Additionally, it would have been nice to see some reference to cold gas propulsion systems, which are still a highly relevant method of propulsion for the space industry.

Throughout the book, there are comprehensive sets of example questions and references for further reading at the end of each chapter. Additionally, in the chapter on combustion and thermochemistry, the text refers to useful and openly available code for chemical equilibrium calculations. The book is completed with a good set of illustrations that clarify the more challenging concepts introduced in the text. While the units in the text are a mixture of imperial and metric, which may be confusing at first glance, this does not take away from the content and analysis methods covered. Finally, the appendices contain key details of the numerical analysis discussed in the main text and a good list of web resources from the authors' own site, including a solutions manual, and figures in PPT/ JPG format available from the publisher's site.

Overall, this is a very good senior undergraduate- or postgraduate-level textbook covering key aspects of rocket propulsion with a focus on thermochemical rocket motor design.

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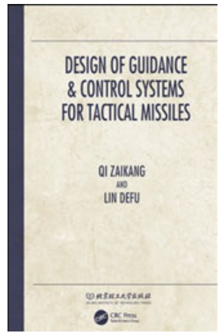

Design of Guidance and Control Systems for Tactical Missiles

Q. Zaikang and L. Defu

CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, USA. 2019. Distributed by Taylor & Francis Group, 2 Park Square, Milton Park, Abingdon OX14 4RN, UK. xiii; 239 pp. £111. (20% discount available to RAeS members via www.crcpress.com using AKQ07 promotion code). ISBN 978-0-367-26041-5.

This book is pitched as an introductory text to the design of guidance and control systems for tactical missiles, and in that respect, it does a pretty good job. Though not as comprehensive as Zarchan(1) for example, it is not intended to compete with books covering state-of-the-art guidance and control strategies, but rather to provide an overview of the missile systems and design processes that must be considered, culminating in an exploration of the ubiquitous proportional navigation guidance strategy. In this respect, the book is tailored more to interested amateurs, senior undergraduate or potentially postgraduate students to ease them into the field, rather than a go-to reference book for practising missile system guidance and control systems engineers.

Chapter 1 introduces the basics of missile guidance by exposing the reader to critical concepts such as Lateral Acceleration (LATAX) as the preferred guidance command, the interplay between guidance, navigation and control within the context of missile systems and a brief overview of the two main classes of missile system architecture: skid-to-turn and bank-to-turn missiles. This discussion provides a nice segue into chapter 2 and the presentation of missile airframe equations of motion. Following an extremely brief presentation of the necessary frames of reference, the authors define both kinematics and axes transformations before presenting a version of the standard Newton–Euler 12-state, six-degree-of-freedom equations of motion, with an emphasis on presentation not comprehensive development. There then follows another brief introduction to control surface deflections and aerodynamic derivatives before finally moving on to the crux of the chapter, the extraction of suitable transfer functions. Chapter 3 is intended to present another brief overview of several pertinent missile sub-systems and sensors, supposedly covering actuator dynamics, rate gyro dynamics, accelerometers and integrated navigation systems. However, at a grand total of three pages for the entire chapter, very little information is actually conveyed. One has to wonder why the authors felt a three-page chapter would be appropriate for a technical textbook. Thankfully, chapter 4 is more comprehensive than its predecessor. Detailing autopilot design, it begins by introducing the reader to some familiar control concepts tailored to missile systems in the skid-to-turn configuration. Several different autopilot architectures are presented at various levels of depth, with the conventional acceleration-feedback autopilot given the greatest page count. Essentially, the book covers the design of two- and three-loop acceleration feedback autopilots consisting of a nested loop structure comprising an inner angular rate feedback stability augmentation loop and an outer loop tracking commanded LATAX. As is common practice, both Bode and step response plots are used to demonstrate the efficacy of each configuration, the impact of adding additional PI compensation and the effect that sensor location can have on the system response. Following this, the book again reverts to very brief presentations of pitch/yaw attitude and flight path angle autopilots before looking at roll axis stabilisation in comparatively more depth. It is here that attention moves to the bank-to-turn system architecture with the aerodynamics revisited and a new autopilot presented. The final few pages of this chapter are given over to thrust vectoring and thruster control as additional control effectors for improving missile agility. However, as before, any reader looking for an in-depth discussion will be disappointed.

Chapter 5 presents a discussion of the radar guidance system and attempts to extract this system's performance characteristics with the greatest impact on guidance loop design and overall system performance. It begins by introducing the classic flypast engagement scenario, where the missile and target are assumed to be moving with respect to each other along two parallel trajectories. Analysis of this simple scenario introduces the reader to the importance of angular acceleration in tracker loop design, which is the primary focus of the chapter. Section 5.3,

https://doi.org/10.1017/aer.2020.117 Published online by Cambridge University Press

which deals with the tracking loop, does an adequate job of presenting the loop architecture and track loop compensator design strategies with one glaring omission – there is no mention of the impact of pure time delay and thus the need for an inner stabilisation loop! Rather, focus is again given to the design of what is actually a relatively simple track loop PI compensator. The remaining few pages of the chapter are given over to the sources and effects of radar sensor noise.

Command Line-of-Sight (CLoS) guidance systems are the topic of chapter 6. The basic premise of CLoS guidance is presented alongside a very rudimentary description of beam rider missiles before deriving expressions for the required LATAX using this guidance strategy. Another simplistic analysis of the guidance loop is presented, along with the effect of using cascade lead compensation to improve the dynamic performance. The remainder of the chapter concerns the application of a lead angle and the reduction in terminal miss distance that can potentially be achieved.

The penultimate chapter, chapter 7, concerns missile seekers. This chapter quickly launches into optomechanical design concepts for some common seeker designs without first presenting any context of why a seeker is needed for missile guidance at all. Indeed, the only context given is a single sentence stating that a seeker is needed for Proportional Navigation (PN) guidance. While this statement is indeed true (with respect to measuring LoS rate at least), it is not a sufficient rationale. Fortunately, the chapter then begins in earnest with some nice schematics of seeker gimbal assemblies for some of the most common missile systems, such as the Sidewinder and Hellfire missiles. There then follows some discussion of the differences between stabilised platform and strapdown configurations for both electro-optic and radar sensors. Next a rudimentary disturbance analysis is introduced, which correctly mentions the disturbance torques acting on each axis, but then replaces them with an 'equivalent' angular rate with no real justification for why. Fortunately, the disturbance torques reappear in the following section but regrettably only as a linear function of the gimbal angular rate, ignoring all other contributions such as bearing Coulomb friction, Stribeck effects and out-of-balance torques. Perhaps the authors decided to omit further investigation into the sources of disturbance torque to ensure that a focus on their impact in creating a parasitic loop within the guidance loop was retained, but this is another opportunity missed. Parasitic loop models and their impact on guidance loop performance is the primary focus for the rest of the chapter.

Finally, in chapter 8, we reach PN and extended PN guidance laws. Thankfully, some effort is made to provide context by mention of the maritime roots of PN and constant-bearing as a sound piloting strategy. A PN controller is then derived from within an optimal control framework, with the actual derivations moved to appendix 1. What follows is then a presentation of the results obtained from first applying PN to successively more complicated missile system models and analysing the results, and then the relative benefits of extended PN with optimal control. A simulation-based approach is used exclusively throughout this first section, with only a cursory, single sentence mention of the method of adjoints at the end, whereas interestingly, an entire chapter is devoted to the method of adjoints in Zarchan(1). The remainder of the book details the application of extended or optimal PN to the same classes of missile system

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model for which the conventional PN guidance law was tested. The only additional component is the inclusion of target dynamics, and target acceleration in particular, into the guidance loop. Clearly there is causation between the target dynamics and guidance loop performance, thus the book then presents a rudimentary target motion observer using a Kalman filter: an interesting topic, but yet again given far too little attention. The interested reader would be better to consult Blackman and Popoli(2) for a much more in-depth discussion of target tracking models. Finally, the optimal trajectory control is formed as a non-linear program with initial and terminal constraints whose solution is proposed via the transcription method (although not explained as such in the text).

Overall, this is a frustrating book to read due, in the most part, to the incredible imbalance between chapters. Best exemplified by the ridiculous three pages of chapter 3, this book leaves the reader with more questions than answers as most of the concepts and techniques are introduced without context and to wildly varying levels of technical depth.

With a little more work, this book could have found a valuable place as both an introductory text and teaching aid – an opportunity missed.

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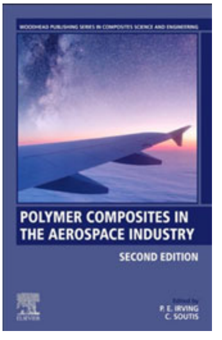

Polymer Composites in the Aerospace Industry – second edition

Edited by P. E. Irving and C. Soutis

Woodhead Publishing, Elsevier, The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK. 2020. xiv; 673 pp. Illustrated. £255. ISBN 978-0-08-102679-3.

The aerospace industry is arguably one of the biggest users of polymer composite materials due to their excellent durability and high stiffness-to-weight and strength-to-weight ratios. Safe and weight-efficient design of composite structures requires that engineers working with composites have an in-depth understanding of their mechanical properties and long-term performance, and this 673-page book undoubtedly provides a wealth of knowledge on the topic.

The revised second edition of the book summarises the latest research and developments in the design, manufacture and performance of composite components for aerospace structures. The 19 contributions