Book Review

Publishers are invited to send two copies of new books for review to Dr. I. Michael Ross, Code: AA/Ro, Department of Aeronautics and Astronautics, U.S. Naval Postgraduate School, 699 Dyer Road, Monterey, CA 93943.

Spacecraft Dynamics and Control: A Practical Engineering Approach

Marcel J. Sidi, Cambridge University Press, New York, 1997, 409 pp., $85.00, ISBN 0-521-55072-6

Writing a book on spacecraft dynamics and control is a difficult endeavor because it involves three different disciplines—orbital mechanics, attitude dynamics, and control—and a thorough treatment in each area would require three different books. This book makes a compromise with a broad coverage of the practical aspects of the three areas. The intended audience includes first-year graduate students and practicing engineers. A background in undergraduate dynamics and classical control theory is assumed. A brief review of the chapters follows.

Orbit dynamics is covered in Chapter 2 (after an introductory Chapter 1), which contains the standard material on Kepler's time equation, Lagrange's planetary equations, perturbing forces, and the Euler–Hill equations. The author's choice of material leaves out discussion of the Lambert problem used in astronautical guidance. Orbital maneuvers are considered in Chapter 3, which contains single-impulse and multiple-impulse solutions and geostationary orbit corrections. Unfortunately, a discussion of interplanetary transfers using the method of patched conics is not included.

Chapter 4 introduces the attitude dynamics of a single rigid body. The presentation is superficial and does not have the depth of treatment of *Spacecraft Dynamics* by Kane, Likins, and Levinson. Gravity gradient stabilization is given a good treatment in Chapter 5 (on the level of *Spacecraft Attitude Dynamics* by Hughes), although there is a minor case of misrepresentation by not attributing the instability of the Debra-Delp region to the presence of damping. Spin stabilization is presented in Chapter 6, and the discussion of dissipation effects is fairly standard, following Agrawal's *Design of Geosynchronous Spacecraft*.

Attitude maneuvers in space by momentum wheels is given a thorough treatment in Chapter 7, with discussions on attitude control by magnetic torque and momentum unloading by magnetic torque rods. However, control moment gyros are not discussed and optimal large angle rotational maneuvers, as in Junkins and Turner's book, are not considered. In fact, the author erroneously states that slewing about the eigen-axis is time optimal, whereas the paper by Billimoria and Wie that he cites for reference showed just the opposite.

In Chapter 8, momentum-biased three-axis stabilization is presented as roll–yaw control using magnetic torque, two momentum wheels, or thrusters. Detailed simulation results for specific examples, given here as well as throughout the book, lend the presentation particular import.

On–off thruster control of attitude is treated in Chapter 9, with an excellent analysis of pulse-width and pulse-frequency modulation. Chapter 10 introduces the important subjects of control–structure interaction as well as fuel slosh, but the treatment is rather disappointing. Practical control design methods using roll-off, notch filters, or modern methods such as robust input shaping are not mentioned. Literature on dynamics of nonlinear truth models of multibody, flexible spacecraft are not referenced, and developments in control of structures over the last twenty years are not discussed.

The book ends with appendices containing a useful collection of practical details on horizon sensors, sun sensors, star trackers, thrusters, reaction wheels, etc., and an example of solar torque computation.

In conclusion, it is fair to say that this is a book meant for a broad study of the dynamics and control of simple spacecraft. While the coverage is somewhat uneven in quality, the author has succeeded in his stated goal of documenting "the basic engineering notions of controlling a satellite," and this reviewer would highly recommend its use to this end.

Arun K. Banerjee
Lockheed Martin Advanced Technology Center