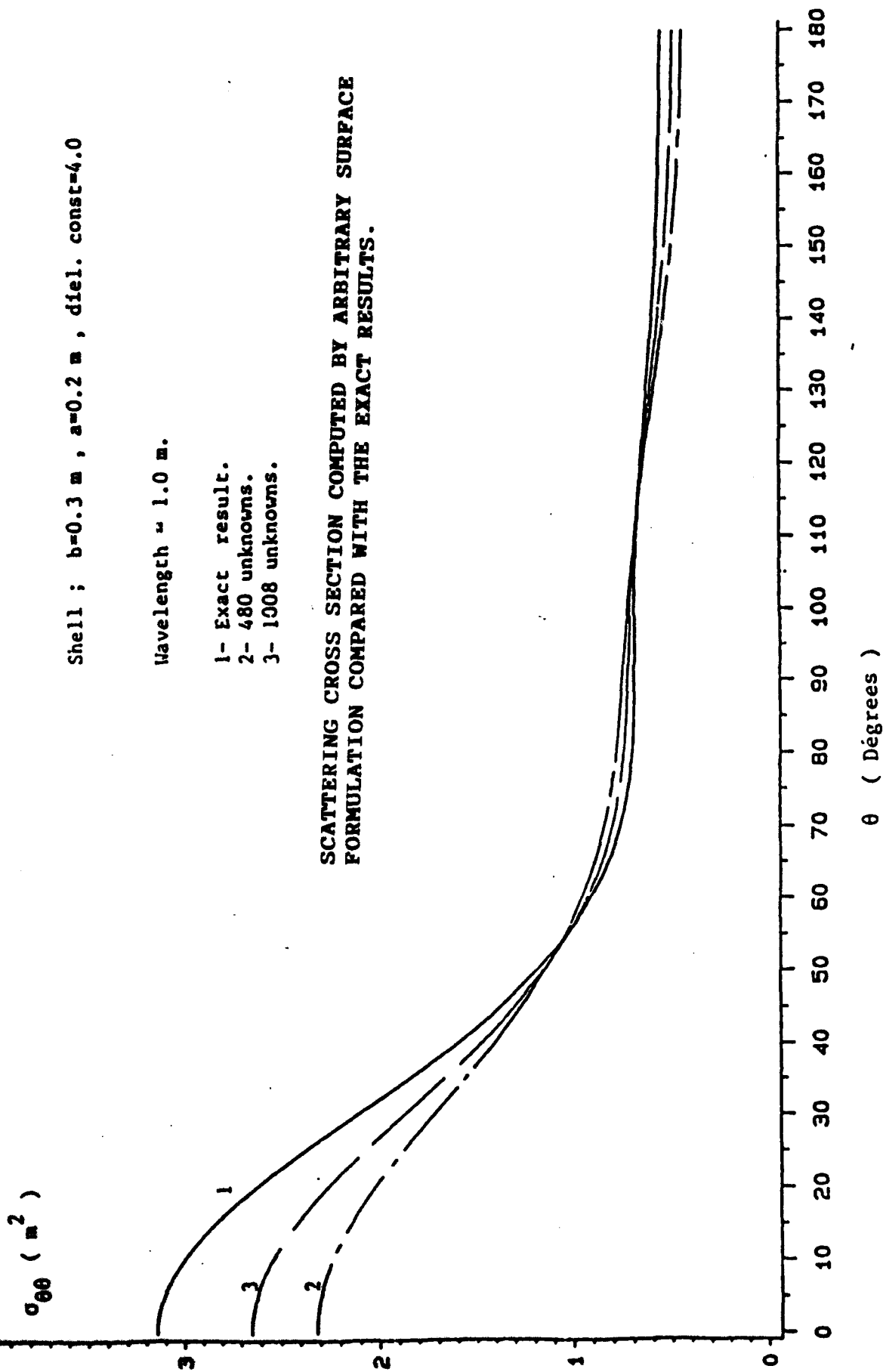


FIGURE 2.

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