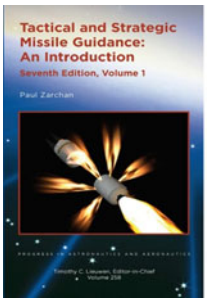
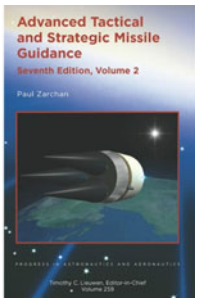
There is some duplication between chapters; a deliberate policy to allow each to stand alone if required. This is excusable, but there are some other stylistic points that simply frustrate. The notations SinΘ and SΘ are used interchangeably throughout the book, occasionally in the same equation, and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

Seventh edition – Vol 1. Progress in Aeronautics and Astronautics Series Volume 258

P. Zarchan

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Advanced Tactical and Strategic Missile Guidance seventh edition Vol 2

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American Institute of Aeronautics and Astronautics, Reston, VA, USA. xxix; 706 pp. 2019. Illustrated. Distributed by Transatlantic Publishers Group, 97 Greenham Road, London N10 1LN, UK. £116 (20% discount available to RAeS members on request; mark.chaloner@tpgltd.co.uk). ISBN 978-1-62410-538-8. (Both books can be purchased also as a two-volume set for £165. (20% discount available to RAeS members on request; mark.chaloner@tpgltd.co.uk). ISBN 978-1-62410-584-5)

Paul Zarchan's book *Tactical and Strategic Missile Guidance* is possibly one of the standard texts on the subject, making any review a somewhat hazardous operation. However, this review is for the seventh edition, and I was fortunate enough to complete the review for the sixth edition for *The Aeronautical Journal* in January 2013, which has given me a good basis for a comparative analysis of the publication.

The most immediate impression is that the 'book' is now published as two volumes – Vol. 1 Tactical and Strategic Missile Guidance: An Introduction and Vol. 2 Advanced Tactical and Strategic Missile Guidance. These two volumes bring the page count up to 1,441, an increase of 40% above the content of the single-volume sixth edition with 1,039 pages. Besides this increase in content, many of the chapters have been re-arranged into in a more logical order. Although sold as separate volumes with different titles, they do, in fact, make up one publication and are best considered as such. A further difference is that the source code examples, which were collected in an additional examples appendix in the sixth edition, have now been moved into the relevant chapters in volumes 1 and 2 of the seventh edition. As noted in the preface, the listings index for the source code is under M, MATLAB Code, in the index of volume 1. However, I was unable to access the MATLAB and Fortran listings on the AIAA website using the password contained in volume 1.

Volume 1 of the seventh edition, the introduction, contains the first 23 chapters of the sixth edition (strictly 22, as one chapter has been moved into volume 2), with the content of almost all having been expanded, a few remaining the same and one chapter being smaller, as much of its content has been distributed into volume 2. A new chapter expanding tactical guidance has been added.

The first six chapters form an introduction to the mathematical techniques of missile guidance, covering among other things, integral transforms, numerical methods and Runge–Kutta integration methods. A detailed examination of the use of adjoints for analysis is covered, as these techniques are favoured by the author. These are based on using only the transient or impulse response of the system, thus simplifying the mathematical analysis without loss of fidelity. Since missile guidance systems are highly dynamic, it is likely that their response will be dominated by transient behaviour. Used widely throughout both volumes, adjoint methods are later used in noise analysis and for advanced filter analysis, both of which are covered in the introductory chapters.

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Volume 1 continues with derivation of the fundamental guidance law and proportional navigation, which is further expanded into more advanced guidance laws together with chapters on fading memory and Kalman filtering techniques. Chapters 11–19 cover many aspects relevant to strategic weapons guidance and interception. Here techniques for the estimation of target ballistic coefficients are derived. Such estimates can be used to differentiate decoys with matched radar returns from 'real' re-entry bodies. Chapter 20, greatly expanded from the previous edition, provides extensive coverage of multiple targets with the final three chapters of volume 1, again expanded from the sixth edition, covering, firstly, the transfer functions of a missile airframe, secondly, flight control design and finally the three-loop autopilot.

Volume 2 of the seventh edition of *Advanced Tactical and Strategic Missile Guidance* contains much new material, and while the remaining 12 chapters of the sixth edition can be mapped into volume 2, a further 10 new chapters and 234 pages have been added. The first five chapters start with two extended versions from the sixth edition, covering unstable airframes with three-loop autopilots and advanced adjoint applications, followed by three new ones covering flexible body dynamics, modern control and autopilot design and shaping filters. The following three chapters bring together sections from the sixth edition, fully covering weaving target aspects, after which three new chapters cover predictor/corrector guidance, means of reducing interceptor jerk and further Kalman filter enhancements.

Chapters 12–16 start with two chapters on guidance law development taken from the sixth edition but with considerable additions. These are followed by three new chapters covering stationary targets, vertical S manoeuvres and high altitude, tail controlled missile performance. Chapter 17 covers three-dimensional engagement simulations (again extended from the sixth edition), followed by a new section examining miss distance of a radar-guided missile. The final four chapters are taken from the sixth edition but are in a different order and all are greatly expanded. They are: comparison of differential game guidance with optimal guidance, boost phase filtering options, kinematics of intercepting a ballistic target and finally kill vehicle guidance and control sizing for boost phase intercept.

In my review of the sixth edition of this work, I commented on ways to make the book more accessible to newcomers. This may well have been wrong, for this is a book primarily for experts in the field and people with more than a good grounding in control theory. It is perhaps better to leave it like this and rely on other works to provide such introductions. I also noted a lack of coverage on way point/ Go to a Location In Space (GOLIS) guidance. This is still not adequately covered, although there is a new chapter entitled 'Guidance Methods Against Stationary Targets' in volume 2. However, it could be that the author considers such techniques to lie within navigation rather than guidance, which would push them outside the scope of this work. These are minor criticisms of an excellent work on missile guidance and control, which has technical depth also matched by great breadth and which should be in the library of every weapons guidance specialist.

John R. Pearce, CEng FIMechE, MRAeS

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