Impact of Optical Baffle on Antenna Pattern

T.K. WU* and R.J. Pogorzelski
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109

Introduction: One of the major concerns of antenna design for spacecraft applications is the effect of surrounding structures which can reflect and diffract the antenna's radiated energy and cause degradation in the antenna directivity, beam shape, and sidelobe levels. A case in point is the NASA Earth Observing System (EOS) spacecraft, shown in Figure 1, which has a large number of instruments on board. Among these is the Multiple Imaging Spectra] Radiometer (MIS]{). The downlink antenna system (DAS) for the spacecraft is a very broad beam antenna and as such irradiates much of the spacecraft leading to the possibility of distortion of its pattern,

MISR, on the other hand, must be protected from optical glint resulting from the structures onboard the spacecraft and to this end the instrument has been fitted with a baffle. The optimal position for this baffle (from the point of view of the MISR instrument) places it in the near-field of the downlink antenna. If not carefully designed, this baffle could cause potentially serious distortion of the downlink antenna pattern by reflecting the energy radiated by the antenna back into another part of its far field; i.e.., by creating a "multipath environ merit." It will also *shadow* or *block* a portion of the radiation of the antenna. '1'bus, the baffle material must be chosen so as 10 minimize the effect on the antenna pattern while adequately protecting the instrument. That is, the material must be optically absorbing and radio frequency (RF) transparent.

To properly assess the pattern distortion which may occur du e to the above situation, one must first determine the reflectivity of the baffle material. in an effort to select an optimum material, several optically black materials were considered, all of which were RF transmissive in varying degrees. The RF reflection coefficient of samples of these materials was found to be less than 0.03 as measured in a waveguide. The rc.suits were then used in an analytical assessment of the antenna pattern perturbation. Details of the modeling arc described below.

Approach: While it is within the current state of the art in computation] electromagn etics to model the clown] ink antenna with high precision, the analysis would require considerable time and computer resources. This was deemed unwarranted unless it could be demonstrated that a significant problem exists whence one could justify a precise assessment of the nature of the interaction. Instead, a simple model was devised which would render a quick determination of the order of magnitude of the baffle effect on the downlink pattern with minimal effort. This mock] comprised an elemental point source. located at the approximate phase center of the downlink and having a far zone pattern approximating that of the proposed antenna. The field of this source was then evaluated on the sui face of the baffle and the far zone reflection computed via physical optics using the. reflectivity determined by sample measurement. The reflected field was coherently combined with the dii ect radiation to determine the pattern ripple induced by the reflection.

Pattern Perturbation calculation: Figure 2 depicts the geometrical arrangement of the antenna, the MISR instrument, and the baffle. The antenna pattern assumed for the calculation is shown in Figure 3. It is designed to approximate the pattern of the actual antenna, The calculation is based on the configuration depicted in Figure 2 wherein the patterned point source radiates from the point O symmetrically about the z axis and the baffle. reflects the radiation such that the specular angle is approximately 7 degrees from the x axis in the diagram.

'1'0 obtain a scalar measure of the level of pattern perturbation, the unperturbed pattern is computed and the perturbing f ic]d ref lect ed from the baffle is computed. Then, the ratio of the magnitudes of these is calculated and plotted versus the aspect angle with the assumed magnitude of the reflection coefficient of the baffle material as parameter. This scalar ratio is just half the maximum peak to peak amplitude of the ripple to be expected in the coherent sum of the two fields relative 10 the. unperturbed field. The results arc plotted in Figure 4. As expected the maximum perturbation occurs at the specular angle of 7 degrees from the x axis. Recalling that the measured reflection coefficients of the proposed baffle materials were on the order of 0.03, it may be inferred that the amplitude of the pattern ripple due to the presence of the baffle will be more than 50 dB below the unperturbed pattern. Moreover, if -26 dB ripple is tolerable, then baffle materials with reflection coefficients of 0.3 (-10.5 dB return 10ss) may be used.

Conclusions: We conclude from the presented results that the design of a suitable baffle for the MISR instrument which will not significantly perturb the downlink antenna pattern is quite feasible. In fact, easily obtainable RF reflection properties result in negligible perturbation of the antenna pattern for the geometry treated.

Acknowledgement: The research described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Figure 1. EOS Spacecraft Configuration.

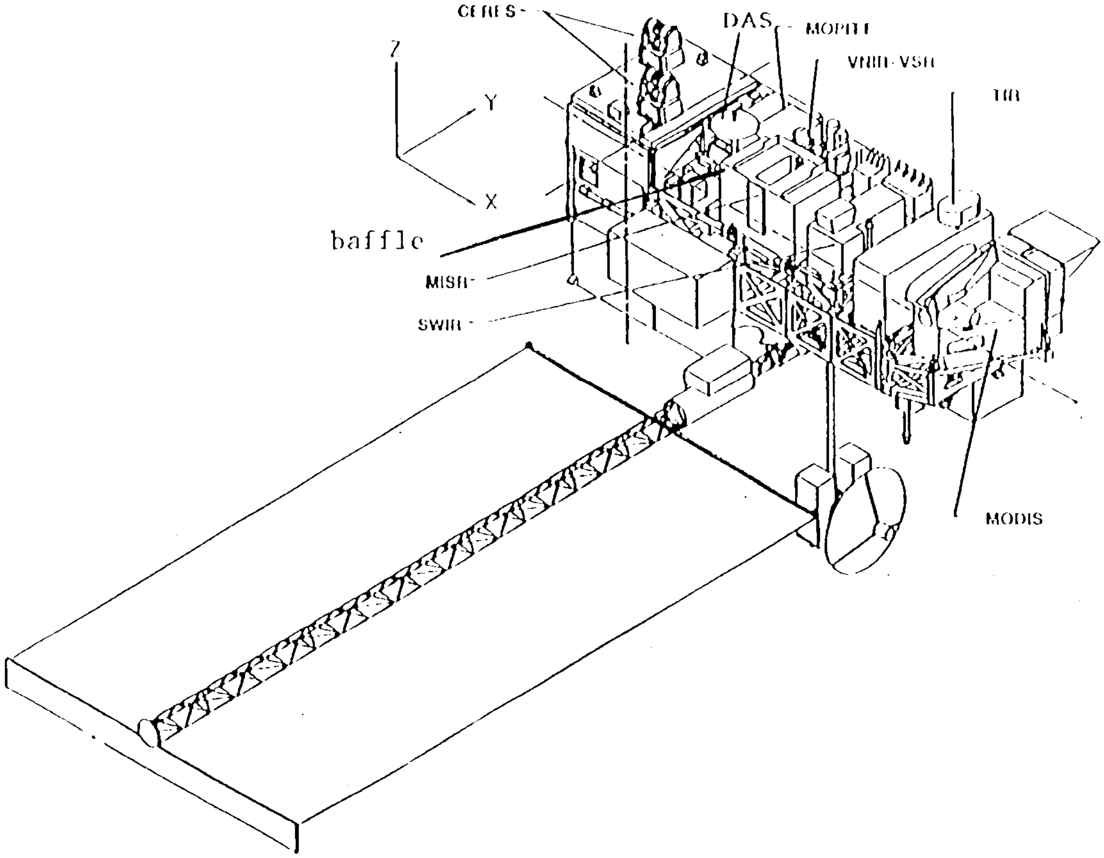

Figure 2. Simplified theoretical model for baffle effects.

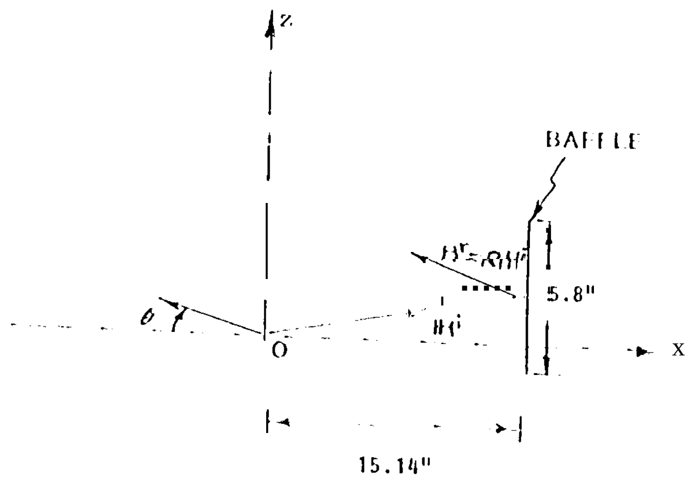

Figure 3. Analytical downlink antenna pattern.

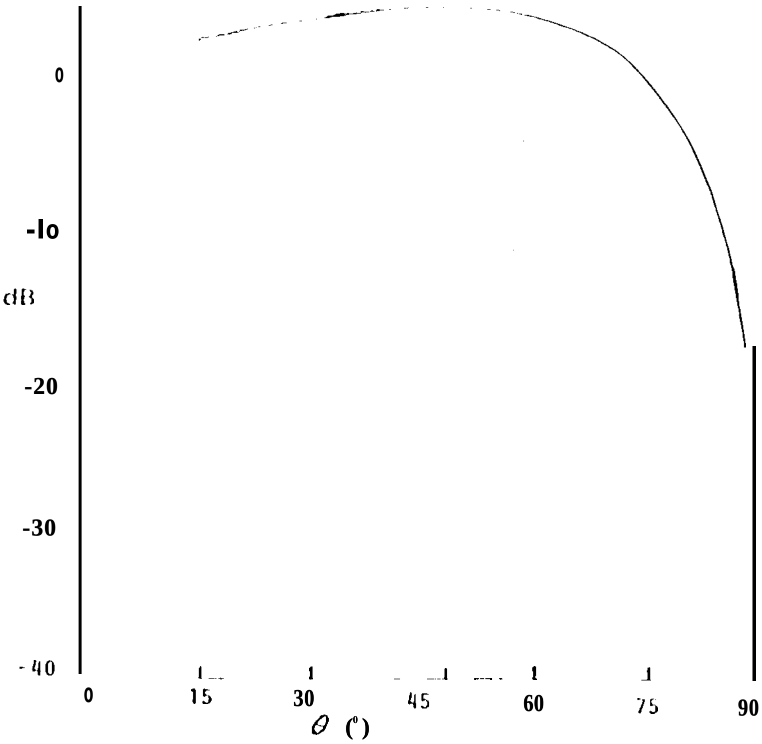

Figure 4. Baffle effects as functions of aspect angle and its reflection coefficient R.