

SPACE SYSTEMS ENGINEERING

FUNDAMENTALS OF SPACE SYSTEMS

Edited by: **Vincent L. Pisacane** and **Robert C. Moore**, *The Johns Hopkins University Applied Physics Laboratory*
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Vincent Pisacane and Robert Moore have produced an excellent book that clearly establishes a prominent niche within the growing field of publications in space systems design. Its most noteworthy quality is its ability to maintain a distinct systems perspective while providing sufficient technical material to satisfy the needs of both the systems engineer and the specialist. In the words of the editors, their intent is to present "...the principles of systems engineering that are necessary to formulate the development process and the salient technical characteristics of the functional subsystems." This is a difficult balance to reach. Pisacane and Moore have succeeded.

The editors have compiled *Fundamentals of Space Systems* from lectures developed for a two-semester graduate program at The Johns Hopkins University. Chapter authors are practicing experts in their specialties who present their material at an appropriate technical level for the purposes of the book. Each chapter includes an extensive bibliography for those who wish to further explore specific topics. The excellence of the material attests to the outstanding qualifications of the authors and the success of the editing process.

Pisacane begins the book with a masterful summary of the space systems engineering process. He describes systems development by defining design phases, tracking requirements flow-down, and emphasizing the phased review process. The discussion is punctuated by clear definitions and germane examples. I found it noteworthy that most of the references were from the '70s and '80s. It is apparent that Pisacane has developed his approach from *in situ* experience at the Applied Physics Laboratory.

Donald Mitchell's description of the space environment in chapter 2 exemplifies the strengths of an edited volume with outstanding contributing authors. His development is considerably more complete than those contained in similar books, yet is presented at the appropriate level.

If one chapter exceeds the book's carefully constructed breadth and depth, it is perhaps chapter 3, the chapter

on astrodynamics. It is difficult to limit this material because, in the words of the authors, "This chapter addresses the fundamentals of astrodynamics that are important to near-Earth and planetary missions." Although an exploration of that much territory is hard, the authors include an extensive reference list for the interested reader.

Chapters 4 through 11 deal with primary spacecraft subsystems. Because a comprehensive discussion of each chapter would exceed the space allocated to this review, only the highlights will be mentioned.

In chapter 4, Pisacane provides an excellent development on the gravity-turn ascent trajectory, which is unavailable in standard propulsion literature. He ties together orbit transfer and propulsion nicely.

In chapter 5, Malcolm Shuster addresses the difficult topic of spacecraft attitude determination and control in a balanced fashion that facilitates an understanding of the relationships between basic concepts and hardware implementation.

Ralph Sullivan's early discussion of orbital considerations in the design of space power systems is well integrated into chapter 6's development of the fundamentals of space power system design. His comprehensive synopsis of energy sources and storage devices is outstanding.

Clarence Wingate concludes his excellent presentation on spacecraft thermal control with a well-constructed design example illustrating all the carefully developed principles in chapter 7.

W. E. Skullney's methodical buildup of spacecraft configuration and structural design is consistent in its undeviating reference to the role of the structure in "...provid[ing] the mechanical interface with the launch vehicle and support to all spacecraft subsystems." Skullney covers the fundamentals from the basic strength of materials to finite-element techniques and emphasizes the role of structural test verification.

Eric Hoffman superbly ties the fundamentals of radio wave propagation to the specifics of spacecraft communications. Each of his topics is strongly linked to that task. He includes a well-constructed example of the design of a space communications link and provides an informative discussion of several appropriate special topics (e.g., encryption, antijam techniques, etc.).

Chapters 10 and 11, written by co-editor Robert Moore, contain well-organized discussions of spacecraft command and telemetry and data processing. Moore has a remarkable ability to hit just the right topics at just the right levels.

Fundamentals of Space Systems concludes with three well-constructed chapters on spacecraft reliability and

Frank J. Redd is the head of the Department of Mechanical and Aerospace Engineering at Utah State University. He also serves as the Associate Director for Advanced Aerospace Projects in Utah State's Space Dynamics Laboratory.

quality assurance, spacecraft integration and test, and mission operations. These chapters attest to the book's dedication to an inclusive coverage of space systems principles. R. H. Maurer's discussion of reliability and quality assurance in chapter 12 is firmly based on practical applications of statistical fundamentals. Max Peterson emphasizes the importance of planning for integration and test, beginning with the earliest stages of system design. Vincent Pisacane concludes with a brief discussion of mission operations.

Although I have been able to present only highlights here, it is important to echo the comments made earlier in this review. Each chapter is written by a

recognized professional with substantiated experience in his field; each contains an excellent balance of technical and practical material; and each begins with a development of fundamental background material before entering a discussion of the details of hardware implementation.

I see this book as one that will find its way onto many bookshelves as a classic, fundamental reference in spacecraft systems design. It will be used by systems engineers in the broadest systems sense, but it will also be used by specialists as an introduction into the essential elements of various spacecraft subsystems. For either use, it's a bargain at \$75.