Large Space Structure Control: Early Experiments

THIS issue focuses on the results of early laboratory tests and planned on-orbit experiments of large space structure control strategies. Principally an outgrowth of an expanding interest in large, high performance space-based communications, surveillance, and weapons systems in the late '70's, the juxtaposition of submicroradian pointing control, rapid maneuvering, and precise surface shape management with complex, low-frequency bending dynamics created a set of difficult control problems whose solution was often beyond current capabilities and experience.

Historically, structural bending was treated by isolating it in flexible appendages, managing controller bandwidths, using notch filters, or by combinations of these techniques. The new mission requirements are, in general, too difficult to be addressed in these ways, and this fact has motivated substantial theoretical research in the last five years. Indeed, nearly every controls-oriented professional society meeting has addressed the topic of large space structure control. The fabric of this research, however, has been directed much more toward analytical methods than toward the area of experimental verification. Those notable experiments which have been performed have not been well developed in the technical literature. Our main purpose in this special issue is improving the technical visibility of this early experimental work.

The issue begins with a survey of the LSS control field by Nurre, Ryan, Scofield, and Sims. This paper provides some historical perspective on the current interest in large space structure control, discusses large vehicles such as Skylab, and brings the reader through the maze of theoretical development which characterizes the subject today. The survey provides a motivation for the more detailed discussion of experimental results which follows in the next three papers.

The experiments described in this special issue deal with active damping augmentation for so-called simple structures like beams and plates. The paper by Schaechter and Eldred examines the control of a vertically suspended beam using electromagnetic actuators attached to the laboratory frame. Aubrun, Ratner, and Lyons then describe a circular plate experiment which uses proof-mass-type actuators coupled with high-performance microvibration optical sensors; both colocated and noncolocated controls are studied. The last experimental paper, by Cannon and Rosenthal, deals with the torsional control of a collection of disks, vertically suspended, which allowed detailed study of noncolocated control laws. The order of the papers represents the historical sequence of the experimental activities, i.e., the Schaechter-Eldred experiment is the earliest one presented here.

While these papers represent a sampling of the more extensive experimental studies, much of the early experimental work, from 1978 to the present, is still to be adequately discussed in the open technical literature. There are at least a dozen other experiments which have been performed which certainly qualify under the rubric of early large space structure control experiments. Hopefully these will also soon appear in the literature.

Although in a sense these experiments are rudimentary, some have demonstrated multimode control (up to 5 bending and 3 rigid body) and near microvibration performance using precision optical sensing. All of the experiments have shown that LSS control implementation may be far less complex than the theoretical foundations and procedures necessary to synthesize the controls—a very desirable state of affairs. The issues of aerodynamic structural damping and suspension design in 1-*g*, expected to produce great experimental difficulties, have been reasonably resolved for the cases studied.

The last paper, by Buchanan, Schock, and Waites, departs from discussions of ground test experimental activities and relates a potential experimental design for in-flight test of a shuttle-based large deployable solar array. The paper addresses control design and flight test objectives.

For subsequent experiments, the important issues which must be addressed include fault-tolerance and performance robustness in a real hardware environment. Since high performance and high model error sensitivity usually come as a package, robustness to structural nonlinear and other unmodeled behavior will become fundamental to any flight test planning for large space structure control systems. New experimental activities can provide important guidelines for quantifying acceptable model error and can help designers avoid unnecessary and expensive refinement of system structural models. The early experiments, though, give us reason to believe that very high performance large spacecraft can become a reality. It is hoped that the discussions here will motivate continuing experimental development in large space structure control.

The credit for making this special issue a reality goes to Dr. Sherman Seltzer, President of Control Dynamics Company, and Mr. Michael Lyons, Vice President of Integrated Systems, Inc. I'd like to thank them for the unusual effort they contributed in the process of bringing this issue to print. They have exhibited incredible perseverance in bringing the issue to fruition. The meeting in which they assumed the charter for developing the issue was held in August 1979. We published a Call for Papers in September 1980, restricting the issue to experimental work. What we learned in the intervening years was the paucity of such work being conducted in this area despite the large number of analytically oriented papers that have been generated. This situation is beginning to change. Dr. Seltzer and Mr. Lyons would find a richer set of possibilities if they were to start today.

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