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LEVEL II

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Technical Memorandum 1 ✓

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**FIELD COMPENSATING SCATTERING STRUCTURES IN ARES
FOR DISPERSED EMP TESTING OF SATELLITES.**

⑨ *Technical memos.*

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ABSTRACT

Measurements up to 130 MHz in the ARES show non-uniform field variations of 10 dB. Similar measurements of the field within a 1/30 scale model of the ARES show similar results. Three different scattering structures tested in the ARES model eliminated the field non-uniformity caused by signal reflections at equivalent frequencies higher than 30 MHz. Current measurement on models of the structures of the fleet communications satellite in the ARES model indicates that a scattering structure is necessary. Resonances that occur below 25 MHz on the wire top plate of the ARES can be tolerated. A potentially inexpensive and effective scattering structure made by stringing wires in the terminating half of the ARES was designed and is recommended for the ARES.

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This memorandum summarizes the work performed on a 1/30 scale model of ARES to provide appropriate information to enable communications satellites to be satisfactorily tested in ARES with a dispersed EMP. The ARES was constructed to propagate EMP containing significant frequency components up to 100 MHz. Model measurements investigated the capability of ARES to propagate a dispersed EMP containing significant frequency components from 13 MHz to 300 MHz.

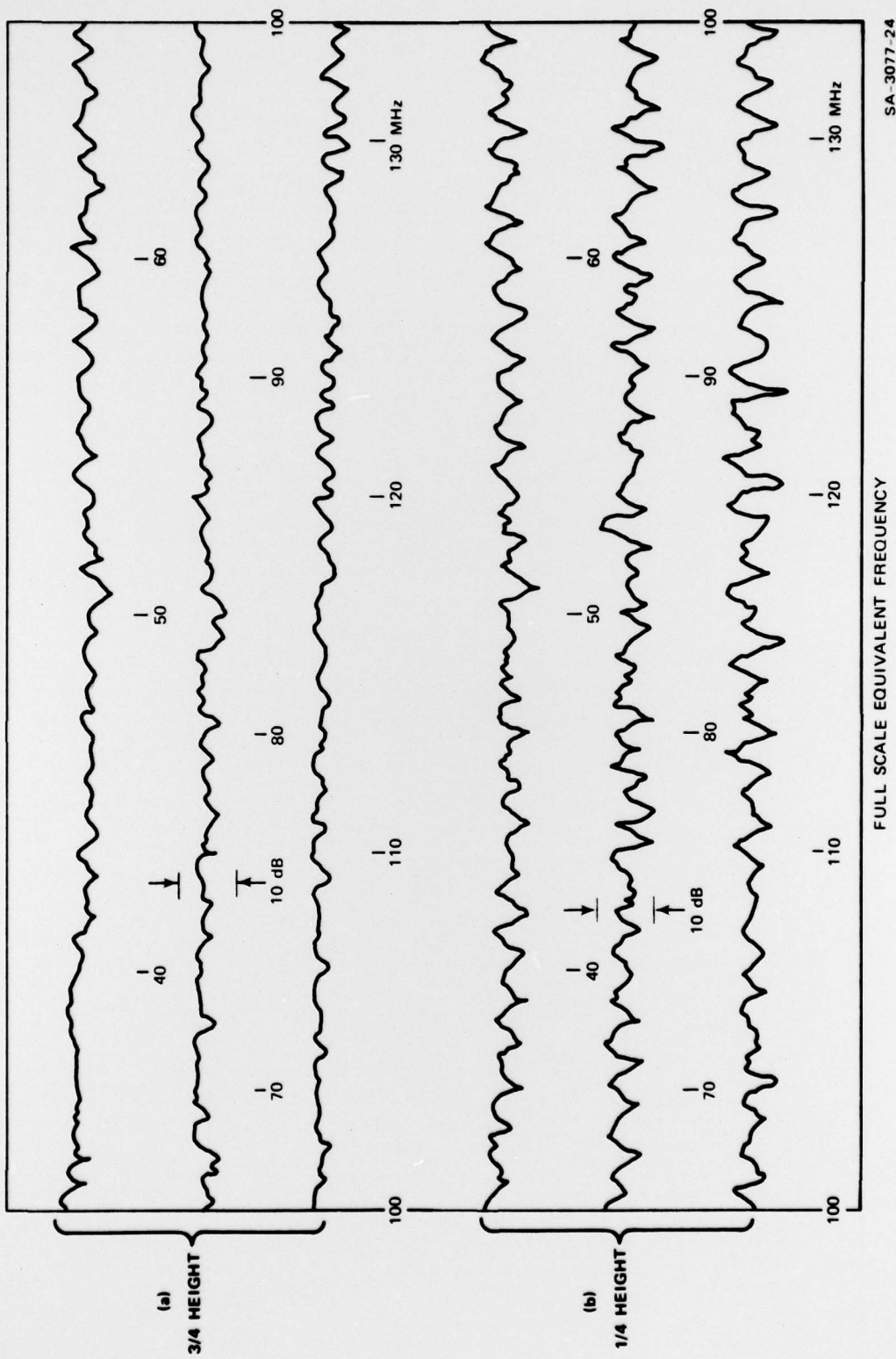
The full-scale ARES has a top plate constructed of 75 wires. These wires exhibit resonance effects below 25 MHz and hence distort the propagated field near the top plate.* A suggestion to eliminate low frequency resonances by cross-wiring the 75 wires to simulate a solid top plate in the ARES was tested in the model. Cross-wiring eliminates low frequency resonances. However, for signal components above an equivalent frequency of 30 MHz, the wavelengths become very small compared to the height of the ARES and hence propagate as rays. Cross-wiring the top plate wires eliminates the low frequency top-wire resonances but the crossings of ray paths create interference field patterns at frequencies above 30 MHz, that makes the cross-wire solution unacceptable. (Scattering structure illustrated in Figure 2a did not help.) An alternate scheme, also tested in the ARES model, to reduce low frequency

* S. Dairiki and W. E. Scharfman, "Study of EMP Testing of Satellites", Interim Report, Contract DNA001-74-C-0105, SRI Project 3077, SRI, Menlo Park, CA (to be published).

resonances successfully, inserts characteristic resistance terminations at the ends of the top plate wires.

With a 75 wire top plate, the electric field in ARES shows some destructive interference as illustrated in Figure 1. The maximum field variations are on the order of ± 6 dB. Similar measurements made on the actual ARES at a slightly different height show 10 dB variations and are consistent. With the scattering structures illustrated in Figure 2, the field amplitude over the entire measured frequency range is smoothed to less than ± 3 dB and over any limited frequency range the field amplitude varies by less than ± 1.5 dB, as illustrated in Figure 3. Figure 2(c) illustrates a potentially economical solution for the full-scale ARES in which the scattering structure is constructed with 115 wires.

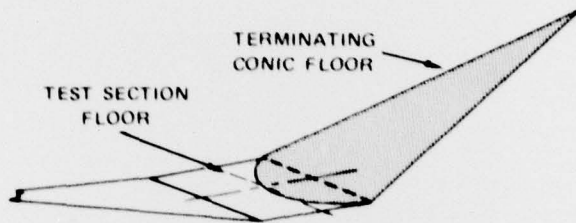
An elementary 1/30 scale model of the fleet communications satellite was used to investigate the effect of ARES destructive interference on currents induced in the satellite structure. Induced currents measured on a boom supporting the solar panels with the solar panels transverse to the length of the ARES are illustrated in Figure 4, with and without the scattering structure. Current variations above an equivalent frequency of 30 MHz that appear without the scattering structure are smoothed by the scattering structure. Below an equivalent frequency of 25 MHz, the current variation caused by the wire top plate resonances are within a tolerable value of ± 1.5 dB.



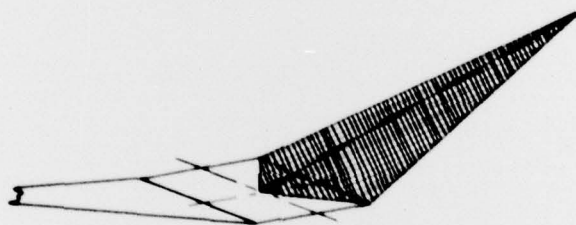
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FULL SCALE EQUIVALENT FREQUENCY

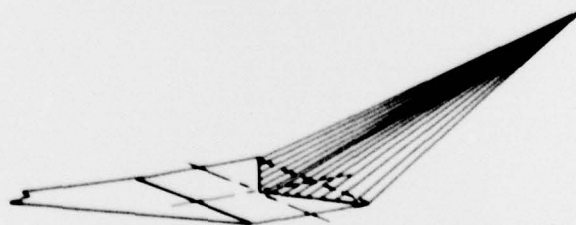
FIGURE 1 FIELD MEASUREMENT ON ARES MODEL (67 m equivalent distance from input)



(a) ROUND SOLID SCATTERER



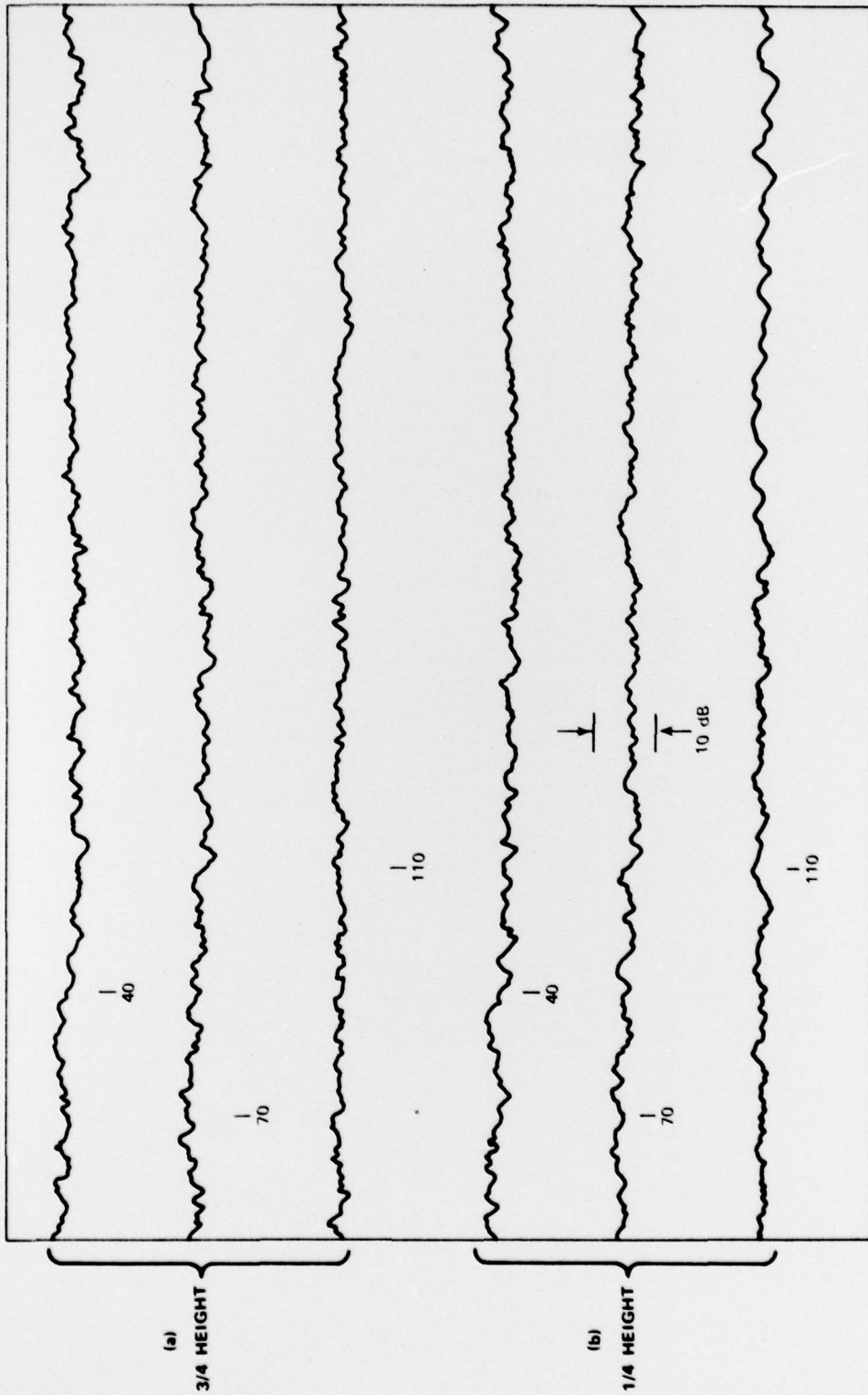
(b) TRIANGULAR CROSS-SECTION MESH SCATTERER



(c) TRIANGULAR CROSS-SECTION WIRE SCATTERER
(recommended design)

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FIGURE 2 SCATTERING STRUCTURES FOR ARES



FULL SCALE EQUIVALENT FREQUENCY

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FIGURE 3 FIELD MEASUREMENT ON ARES MODEL WITH WIRE TRIANGULAR CONIC SCATTERING STRUCTURE
(67 m equivalent distance from input)

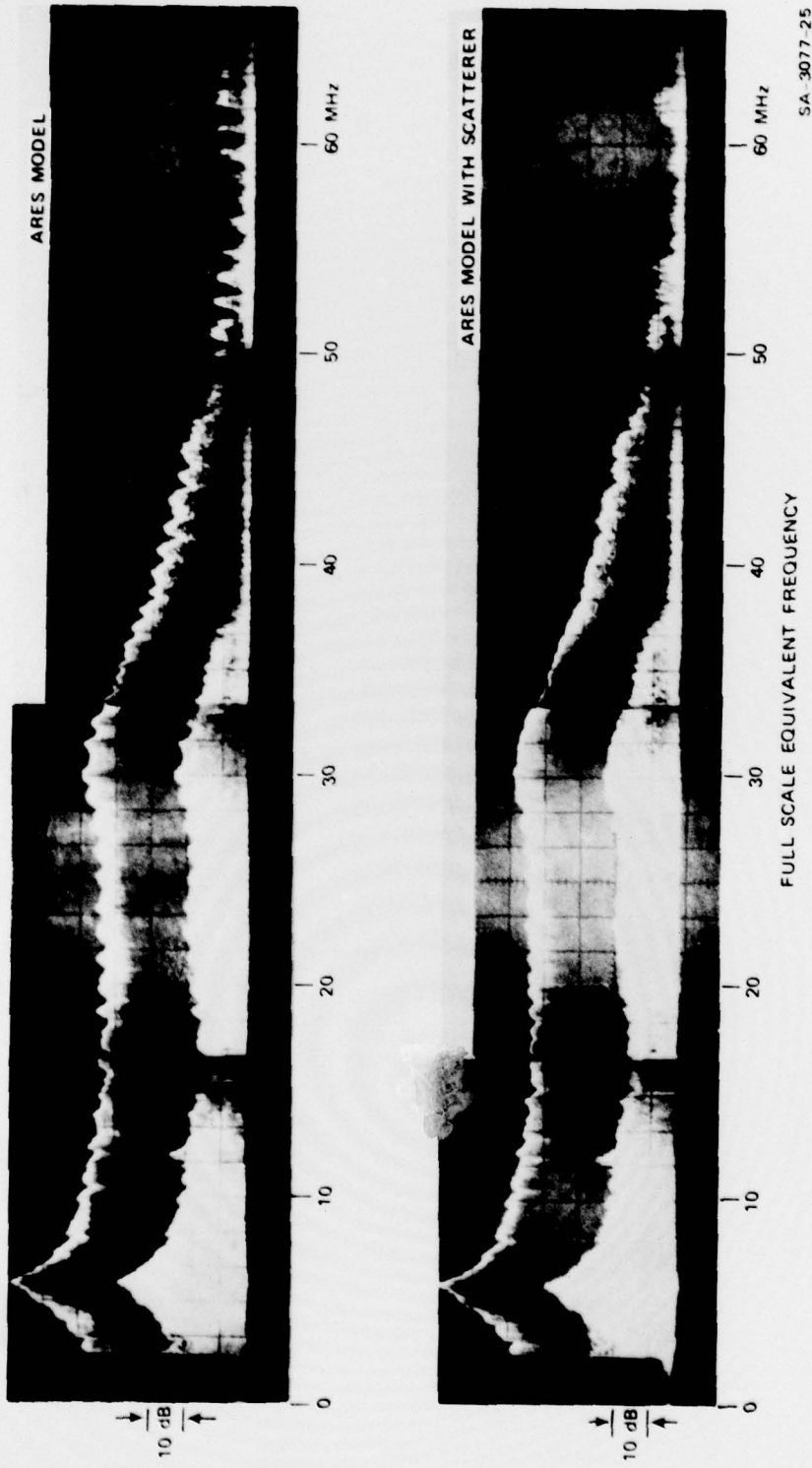


FIGURE 4 INDUCED CURRENTS ON A BOOM OF THE SOLAR PANEL ON SPACECRAFT MODEL

In conclusion, measurements of the electric fields in the ARES model and of the currents on satellite-like models indicate that a scattering structure reduces the field variations within the ARES and is necessary to reduce induced current variations on satellite-like objects for dispersed EMP tests. The triangular cross-section wire scattering structure is recommended [Figure 1(c)].

Low frequency resonances below 25 MHz in the ARES top-plate wires can be successfully reduced by insertion of series resistance in the wires at the ARES termination. However, currents induced on a crude model of a communication satellite indicate that the low frequency components in the dispersed EMP that causes wire resonances in the ARES are tolerable.