

# Book Review

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## ***Spacecraft Structures and Mechanisms—From Concept to Launch***

Thomas P. Sarafin (Ed.), Kluwer Academic, Boston, MA, and Microcosm, Torrance, CA, 850 pp., Hardbound \$139.50, Softbound \$44.50

First published in 1943 during World War II, the structures book *Analysis and Design of Aircraft Structures* by Elmer E. Bruhn gained widespread acceptance in both engineering schools and industry. By 1965 the book had gone through several editions and had been retitled *Analysis and Design of Flight Vehicle Structures* in recognition of the emerging importance of spacecraft. Bruhn's popular large books were not typical of texts written by engineering professors, although he was a professor at Purdue University. His books emphasized practical stress analysis; derivations and theoretical developments were minimized. Their large page size accommodated concise explanations and a large number of numerical examples in a double-column format. There were also numerous design charts and data tables.

There have been several new aerospace structures books since the 1960s. Most emphasize structural analysis, and often they are heavy on analytical and computational methods. Since Bruhn's books, there has been growing deemphasis on hand calculations, and finite element structural analysis has become widely used. Over the last 30 years, in spite of the major importance of spacecraft, there have been few books devoted to spacecraft structures. Only two books come to mind: *Structural Design of Missiles and Spacecraft* by Lewis H. Abraham, McGraw-Hill, 1962, and *Spacecraft Structures* by Carl C. Osgood, Prentice-Hall, 1966. These books are now more than 30 years old and outdated.

The Preface of *Spacecraft Structures and Mechanisms—From Concept to Launch*, edited by Thomas P. Sarafin, states: "The book's breadth tempted us to leave the word 'structures' out of the title because most structures books are solely about analysis. We were afraid many of our intended readers—which include not just analysts but also mechanical designers, materials engineers, systems engineers, technical leads, and program managers—would never pick up a 'structures' book to see what's in it." These sentences set the tone of the book. It is intended for practical development of spacecraft structural systems by people in industry.

The book consists of 21 chapters written by 24 space industry engineers, mostly from Martin Marietta Astronautics. The book is organized in six parts:

I, Introduction; II, Requirements; III, Analysis; IV, Verification and Quality Assurance; V, Design; and VI, Final Verification. By page count, about two-thirds of the book is devoted to analysis and design. The treatment of mechanisms is relatively short, consisting of only one of the six chapters devoted to design.

The early chapters are devoted to the key considerations and requirements for developing spacecraft structures and mechanisms. These chapters describe the design process, the basic requirements for a space structure, and structural loads. The analysis part has good balance between statics and dynamics. There are chapters on classic mechanics of materials, loads analysis for single-degree-of-freedom systems, flexible dynamics, and strength analysis, and short chapters on structural life analysis (fatigue and fracture mechanics) as well as thermal effects. The design section has chapters on configuring a spacecraft, conceptual design, idealizing and modeling structures, controlling structural responses, and design loads cycles, as well as the chapter on mechanisms. Both metallic and composite materials are considered. There is a discussion of modeling and analyzing structures with finite elements, but it is surprisingly short. Statistical methods are employed in structural reliability analysis. The background required to understand the analysis and design chapters is probably above the knowledge of a typical "fresh-out" aerospace engineer. Some graduate courses and/or experience are likely to be required for complete comprehension. Concluding chapters of the book describe designing for producibility and final verification of the design. Seven appendices provide supporting information.

*Spacecraft Structures and Mechanisms—From Concept to Launch* provides a reality check. The book demonstrates that design and development of modern spacecraft structures is much more than structural analysis. In that sense, it brings us back to the Bruhn perspective of the practical design of flight structures. *Spacecraft Structures and Mechanisms* is a valuable addition to modern aerospace structures literature.

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