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PERIOD COVERED	15 March - 15 April 1973
CONTRACT NR, PROJECT and TITLE	F33615-73-C-1174, 7633 "Non-Specular Radar Cross Section Study"
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This is the first monthly progress letter on Contract F33615-73-C-1174 and covers the period 15 March - 15 April 1973.

As discussed in the Final Report of the predecessor contract (AFAL Report No. TR-73-70, 1973) we can overcome the erroneous predictions of program RAM1B for E-polarization by densely packing the sampling points near the edges and by easing the sharp edges with tiny radii of curvature ($\sim 0.013\,\lambda$). Although this technique produces far field scattering that agrees within 2.0dB of that predicted by GTD, a small current spike persists to appear at the rear edge of the body. During this reporting period we imposed a linear, resistive impedance variation over the rear half of the body in an attempt to suppress the rear edge current spike and, with a terminating impedance of $Z_{max} = 1.0$, managed to produce a far field pattern that is within 1.5dB of that predicted by GTD. Higher terminal values of impedance (greater than 1.0) improve the agreement in the nose-on region, but degrade the agreement at larger aspect angles. Active loadings (negative impedances) are not as effective as passive ones. The results of this latest attempt are compared with the far field predictions of GTD in Figure 1.

We believe that the E-polarization difficulties are due to the lack of an interpolation formula in the program itself. The program assumes that the surface current over an elemental cell is constant which, for elements not near an edge, is entirely adequate. However, the current increases quite rapidly as the edge is approached and the assumption of constant current over the cell becomes an ever poorer approximation. In an attempt to improve the program's capability to handle edges for E-polarization, we are exploring the possibility of using an interpolation formula of the form $A/\sqrt{s}$, where A is a constant (over a given cell) and s is the distance from the edge, applicable within some specifiable range of s. The scheme could be extended to the entire profile if a formula of the form

$$A/\sqrt{s} + B + C\sqrt{s}$$

were to be used. We are optimistic about the success of this technique and we should have some results by the end of the next reporting period.

Experimental difficulties have persisted during this reporting period, but we have made at least one important discovery: it is extremely difficult to measure the tangential electric field at an imperfectly conducting surface. We believe this is due to dependence of the signal output of a magnetic and electric probe upon the electrical characteristics of the medium surrounding the probes. In order for a magnetic probe to faithfully indicate the magnetic field strength, the effective permeability of its immediate environment must be that of free space ($\mu = \mu_0$); in much the same way, an electric probe indicates the true electric field strength only if the effective permittivity of the immediate environment is that of free space ($\epsilon = \epsilon_0$). Thus if the fields at the surface of a magnetic material such as SFT-2.5 are to be probed, neither the magnetic nor electric field measurements can be expected to be correct, since both the permeability and permittivity of the volume surrounding the probe are greater than the free space values. However, because the material permittivity is some 5 times greater than the permeability, we would expect greater errors in the electric field than in the magnetic field measurements. And this is in fact what happens.

There appears to be no way to circumvent this difficulty in a general case. It is possible to withdraw the probes and sample the fields over an imaginary profile displaced some small, but constant, distance above the actual profile in order to reduce the effective μ and ϵ surrounding the probes and thereby increase their fidelity. And although such measurements could then lead to an estimate of the actual fields on the true profile for a TEM (normal incidence) case, it is not apparent that such a deduction could be made for arbitrary incidence. Thus it appears that we have only magnetic field measurements to rely on, whence the surface impedance cannot actually be determined experimentally.

Although the experimental determination of surface impedance may continue to elude us, there are useful "half-way" verifications that can be made on the basis of magnetic field measurements alone. An example of this is the comparison of computed and experimental values of the tangential magnetic surface field shown in Figure 2. The computed data were obtained from program RAM1B in which a constant impedance was specified over the entire profile, the impedance being that deduced from the measured properties (μ and ϵ) of SFT-2.5 absorber when applied to an infinite, flat surface. Except for the first quarter wavelength near the front edge, the agreement is very good and suggests that the impedance approximation works well, at least over broad surfaces of large radii of curvature. We believe the approximation is poor near edges, however, and the data tend to confirm this notion. A sequence of tests could now be run using RAM1B, in which the impedance is varied near the edge in an attempt to reproduce the measured magnetic field, and the best-fitting case might then lead to a correlation between impedance and the known properties of the material. Some of these ideas were discussed at a meeting with the Contract Sponsor and representatives of Teledyne Ryan Aeronautical Corporation on April 11, 1973 at AFAL, WPAFB, Ohio.

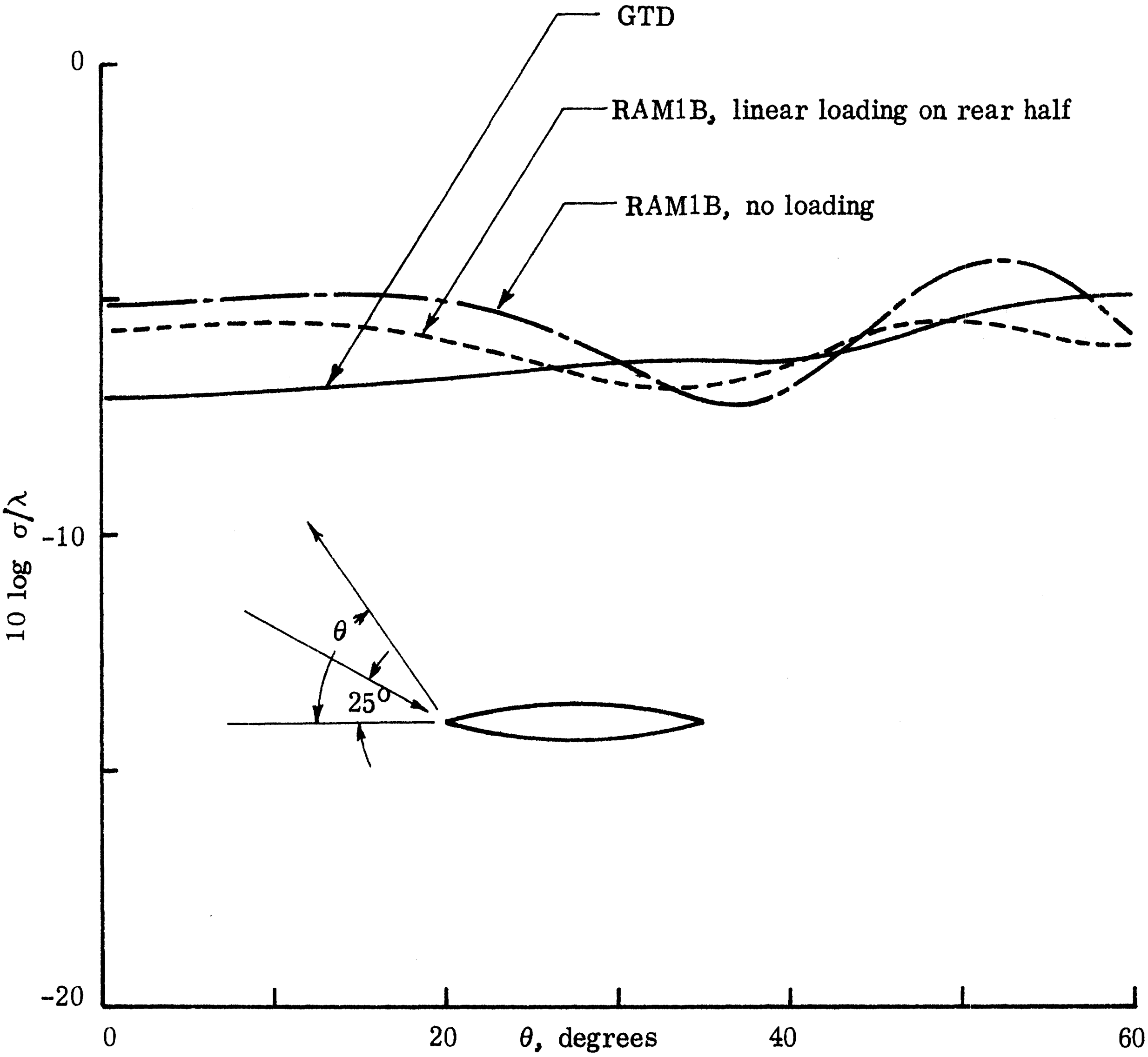

Figure 1: Combination of dense sampling at edges and impedance loading over rear half produces agreement within 1.5dB of that predicted by GTD.