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# DESCRIPTION OF THE MAST FLIGHT SYSTEM

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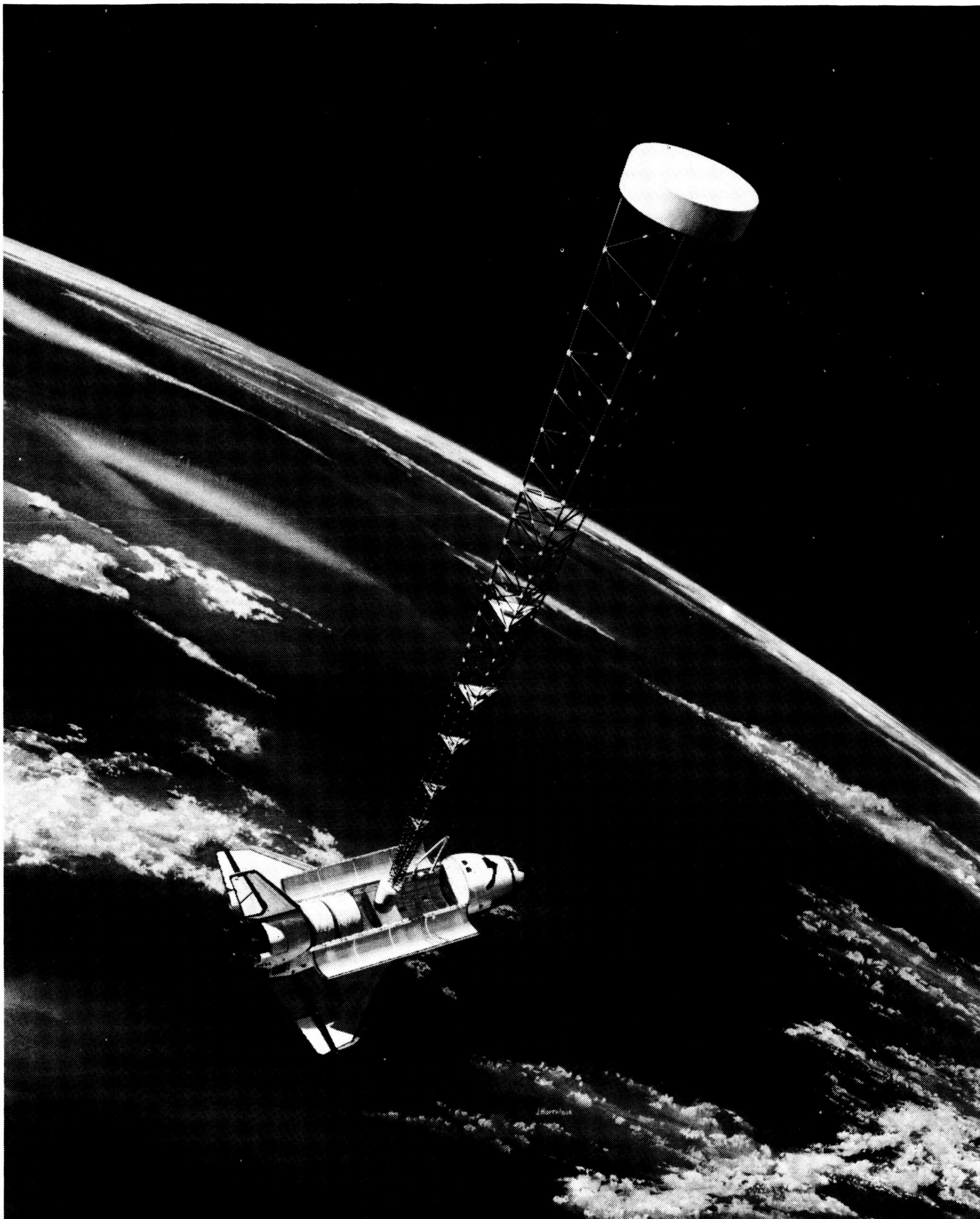

## MAST FLIGHT EXPERIMENT FLIGHT SYSTEM CONCEPT

The Mast Flight System is composed of several subsystems. Primary among these is the Deployable Mast Subsystem (DMS) which consists of a beam assembly and an associated mechanism for deploying and retracting the beam. The beam assembly is a joint dominated graphite epoxy and titanium truss as is expected of future large space structures. Important beam characteristics are listed below. Integral to the beam assembly are actuators, sensors and associated electronics which are available for excitation and damping as desired by the experimenter. The beam structural characteristics can also be modified as desired by the experimenter using the Parameter Modification Device installed at the end of the beam. Data measured on the beam by the sensors and commands to the actuators are transmitted along the beam digitally at 150 Hz using a standard 1553 type bus. The Modular Distributed Information Subsystem (MDIS) computer functions as bus master and ensures that all experimental data is saved for future analysis. The MDIS computer also performs a safing function to prevent inadvertent overexcitation of the beam. Finally, the Excitation and Damping Subsystem (EDS) computer is available to the experimenter for implementation of control algorithms or any other numerical operations as desired. Data from all system sensors can be accessed by the EDS computer.

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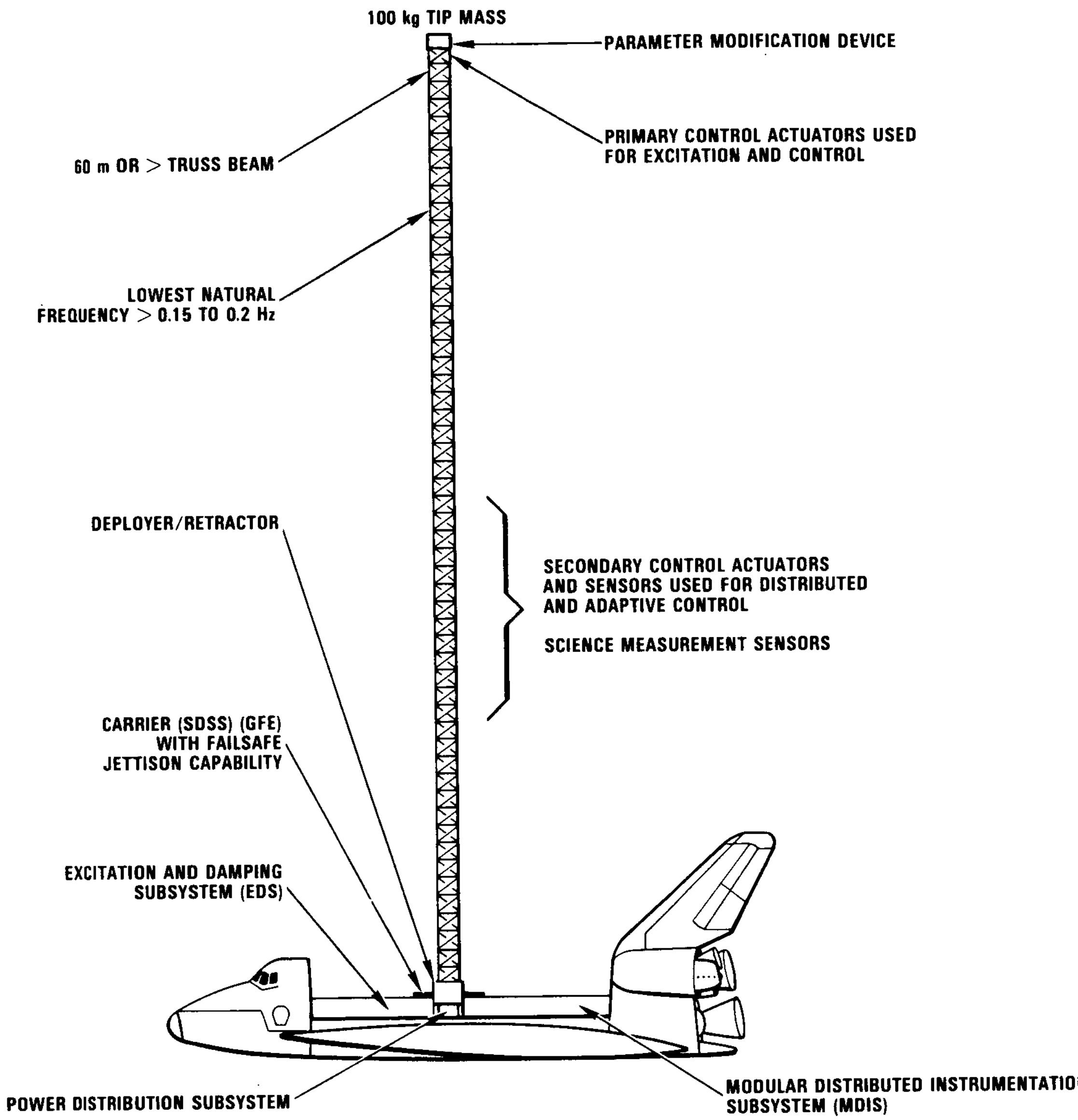


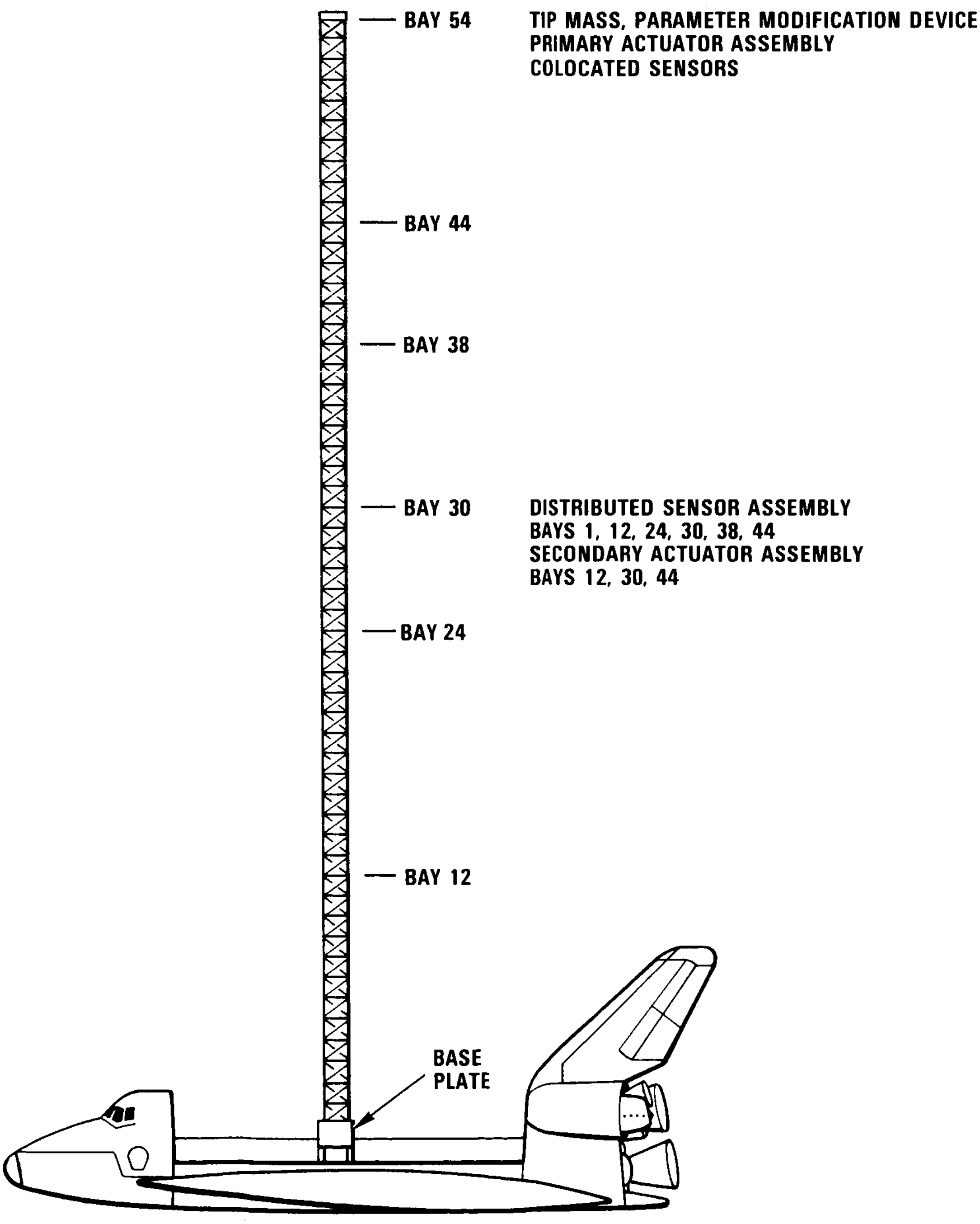

## MAST (BEAM) DESIGN PARAMETERS FOR THE FLIGHT SYSTEM

| | |
|---|---|
| DIAMETER | 1.4 METERS |
| BEAM LENGTH, DEPLOYED | 60.7 METERS |
| BAY LENGTH | 1.124 METERS |
| PACKAGING RATIO | 29.5 (3.4% OF DEPLOYED) |
| MASS PER UNIT LENGTH | 4.64 kg/m |
| BENDING FREQUENCY* | 0.239 Hz (Y-AXIS) |
| | 0.181 Hz (X-AXIS) |
| TORSIONAL FREQUENCY* | 0.300 Hz |
| COEFFICIENT OF THERMAL EXPANSION | $<0.7 \times 10^{-6}$ $K^{-1}$ |

*COUPLED TO THE ORBITER

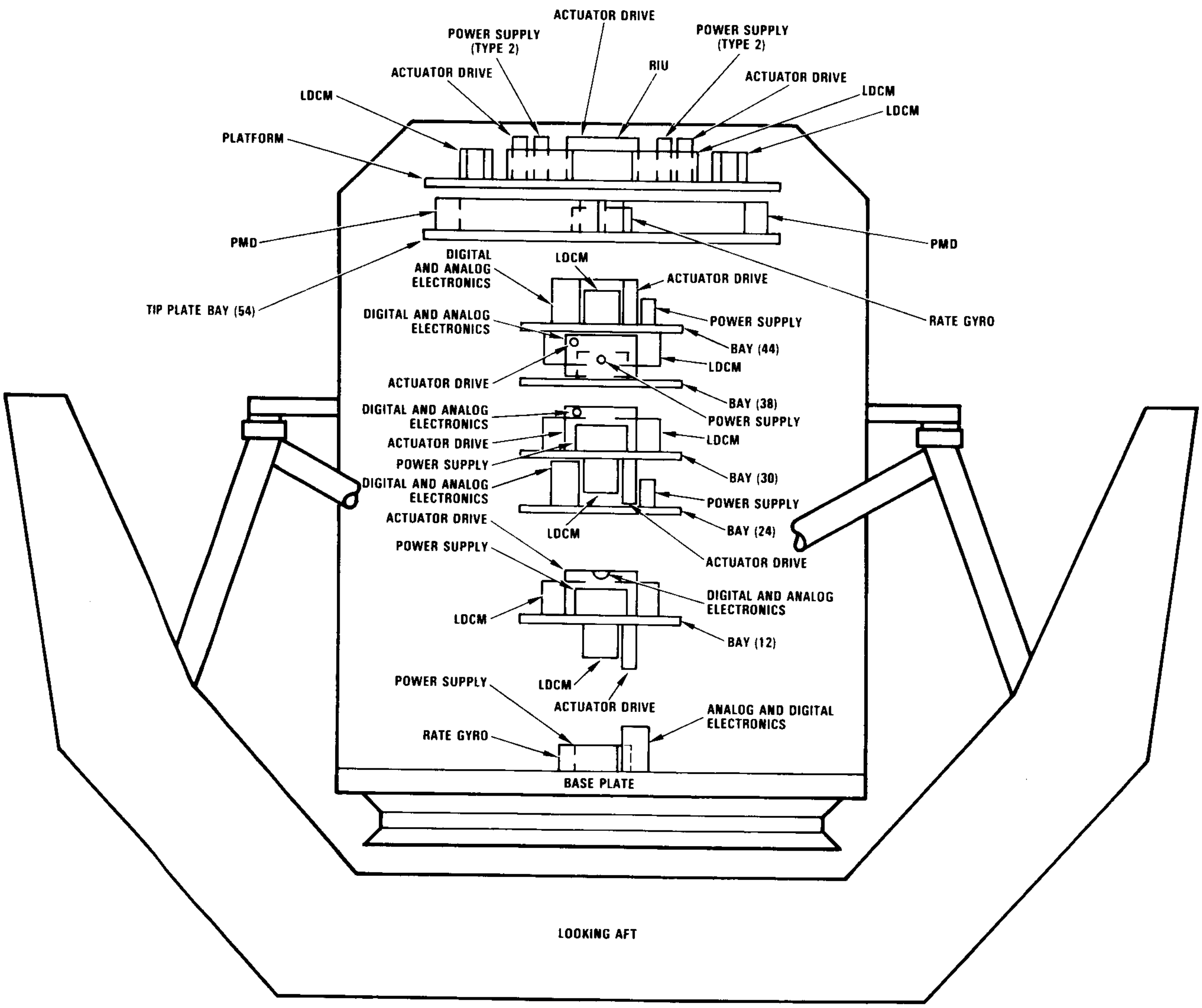
MAST FLIGHT EXPERIMENT SENSOR AND ACTUATOR DISTRIBUTION

The actuators and sensors are mounted on platforms integral to the beam. When the beam is extended the distribution of the actuators and sensors provides excellent observability and controllability of the beam lowest ten structural modes. These include first, second, third and fourth bending in two orthogonal planes and first and second torsion. In addition a sensor complement is provided at the DMS to pallet interface so that base disturbances can be quantified and accounted for if desired.



## STOWED MAST FLIGHT EXPERIMENT

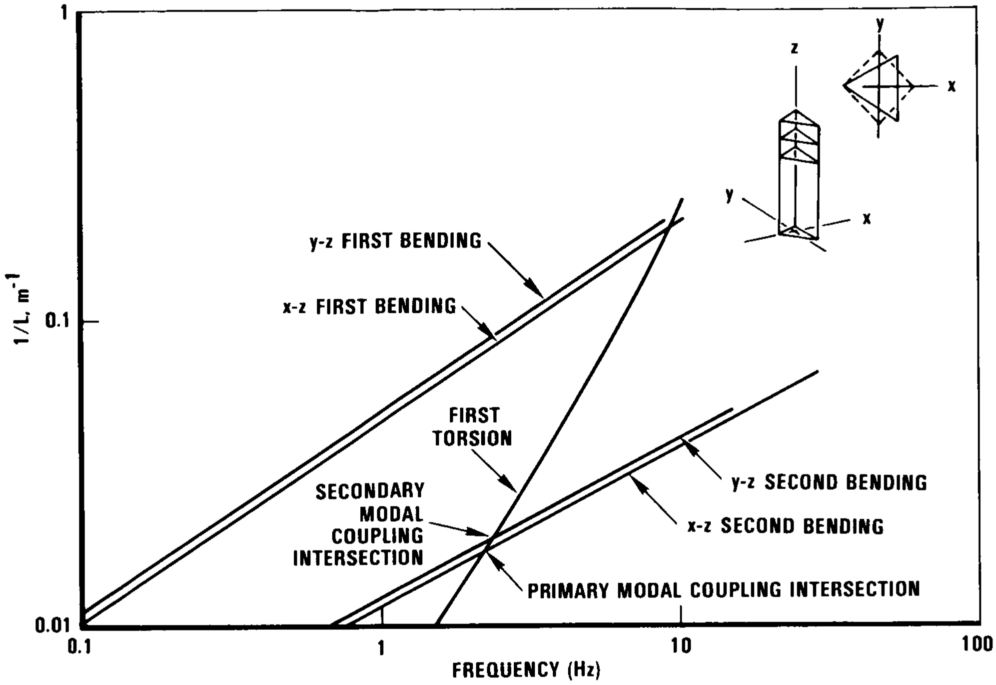
When not in use the system is stowed within a protective cannister inside the Orbiter payload bay. Shown below is a diagram depicting the placement of the electronic equipment platforms (remote stations) when the beam is stowed. Partially shown, for clarity, is a support structure for launch and landing loads. The system and support structure will be mounted within an enhanced MDM/STEP pallet. The MDIS and EDS computers, along with elements of the Power Distribution Subsystem, are mounted on pallet coldplates (not shown below).



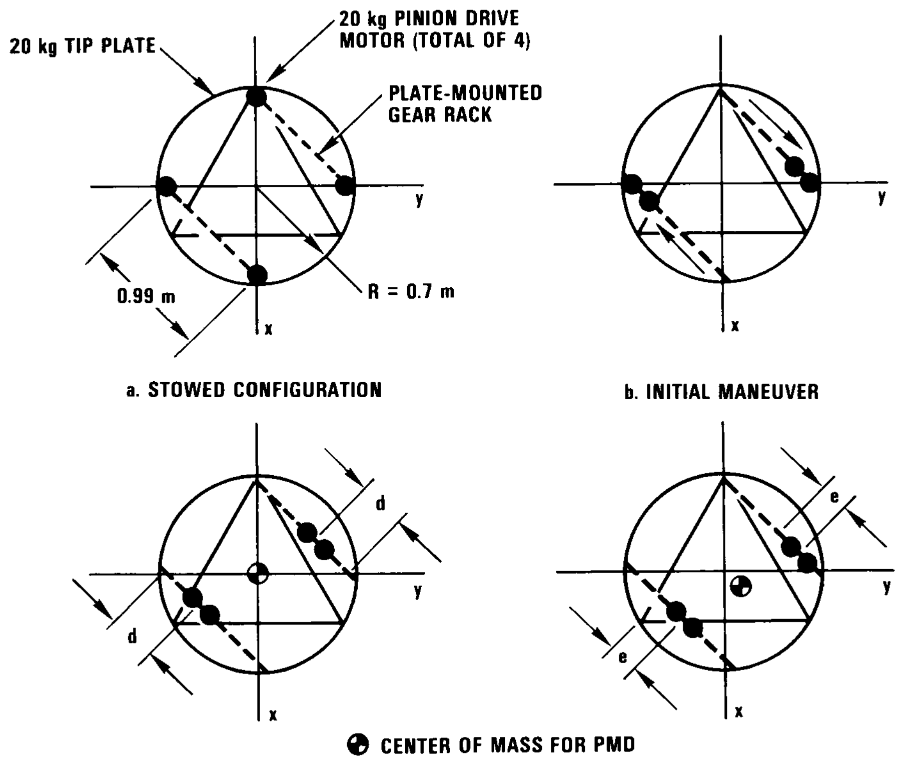
## MODIFICATION OF STRUCTURAL SYSTEM CHARACTERISTICS

Beam length can be changed by the experimenter to coarsely alter beam structural characteristics. In addition, the Parameter Modification Device (PMD), located at the tip of the beam, can be used to effect fine changes in the beam structural characteristics and to cause frequency matching and coupling between either of the two beam second bending modes and the first torsion mode. The PMD functions by changing the moment of inertia of the tip station about the beam axis. Additionally the PMD can be used to move the center of gravity of the tip station creating mass coupling between the bending and torsion modes. The experimenter can move the PMD masses as desired, including a slow sweep of the PMD masses from one location to another while excitation and damping are occurring. A typical modal coupling maneuver is shown below. The beam length is first adjusted to nearly match a second bending mode and the first torsion mode (48 bays). The PMD masses are then adjusted to precisely match the torsion mode frequency with the selected bending mode frequency. The masses are then moved in the same direction to offset the tip station center of gravity and cause the coupling desired by the experimenter.

## CONCEPT FOR MODAL FREQUENCY COUPLING VIA PARAMETER MODIFICATION




## PARAMETER MODIFICATION DEVICE OPERATION




a. STOWED CONFIGURATION

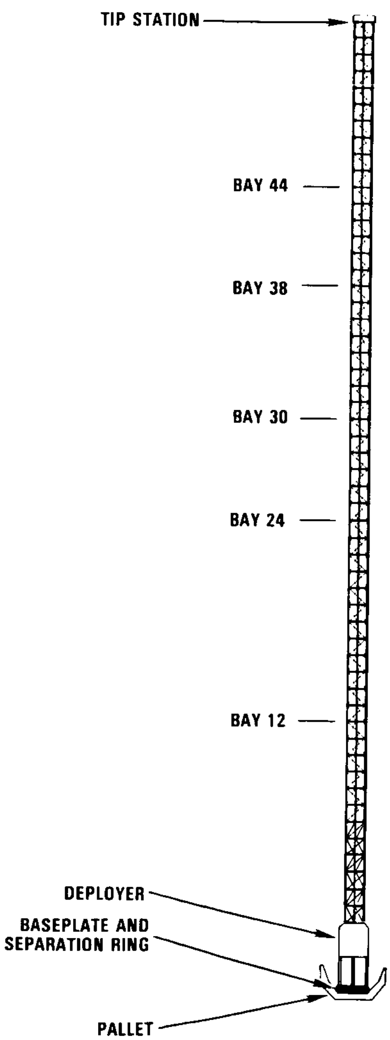
b. INITIAL MANEUVER

c. TORSIONAL FREQUENCY TUNING MANEUVER

d. MODAL COUPLING MANEUVER

## MAST SYSTEM ACTUATORS AND INSTRUMENTATION

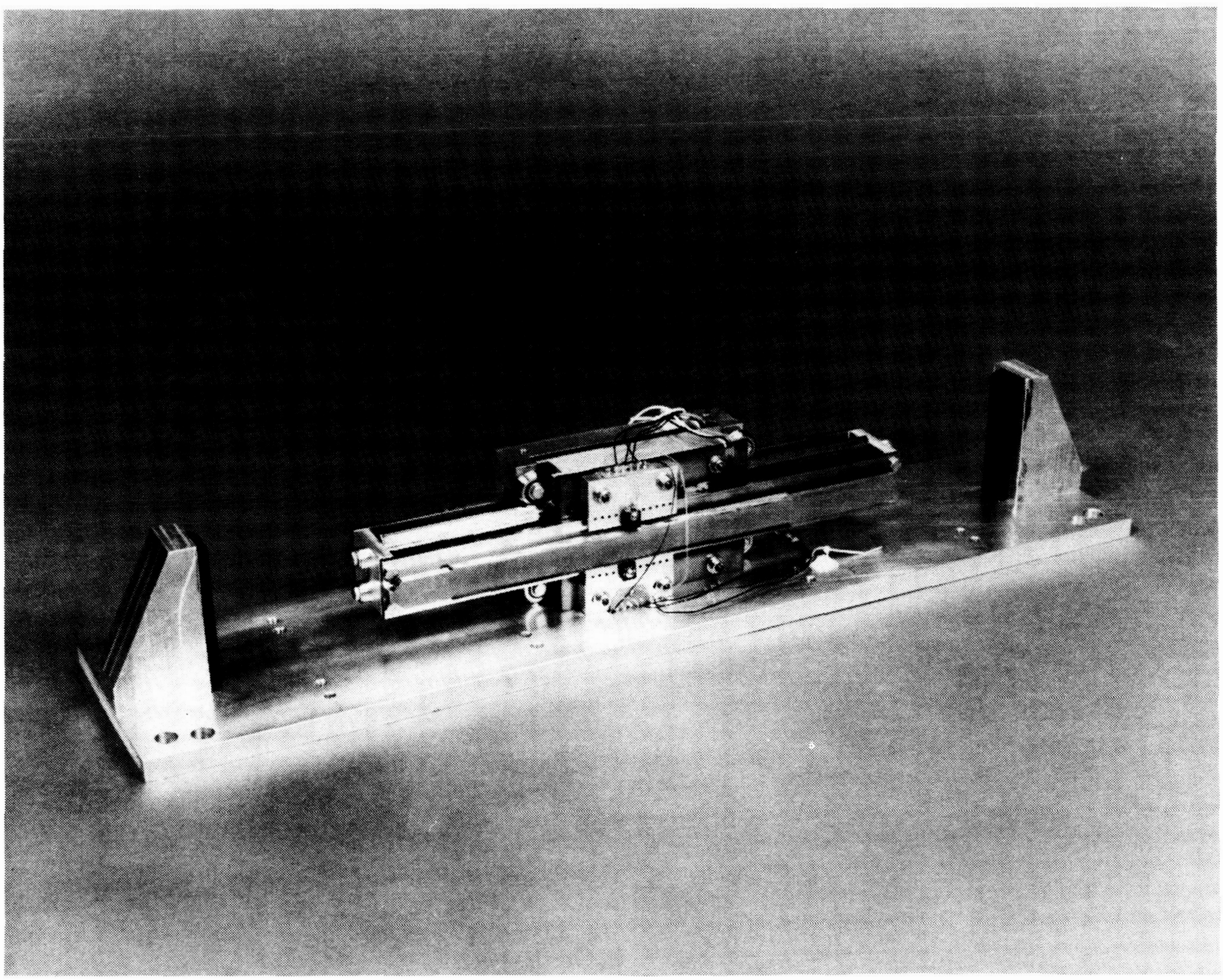
Actuators and sensors are distributed along the beam as shown below. All sensor outputs are available to the experimenter for control or monitoring of beam performance. In addition, select accelerometer channels have dual ranges and filtered or unfiltered outputs. The filters used are two pole butterworth filters, with a 3 db cutoff at 45 Hertz, for aliasing protection. Strain gages are additionally high pass filtered to eliminate drift and thermal apparent strain. Actuators are provided at three of the intermediate remote stations and the tip. The actuators used at all locations are Linear Direct Current Motors (LDCMs). The LDCMs can be used to provide linear forces perpendicular to the beam axis (parallel to the Orbiter X and Y axes) at each remote station and torque about the beam axis at the tip remote station. Accelerometers are equipped with self calibration ports and strain gage bridges have shunt calibration circuits for pre and post experiment instrumentation health checks if desired. Select temperatures, voltages and currents are measured to provide further health and status information (not shown below for clarity).




| | ACTUATORS | ACCELEROMETERS AND INSTRUMENTATION |
|---|---|---|
| TIP STATION | 4 LDCMS | 3 RATE GYROS<br>3 LINEAR ACCELEROMETERS<br>9 STRAIN BRIDGES |
| BAY 44 | 2 LDCMS | 1 ANGULAR ACCELEROMETER<br>2 LINEAR ACCELEROMETERS<br>6 STRAIN BRIDGES |
| BAY 38 | | 1 ANGULAR ACCELEROMETER<br>3 LINEAR ACCELEROMETERS<br>6 STRAIN BRIDGES |
| BAY 30 | 2 LDCMS | 1 ANGULAR ACCELEROMETER<br>2 LINEAR ACCELEROMETERS<br>6 STRAIN BRIDGES |
| BAY 24 | | 1 ANGULAR ACCELEROMETER<br>3 LINEAR ACCELEROMETERS<br>6 STRAIN BRIDGES |
| BAY 12 | 2 LDCMS | 1 ANGULAR ACCELEROMETER<br>2 LINEAR ACCELEROMETERS<br>6 STRAIN BRIDGES |
| BASEPLATE | | 3 RATE GYROS<br>3 LINEAR ACCELEROMETERS<br>6 STRAIN BRIDGES |

## LINEAR DC MOTOR

The actuators used are direct current brushless motors. The motor has a fixed stator and a moving magnetic secondary. The secondary is used as a reaction mass. Output force is controlled by controlling motor current. In addition the motor is designed with a sensing system to provide accurate secondary position information. A position loop has been implemented to keep the secondary centered. The LDCM, including the position loop, has a straight forward two pole transfer function. Secondary position, like all other sensor data, is available to the experimenter. The figure below shows a development model LDCM. This motor is capable of a 30 Newton force output.



MAST FLIGHT SYSTEM BLOCK DIAGRAM

A block diagram of the system is shown below. The diagram illustrates the primary elements of the system and the provisions for experimental commands and data gathering. The mission specialist will interface to the system from the orbiter aft flight deck through the DDCU. The beam will be deployed and retracted through this interface via the MDIS computer which commands the motor controller. Experiments will also be executed through this interface via the MDIS computer. Each experimenter's software will be contained within the EDS computer. Standard system commands, such as sine sweep or broadband random actuator force and PMD commands, will be furnished with the system and can be called upon by the experimenter singly or in series.

All experimental data (as well as system housekeeping data) is passed through the HRM onto the high data rate link through TDRSS to the ground where it is stored on magnetic tape for detailed post flight analyses.

A limited amount of selectable data (limited by 2Kbps serial data link), as determined by the experimenter, can be passed to the ground during the mission for near real time evaluation to verify proper experiment conduct.