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SPACE TRUSS ZERO GRAVITY DYNAMICS

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OVERVIEW

The Structural Dynamics Branch of the Air Force Flight Dynamics Laboratory in cooperation with the Reduced Gravity Office of the NASA Lyndon B. Johnson Space Center (JSC) plans to perform zero-gravity dynamic tests of a 12-meter truss structure. This presentation describes the program and presents all results obtained to date.

I. HISTORICAL BACKGROUND

II. PROGRAM OBJECTIVES

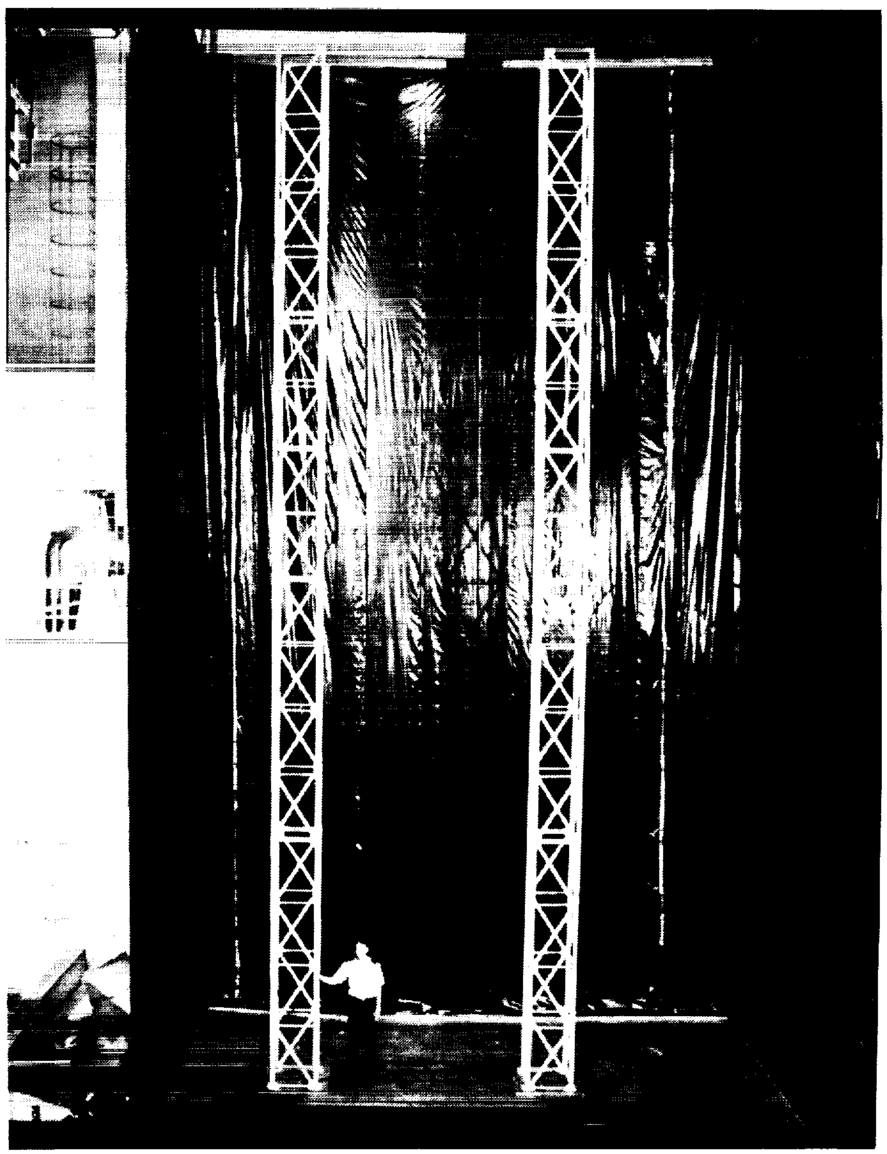
III. THE JSC FACILITY

IV. TEST SPECIFICS

V. CONCLUSIONS

BACKGROUND

The Flight Dynamics Laboratory's inhouse Large Space Structures Technology Program (LSSTP) is currently investigating methods for ground test and analysis of large space structures to predict on-orbit dynamic behavior. Two 12-meter truss structures were fabricated for analysis and modal characterization studies. These trusses are being tested in a cantilevered (see figure below) and a simulated free-free condition. Questions to be answered include how much damping a suspension device puts into the structure and the effect this has on the truss mode shapes and modal frequencies.



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OBJECTIVES

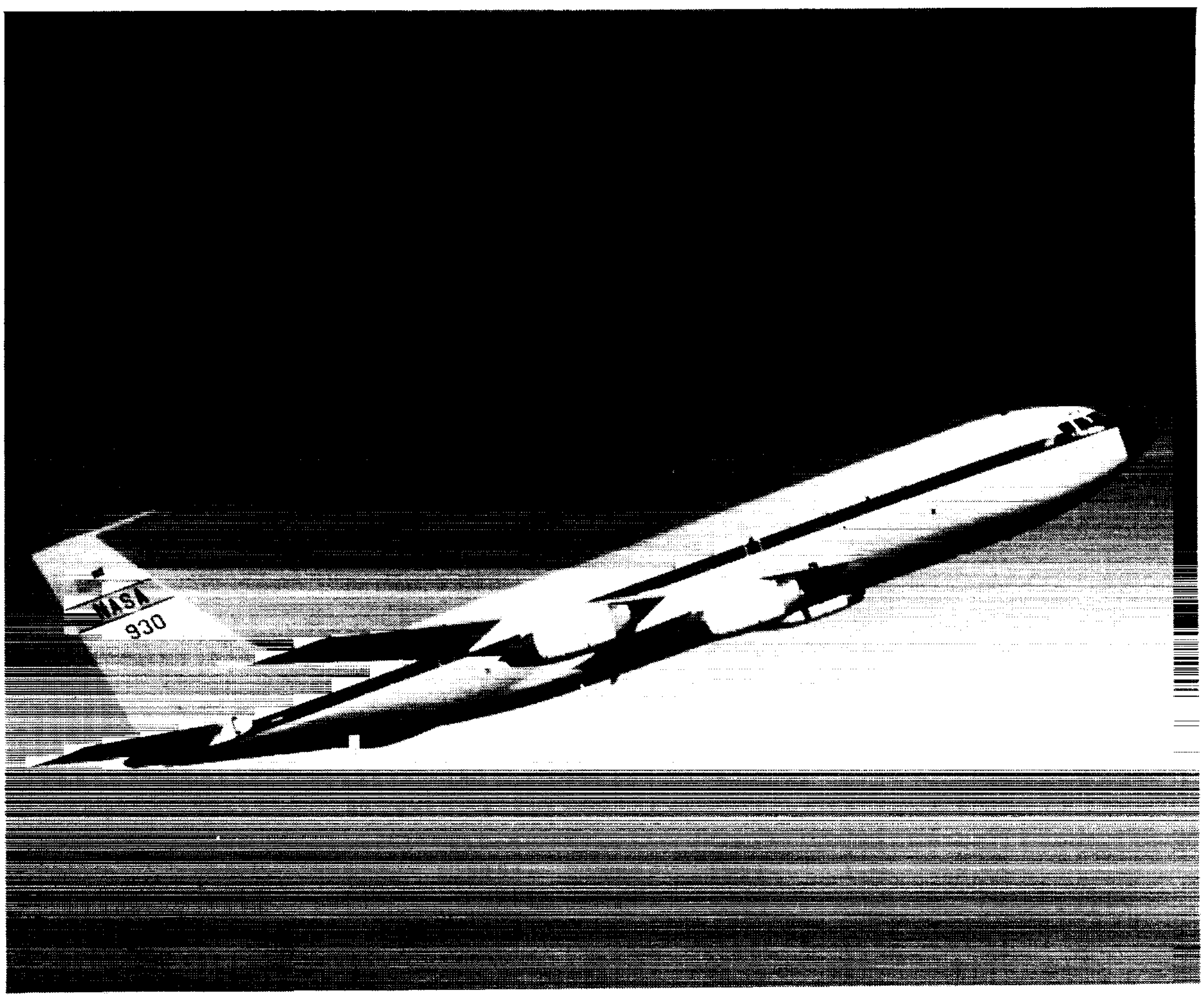
A reduced gravity flight test will be performed to determine the 12-meter truss zero-g dynamic behavior for validation of space structure ground test and analysis methods. A primary aim of the test is to determine the effects ground suspension systems have on these structures. A secondary objective is to evaluate the reduced gravity aircraft facility for the testing of other large space structures.

- **DETERMINE EFFECTS OF SUSPENSION SYSTEMS ON LARGE SPACE STRUCTURE DYNAMICS**

- **EVALUATE REDUCED GRAVITY INSTRUMENTATION AND TEST ENVIRONMENT ON THE NASA AIRCRAFT**

REDUCED GRAVITY FACILITY

The Reduced Gravity Office (RGO) of the Lyndon B. Johnson Space Center currently operates a modified KC-135A turbojet transport (see figure below) to provide a reduced gravity environment for research projects. The aircraft offers a sixty by six by ten foot test section, ample room for the truss and support equipment. Also available are 110V power, an attachment grid for securing test equipment, and audiovisual and test engineer support.



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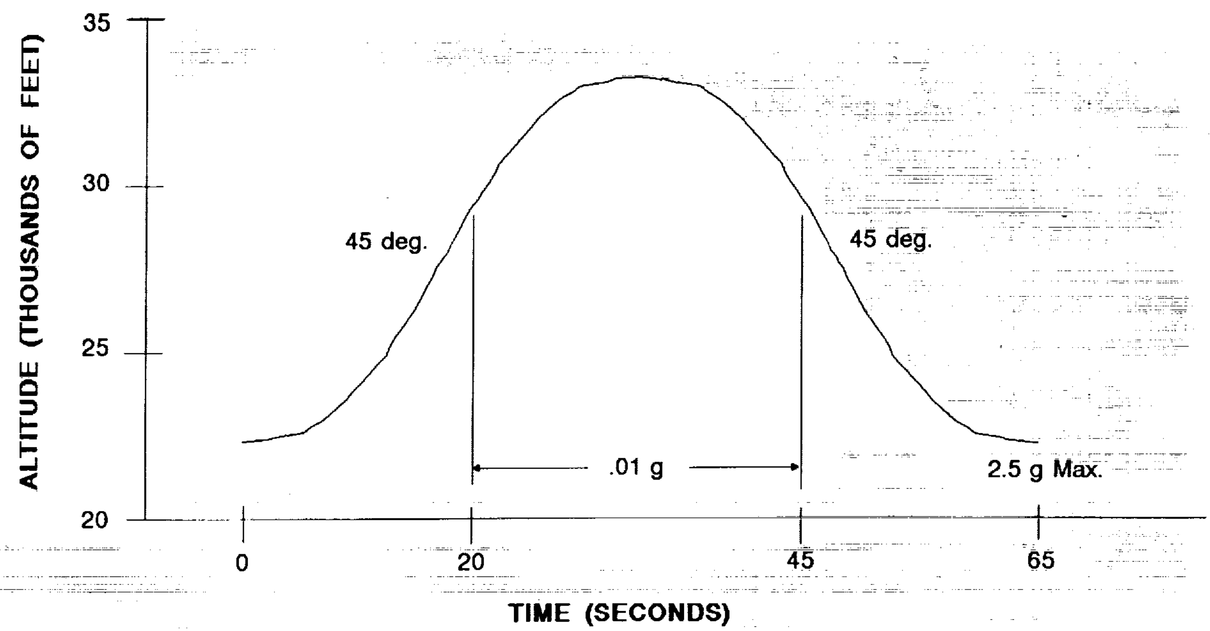
ZERO-g FLIGHT PROFILE

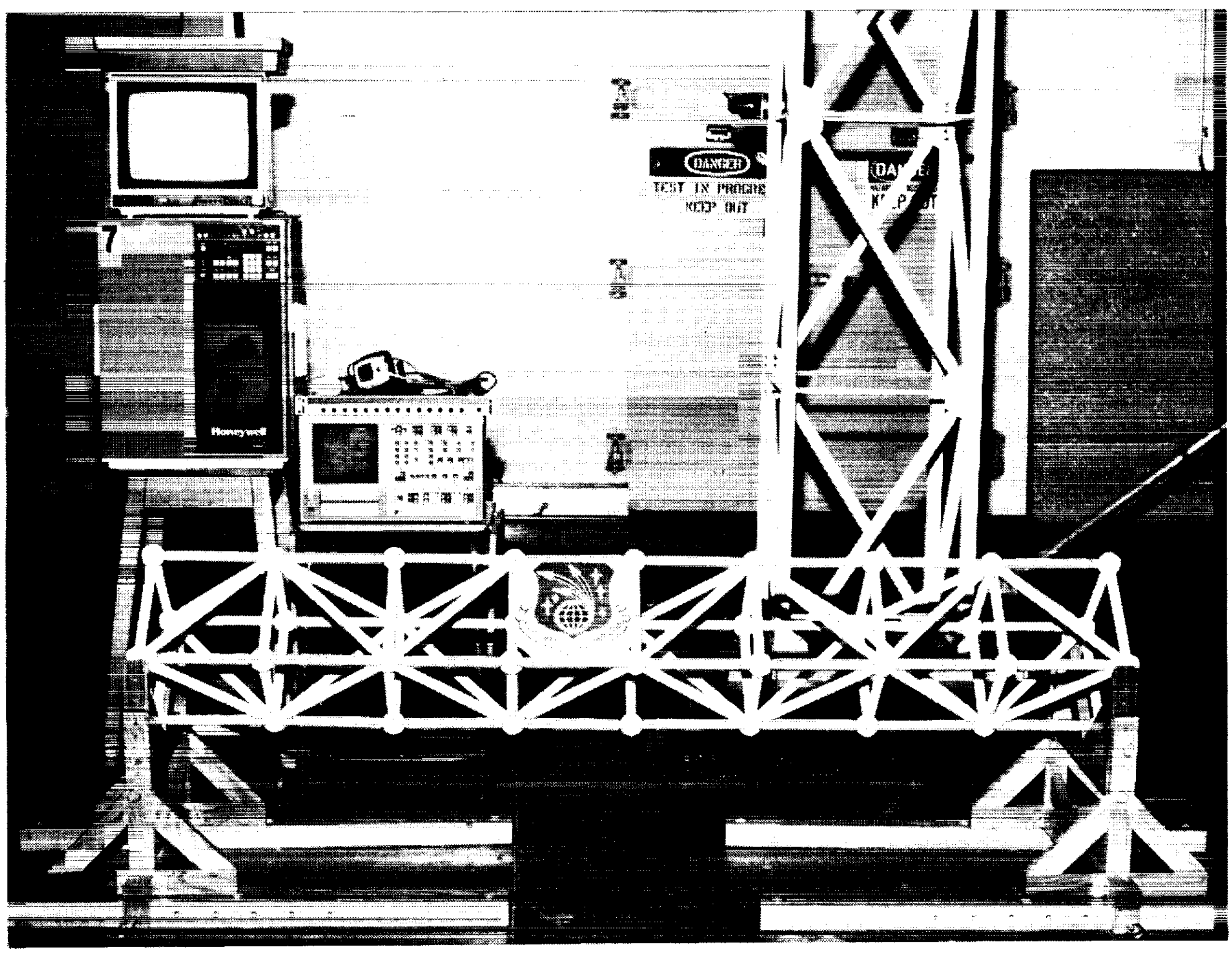
Zero-gravity (in reality, micro-gravity) will be achieved through parabolic flight profiles flown by the modified KC-135A. The RGO aircraft will provide up to forty 25 second intervals of zero gravity per flight by flying repetitive parabolic arcs as illustrated below.



PARABOLIC FLIGHT TRAJECTORY

2-METER TRUSS

Preceding the tests of the 12-meter structure will be a series of ground tests and two flights with a two-meter truss. Because of the aircraft's mass distribution, it will be impossible to collocate its center of gravity with that of the truss. This will cause the truss to translate about the test section. The truss, shown below, will be released at different locations and its motion will be recorded with accelerometers and videotape. This first test will also measure the aircraft's deviations from the planned flight path. During the period of zero-g, the aircraft will be rotating at a constant rate of three degrees per second. If the truss is released during this period, its rotation will track that of the test section. Deviations from the nominal rotation rate will be important for the 12-meter truss and will be evaluated during the precursor flights.



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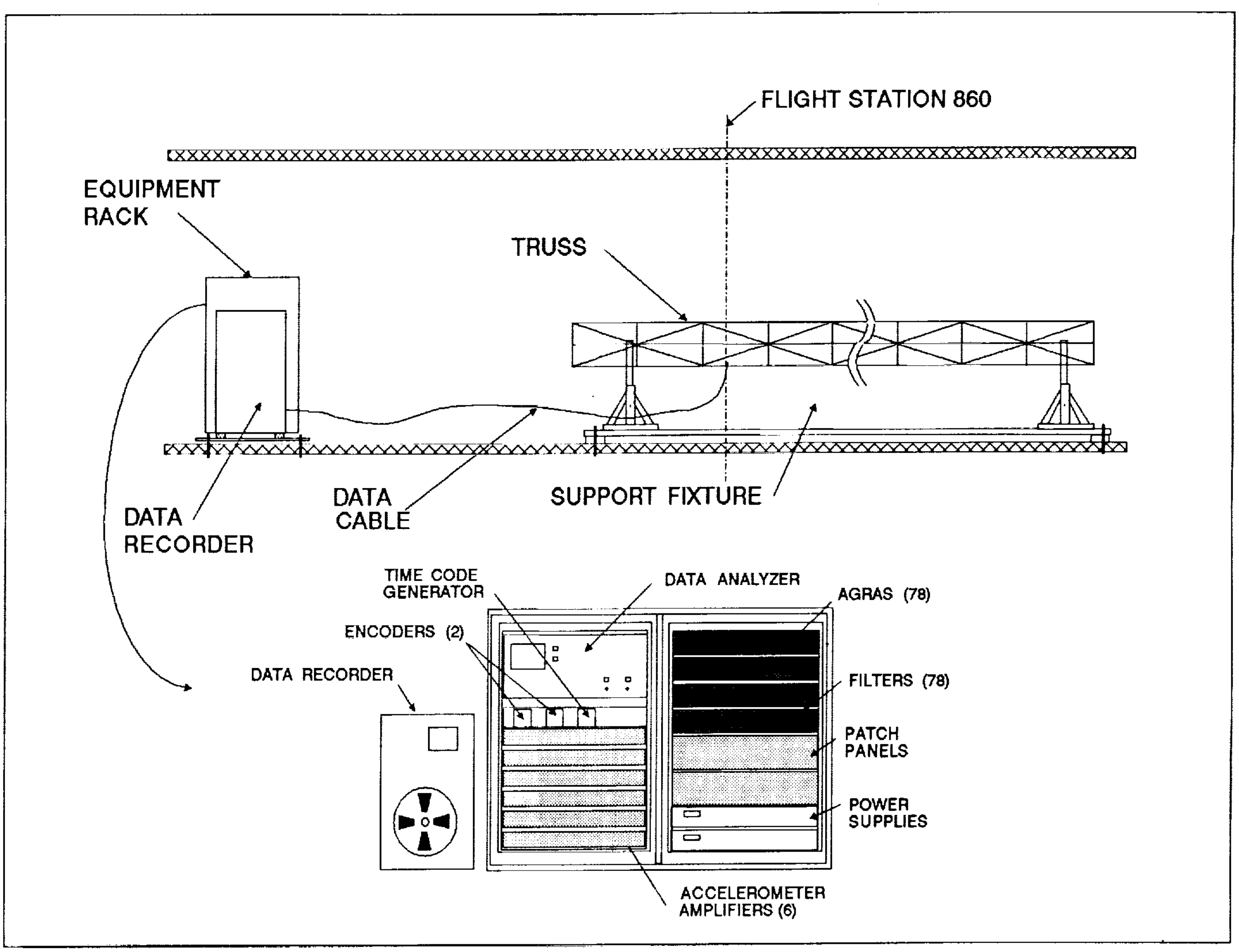
DATA ACQUISITION

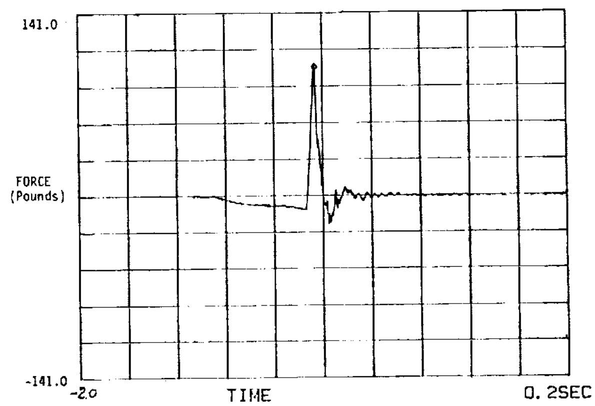
The 12-meter truss will be instrumented with 72 Structcel accelerometers. The accelerometers will be attached on every other bay, two positioned orthogonally at each corner. This arrangement is used to parallel the ground test setup to ease the comparison of results. The accelerometer signals will be amplified, filtered, multiplexed, and recorded on FM tape. A schematic of the test setup is shown below. During the test, data lines will be monitored real time on an FFT* analyzer and may be replayed during flight to verify that the system is operating properly.

*fast Fourier transform (FFT).



TRUSS EXCITATION

To provide excitation to the truss for modal parameter identification, impact devices have been fabricated from twenty pound-force solenoids. The devices may be oriented to produce both truss bending and torsion. An impact device and impulse function are shown below.



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DIFFICULTIES AND SOLUTIONS

The difficulties particular to the reduced gravity test facility are listed in the figure below. The offset of the truss and aircraft centers of gravity causes the truss to drift. This effect can be minimized by proper initial location of the truss cg. The short (25 second maximum) test time adversely effects the low frequency resolution, especially important for lightly-damped structures. The effect can be minimized through analysis technique. The release of the structure without disturbance may also be difficult. Adding to the problem is the inherent aircraft noise and vibration. Analysis of release techniques will be investigated and the vibration environment will be measured. The aircraft vibration is likely to be well out of the bandwidth of the structure and may be eliminated with filtering and isolation. Finally, the roller-coaster environment may provide discomfort to the test crew. Backup crew and test experience appear to be the best solutions.

TEST DIFFICULTIES

- TEST ARTICLE MOTION
- SHORT TEST TIME
- TEST ARTICLE RELEASE
- DISCOMFORT
- AMBIENT AIRCRAFT NOISE/VIBRATION

SUMMARY

The Lyndon B. Johnson Space Center Reduced Gravity aircraft provides a low-cost, innovative means of validating large space structure ground test and analysis techniques. While the facility has its inherent difficulties, their effects may be eliminated or minimized through data analysis and test technique and equipment, training, and prudent selection of test article position.