ISSUES AND TECHNIQUES IN FINITE ELEMENT MODELING OF THIN-FILM STRUCTURES

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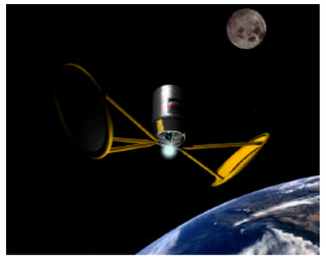
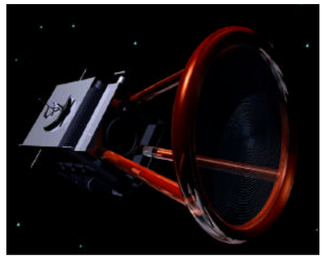
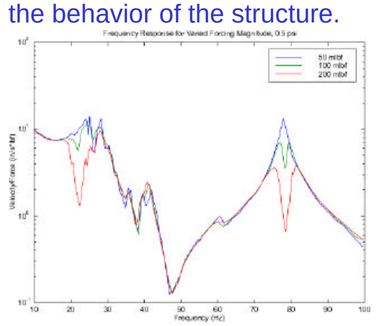
The Solar Thermal Upper Stage (STUS) and the Shooting Star Experiment (SSE) were concepts utilizing inflated torus and strut structures constructed of 2 mil Kapton film to support a lens.





To facilitate understanding of the structure, individual cylindrical struts were studied first, both experimentally and analytically. The results confirmed that the details of fabrication, such as seams, had a significant impact on the behavior of the structure.

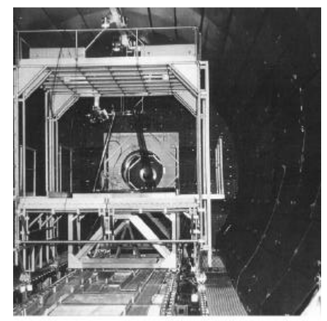


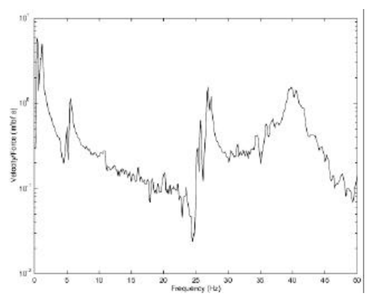
Experimental sine sweep results indicate force-dependent divergence of modes due to coupling.

A shell element model in MSC/NASTRAN was generated, both with and without the details of the seam included. The results indicated that inclusion of the seam led to significant differences in the behavior of the model, consistent with experimental results.

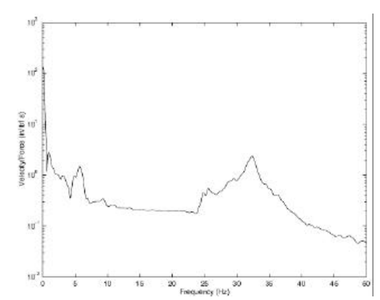
Mode number	Direction	Frequency, Hz No seam	Frequency, Hz With seam
1	X	2.18	2.18
1	Y	2.18	2.33
2	X	28.761	27.904
2	Y	28.768	29.827
3	X	85.768	83.418
3	Y	85.783	88.335

Modal testing of the solar concentrator structure was conducted in both vacuum and ambient conditions. The results indicated that structural behavior in ambient conditions is completely different from that in vacuum.



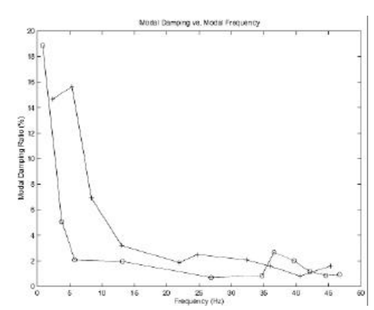


Vacuum Frequency Response



Ambient Frequency Response

The differences in damping between the two test cases are clearly evident. As a result, vacuum modal testing is recommended for the purposes of structural characterization.

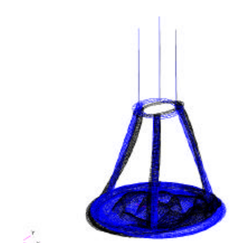


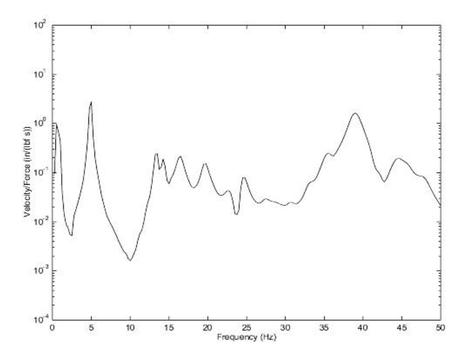
Modal damping vs. frequency for vacuum (o symbols) and ambient (+ symbols) testing, 0.5 psig pressure.

Shell element models of the concentrator and lens were constructed in MSC/NASTRAN, and correlated well to the vacuum test results.

Mode	Model (Hz)	Test (Hz)
1	0.5	0.85
2	4.25	3.81
3	5.25	5.80
4	13.5	13.16
5	27.5	26.86
6	30.72	34.72
7	35.5	36.55
8	39.0	39.67
9	44.5	42.12
10	47.5	44.58
11	49.75	46.68

Eigensolution methods on their own, however, produce hundreds of not thousands of modes in the frequency range of interest, making the identification of the relevant behaviors difficult. By using frequency response methods, global bending modes may be differentiated from radial shell modes.





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