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FUNDAMENTAL STUDIES OF HEAT LOAD AND THERMAL-STRUCTURAL ANALYSIS OF LARGE SPACE STRUCTURES

By

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FUNDAMENTAL STUDIES OF HEAT LOAD AND THERMAL-STRUCTURAL ANALYSIS OF LARGE SPACE STRUCTURES

By

Earl A. Thornton*

INTRODUCTION

Research pursued in the early months of the grant was described in "Progress in Thermostructural Analysis of Space Structures," presented at the NASA Conference on Large Space Antenna Systems Technology - 1982, held at the NASA/Langley Research Center on November 30 to December 3, 1982 (see enclosure). This report summarizes those results and describes grant activities since the previous paper was presented at the Langley conference.

TASK 1: SPACE STRUCTURES SELF-SHADOWING EFFECTS

The basic requirements for modeling slender-member shadowing effects on thermally-induced deformation are being investigated. The November 1982 paper described the approach of predicting truss member shadow movements and a simplified approach for assessing shadowing effects on the thermal response. The simplified approach assumed a "worst case" condition that neglected solar heating on shadowed sub-elements and fixed typical shadows on the member. The results showed that there is a significant alteration of the local temperature history during the local shadowing duration. However, only about six percent of the member was shadowed, and the average member temperature was reduced only slightly indicating only a very small effect on the structural response.

Current efforts are focused on eliminating the simplifying assumptions to yield a rigorous analysis that will permit a careful evaluation of the shadowing effects on the structural response. The theoretical formulation is complete and computer programming is underway. Once the program is complete detailed parameter sutdies on truss members of several designs

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(e.g. resin-matrix composites, metal-matrix composites, both with and without metallic joints) will be analyzed to establish shadowing effects on the structural response. Simplified modeling techniques will also be evaluated using the rigorous shadowing analysis program.

TASK 2: FINITE ELEMENT THERMAL MODELING

This task has the objective to determine basic requirements for thermal finite elements to model heat transfer in orbiting structures and develop new thermal elements as required. In October 1982 and January 1983, meetings were held with engineers at Martin-Marietta (Denver), and the thermal modeling requirements for a large space structure was discussed in detail. These meetings established that there is a need for planar isothermal elements to model large space structures' antenna meshes. The basic requirements for the new elements have been established, but programming of the new elements has not begun. The benefit of the isothermal element in modeling antenna meshes is to extend the geometric modeling concept inherent in the LASS and IDEAS programs to permit more realistic thermal modeling.

TASK 3: STRUCTURAL MODELING OF CABLES AND MEMBRANES

An investigation of finite element approaches for modeling space structure cable and membrane components with thermal effects is underway. In the initial part of the study the thermal response of a cable stiffened structure was investigated. The November paper described this work that demonstrated the thermal response depends strongly on the material. Specialized finite element thermal models were shown to be effective.

As a result of a literature search and industry visits, three levels of structural modeling and analysis have been identified:

(1) A linear-elastic small deflection analysis that does not permit cable slackening,

(2) A linear-elastic analysis that includes stress stiffening (e.g., the ANSYS program), but not large deflections; and

(3) Full nonlinear large deflection analysis (e.g. Harris Corporation) with stress stiffening.

All of these methods have advantages and disadvantages and will require detailed analysis on a realistic structure to evaluate. A common feature required for any of these analysis is a method to determine cable tensions required to form a prescribed antenna shape prior to the application of on-orbit loads. Methods of determining cable initial tensions are currently being evaluated.

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