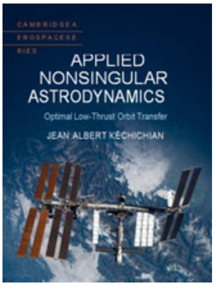


Applied Nonsingular Astrodynamics: Optimal Low-Thrust Orbit Transfer

J. A. Kéchichian

Cambridge University Press, University Printing House, Shaftesbury Road, Cambridge CB2 8BS, UK. 2018. xvii; 461 pp. Illustrated. £89.99. ISBN 978-1-108-47236-4.

This is a book for specialists in orbital dynamics, authored by one of the leading current practitioners in the field. Its subtitle, 'Optimal Low-Thrust Orbit Transfer', reflects one of the principal technical drivers behind the book, namely that an increasing number of satellites in Earth orbit are now using more fuel-efficient ion thrusters which have far lower thrust levels than their chemically propelled predecessors. As a consequence, there is an increasing need to optimise the longer trajectories – in terms of both time and distance travelled – that result from the use of this technology.

The term 'nonsingular' in the title refers to the fact that, among the standard Keplerian orbital elements which describe a satellite's orbit, there are two parameters – eccentricity and inclination – that can go to zero. The alternative approach adopted by Kéchichian uses a set of equinoctial orbital elements, which avoids this problem and allows the various equations of motion to be integrated.

The early chapters of the book establish the relationships between the standard orbital elements and the equinoctial formulation and demonstrate how the latter can be used to derive 'minimum time' and 'minimum fuel' transfers between orbits. It is also demonstrated how the approach can be used to address both constant-thrust and variable-thrust trajectories. There is also some discussion of the constraints associated with the thrust vector direction relative to the Sun. Ion engines typically require significant amounts of power, hence the degrees of freedom to rotate the satellite's solar panels relative to a standard pitch, roll and yaw attitude control scheme become a relevant component of the overall problem.

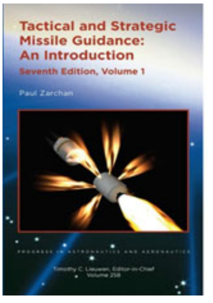
Later chapters in the book introduce the various gravitational perturbations that apply to satellites in Earth orbit. The J2 term resulting from the Earth's oblateness is addressed first, and there are subsequent chapters dealing with the higher-order harmonics (J3 and J4) and the gravitational effects of the Sun and the Moon. Given the constant changes in the Moon's orbit around the Earth resulting from the Sun, it should come as no surprise that some of the trajectory graphics later in the book are impressively complex.

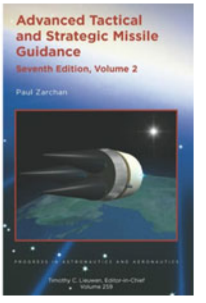
It is probably fair to say that only a competent mathematician will derive full benefit from this work. There are complex equations on almost every one of its 461 pages, and the production of this volume is a triumph of the typesetter's art; few books are likely to have more frequent recourse to superscripts and subscripts!

There is some duplication between chapters; a deliberate policy to allow each to stand alone if required. This is excusable, but there are some other stylistic points that simply frustrate. The notations SinΘ and SΘ are used interchangeably throughout the book, occasionally in the same equation, and this is an impediment to rapid comprehension.

You would not expect to find much humour in a book of this density, but there is some nevertheless. The author chooses to compare the results of his method with software that has been used by NASA since the early 1970s. The NASA software suite in question is called SECKSPOT (try saying it out loud – an acronym for Solar Electric Control Knob Setting Program by Optimal Trajectories) and testifies to a more liberal naming regime in the IT sector at that time! One final note of caution for those who would seek to use the techniques described in this book to optimise their satellite's orbit-transfer performance: On page 328, in the introduction to chapter 13, the word 'equational' appears when surely 'equatorial' was intended. It is clearly very arbitrary to pick up on a typographic error of this sort, but it is simply evidence that books are written (and typeset) by humans, and humans occasionally make errors. In view of the complexity of the mathematics contained in this work, it is feasible that other errors may have slipped through the editorial net.

Dr Stuart Eves





Tactical and Strategic Missile Guidance: An Introduction

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