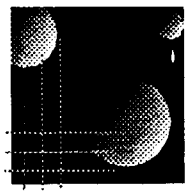


MIT
Space
Engineering
Research
Center

MODE: STRUCTURAL TEST ARTICLE (STA)

Prof. E. Crawley MIT
Mr. Brett Masters MIT

N93-27894

MODE: Structural Test Article Motivation

- DETAILED MODEL AND UNDERSTANDING OF ON-ORBIT STRUCTURAL DYNAMICS IS IMPORTANT SINCE:

  Resonant and transient response influence on-board vibration / acoustic environment.

  Incorrect modeling of dynamics can cause inadvertent CSI with attitude dynamics.

  Detailed modelling is vital for robustness / performance of precision controlled structures.

- NEED TO CORRECTLY MODEL AND UNDERSTAND NON-LINEAR EFFECTS ON A COMPONENT AND SUB-COMPONENT LEVEL.

- UNDERSTANDING ON-ORBIT DYNAMICS WILL REDUCE UNCERTAINTIES BY:

  comparison of earth test results with 0-gravity test results.

  verifying and validating analytical models.

  adding to the scant data base of quality data available on the dynamics of large flexible space structures in 0-gravity.

Why Test STA In Space?

- GROUND BASED SIMULATIONS HAVE BEEN EXPLOITED

  Options
  (a) Suspended in air
  (b) Suspended in vacuum
  (c) Lofted in vacuum (Free-fall)

BUT:

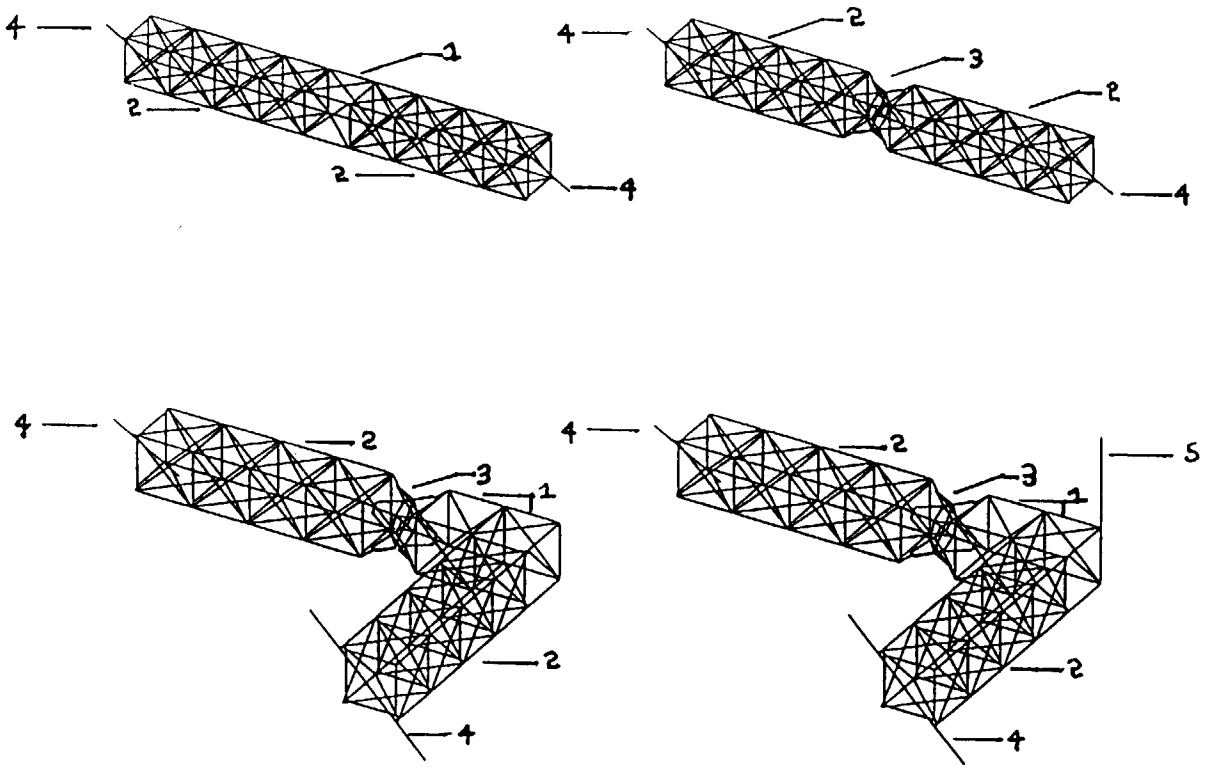
(a) Air damping undesirable, suspension systems corrupt modal measurements, and the gravity field causes pre-loads and pre-deflections in the structure.

(b) Suspension and gravity!

(c) Short time periods of free-fall reduce accuracy of modal identification due to

  (i) Uncertain initial conditions (inhomogeneous terms)
  (ii) Difficulty in exciting the structure
  (iii) Poor signal-to-noise ratio

Hardware



Four Test Configurations of the STA

KEY

1: Erectable Bay

2: Deployable Bays (4)

3: Alpha Joint

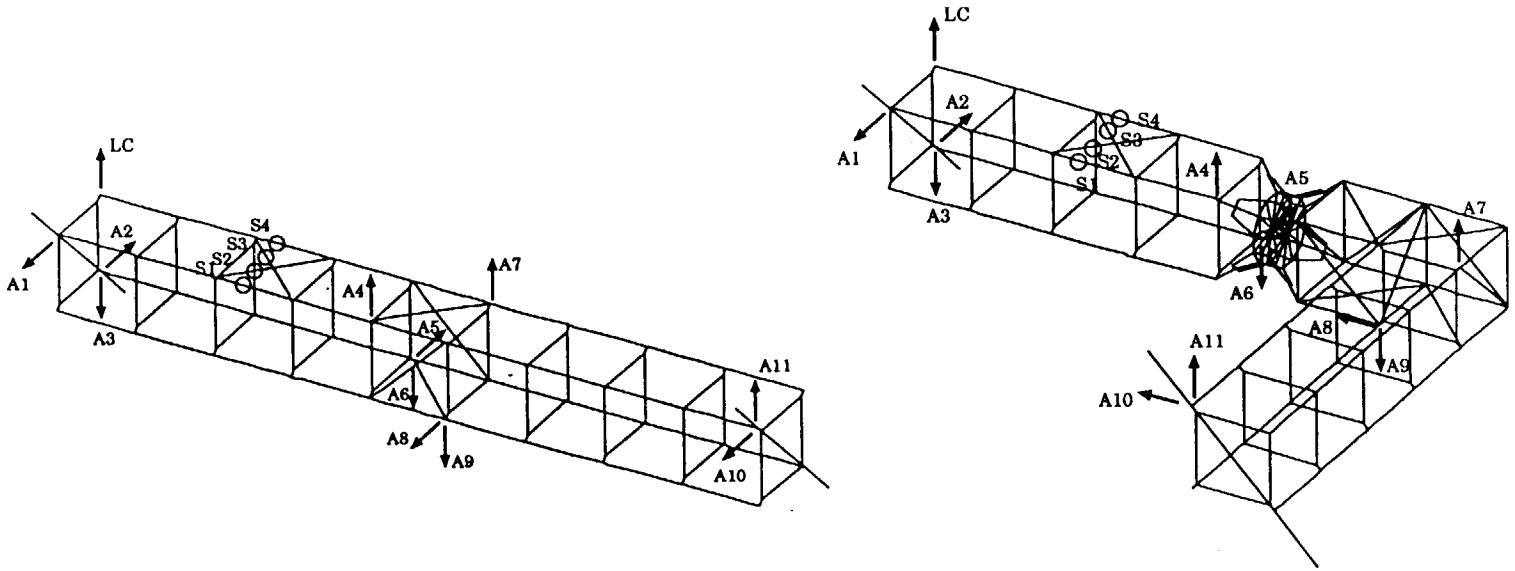
4: Rigid Appendage

5: Flex. Appendage

Sensors and Actuator

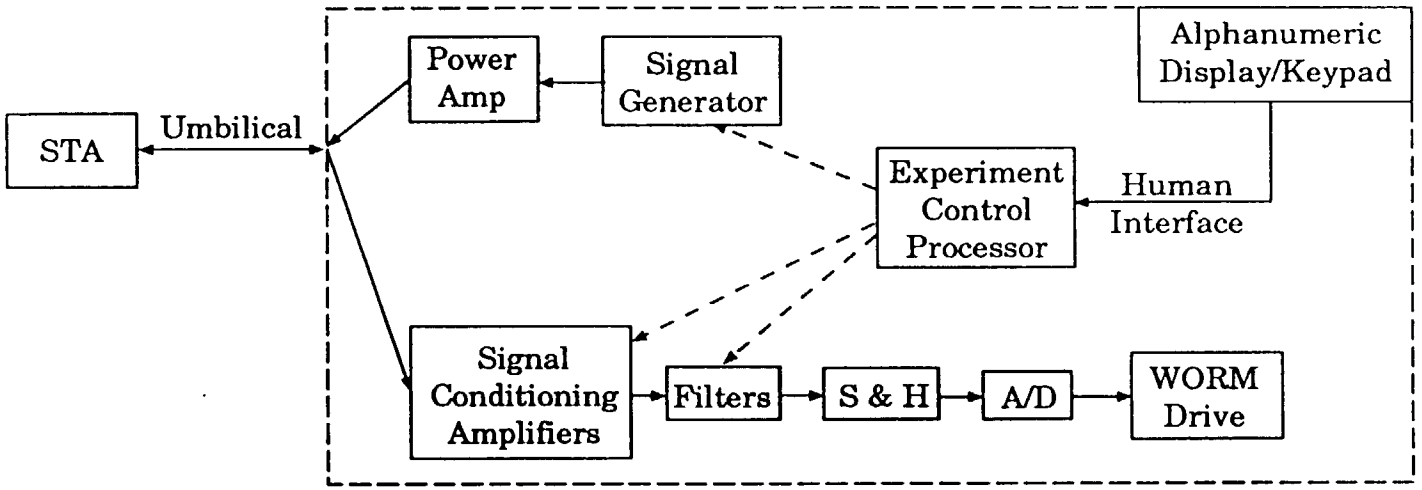
Sixteen sensor channels arranged and conditioned as full-bridge resistive gages

- four strain gage pairs located on one face of adjustable preload bay
- eleven accelerometers (piezoresistive) at predetermined locations
- one load cell located in the proof-mass actuator housing



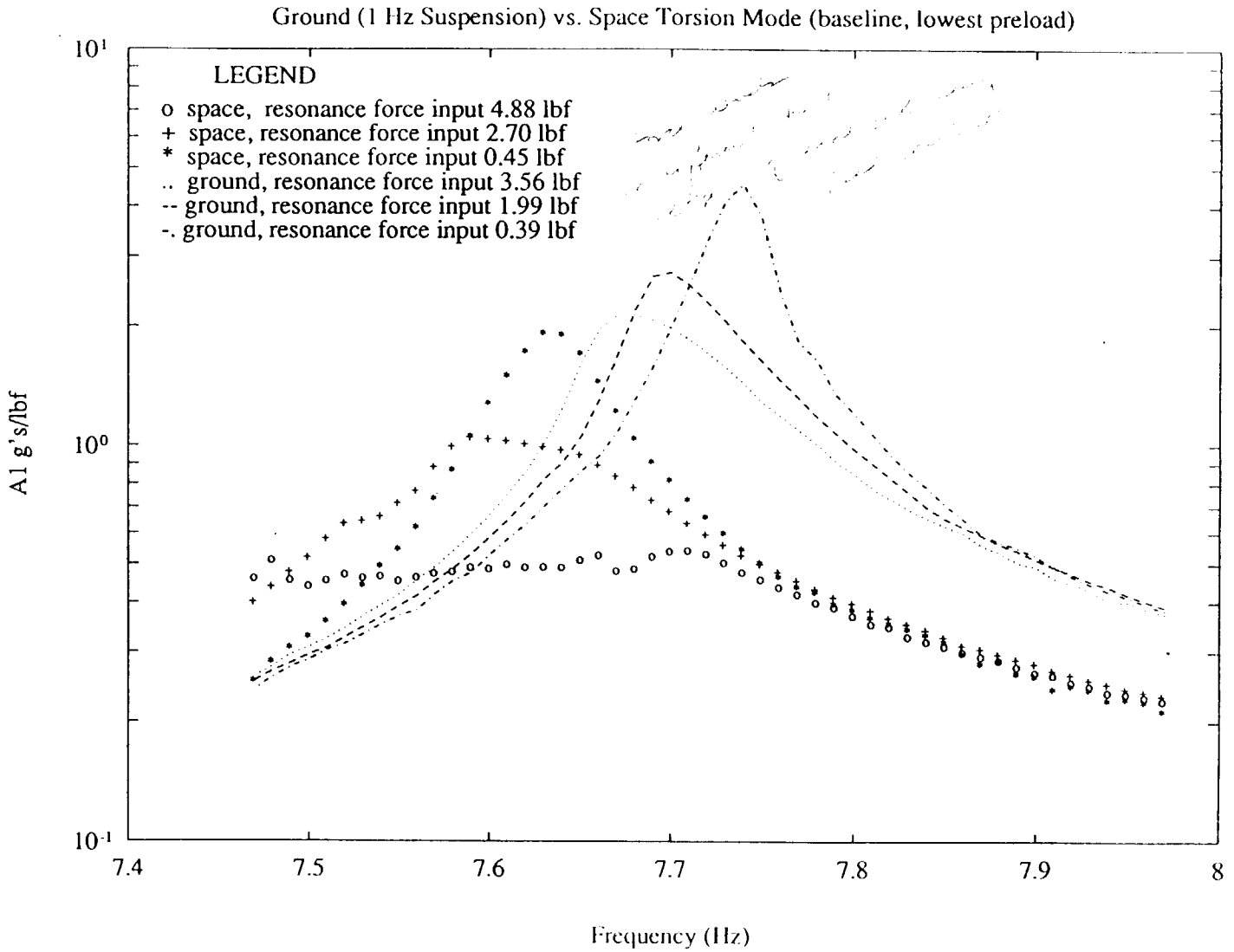
Sensor and actuator locations for Straight and L configurations.

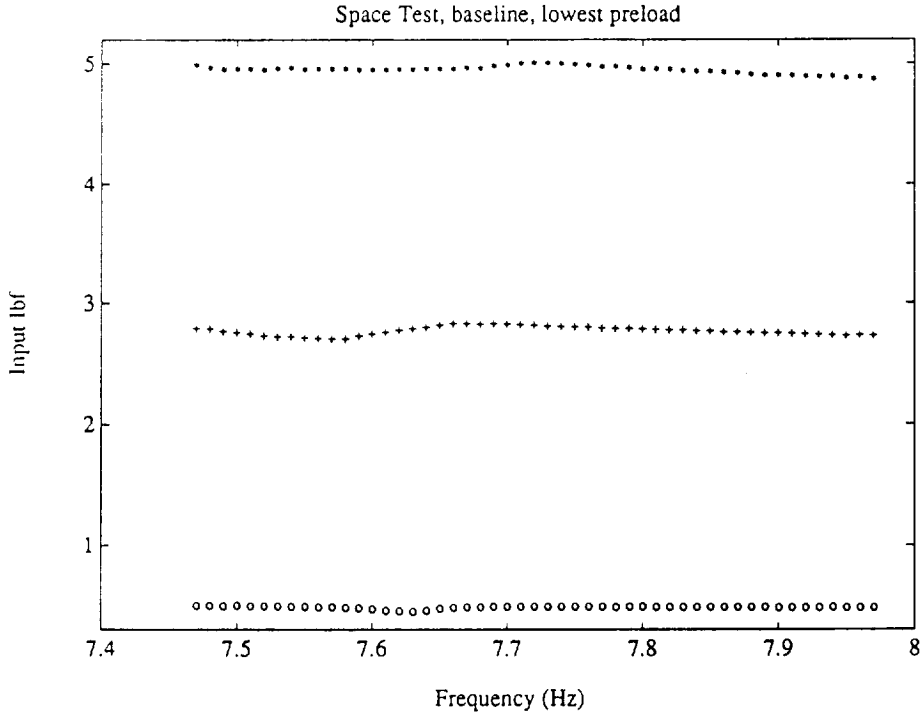
Experimental Support Module

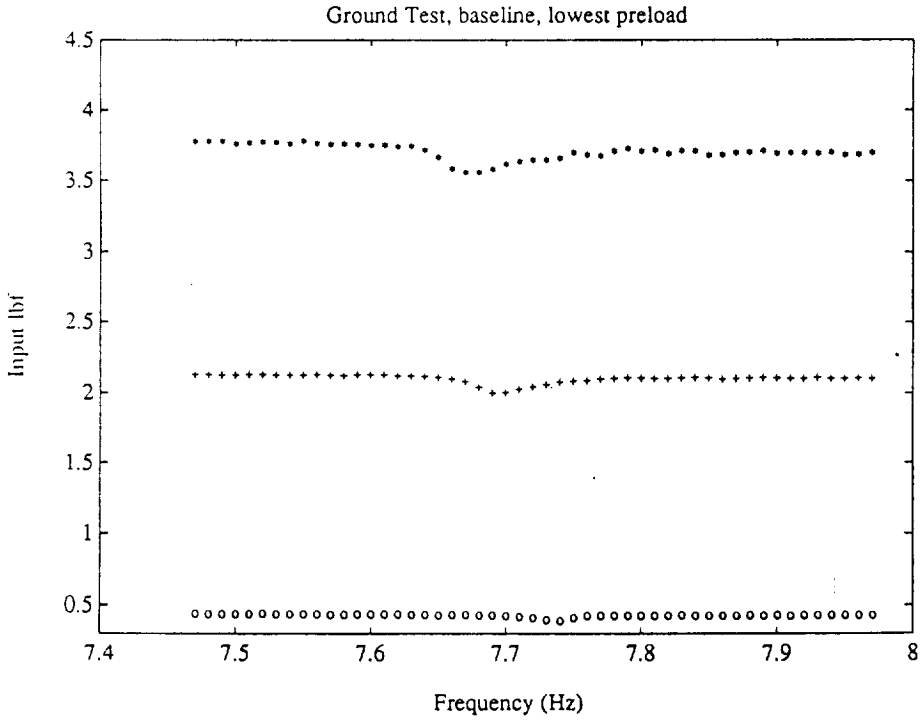


ESM Driven Flow Diagram

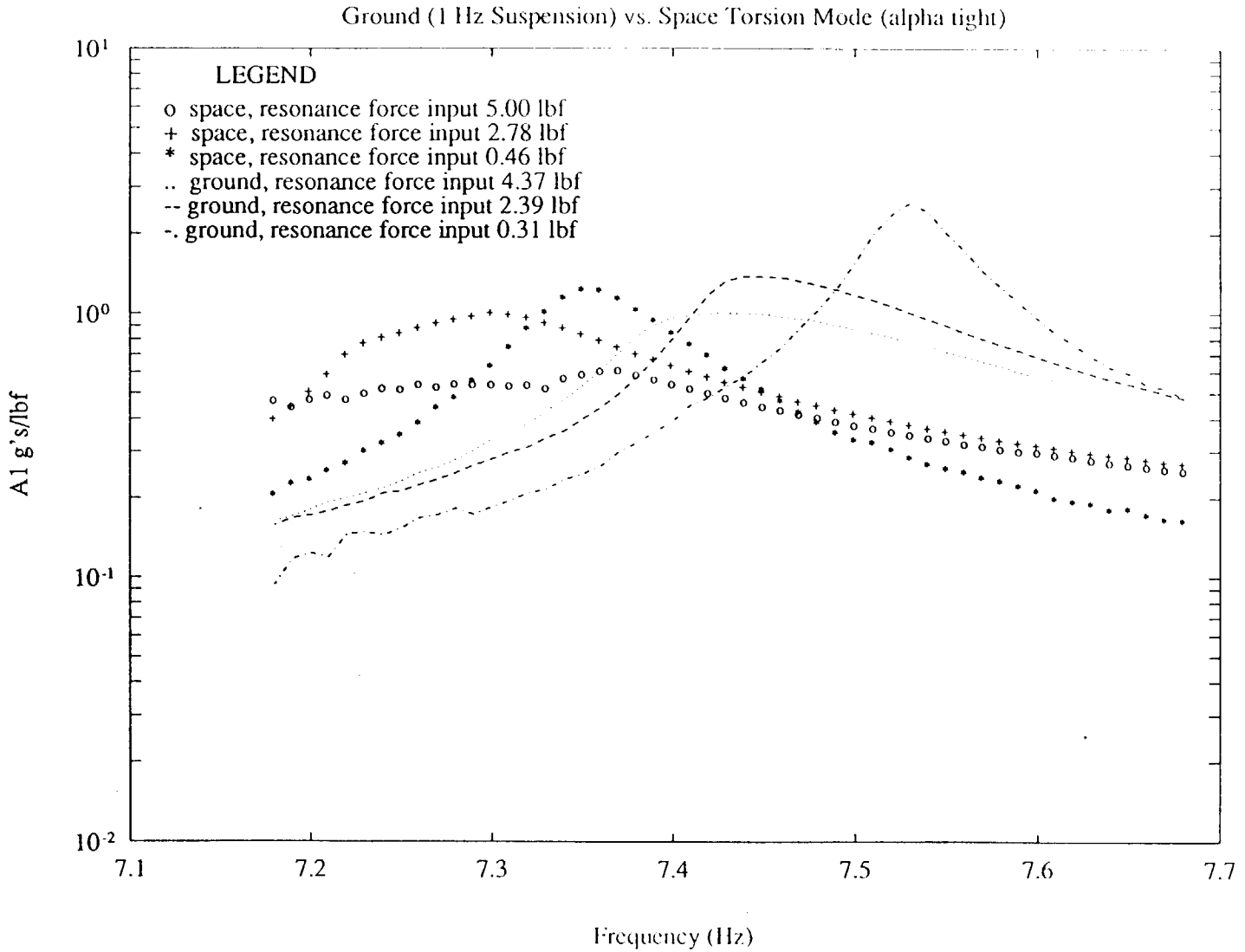
Data


Ground (1 Hz Suspension) vs. Space Torsion Mode (baseline, lowest preload)
LEGEND
o space, resonance force input 4.88 lbf
+ space, resonance force input 2.70 lbf
* space, resonance force input 0.45 lbf
.. ground, resonance force input 3.56 lbf
-- ground, resonance force input 1.99 lbf
-. ground, resonance force input 0.39 lbf
A1 g's/lbf
10¹
10⁰
10⁻¹
7.4
7.5
7.6
7.7
7.8
7.9
8
Frequency (Hz)


Space Test, baseline, lowest preload
Input lbf
5
4
3
2
1
7.4
7.5
7.6
7.7
7.8
7.9
8
Frequency (Hz)


Ground Test, baseline, lowest preload
Input lbf
4.5
4
3.5
3
2.5
2
1.5
1
0.5
7.4
7.5
7.6
7.7
7.8
7.9
8
Frequency (Hz)

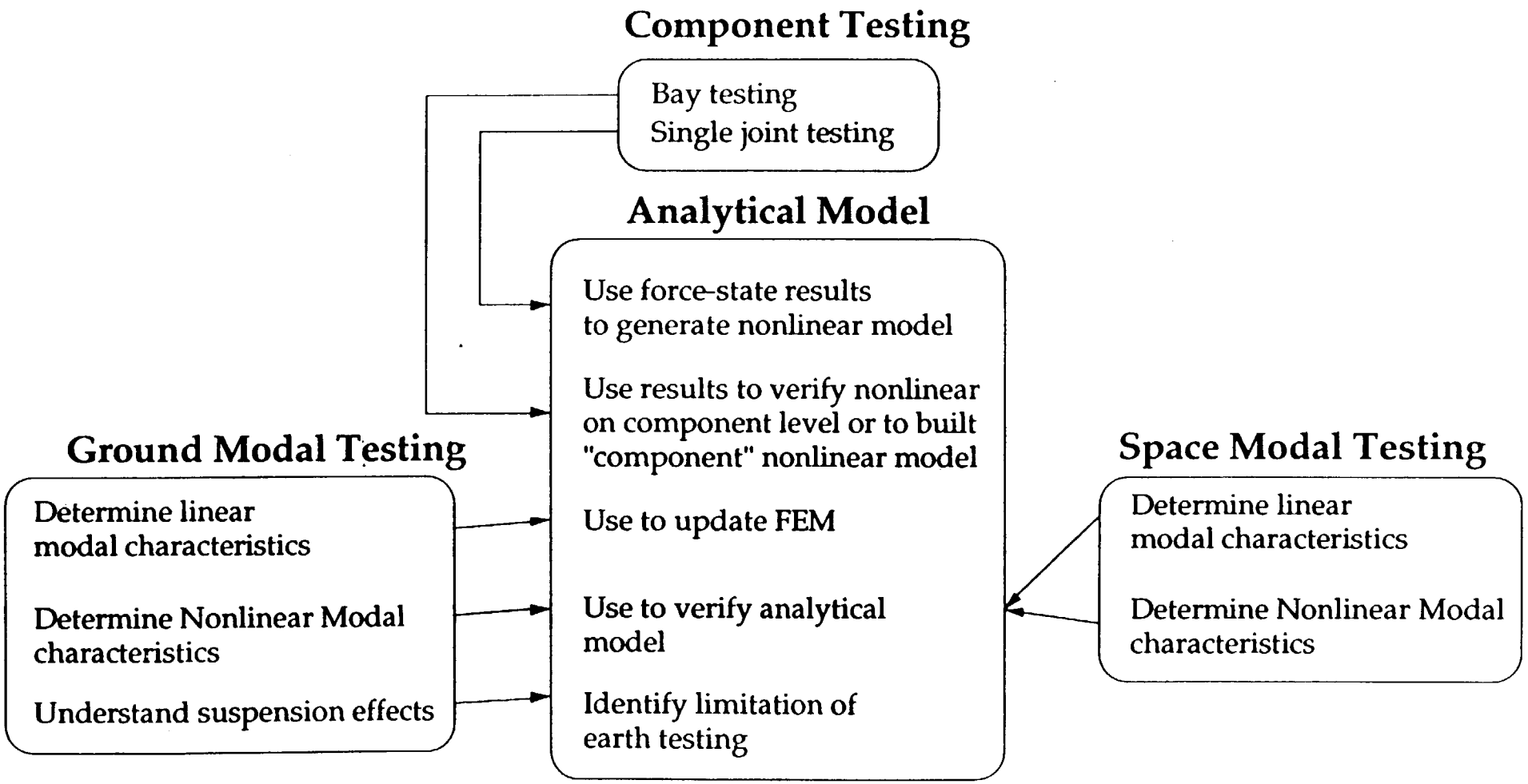
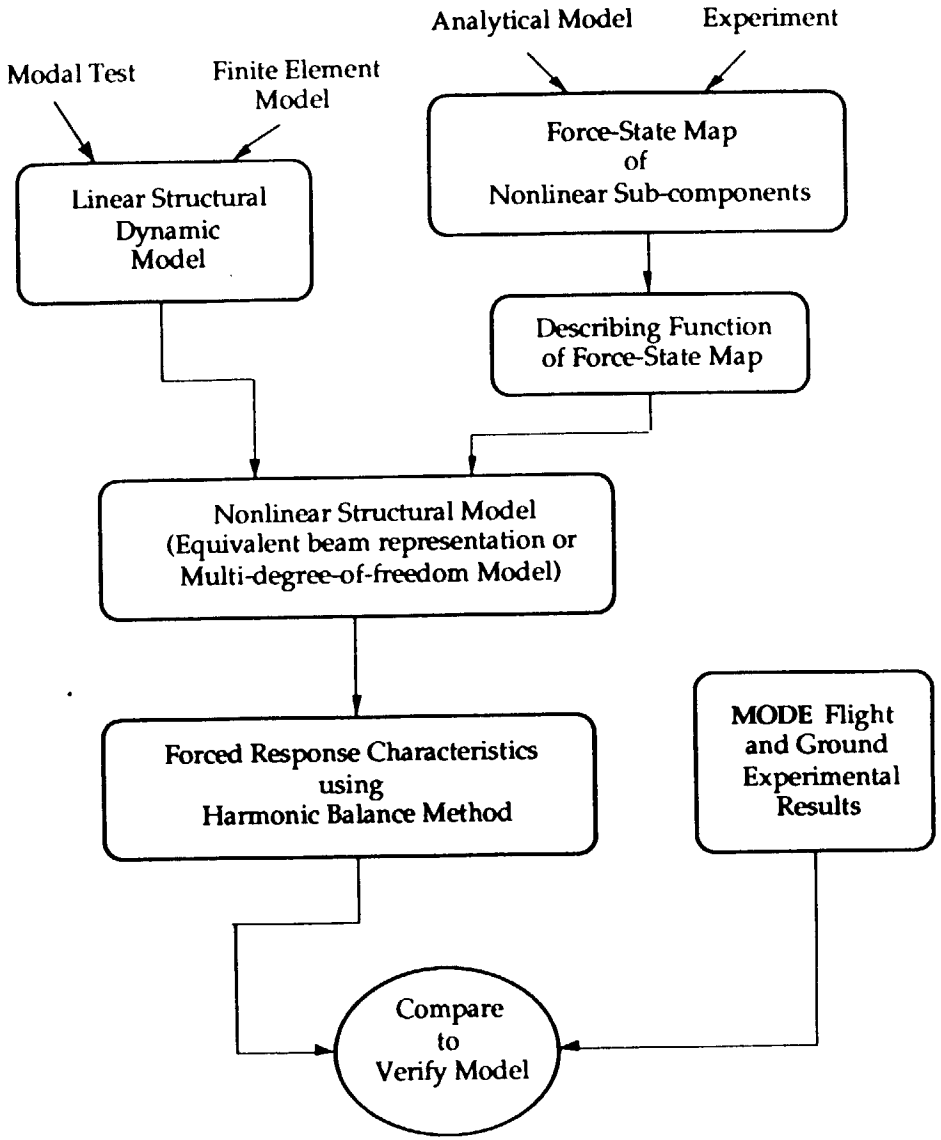
Data (cont.)


Ground (1 Hz Suspension) vs. Space Torsion Mode (alpha tight)
LEGEND
o space, resonance force input 5.00 lbf
+ space, resonance force input 2.78 lbf
* space, resonance force input 0.46 lbf
.. ground, resonance force input 4.37 lbf
-- ground, resonance force input 2.39 lbf
-. ground, resonance force input 0.31 lbf
A1 g's/lbf
10¹
10⁰
10⁻¹
10⁻²
7.1
7.2
7.3
7.4
7.5
7.6
7.7
Frequency (Hz)

Preliminary Results

- MODES GENERALLY APPEAR SOFTER IN 0-GRAVITY
- RESONANCES EXHIBIT SIMILAR SHIFTS, ON THE GROUND AND IN 0-GRAVITY, RELATIVE TO INPUT FORCING LEVEL.
- MODES ARE GENERALLY MORE DAMPED IN 0-GRAVITY.
- DATA EXHIBIT SOME ANOMALIES, TO BE EXPLAINED BY NON-LINEAR ANALYSIS?
- SOME MODES OUT OF 0-GRAVITY TEST WINDOWS!

Supporting Analysis Program



Modelling Approach