ACHIEVABLE FLATNESS IN A LARGE MICROWAVE POWER TRANSMITTING ANTENNA

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SUMMARY

The efficient and practical operation of a large aperature planar phased array for the transmission of microwave power requires accurate mechanical pointing and minimal structural deformation. The Solar Power Satellite (SPS) has a definite advantage for satisfying tight mechanical requirements due to the benign external load environment of space. Potential distortion associated with the thermal environment has led to consideration of low coefficient of thermal expansion (CTE) structural materials to minimize this effect.

An evaluation of the achievable flatness in a large microwave power transmitting antenna has been performed by F. Leinhaupel and associates[1]. This study considered manufacturing and assembly tolerances, maneuvering and environmental accelerations as well as thermal distortion. Quantitative results required consideration of a specific microwave power transmission system (MPTS), SPS configuration and structural material. The configuration which was evaluated was basically a dual reference SPS system with pseudoisotropic GY-70/X-30 (graphite epoxy) as a representative dimensionally stable composite for the structural material. This particular material was selected due to the availability of statistical material property data and because of experience with manufacturing and assembly tolerances which have been achieved.

The loads, accelerations, thermal environments, temperatures and distortions were calculated for a variety of operational SPS conditions along with statistical considerations of material properties, manufacturing tolerances, measurement accuracy and the resutling loss of sight (LOS) and local slope distributions. The basic result of the study is that a LOS error and a subarray rms slope error of two arc minutes can be achieved with a passive system. This encompasses all manufacturing errors, thermal distortions, static structural loads and dynamic

movement resulting from transient loads.

Significant specific results of this study include:

- Existing materials measurement, manufacturing, assembly and alignment techniques can be used to build the MPTS antenna structure, orders of magnitude larger than current space systems.

- Manufacturing tolerance can be critical to rms slope error. Study results show that the slope error budget can be met with a passive system. As a backup approach, initial active alignment can be used to correct the interface between prome and secondary structures and/or between secondary and subarray structures. Tolerance then is limited by measurement accuracy and actuator resolution.

- Structural joints without free play are essential in the assembly of the large truss structures. Joint "slop" as contrasted to joint tolerance, can be eliminated by bonding or welding. Joint tolerance is a small part of overall strut length, and makes a minor contribution to slope error.

- The material properties of GY-70/X-30 pseudoisotropic graphite/epoxy composite were used as representative of strength, modulus and CTE. Variation in material properties, particularly for CTE, from part to part is more significant than the actual value. The design can accommodate predictable length changes and still achieve the required flatness. The uncertainty in CTE leads to the thermal distortion that degrades performance. However, thermal distortion is small over the range of operating temperatures and material properties not as well regulated as those of GY-70/X-30 will meet requirements.

Although the results of this study are applicable to a particular configuration, it is evident that the MPTS structure represents a reasonable extension of the present state-of-the-art. Furthermore, the probability is high that the accuracy requirements can be achieved with a passive system.

REFERENCE

1. Achievable Flatness In A Large Microwave Power Antenna Study, General Dynamics Conair Division Report No. CASD-NAS-79-011, under Contract No. NAS9-15423, Tech. Monitor F. J. Stebbins, August 1978.