THE UNIVERSITY OF MICHIGAN RADIATION LABORATORY

2455 Hayward Street
Ann Arbor, Michigan 48105

(313) 764-0500

17 October 1973

011764-7-L

Air Force Avionics Laboratory
Air Force Systems Command
4950 Test Wing (Technical)
ATTENTION: AFAL-WRP
Wright-Patterson AFB, Ohio 45433

SUBJECT	Monthly Progress Letter No. 7
PERIOD COVERED	15 September - 15 October 1973
CONTRACT NR, PROJECT and TITLE	F33615-73-C-1174, 7633 "Non-Specular Radar Cross Section Study"
CONTRACTING OFFICER	George E. Himes
REPORT SUBMITTED BY	Thomas B. A. Senior and Eugene F. Knott

DISTRIBUTION

AFAL/WRP - 2
ONRRR - 1
Hiatt/File
Knott
Senior

11764-7-L = RL-2235

This is the seventh monthly progress letter on Contract F33615-73-C-1174 and covers the period 15 September - 15 October 1973.

As mentioned in the previous progress letter, program TWOD is being extended to include magnetic layers as well as purely dielectric ones, and to accommodate H-polarization as well as E. During this reporting period the programming has progressed sufficiently far that a test could be carried out for a magnetic sheet. Contrary to expectations, the far field scattering turned out to be independent of the magnetic properties of the sheet and was traceable to an insufficient formulation of the integral equations. This discovery compelled us to closely examine the derivation of the integral equations.

After several weeks of intensive effort, we have succeeded in producing the correct equations and in doing so have pinpointed the cause of the difficulties experienced with program RAM1B some months ago. RAM1B is based upon the impedance boundary condition, which explicitly relates the electric and magnetic currents at the surface. As a result, two integral equations can be generated for a given polarization, one in terms of the electric currents and the other in terms of the magnetic currents. Either of the two may be used to solve the problem, and while one has at most a first derivation singularity, the other has a second derivative (higher order) singularity. Although either of the pair may be used as a basis for a computer program, it is prudent to choose the simpler one and this is, in fact, what was done to produce program RAMD, as mentioned in the fifth monthly progress letter. RAM1B used the simpler form for one polarization, but the more complicated form was inexplicably used for the other, thus giving rise to the difficulties we noted earlier in the Contract.

The infinitely thin sheet requires a more careful consideration of the boundary conditions. In contrast to the impedance boundary condition used for relatively thick bodies, the electric and magnetic currents flowing in an infinitely thin sheet are independent of each other. The electric currents depend only upon the electric properties of the layer and the magnetic currents depend only upon the magnetic properties. Thus, the integral equations may be developed separately for each kind of sheet, yet in order to synthesize thin layers of actual materials it is mathematically possible to superpose one kind of sheet on the other. The integral equations for an electric sheet illuminated by an E-polarized wave contain no derivatives of the kernel, but contain a second derivative for H-polarization. Conversely, the H-polarized integral equations contain no derivatives for the magnetic sheet, but the E-polarized equations contain the second derivative. Obviously the equations for an arbitrary sheet will embody both kinds of singularities, regardless of polarization.

Of the computer programs available thus far, RAM1A employed only the impedance boundary condition, but for both polarizations, and TWOD treated electric sheets in the presence of a metallic body, but only for E-polarization. Now, however, we shall be able to include within a single program the impedance boundary condition as well as the capability to model magneto-dielectric sheets, for H- as well as E-polarization. The formulation necessary to construct such a program is well in hand, but there is one obstacle yet to surmount: the numerical evaluation of the second derivative kernel. Our efforts will be bent on this task in the coming reporting period.

Analysis and interpretation of data generated by program REST has continued during this reporting period. Of considerable utility was a program modification that prints out the phase and amplitude of the contributions of various parts of the body. By using this version we have succeeded in decomposing the scattering from an ogival cylinder-resistive sheet combination into components due to the leading and trailing edges of the sheet. The results show that the leading edge return is quite well approximated by a theoretical consideration of an impedance half plane, and that the return from the rear edge of the sheet is sensitive to the nature of the resistance distribution there. The factors producing a "resonance" phenomena (noted in our last monthly progress report) are now clear, and although the description of the trailing edge component is, as yet, empirical, the estimation of the leading edge component rests on firm theoretical ground.