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SPACE STATION FREEDOM: DYNAMIC INSTRUMENTATION FOR A LARGE SPACE STRUCTURE

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INTRODUCTION

The purpose of this paper is to discuss a proposed approach called Modal Identification Experiment (MIE) for obtaining on-orbit dynamic response measurements on Space Station Freedom, the first of a family of large, flexible space structures.

NASA's Office of Aeronautics, Exploration, and Technology (OAET) has supported a Phase A feasibility study completed in March 1989 and a recently concluded Phase B conceptual design study which provides a conceptual design of a proposed measurement system and an experimental protocol for inobstrusively collecting dynamic response data critical to characterizing important vibration modes of Space Station Freedom.

The objectives in collecting on-orbit dynamic data are fourfold. First, there a need to develop and demonstrate the technology to perform on-orbit structural testing of large space structures. Second, modal realization or system identification methodology must be developed, improved, and validated adequate to the stringent requirements imposed by on-orbit structural characterization. Third, there is a need to improve upon our capability to model large space structures. Utilizing on-orbit data, structural engineers can evaluate and devise improved methods for modelling the complex structures that constitute a significant portion of NASA's future missions. Finally, the proposed measurements will provide an invaluable characterization of the on-orbit dynamic environment and response behavior of Space Station Freedom which can be used to validate prelaunch loads calculations.

BASIC MIE RESEARCH OBJECTIVES

- DEVELOPMENT OF IN-SPACE MODAL TEST TECHNIQUES FOR LARGE SPACE STRUCTURES.
- VALIDATION OF MODAL REALIZATION TECHNIQUES FOR LARGE SPACE STRUCTURES.
- DEVELOPMENT OF VALIDATION/MODIFICATION TECHNIQUES FOR ANALYTICAL DYNAMIC MODELS OF SPACE STRUCTURES.

ENGINEERING OBJECTIVE

- CREATION OF AN ENGINEERING DATABASE DEFINING THE DYNAMIC ENVIRONMENT OF THE SPACE STATION FOR PAYLOAD APPLICATIONS.

pac 10/18/90

MIE RESEARCH REQUIREMENT

THE EXPERIMENT REQUIREMENT IS:

TO OBTAIN A SUFFICIENT QUALITY AND QUANTITY OF ON-ORBIT, TIME-DOMAIN TEST DATA COMPOSED OF MEASURABLE ACCELERATIONS TAKEN OVER SUFFICIENT TIME AND ADEQUATELY DISTRIBUTED SPATIALLY TO REALIZE IMPORTANT MODES FOR A SEQUENCE OF INTERMEDIATE AND FINAL BUILD CONFIGURATIONS OF SPACE STATION FREEDOM.

WHY SPACE STATION FREEDOM?

As the world's first large flexible space vehicle, Space Station Freedom presents a unique opportunity to commence the timely development of on-orbit structural characterization technology. In addition, the planned station build sequence presents the opportunity to acquire dynamic response data from the early unmanned structures up through assembly complete (AC). For example, assessment of the dynamic behavior of the photovoltaic power system structures should be greatly enhanced by data from several configurations of which it is an integral part.

SPACE STATION PROVIDES ON-ORBIT TEST OPPORTUNITY

- RESONANT FREQUENCIES WITH HIGH MODAL DENSITY CHARACTERISTIC OF LARGE SPACE STRUCTURES (BELOW ONE HZ).
- CONTROLLED AND MEASURABLE EXCITATIONS AVAILABLE.
- DATA HANDLING OF DISTRIBUTED SIGNALS PROVIDED.
- ORDERLY INCREASE IN COMPLEXITY OCCURS WITH BUILD-SEQUENCE CONFIGURATIONS.
- REFINED INTEGRATED MATH MODEL AVAILABLE FOR EACH BUILD CONFIGURATION.
- COMPONENT TEST RESULTS AVAILABLE TO STUDY COMPONENT MODE SYNTHESIS TECHNIQUES.

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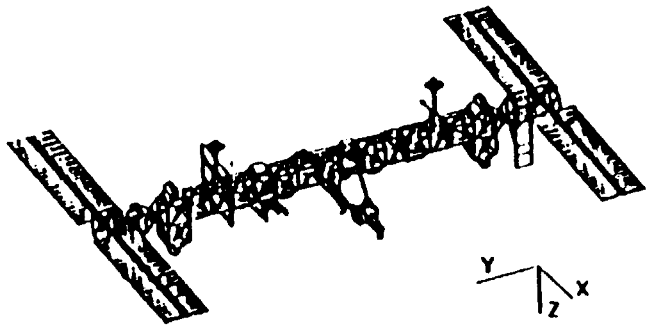
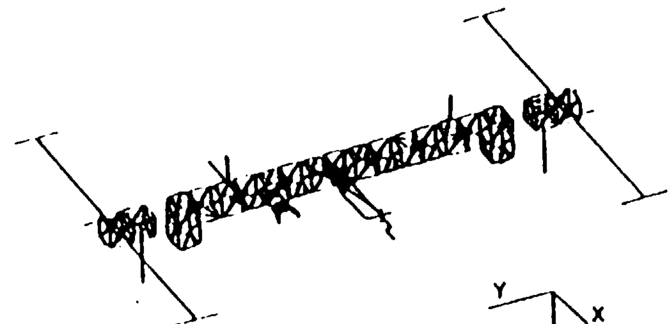
Range of Test Configurations

Several test configurations will be available between the first opportunity and the fully operational or assembly complete station. Data obtained from these intermediate configurations will allow improved insight into the individual effects of incremental additions of structural and systems components on overall station dynamic characteristics. These data obtained during station assembly become critical to the thorough assessment of station dynamic behavior in the light of the extreme complexity of the assembly complete station as currently baselined.

RANGE OF TEST CONFIGURATIONS

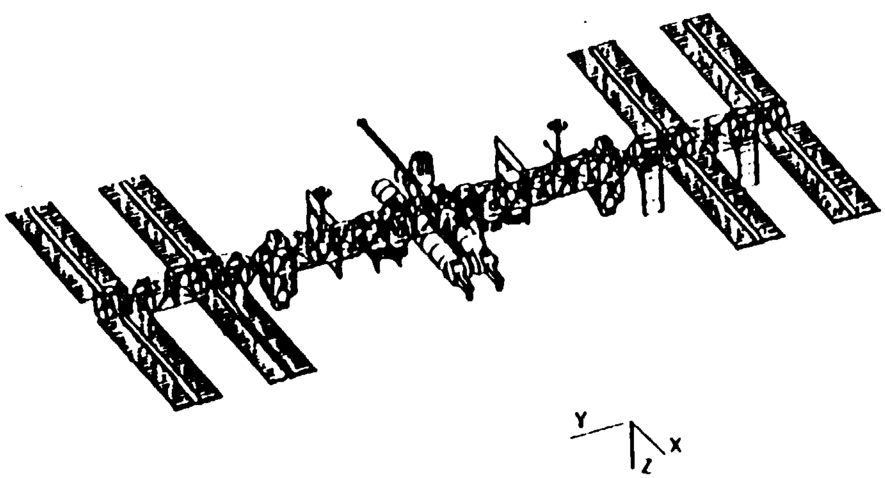
FIRST TEST OPPORTUNITY

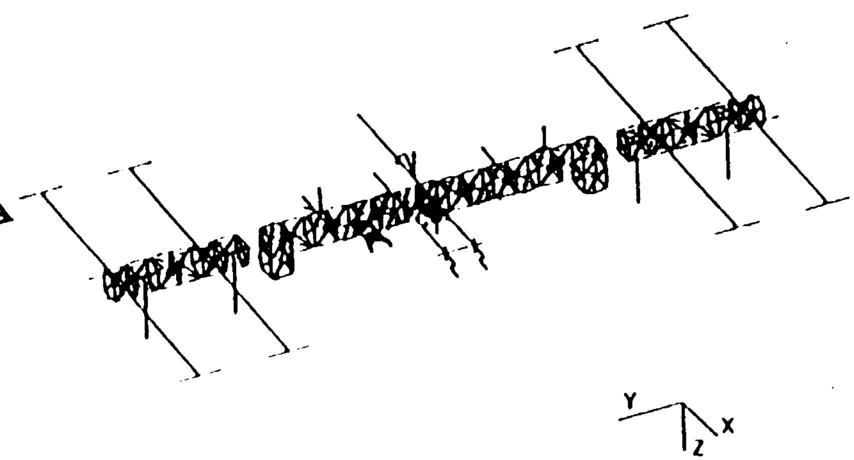




TOTAL MASS
72,300 KG

FINAL CONFIGURATION OF FULLY OPERATIONAL STATION





TOTAL MASS
265,900 KG

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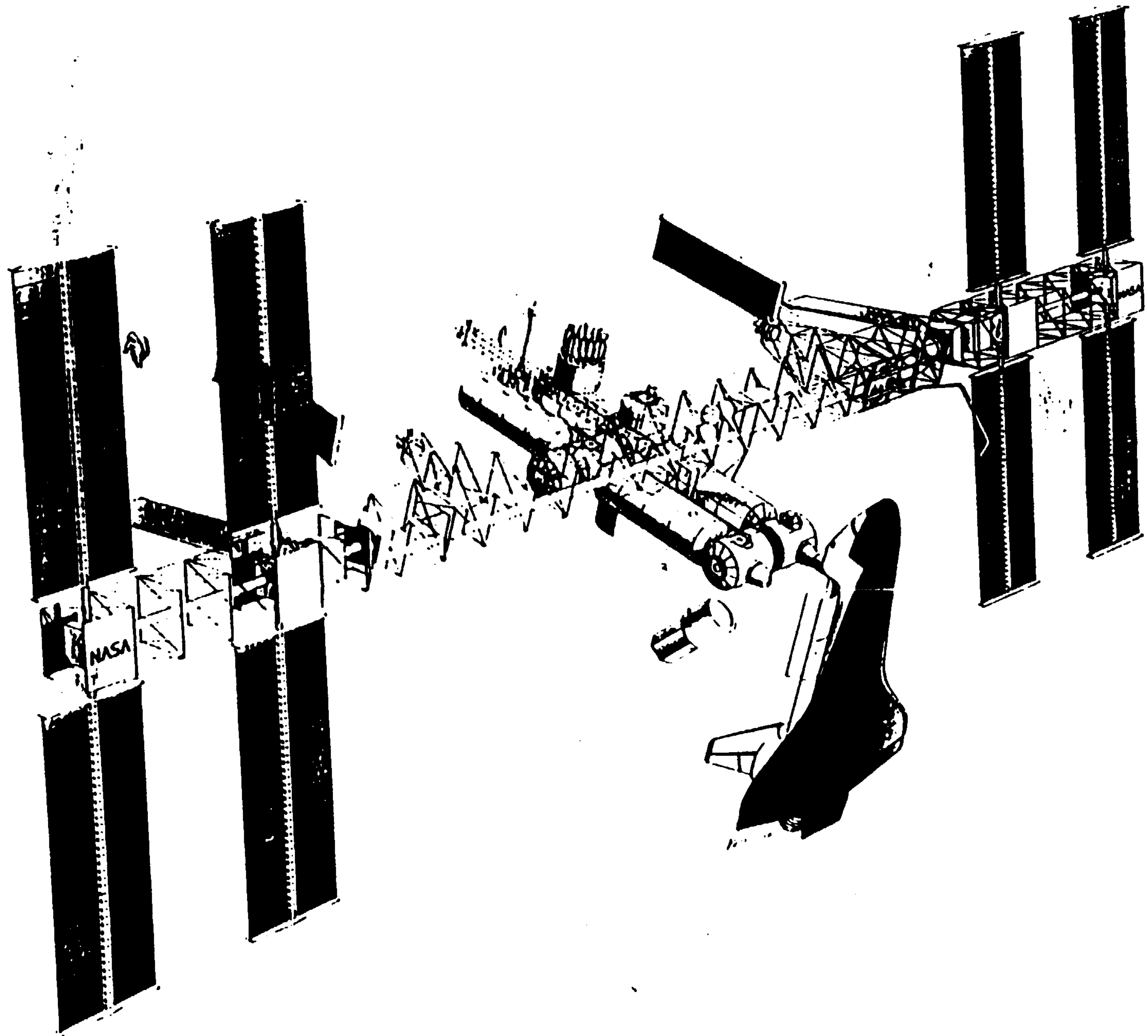
Space Station
A Research Laboratory In Space



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Uniqueness of On-Orbit Modal Testing

The identification of the dynamics of spacecraft in the past has been accomplished through ground testing since systems were typically designed to tolerate ascent loads and were thus usually stiff and strong enough to be tested on earth without having the test environment adversely affect the results of the test. The test environment for on-orbit modal testing is hostile to the test engineer in several respects. The test engineer must contend with the absence of gravity and must test in a vacuum. The test article is in a true free-free condition and the consequences of unbalanced test excitation forces must be considered and countered to prevent uncontrolled attitude changes. The thermal environment is uncontrolled and continuously varying causing thermal gradients due to shadowing of one component of the system by another. The test structure also experiences thermal transients and wide temperature swings from -80° C to $+75^{\circ}$ C as the orbital environment changes from night to day and back again every 90 minutes.

The space station as a test article is highly complex. The station will offer several distinct test configurations during the construction phase so that test procedures must be able to adapt to the large range of frequencies, response levels and excitation requirements. The major load transfer components of the station are truss structure which means that the station behavior should be similar to joint dominated structure. Joint dominated structure often exhibits nonlinear behavior. Because of the size and low frequency character of the station, long test times will be required to obtain reasonable test information especially if the response has some nonlinearities. Because of the configuration of the station with multiple components (PV and radiators) attached to the truss, high modal densities are expected and will be difficult to separate. Since the station attitude must be maintained at all times, an attitude control system will be active and the dynamics of the control system must be filtered from the modal test data if possible. The station has lineal dimensions on the order of 100 meters in the later build configurations and the limited number of sensors available will restrict the amount of spatial information available to reconstruct the modes.

UNIQUENESS OF ON-ORBIT MODAL TESTING

ENVIRONMENT HOSTILE

- TO TEST ENGINEER - MINIMAL GRAVITY, VACUUM
- TO TEST ARTICLE -
  - TRUE FREE-FREE CONDITIONS
  - TEMPERATURE GRADIENTS - SHADOWING, THERMAL TRANSIENTS
  - WIDE TEMPERATURE RANGE

SPACE STATION STRUCTURE HIGHLY COMPLEX

- MULTIPLE TEST CONFIGURATIONS - ADAPTIVE TESTING PROCEDURES
- JOINT DOMINATED STRUCTURE - POSSIBLE NONLINEARITIES
- LOW FREQUENCIES REQUIRE LONG TEST TIMES
- HIGH MODAL DENSITIES
- ATTITUDE CONTROLLERS ACTIVE DURING TEST
- LARGE DIMENSIONS

Uniqueness of On-Orbit Modal Testing (Cont.)
Test Parameters

Normal considerations associated with laboratory and field test parameters sometimes differ considerably for on-orbit testing. For instrumentation, the number of sensors which can be used is severely reduced and once installed cannot in general be easily moved. The sensors must be calibrated before installation, undergo the rigors of ascent and then be used for several years without recalibration. The sensors, where possible, must be installed on structural components on earth and then be connected to signal transmission systems on-orbit after the components are assembled. Installation procedures must be validated on-orbit to assure proper direction and connections were made. Since there will be large variations in temperature, compensation will be required either by measurements of nearby transducers which doubles the number of sensors required or by internal compensation in the accelerometers. Since the tests will occur over a several year period and the sensors will be subject to continual thermal cycling, transducers could fail and replacement of these sensors would be most difficult or impossible so that redundant sensor placements in important locations would be prudent.

Since excitation and response levels will vary from configuration to configuration and system damping levels will be unknown until the tests are performed signal conditioning and management systems must have variable gain amplifiers. The amount of information stored on-orbit will be limited by the storage capacity of the on board equipment and by the amount of information which must be managed during normal operations.

The location and force levels of the excitation will be fixed and only the force-time history can be varied, consistent with safety, to excite modes of interest. Modes with node points near excitation locations will be difficult to recover.

Noise levels will be uncontrollable and will vary from one configuration to another as operational payloads and equipment are added to the station. The test engineer will not be able to increase the excitation level to improve the signal resolution.

Test procedures will differ in that test times will be severely limited and there will most likely not be direct measurements of the applied excitation level available to compute frequency response functions. The station will have attitude and pointing control systems active and the station configuration might be continuously changing during acquisition of test information so that the station dynamics will be non-stationary.

UNIQUENESS OF ON-ORBIT MODAL TESTING (CONT)

TEST PARAMETERS

INSTRUMENTATION

- NUMBER AND LOCATION LIMITED AND FIXED
- INSTALLATION AND CALIBRATION DIFFICULT
- COMPENSATION REQUIRED FOR TEMPERATURE VARIATION
- NO REPLACEMENT OF FAILED TRANSDUCERS

SIGNAL CONDITIONING AND MANAGEMENT

- ADJUSTABLE GAIN AMPLIFIERS REQUIRED TO IMPROVE RESOLUTION
- NUMBER OF CHANNELS AND DATA STORAGE LIMITED

EXCITATION

- TYPE, LOCATION AND AMPLITUDE FIXED

NOISE

- LEVEL UNCONTROLLABLE
- WILL CHANGE FOR EACH TEST CONFIGURATION
- CAN'T INCREASE FORCE LEVEL TO INCREASE S/N RATIO

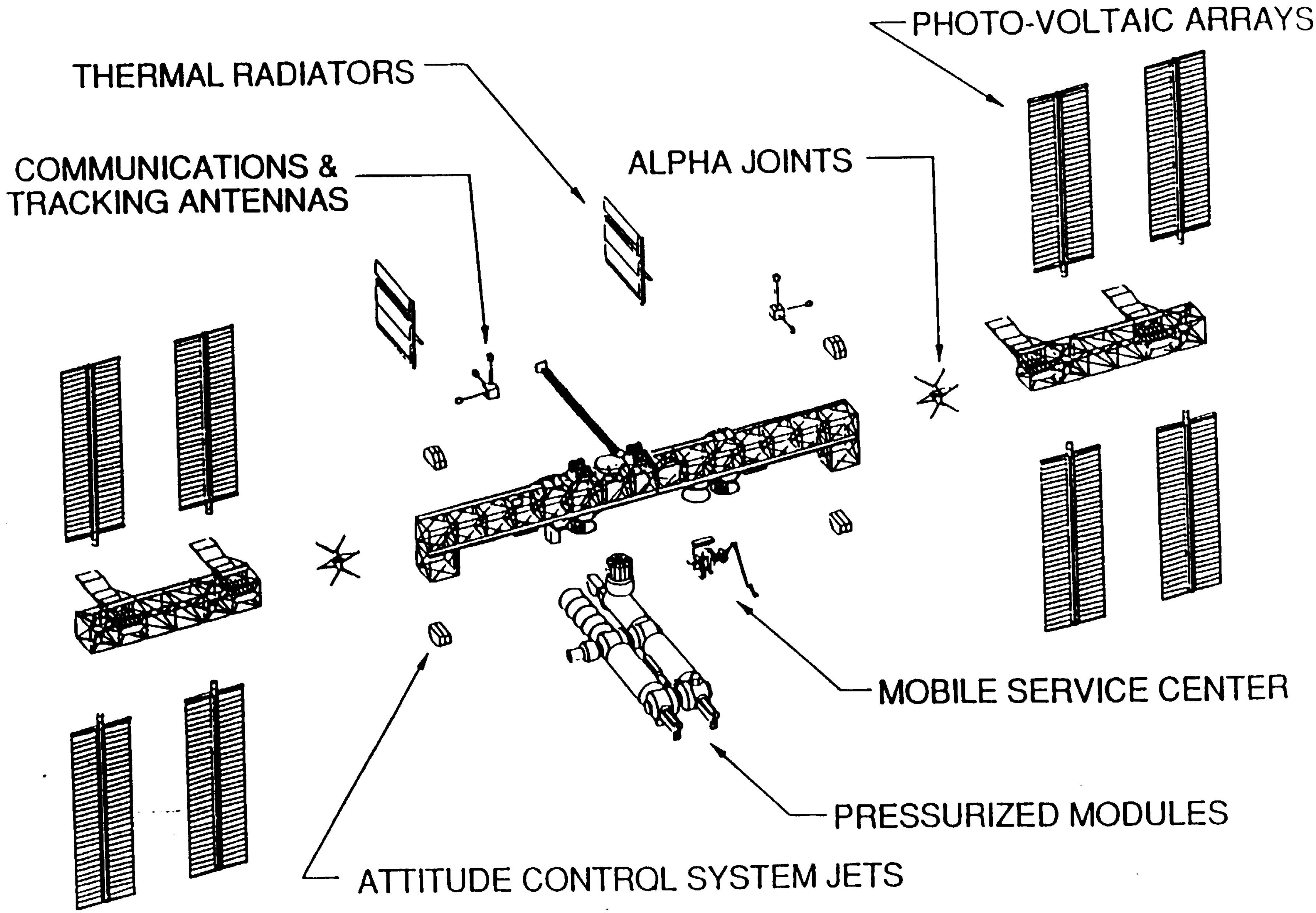
PROCEDURAL DIFFICULTIES

- TEST TIME SEVERELY LIMITED
- ABILITY TO MEASURE EXCITATION FORCES IN DOUBT
- NON-STATIONARY TEST ARTICLE
- TEST MUST BE NON-INTRUSIVE TO STATION OPERATIONS

Space Station Freedom Assembly Complete Configuration

The assembly complete configuration is the final construction configuration for which a modal test is planned under the MIE research program. This configuration has 267,400 kg mass. The various components which make up the station are installed on a truss structure with longerons, battens, and diagonals composed of thin-wall graphite-epoxy composite tubes with protective aluminum coating. The major component of the station is the pressurized module cluster which contains five modules of which one is a habitation module, three are laboratory modules and the fifth is a smaller supply module replaced after each Shuttle rendezvous. The station is powered by eight photo-voltaic arrays which track the sun. The tracking is supplied by alpha joints which use motors to rotate the outboard sections of the truss and the arrays with respect to the inboard section of the truss. The inboard truss and module cluster is held at a constant attitude with respect to the earth radius vector by a momentum management and attitude control system which uses control moment gyros, gravity gradient torques and torques caused by drag forces to maintain the attitude. Four reaction control modules are installed on the main inboard truss to provide both forces and torques for major maneuvers such as reboost of the station to higher altitudes. There are two types of thermal radiators installed, one near the arrays which is used to reject excess heat generated by the solar energy systems and the second type is located at two places on the inboard truss and used to reject excess heat generated in the pressurized modules.

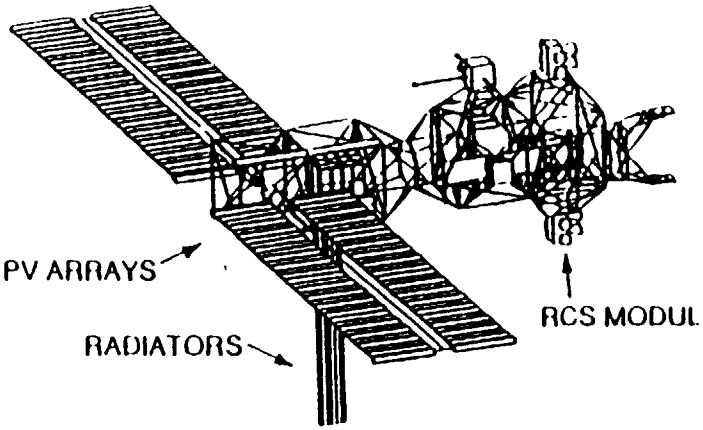
SPACE STATION FREEDOM ASSEMBLY COMPLETE CONFIGURATION



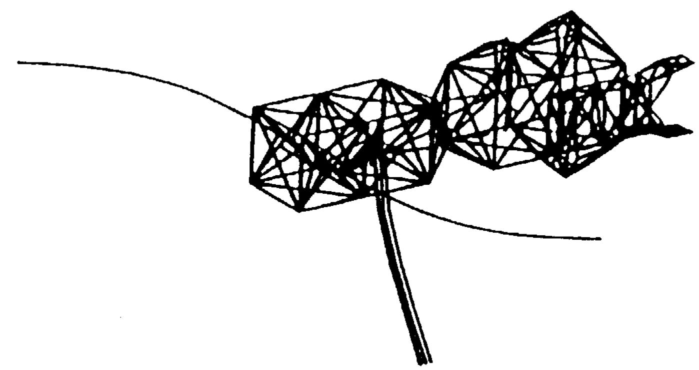
Selection of Target Modes Using Structural Response to Reboost Excitation

A complete end-to-end on-orbit modal test simulation of an early flight configuration was performed to assess the feasibility of the MIE experiment. A finite element model of an early flight configuration was developed and the undamped elastic modes below 5 Hz were identified. The dynamic response was computed of the spacecraft to jets located at the Reaction Control System (RCS) module firing in a manner consistent with a reboost maneuver and results were used to define a set of target modes for modal testing. Of the 88 undamped modes below 5 Hz, the 19 modes which accounted for 95% of the global acceleration response of the structure were selected as target modes. The lower frequency target modes were complex modes coupling truss rigid body motion with motion of the photovoltaic (PV) arrays and modes with deformation in the alpha joint region. The higher frequency target modes were, in general, radiator bending modes.

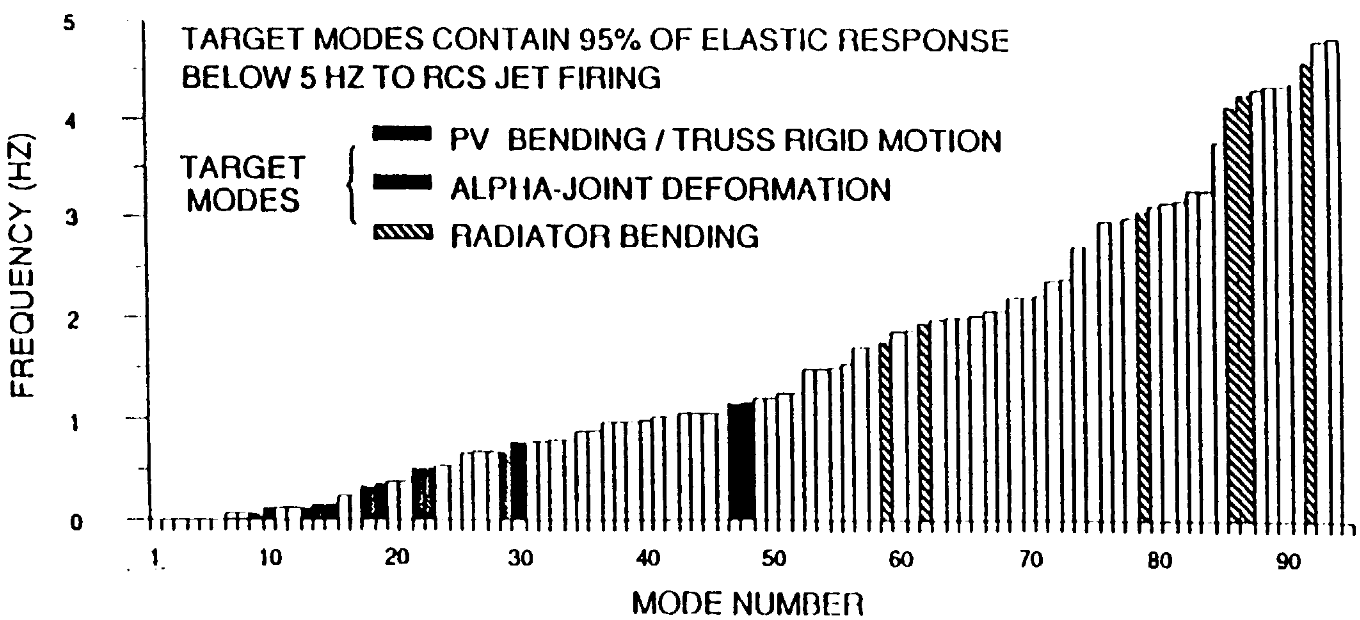
Selection of Target Modes Using Structural Response to Reboost Excitation



EARLY FLIGHT CONFIGURATION



FINITE ELEMENT MODEL
(MODE 15, f = 0.166 Hz SHOWN)



SELECTED TARGET MODES

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Identification of Target Modes Using Eigensolution Realization Algorithm and Measurement With Added Noise

A set of 43 accelerometer response measurements were taken at the sensor locations shown. The Eigensolution Realization Algorithm (ERA), was used to identify the modes from computed response measurements corrupted with various levels of white noise. The criteria for accepting that the procedure has accurately identified a particular mode is that the measured frequency and damping errors were less than 10%, that the modal assurance criteria was greater than 70%, and that the cross-orthogonality between the measured mode and the actual mode was greater than 90%. The simulation results indicated that on-orbit modal testing using RCS jets as an excitation device and accelerometers as sensors should be successful in identifying the target modes with noise in the measurement. Without noise, 52 modes including all 19 target modes were identified. When white noise levels of 10 microG (0.56 % S/N) and 50 microG (2.8% S/N) were added to the measurements, 20 and 17 modes were recovered respectively. Only one target mode could not be recovered with 10 microG noise and three target modes could not be identified with 50 microG noise in the measurement signal.

This in-house study helped to establish the confidence required to proceed with the MIE phase B conceptual design study, the results of which are summarized below.

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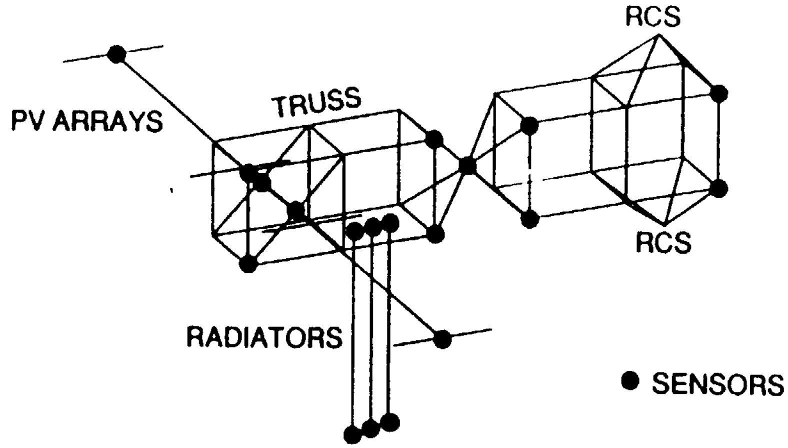


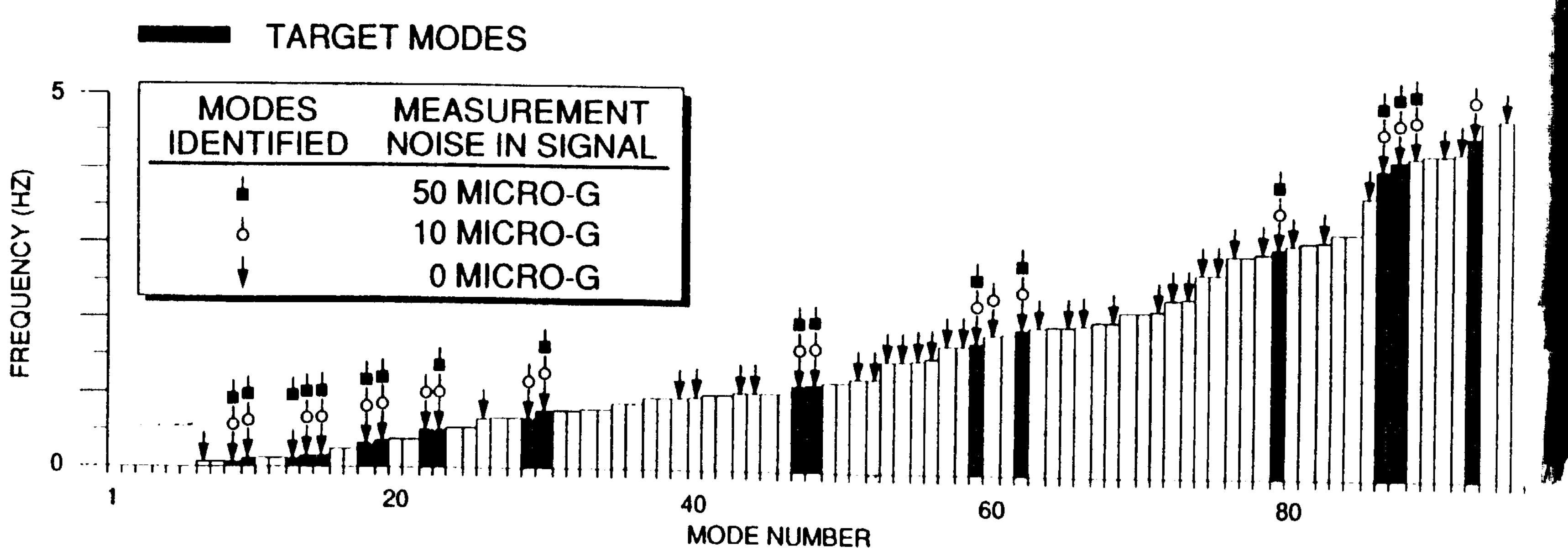
43 DISCRETE MEASUREMENT CHANNELS WITH NOISE ADDED

CRITERIA FOR MODE IDENTIFICATION

FREQUENCY AND DAMPING ERROR < 10%

EXTENDED MODAL ASSURANCE CRITERIA > 70%

CROSS-ORTHOGONALITY > 90%



SIMULATION RESULTS

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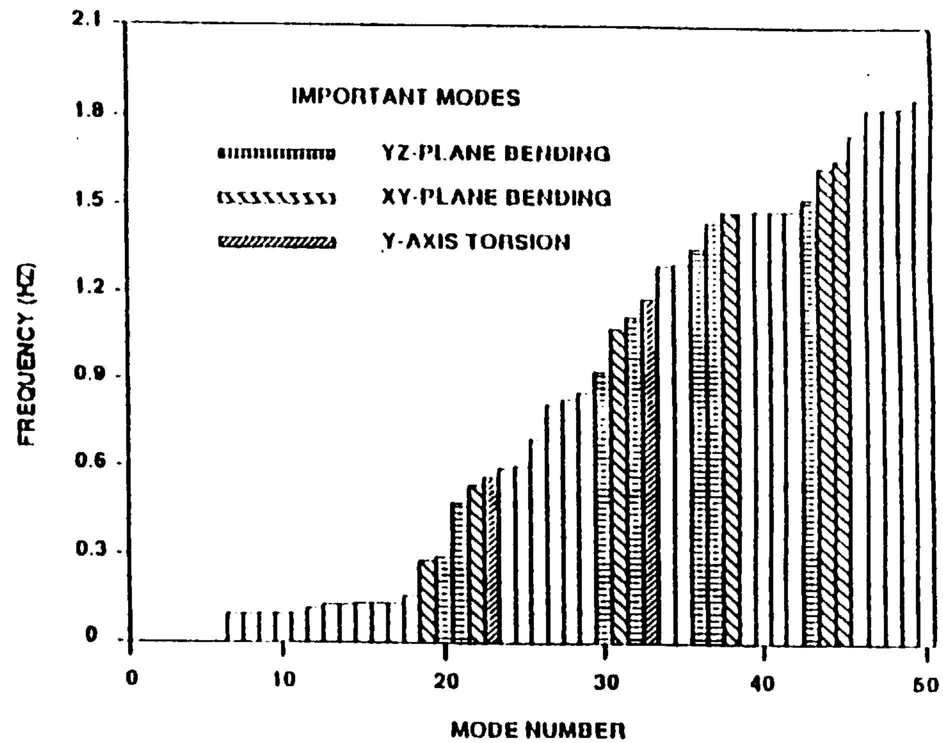
SELECTED MIE CONFIGURATIONS AND THEIR IMPORTANT MODES

MB6 CONFIGURATION

FREQUENCY DISTRIBUTION



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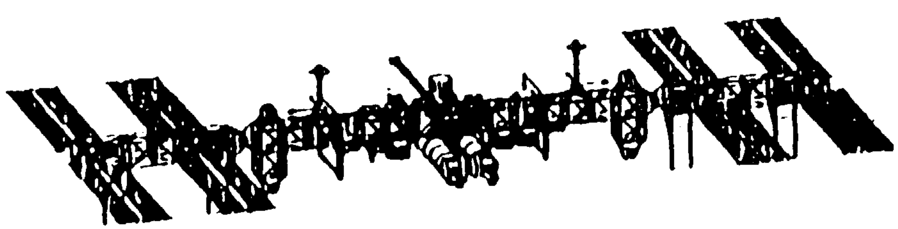
Assembly Complete Frequency Density

The finite-element model used to represent the low frequency dynamic characteristics of the assembly complete station configuration has over 3800 degrees of freedom but contains no detailed representation of the photovoltaic blankets or the array mast structure. Low frequency modes associated with blanket motion are not modelled. These blanket modes do occur in the range of interest of the experiment but will most likely be equilibrated locally and should not contribute to the overall dynamic response of the station to major loads. The array mast and the radiators are modelled using an equivalent beam representation where the beam is sized to give the same first four beam bending and torsion modes and similar mass distributions as the actual components. The pressurized modules have fundamental frequencies well above the frequency range of interest in the experiment so that the modules are represented as beam elements with appropriate mass distributions and truss attachment points to simulate the rigid body dynamic character of the module cluster.

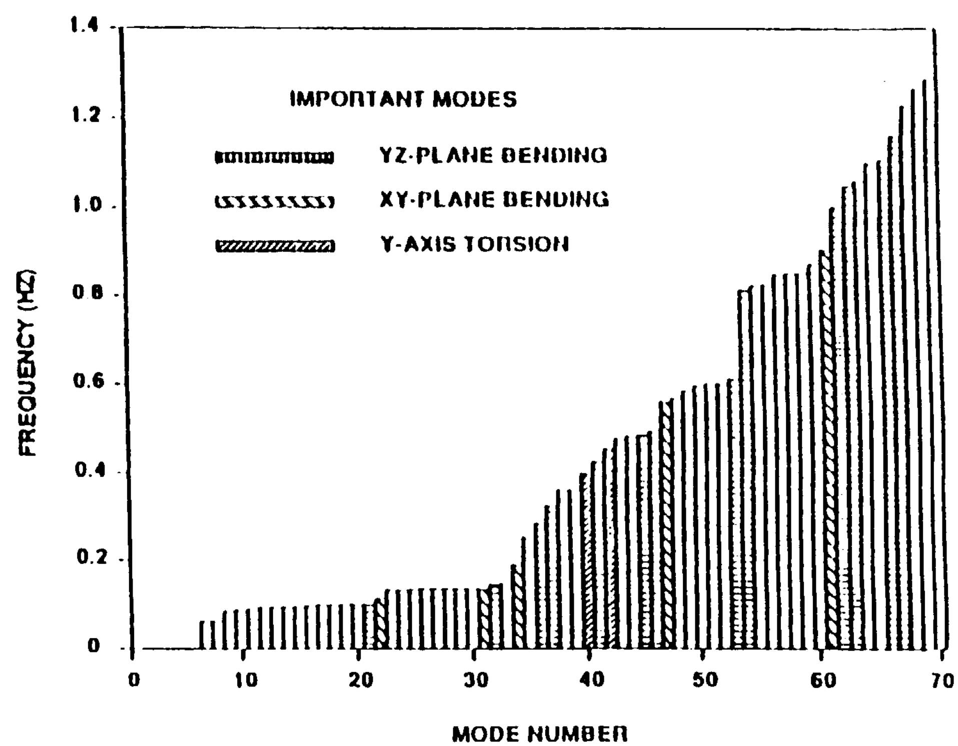
The model has 169 modes under five Hz. The lowest mode with considerable modal strain energy in the truss structure occurred at 0.115 Hz and is characterized by truss bending , coupled with PV array motion.

SELECTED MIE CONFIGURATIONS AND THEIR IMPORTANT MODES

ASSEMBLY COMPLETE CONFIGURATION



FREQUENCY DISTRIBUTION



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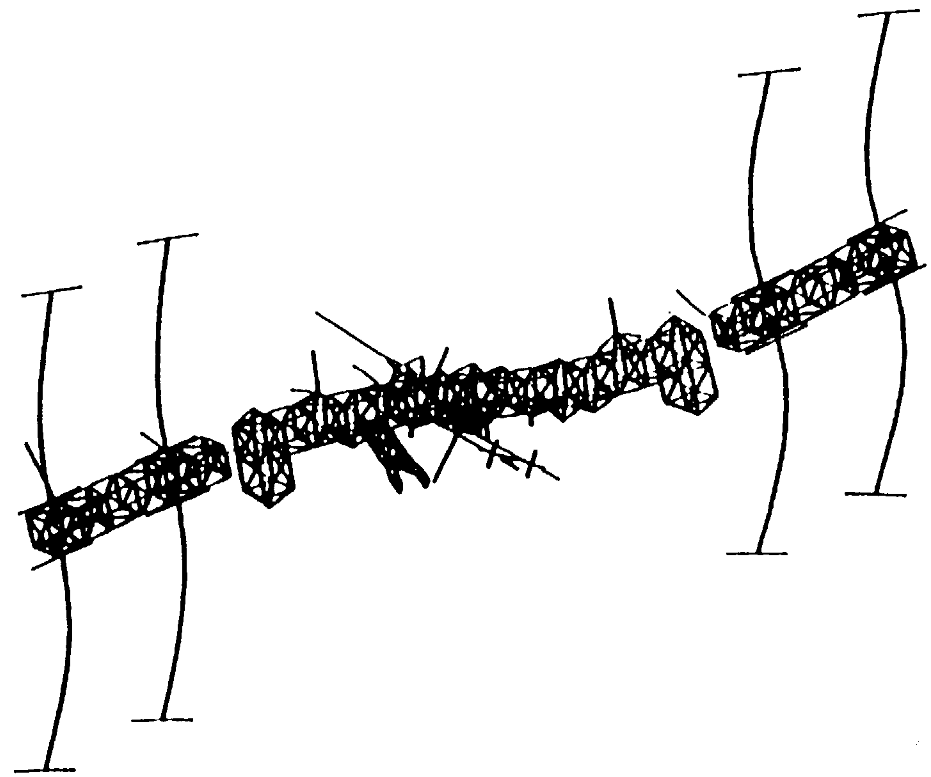
SELECTED MIE CONFIGURATIONS AND THEIR IMPORTANT MODES

TYPICAL ASSEMBLY COMPLETE CONFIGURATION MODE SHAPE



MIE Definition Studies

A Phase A study was conducted in 1988 to begin experiment definition for MIE. The study objective was to evaluate various methods for exciting the Space Station structure, measuring its response, and recovering the vibration modes. Disturbance events from orbiter docking, module berthing, reboost, CMG's, and crew activities were evaluated. A wide variety of measurement devices , including optical sensors to measure displacement, fiber optic sensors,laser doppler velocimeters, and geometric position sensors were considered.

It was determined that the experiment was feasible using RCS thruster firings during reboost as the excitation. Linear servo accelerometers to measure the responses, and free decay time domain modal identification in order to minimize the excitation time required.

A Phase B study, which provided a baseline experiment design, was completed in August 1990. This design includes experiment-unique forcing functions for thruster firings, 189 single axis acceleration measurements located at 107 points on the station at assembly complete, and a minimum 100 second free decay period for modal recovery. The baseline design is derived from trade studies and sensitivity analyses conducted by numerically simulating modal test using finite element models of selected Space Station assembly configurations. After choosing a baseline design for the MB-6, PMC, and Assembly Complete configurations, end-to-end simulations were conducted to estimate experiment performance for each case.

MIE Definition Studies

- Phase A Study Established Feasibility, December 1988
  - Excitation — Reboost Transients
  - Response Measurements — Acceleration
  - Modal Identification — Free Decay
- Phase B Study Povided Baseline Design Concept, August 1990
  - Excitation — Random RCS Thruster Firing
  - Response Measurements — 189 Accelerations
  - Modal Identification — Free Decay

MIE Baseline Experiment Design

Simulation of a Typical On-Orbit Test

Numerical simulations of on-orbit modal tests were used during Phase B in trade studies, sensitivity analyses and end-to-end performance analyses. For design studies on any given Space Station assembly configuration, target modes were first identified using MSC/NASTRAN normal mode analysis and selection criteria derived from the MIE research requirements. These target modes were then used in the design process and in assessing performance. The end-to-end simulation of a modal test included selection of a set of forcing functions for the various RCS thrusters used for excitation, selection of a set of measurement points on the system, computation of the forced response of the system at the selected measurement points, and recovery of the system modes from the response set using standard time domain free decay identification techniques.

The station design includes RCS thrusters located on both the port and starboard sides of the module cluster and both above and below the transverse boom. There are four individual thrusters in each of the X and Z directions at each location for attitude control. For example, there are two 25 pound thrusters for the +X direction and two for the -X direction. There are also reboost thrusters at each location. The attitude control thrusters are used for the random pulse excitation functions that were baselined for the experiment. Both random pulsing and reboost were evaluated as excitations during Phase B.

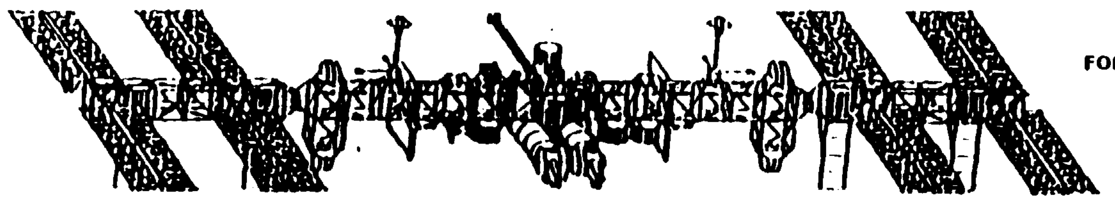
Simulations were run with measurements located on the truss, PV arrays, thermal radiators, and in the module cluster. Measurement sets ranging from greater than 200 single axis accelerations to sets with less than 50 were considered. Additive noise and measurement system errors were included in the simulated measurement time histories.

Both the Eigensystem Realization Algorithm, ERA, and Time Domain Polyreference were used to recovery modes from the response time histories. In applying these algorithms, emphasis was placed on recovering Target Modes.

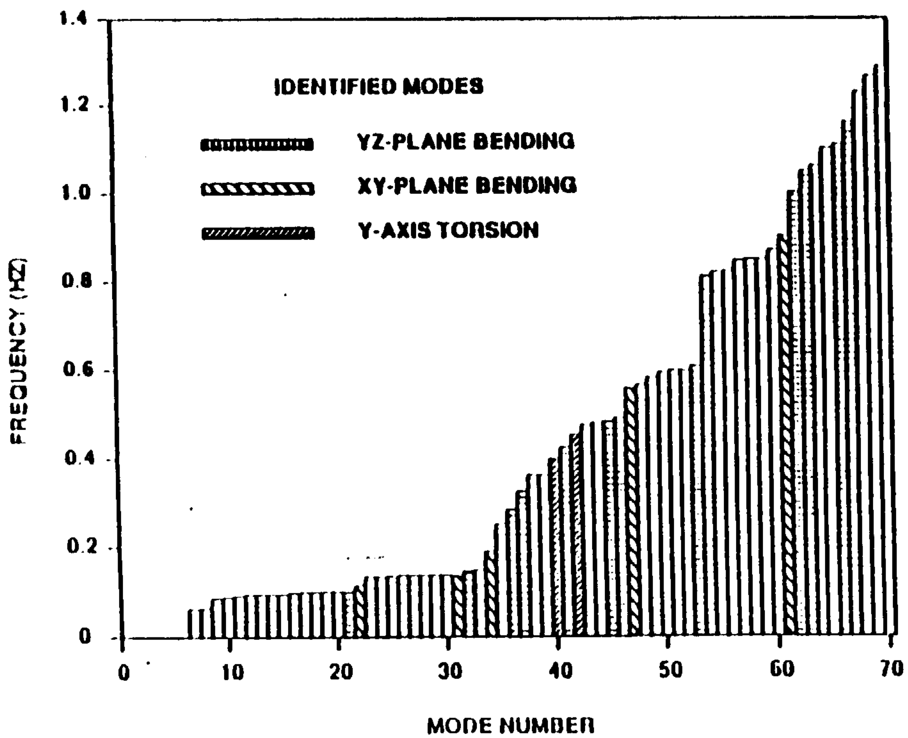
MIE BASELINE EXPERIMENT DESIGN

SIMULATION OF A TYPICAL ON-ORBIT TEST

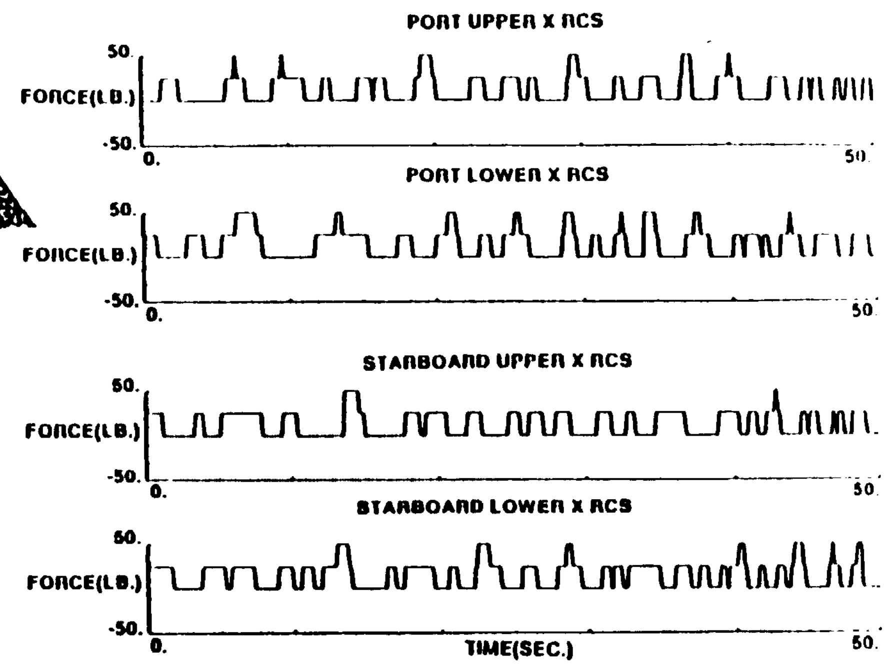
ASSEMBLY COMPLETE CONFIGURATION



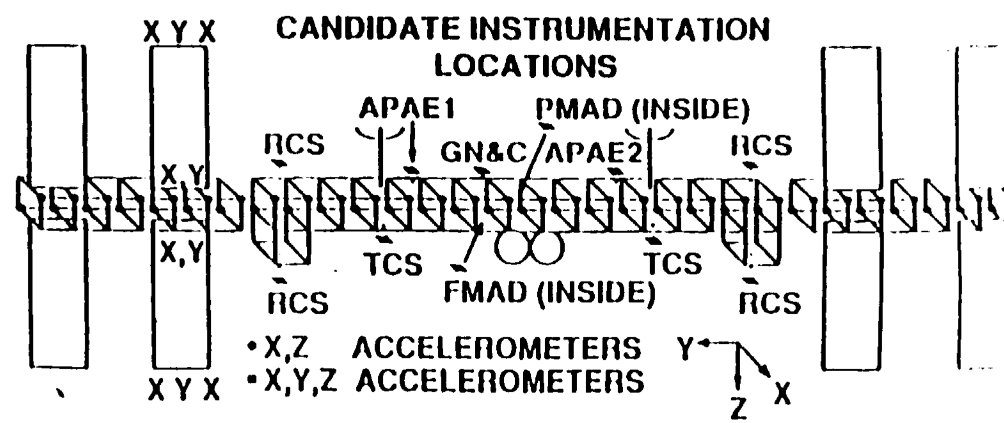
ASSEMBLY COMPLETE CONFIGURATION FREQUENCY DISTRIBUTION



RANDOM X RCS FIRINGS



CANDIDATE INSTRUMENTATION LOCATIONS



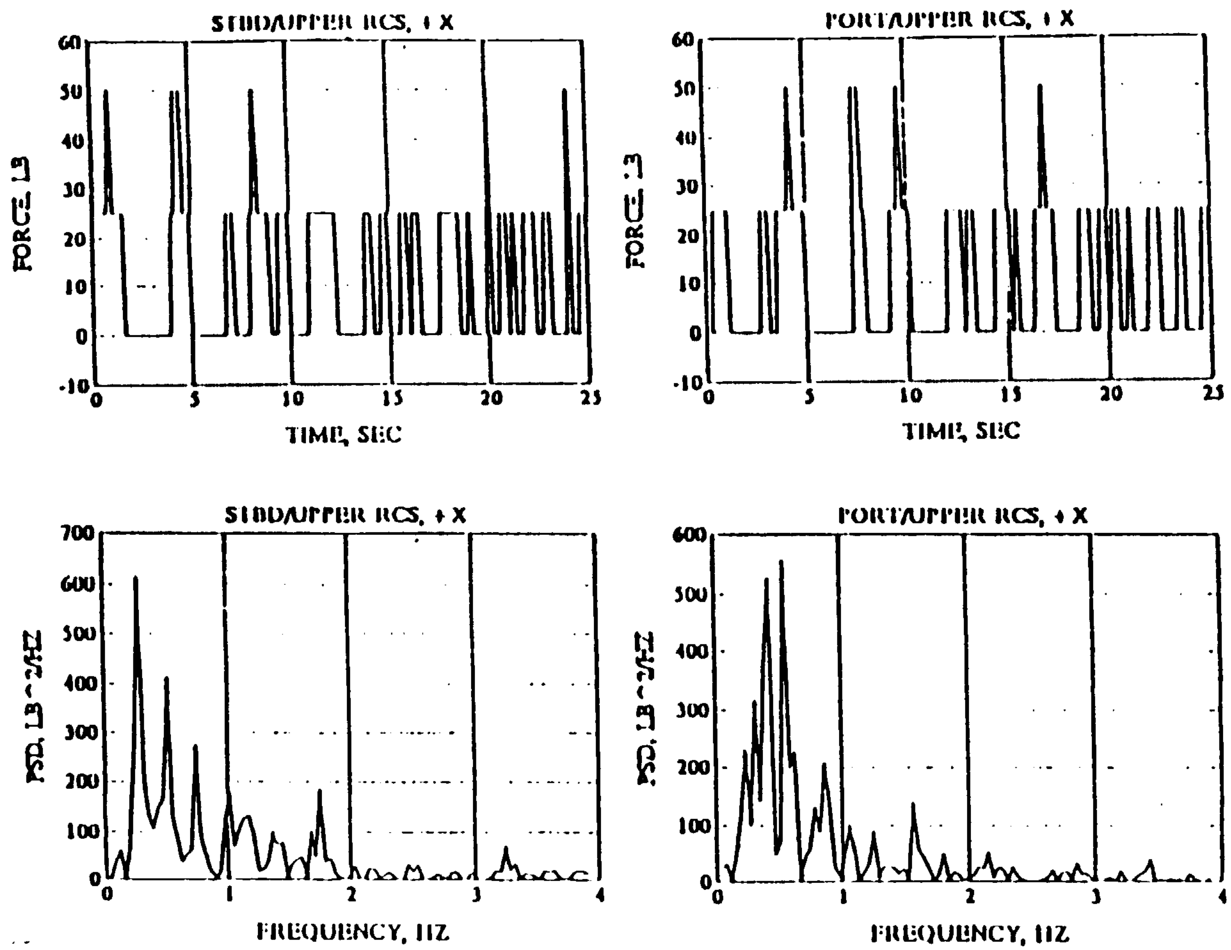
MIE Baseline Experiment Design

Forcing Functions

Several potential excitation sources for MIE were evaluated during the Phase B Definition Study. Reboost was identified as the best operational excitation for conducting MIE. However, response levels of the important modes are increased by pulsing the thrusters. Even though there is coupling between many modes with motions in the XY and YZ planes, some modes cannot be adequately excited without using Z thrusters. The forcing functions are designed to excite each important mode but not exceed any of the SSF safety limits. Multiple linearly independent forcing functions are necessary for identifying closely spaced modes and assessing nonlinearities. The forcing functions are also designed to permit modal identification by other methods.

The pulsed thruster firings can be designed to maintain attitude and attitude rates within their limits and not exceed acceleration or load limits but excite important modes to measurable levels. The length of an excitation is at least five cycles of the lowest frequency important mode with a minimum of twenty seconds, so that there is sufficient excitation for the lowest frequency imortant modes to reach measureable resonse levels. The thruster on/off times are rounded to the nearest minimum thruster pulse time, which is currently 0.2 seconds. The effects of the thruster firing on attitude and attitude rates are minimize by balancing the moments from the thruster firings. The +Z and -Z thrusters on the same side of SSF are not allowed to fire at the same time. Each free decay period is at least fifteen cycles of the lowest frequency important mode with a minimum of 100 seconds.

MIE BASELINE EXPERIMENT DESIGN
RANDOM EXCITATION DESIGN
TYPICAL FORCING FUNCTIONS AND PSDs



MIE Baseline Experiment Design

Measurement Locations

The frequency and damping factor of the important modes may be determined with only one accelerometer. Describing
the mode shape requires more accelerometers. Modal assurance criterion and spatial distribution were used to select a
measurement set. The accuracy required in describing mode shapes determines the number of accelerometers.
During the Phase B study, good spatial coverage of the SSF was found to be desirable to minimize the effects of
changes in configurations. Spatial coverage is also necessary for determining the global characteristics of mode
shapes. The maximum truss motion generally occurs at the truss tip, so instrumentation will be located there whenever
possible. Accelerometers are located at the PV array tips and bases to provide data for identifying PV bending and
torsion modes, separating closely spaces modes, and integrating math models. Separation of closely spaced modes is
also the reason for the instrumentation on the TCS radiators. Data from the instrumentation on the various pallets will
aid in determining local dynamics and math model verification. The module cluster is instrumented to provide data for
verifying the math models of the module attachments and the dynamic motion of the modules. The utility trays are
instrumented as they are anticipated to be a source of nonlinear structural behavior because of the utility tray to truss
attachment. Instrumentation on the utility trays will also provide data for describing the global mode shapes.

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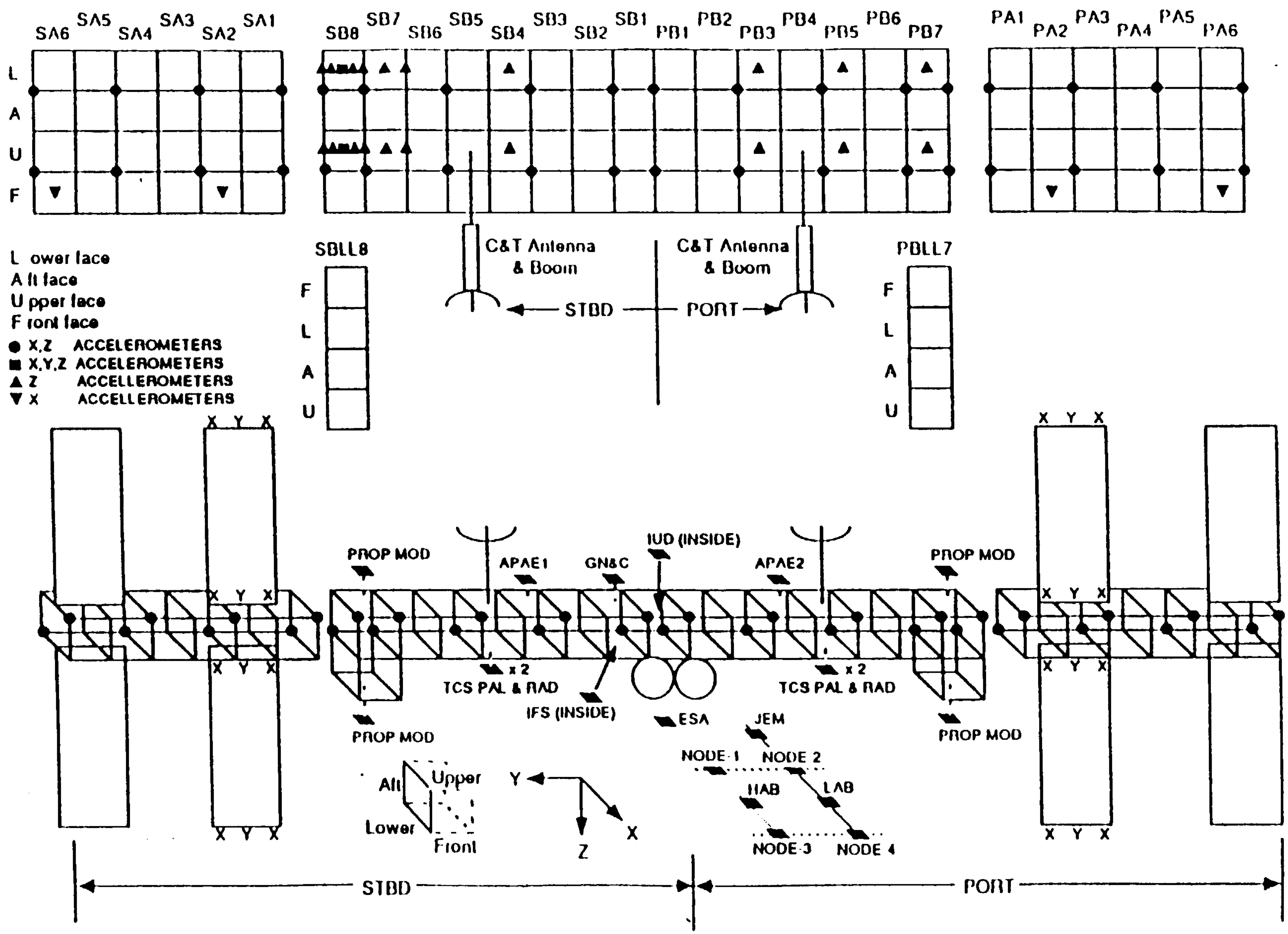
MIE BASELINE EXPERIMENT DESIGN
MEASUREMENT LOCATIONS



MIE Baseline Experiment Design

Simulation Results

The on-orbit MIE was numerically simulated to assess the performance of the baseline experiment design. The simulations were made with the structural responses corrupted with data acquisition system errors to determine modal identification capability on data with noise and errors. A short reboost was simulated by two diagonal X thrusters firing for ten seconds with fifty pounds of force followed by 100 seconds of free decay. Also, four linearly independent forcing functions were designed to excite each configuration's important modes to more measurable levels. The measurement locations used in the simulations were the 189 accelerometers distributed throughout the SSF truss, pallets, modules, PV arrays, and TCS radiators. The thirty utility tray measurement locations are not included in the FEMs. Data acquisition system errors were included in the responses at each measurement location. ERA was used to determine the effects of the corrupted response and damping on modal identification capability.

All of the important modes were identified from the random forcing function responses, regardless of damping. Except for the PMC 1% damping factor case, only about one third of the important modes were identified from the reboost responses. Large damping factors significantly reduce the number of modes identified from the reboost responses. Although all of the important modes were identified for the PMC 2% damping factor cases, additional filtering within ERA was required.

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MIE BASELINE EXPERIMENT DESIGN

SIMULATION RESULTS

CONFIG	FORCING FUNCTION	DAMP, %	NO OF IDENTIFIED IMP MODES	NO OF TOTAL ID MODES
MB6	RANDOM	1.0	15	18
	REBOOST	1.0	5	6
PMC	RANDOM	1.0	15	16
		2.0	15	16
	REBOOST	1.0	12	13
		2.0	4	4
AC	RANDOM	1.0	20	22
	REBOOST	1.0	7	8

MIE Laboratory Simulations

As previously observed, on-orbit testing of a structure which cannot be tested fully assembled in a 1 g environment presents a unique set of challenges. For example, the opportunity to conduct a series of tests (possibly relocating sensors and excitation sources until satisfactory results are obtained) is not available to the on-orbit test engineer.

Use of a dynamically scaled model such as the Langley DSMT can partially compensate for some of the uncertainties encountered.

The DSMT will be utilzed in the evaluation of sensor placement strategy, forcing function design, and evaluation of robustness of proposed modal recovery algorithms.

MIE Laboratory Simulations

Vibration Testing of Complex Structures

- Conventional Ground Test:

First Test		Additional Tests		Final Confirmation
Based on Initial FEM Predictions	→	Relocate Transducers Relocate Excitation Modify FEM	→	Minor Adjustments Only
Large Disparity of Results	→	Improved Agreement of FEM with Test Results	→	Acceptable Agreement Assured

- On-Orbit

  - Testing Limited to Components only
    No testing of complete Space structure in 1 g

  - Laboratory Simulation 1g tests will substitute for the usual 1g ground tests to validate:
    - Sensor Location Strategy
    - Modal Recovery Algorithm

Utilizing the DSMT Hybrid Scale Model

The Langley hybrid scale model of the Space Station and its suspension system and data acquisition in use in the Dynamic Scale Model Technology program will be used to conduct the MIE Laboratory Simulations. These simulations will, however, be unique since the objective is to simulate the MIE on-orbit modal test rather than conduct a traditional ground vibration test. For example, the excitation, data records, and modal recovery methods applied will duplicate those planned for MIE.

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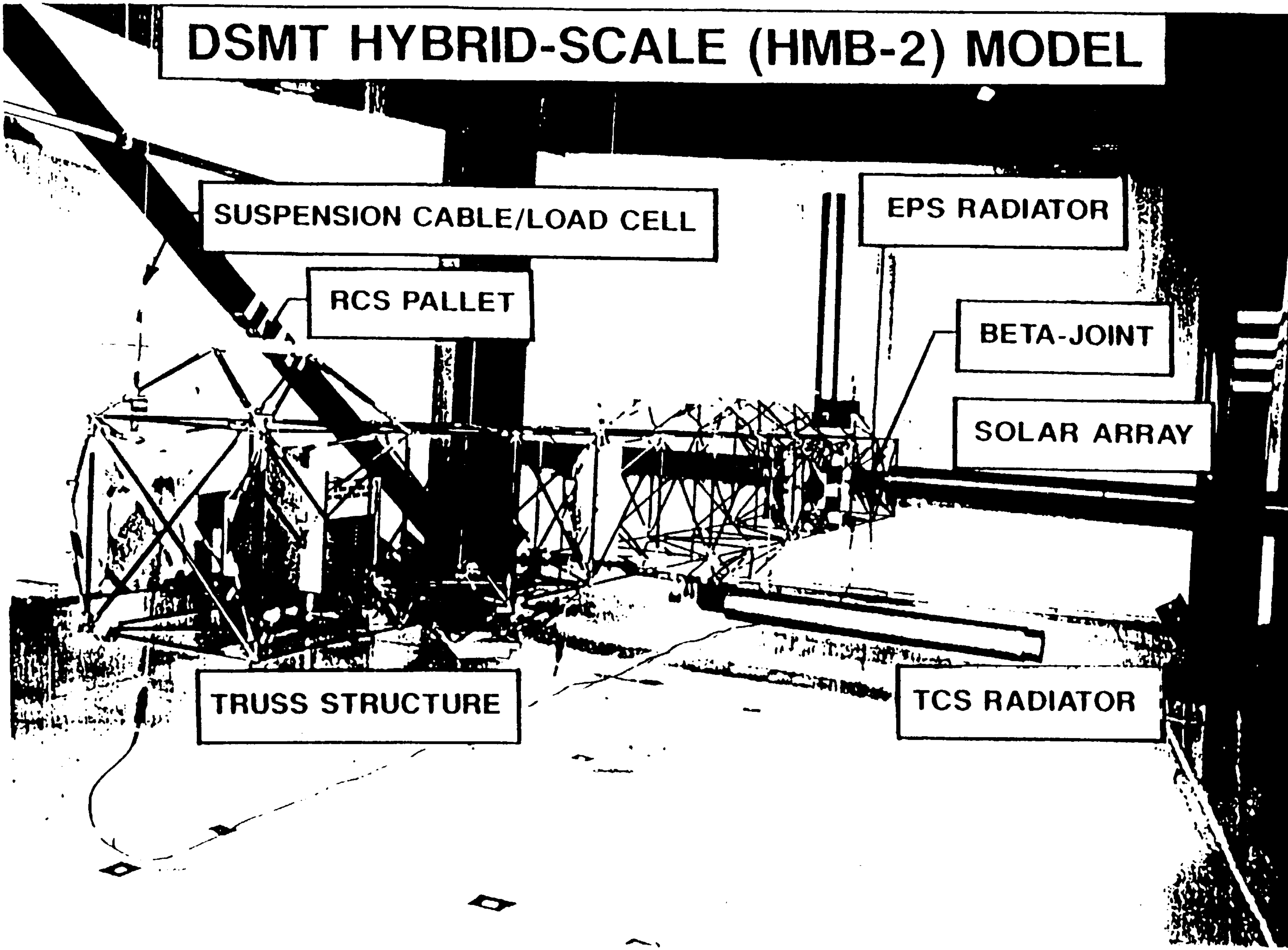
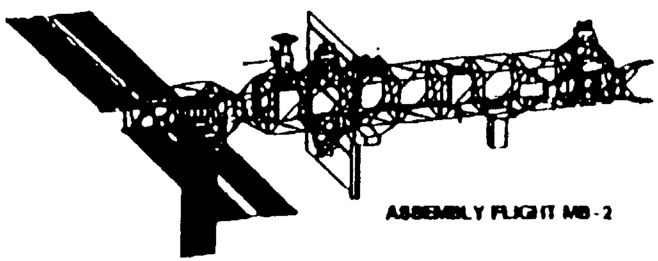

DSMT HYBRID-SCALE (HMB-2) MODEL
SUSPENSION CABLE/LOAD CELL
RCS PALLET
EPS RADIATOR
BETA-JOINT
SOLAR ARRAY
TRUSS STRUCTURE
TCS RADIATOR

MIE Engineering Model

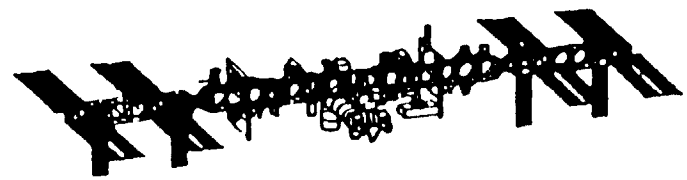
The DSMT hybrid scale model hardware consists of a set of erectable joints, struts and standardized components so that many different configurations of the Space Station may be assembled. The plan is to use three assembly configurations for testing. Excitation forces scale as 1/25 and modal frequencies scale as 1/10. The three models to be used include an early configuration, an intermediate configuration, and the Assembly Complete configuration. The truss length will vary by more than a factor of 2 and the weight by a factor of 10 between the early configuration and the Assembly Complete.

MIE ENGINEERING MODEL

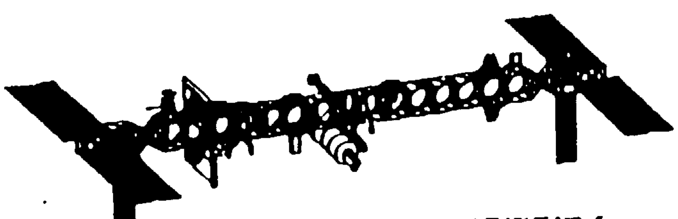
- ERECTABLE JOINTS AND STANDARDIZED COMPONENTS PERMIT TESTBED TO BE ASSEMBLED IN ANY CONFIGURATION
- MASS PROPERTIES OF MANY COMPONENTS CAN BE ADJUSTED VIA MODIFICATION OF LUMPED WEIGHTS



ASSEMBLY FLIGHT MB-2



ASSEMBLY FLIGHT MB-15



ASSEMBLY FLIGHT MB-5

1/5:1/10 Scale	HMB-2	HMB-5	HMB-15
Dimensions (ft)	19 x 23	35 x 23	48 x 23
Weight (lbs)	363	1306	3621
Freq Range (Hz) (1st 10 Sys Modes)	9 - 37	2 - 8	1 - 7

Concluding Remarks

The MIE is a well defined experiment which, if implemented, will return invaluable scientific and engineering dynamic response data leading to validation of on-orbit modal recovery procedures in addition to dynamic characterization of Space Station Freedom and its dynamic environment. It is supported by the structural dynamics community and its importance is generally recognized within the Space Station Freedom Project activity.

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Concluding Remarks

- The OAET-sponsored Modal Identification Experiment could Provide Critical On-Orbit Dynamic Data for the World's First Large Space Structure

- The Experiment is Feasible, Relatively low cost and Schedule Risk, and is Supported by the Structural Dynamics Community

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16. Abstract
The purpose of this paper is to discuss a proposed approach called Modal Identification Experiment (MIE) for obtaining on-orbit dynamic response measurements on Space Station Freedom, the first of a family of large, flexible space structures.

NASA's Office of Aeronautics, Exploration, and Technology (OAET) has supported a Phase A feasibility study completed in March 1989 and a recently concluded Phase B conceptual design study which provides a conceptual design of a proposed measurement system and an experimental protocol for inobstrusively collecting dynamic response data critical to characterizing important vibration modes of Space Station Freedom.

This paper presents the case for conducting such a measurement program and lists the specific MIE objectives that have been identified. The sequence of discreet Space Station Freedom assembly configurations is described, and the Phase B conceptual design of the experiment and instrumentation system are defined. In addition, a plan to utilize a space station hybrid scale model in laboratory simulations as part of the design process will be discussed.

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