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# STS41-D Solar Array Flight Experiment

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ABSTRACT

The Solar Array Flight Experiment (SAFE) developed under the direction of the Marshall Space Flight Center, scheduled for launch on STS 41-D, will demonstrate a lightweight solar array technology which offers a factor of 3 improvement in weight and a factor of 10 improvement in specific volume over solar array systems currently in use in the space program. The experiment, which will include multiple deployment and retraction demonstration, verification of electrical and thermal performance, and verification of structural dynamic math models is 15 feet by 105 feet in size and, if completely covered with solar cells, would produce approximately 12.5 kW of electrical power. The unit has now been developed, tested, and is at Kennedy Space Center (KSC) being prepared for launch.

This paper presents a summary of system design characteristics, ground test history, and present status.

1. General Description

Since 1975, NASA has undertaken a technology development program aimed at providing a large lightweight solar array capability for advanced shuttle-launched missions requiring power in the 10 - 100 kW range. A key milestone in this program is the Solar Array Flight Experiment which culminates nine years of development with the launch, deployment, and operation of a 12.5 kW solar array wing on STS 41-D.

The experiment is designed to accomplish several objectives:

- Demonstration of functional operation of the wing deployment and packaging system.
  - Survival of launch loads
    - 70% and 100% multiple extensions and retractions.
    - Complete retraction with automatic reapplication of preload.
    - Operation of mast with maximum temperature gradient across deployer nut.
    - Survival of landing loads.
  - Electrical Performance
    - Measure on-orbit performance of 5.9 x 5.9 x .02 cm, 2 x 4 x .02 cm and 2 x 2 x .005 cm solar cell panels.
  - Thermal Performance
    - Obtain electrical and mechanical performance data during stable operation, deployment and retraction under various sun angles.
  - Dynamic Performance
    - Obtain mode shapes and frequencies of the array wing when excited with the orbiter VCS

- Measure dynamics using three independent instrumentation techniques- accelerometers, photography, and optical displacement measurement.

The general features of the solar array wing are shown in Figure 1. The blanket is composed of 84 panels in a flat-fold configuration which make up, when deployed, a 32 x 4 meter array. The wing is of flight design except that only one of the panels, the third from the outboard end, is a full electrical module. It is composed of half 2 x 4 x .02 cm and half 5.9 x 5.9 x .02 cm cells. Figure 2 shows the stowed assembly mounted on its handling dolly, and Figure 3 shows the installation of the unit as part of the OAST-1 assembly in the orbiter bay. When stowed, the 32 meter long blanket folds into a package less than 9 cm thick. The array is mounted on a government-furnished support structure which includes support brackets, MLI blankets, electrical cables, a Flexible Multiplexer/Demultiplexer, and a power control box. It is secured to the orbiter with four standard pallet trunnion fittings and one keel fitting.

In addition to the goals normally associated with an orbital test of a power system, the SAFE also serves as the Nation's first major Large Space Structures experiment in that it provides us with our first opportunity for rigorous measurement of the dynamics of a large flexible body in orbit. Accordingly, a great deal of effort is being put into measurement of mode shapes using two separate instrumentation systems.

Using an analytical model of the experiment structure, Lockheed has predicted motions of the array for various levels and modes of Vernier Control system excitations transmitted to the base of the solar array. From this, NASA has derived VCS firing directions and durations to provide these excitations. Responses of the structure to these excitations will be measured and later compared back against models of the flexible body and its predicted interactions with the orbiter control system.

To accomplish these objectives, two remote sensing systems have been developed. The first, an adaption of a multi-field star tracker, was developed by MSFC. The second, a photogrammetric technique, was developed by LaRC. In the star tracker system, the emitter, positioned at the base of the solar array, illuminates an array of retroreflectors. The retroreflectors return the emitted energy to the receiver. The receiver focuses the reflector images on a solid state sensor. A scanner samples the sensor and feeds reflector image positions to a microprocessor. The microprocessor computes the dynamic array displacement from the initial or rest position and provides a digital output through a data conditioner to a digital tape recorder. The recorded data is stored and returned for ground processing.

Ground processing will define the dynamic characteristics of the array, such as frequencies, mode shapes, and damping. These characteristics will be used to verify math models, provide test defined inputs for control software, and provide zero g correlation to one g ground test data.

The second remote sensing system employs four orbiter closed circuit TV cameras at standard bulkhead locations to obtain stero video observations of a pattern of targets on the sollar array. The video observations will be stored on tape for post flight analysis. Photogrammetric triangulation analysis will be employed to produce a time history of the displacement of each target observed. Appropriate system identification techniquews will then be employed to describe the dynamic modal and frequency responses exhibited by the solar array during the flight tests for both structural dynamics and control dynamics purposes.

2. Program Status:

The solar array hardware was delivered to KSC on 1 Feb 1984 for checkout and installation for a launch on STS 41-D on 4 Jun 1984. This came after a test series on the solar array system which included:

- Static Loads Test - A proof test was conducted to demonstrate load carrying capability and to verify design margins.
- EMI Test - For conformance of electronics and drives to Mil-Std-461.
- System Separation Test - Demonstrated automatic pyro - initiated separation of the wing in the event of a hazardous hardware failure, (see Figure 4).

- <u>Pre-Environment Deployment Test</u> - Deployment and retraction test in a horizontal test fixture (see figure 1) including operating of electronics and tape recorder.

- <u>Acoustic Test</u> - Subjected the stowed assembly to full anticipated launch acoustic loads (See Figure 5).

- <u>Thermal Vacuum</u> - Operation of deployment drives and electronics during three temperature cycles between upper and lower hardware temperature limits plus firing of pyros at the lower temperature limit. During this test, a mast failure occurred due to accidental overload. The mast was rebuilt, reacceptance tested, and the thermal vacuum test was repeated successfully (See Figure 6).

- <u>Final Deployment Test</u> - Repeat of the previous deployment test to check for electrical degradation and/or mechanical damage.

After this test series, which was completed in April 1983, the unit was stored until November, when a post storage deployment test was conducted to insure that no storage-caused degradation occurred. This final test also served as a training session for the flight crew.

The unit is now undergoing orbiter integration and testing for a June 4 launch. Figure 7 shows an artist's concept of the orbital configuration. As a demonstration of a major set of advances in solar array design as well as the nations first major large space structure experiment, the OAST-1 stands as one of the most important tests to be conducted in the Shuttle program to date.

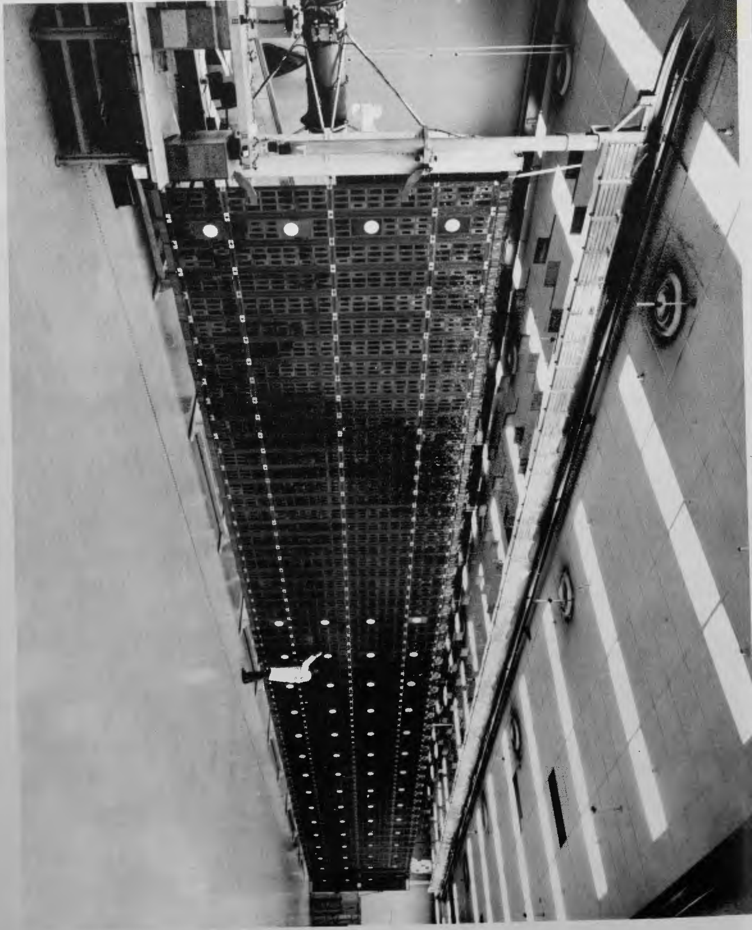
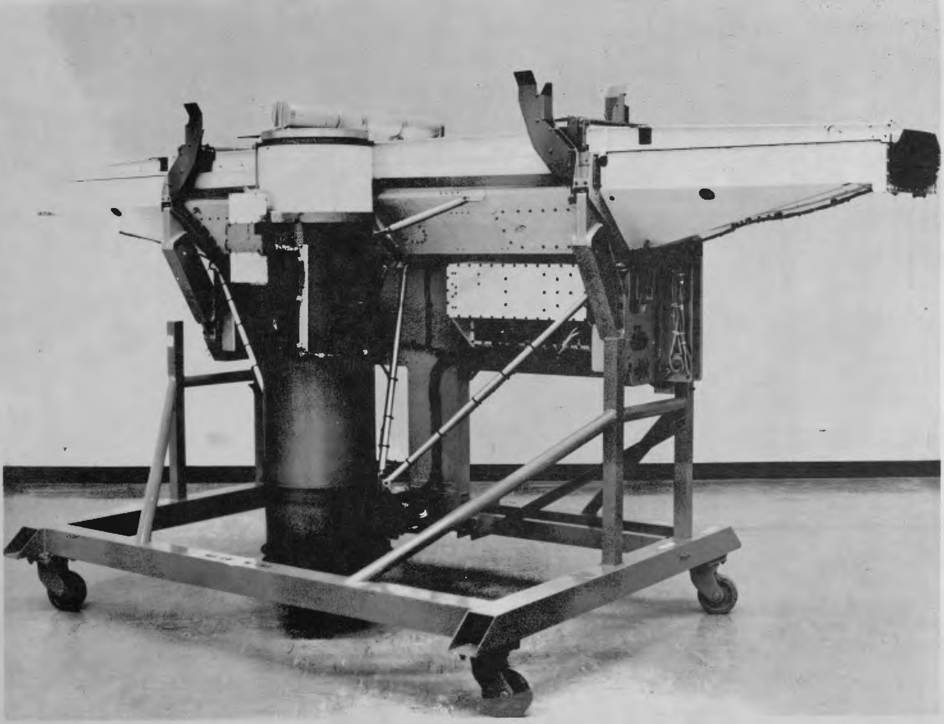


Figure 1     Solar Array Wing



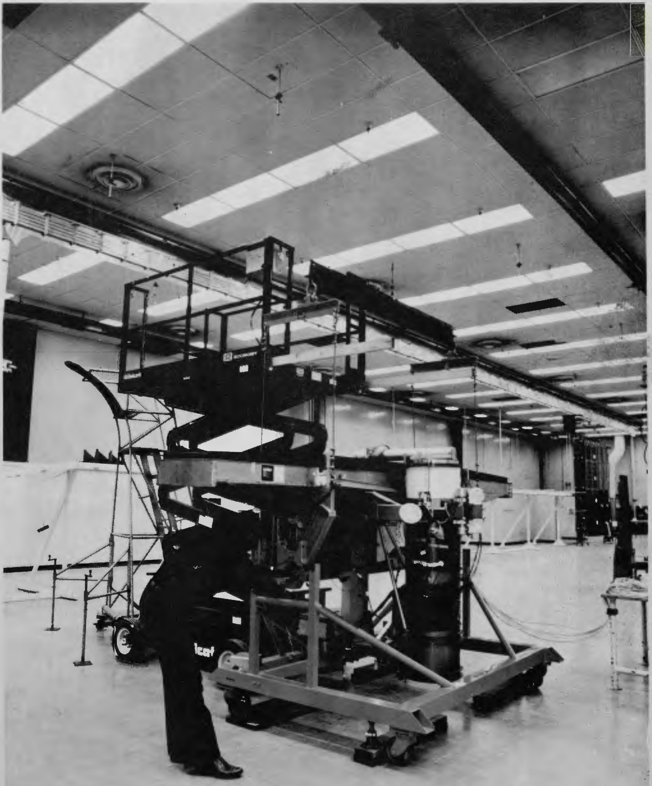


Figure 4    Separation Test Setup

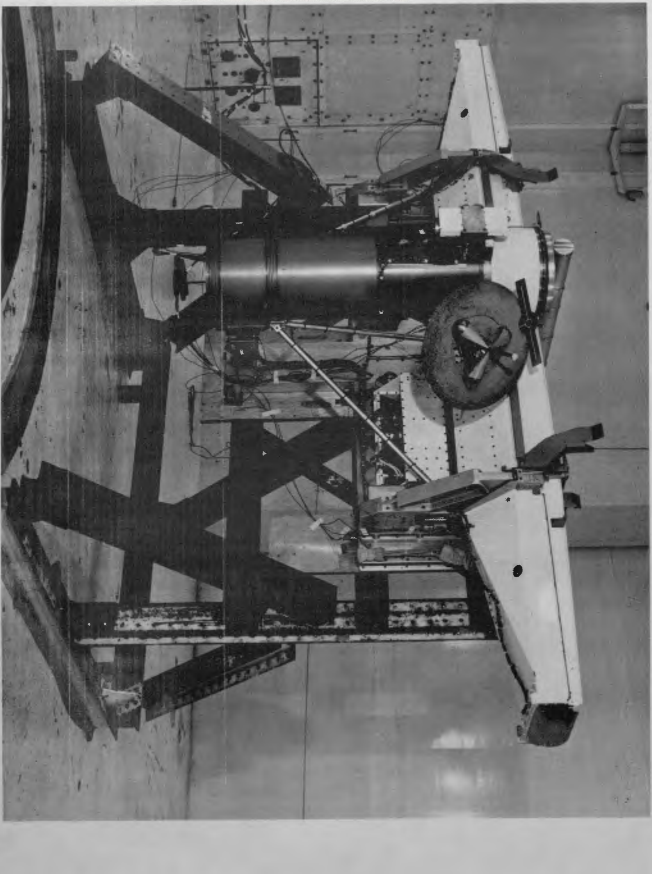


Figure 5 Acoustic Test Setup

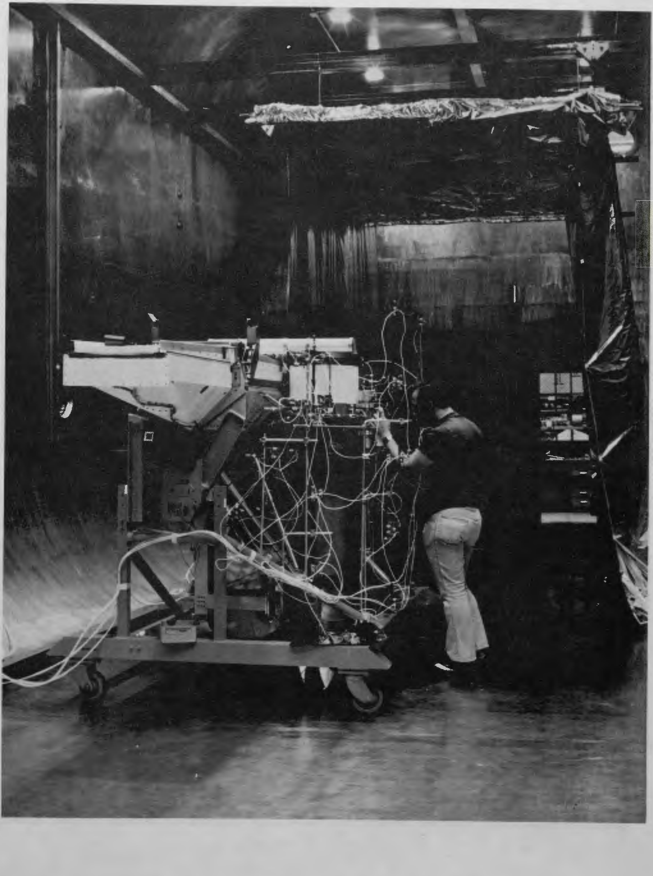


Figure 6 Thermal Vacuum Test Setup

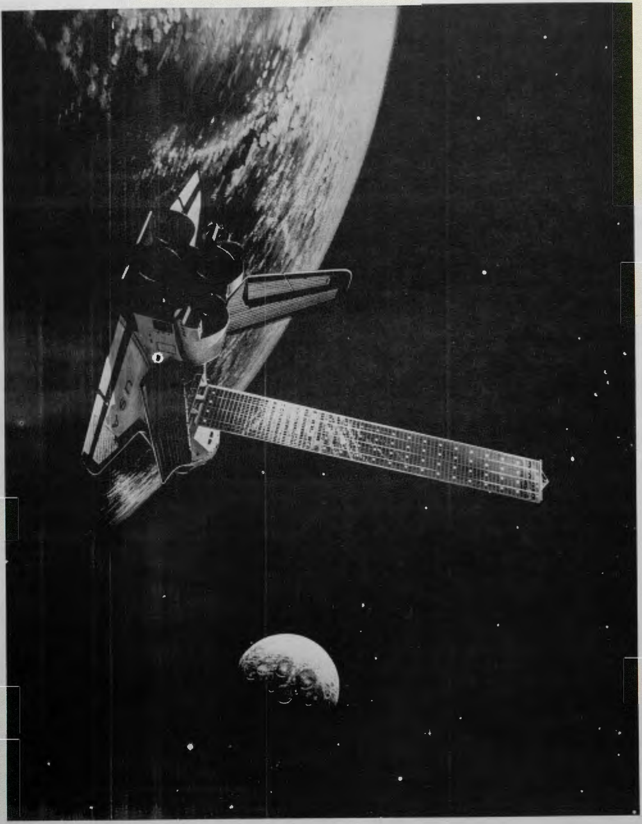


Figure 7 STS 41 D