BOX TRUSS ANTENNA TECHNOLOGY STATUS

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ABSTRACT

This paper summarizes recent technology development activities for box truss structures and box truss antennas. Three primary activities will be reported: the development of an integrated analysis system for box truss mesh antennae; dynamic testing to characterize the effect of joint free play on the dynamic behavior of box truss structures; the fabrication of a 4.5 meter diameter offset fed mesh reflector integrated to an all graphite epoxy box truss cube.

Analysis of Box Truss Mesh Antennas

An integrated analysis system has been developed to model, analyze, and predict RF performance of box truss antennas with reflective mesh surfaces. This analysis system is unique in that it integrates custom-written programs for cord-tied mesh surfaces, thereby drastically reducing both the man-hours and computer-dollars required to design and analyze mesh antennas. The program can be used to analyze the effects of (1) on-orbit thermal environments, (2) solar pressure, (3) on-orbit calibration or continuous adjustment of the mesh tie system to improve surface accuracy, and (4) gravity distortions during setting.

The analysis system uses nonlinear finite-element, surface topography and interpolation, and RF aperture integration techniques. The system provides a quick and cost-effective final link in the design process for box truss antennas.

Dynamic Testing of Box Truss Space Structures

Testing was performed to quantify the effect of joint free play on a multi-bay statically determinate truss, and then assess the effects when the structure is modified to incorporate pretensioned diagonals producing a statically indeterminate truss. Also evaluated were the effects of levels of dynamic load on the dynamic performance of the truss. Testing of four truss configurations was performed:

1. Truss with tight joints

2. Truss with joints having normal free play

3. Truss with joints having excessive free play (three times or more than normal free play)

4. Truss with normal free play and cross-tension diagonals

The effect of magnitude of dynamic load was assessed for each test.

A test article for this purpose was designed and built. The test article consisted of ten bays of planar truss, each measuring 2 meters per side, suspended by long wires at each joint. Each side was made of square aluminum tubing, and all corner fittings were made of cast aluminum. Pins of varying size were used to assemble the truss thereby simulating various joint free play conditions. All joints could be shimmed and bolted tight to assure a no free play condition. Single, unloaded tube diagonals were interchangeable with dual, tensioned steel rod diagonals. Modal analyses of the suspended tube diagonal configuration were conducted and used to calculate frequency response functions simulating proposed test conditions for the purpose of evaluating the suspension system.

Fabrication of a 4.5m Box Truss Antenna

A 4.5 meter diameter offset mesh reflector was fabricated and integrated to an all graphite epoxy box truss cube. The reflector surface was designed to operate at X-Band (10 GHz) with a surface accuracy of $\lambda/20$ where λ = wavelength (30 mm). Four objectives were achieved during the fabrication, setting and testing of the antenna. They were: 1) demonstrated fabrication methods for both mesh and tie system, 2) demonstrated performance of modular tie system to precisely position and hold mesh surface, 3) verified nonlinear stress stiffened finite element analysis of the tie system.