Book Reviews

Modeling and Simulation of Aerospace Vehicle Dynamics – Third edition

P. H. Zipfel

American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, USA. 2014. Distributed by Transatlantic Publishers Group, 97 Greenham Road London N10 1LN, UK. (Tel: 020-8815 5994; email: mark.chaloner@tpgltd.co.uk). 661pp. Illustrated. £80. (20% discount available to RAeS members on request). ISBN 978-1-62410-250-9.

When the First edition of this book appeared thirteen years ago there existed a great gap in the literature of modern flight dynamics. Classic works such as that of Etkin[1] had been used by a generation of flight dynamicists, but the subsequent forty years involved major computer developments that profoundly effected how flight dynamics was practised and that was not reflected in the available textbooks. Peter Zipfel's book corrected the situation but also did more.

The most important aspect of Zipfel's book is the use of tensors for the derivation of the equations. The conventional derivation uses vectors and these have the advantage of being independent of the co-ordinate systems used, until that is we have to consider rotating frames or differentiation. At that point one has to introduce matrix representation and that is co-ordinate system specific. Zipfel avoids this by treating the vectors as first order tensors and introducing two new concepts, the rotation tensor and the rotational time derivative tensor, both second order tensors. as tensors they are all independent of the co-ordinate systems used and this produces a great simplification in the resulting derivations, only at the end of the manipulations do we have to revert to co-ordinate systems and matrices. At that point the resulting matrices can be handled manually or we can use the computer to evaluate them numerically or even symbolically.

Flight dynamics has always been bedevilled by complex symbology due to the many axis systems involved, Etkin's (1) book and more recently Boiffier's (2) have a multitude of alphabets, subscripts, superscripts and dressings. Zipfel's tensor notation is much simpler by comparison, first order tensors (vectors) are bold lower case whilst second order tensors are bold upper case. For both of these, superscripts give the reference frame whilst subscripts give reference points, matrix versions are enclosed in ( ) brackets. The resulting equations are a joy to use.

The Second section of the book was concerned with the development of simulation models. It covered 3, 5 and 6 degree of freedom simulations. It did not deal with the development of code, that is covered by Appendices C and D; instead it concentrated on the other aspects of simulation not covered in Section 1. In the section on 6 degree of freedom simulation alone, subjects such as hypersonic vehicle motion around an elliptical Earth, aircraft and missile aerodynamics, autopilots, actuators, inertial navigation systems, guidance, infrared seekers, Monte Carlo methods and wind and turbulence were covered.

The Third edition retains the structure of the previous editions in that it has 11 chapters split between two parts, Part 1 is 'Modelling of Flight Dynamics' and Part 2 is 'Simulation of Aerospace Vehicles'. In the first Part the author provides the tools to derive and set up the equations used in the second Part. It has two additional appendices compared to the First edition, making five in all. The Second edition added Appendix D 'Foundation of Tensor Flight

Dynamics', whilst for the Third edition Appendix C has been rewritten as 'Aerospace Simulations in C++' and Appendix E 'CADAC++' added. In addition a great many corrections have been made to the formulae and equations.

Throughout the book the author gives numerous worked examples that not only address conventional aspects of flight dynamics but also many of the ancillary kinematic and geometrical problems encountered by the modern flight dynamicist. Here you will find examples as diverse as onboard computer determination of the position of ground based radars or the dynamics of the Space Shuttle during satellite release.

The major change in this edition is the addition of Appendices C and D. The previous FORTRAN coded examples have been superseded and augmented by C++ examples. They are supplemented by three self study courses released by the AIAA (they were not available when this review was undertaken). The examples exploit the object orientated nature of C++ and the most complex, GHAME6, is a six degree of freedom (DoF) model involving a hypersonic vehicle which once it has left the atmosphere releases a transfer vehicle, which in turn sends an interceptor to rendezvous with an orbital object like the Space Station. This involves a 24 GPS satellite constellation, inertial navigation, endo- and exo-atmospheric guidance, a SAR sensor and Kalman filters.

The major new thrust in this edition (contained in appendices C and D) is in the use of C++ with its polymorphism, inheritance and encapsulation features exploited to the full so as to enable complex multi vehicle simulations to be produced. However on its own the book only gives a feel of what these are and the self study material needs to be assessed so as to see how well all this works in practice. The indications are that it works very well and an experienced C++ programmer would have no trouble in following it all, but those unfamiliar with C++ could have a steep hill to climb.

In summary this is an excellent book that should be read and on the bookshelves of all flight dynamicists, the tensor approach is by far the simplest way to describe the physics of multi vehicle scenarios and any student, practicioner or instructor of flight dynamics is well advised to follow this route.

Peter Thomasson

(1) Etkin, Bernard Dynamics of Atmospheric Flight (John Wiley. 1972)

(2) Boiffier, Jean-Luc. The Dynamics of Flight: the Equations (John Wiley. 1998)

Introduction to Compressible Fluid Flow – Second edition

P. H. Oosthuizen and W. E. Carscallen

CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL, 33487-2742, USA. 2014. Distributed by Taylor & Francis Group, 2 Park Square, Milton Park, Abingdon, OX14 4RN, UK. 558pp. Illustrated. £76.99. ISBN 978-1-4398-7791-3.

Compressible flow plays an important role in a wide variety of natural phenomena and in many engineering devices. The book introduces major concepts and the fundamental principles related to compressible flow. The emphasis is on the physical understanding of the phenomena.

The text is concise, clearly written and systematically organised. It contains the derivation of the equations and analytical formulas needed to solve practical problems. The text is amply illustrated. The supportive drawings facilitate

understanding of the theory and are of good quality.

The book starts with the introduction of the principles of conservation of mass, momentum and energy. These laws with the necessary assumptions are later used in analysing typical flows in one and two space dimensions to enable a thorough understanding of the material. The derivations are clear and properly discussed. The first seven chapters are dedicated to the fundamental aspects of the subject. They contain the analysis of isentropic flows with a separately discussed isentropic flow through a variable-area duct, the definition of normal, expansion and oblique shock waves. The following chapters have more applicable character and cover nozzle characteristics and flows with friction and heat exchange effects. As these topics are often neglected in other books dedicated to the compressible fluid mechanics their inclusion further enhances the understanding of the subject matter. The book also successfully attempts to lay the foundations for more advanced problems of hypersonic, high-temperature and low density flows.

All the chapters are followed by worked examples and a list of problems to solve, which are extremely useful in demonstrating the practical implementation of the concepts. The book has appendices containing an additional practical material including the description of the optical methods used as compressible flow visualisation techniques as well as a selection of important tables, constants, conversion factors and diagrams to enable the readers to comprehend the subject with ease.

The book is comprehensive and well-presented and will appeal to the undergraduate as well as the graduate level mechanical and aerospace students. It could also be useful for practising engineers engaged in compressible-flow applications. The book is supported by a numerical code COMPROP2 for compressible flow computations, which is available, free of charge and described in the book. It also includes bibliographical references to other books in the field and to a selection of interesting NASA reports concerned with compressible flow.

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Information Warfare and Electronic Warfare Systems

R. A. Poisel

Artech House, 16 Sussex Street, London, SW1V 4RW, UK. 2013. 414pp. £89. (20% discount available to RAeS members via www.artechhouse.com using RAES2014 promotion code). ISBN 978-1-608-07705-2.

This is one of the latest additions to the Artech House series on Information Warfare (IW) and Electronic Warfare (EW). It addresses a key aspect of modern military operations – the need for robust and private battlespace communications in the presence of hostile and friendly EW activity.

Dr Richard Poisel is an expert on IW and Communications EW (CEW). He has published nine books on these topics. An EW engineering consultant, he was a Senior Engineering Fellow at Raytheon Missile Systems, prior to which he was chief scientist at the U.S. Army Research, Development and Engineering Command, Intelligence and IW Directorate.

The book's target audience is primarily bachelor degree-level engineers new to EW or who desire a different view of EW system performance evaluation. Written largely from the army/marine viewpoint, it focusses on

land-based CEW. Principal aspects are noted as applicable to most EW use situations, which is consistent with this reviewer's experience on radar frequency airborne EW systems. This book is well-organised, is extensively referenced (198 in total) and has a useful list of most specialist acronyms used. It focuses on EW and how Radio Frequency (RF) EW systems and principles can be employed in the IW and Information Operations (IO) discipline. The reader is assumed to have a working knowledge of linear system and probability theory.

Chapter 1 commences with an introduction to IW and EW systems and gives a foundational perspective of the US military service's view of IW. Although not defined until Chapter 2 (section 2.4), the terms IW and IO are broadly synonymous, with the former a war-/conflict-constrained version of the latter. EW, which in this book principally comprises Electronic Support (ES) and Electronic Attack (EA), is identified as one of the five legs of Information Operations (IO). The other four legs are computer network operations, psychological operations, military deception, and operations security. Whilst this is an IW/IO community view, there remains ongoing international debate on electromagnetic spectrum operations and how the formerly disparate disciplines of IW/IO, EW and ISTAR (intelligence, surveillance, target acquisition and reconnaissance) dovetail together in the modern era of network-centric warfare (NCW, a.k.a. 'network-enabled warfare' or 'network-centric operations') and cyber warfare. Whilst this does not detract from Poisel's book, it is suggested a future update would benefit from some discussion of this aspect and inclusion of an inter-relationship block diagram.

Chapter 2 provides a detailed introduction to information, IO and IW. The OODA (Observe, Orient, Decide, Action) Loop is introduced, as is cognitive hierarchy, which together underpin the decision making process. The information environment is explained against the three domains of conflict – cognitive, information and physical. An important point is made that the information environment, in contrast to other environments in which the military operate, is largely non-physical and abstract.

Chapter 3 introduces fundamental concepts in information theory, as formulated by Shannon, by way of a tutorial. It provides 15 references that together provide a comprehensive treatise.

Chapter 4, much of which is reproduced (with permission) from research publications by Dr Carlo Kopp (Monash University), introduces a model to aid understanding some basic IW characteristics. It explains Shannon model limitations and describes four IW strategies – denial of information/passive denial; disruption and denial/active denial; deception and mimicry and subversion. Potential use is described of game theory-based hypergames in IW to resolve a Shannon model key limitation.

Chapter 5 introduces RF EW systems and explains how they fit into NCW. Important NCW characteristics are presented and EW integration into networks is discussed. Data and information fusion and subsequent use for development of combat information and intelligence are also discussed.

Chapter 6 starts with networking basics, including the internet and mobile networking. Key aspects of MANET (Mobile Ad Hoc Network) communication systems, the prime technology underpinning NCW, are discussed. MANET capability, security and attack by EW systems are covered in some detail. Chapter 7 presents key aspects of Situation Assessment (SA), the process of status quo evaluation within the military decision maker's area of responsibility. SA levels are illustrated against data/information fusion levels and SA strategies are explored. Bayesian reasoning is indicated as a

way to model knowledge and conflict, and it is shown that, by using Bayesian logic, quantifiable SA can be generated.

Chapter 8 provides an overview of EW system elements relevant to this book's consideration of IW and CEW and references are provided for those desiring further detail. EW system architectures are discussed, with focus on RF receiving and jamming systems, and operational considerations are commented upon. Chapter 9 contains theoretical analyses of EW system performance, based on information theory principles introduced in Chapter 3. Five CEW scenarios are discussed and some EW system performance measures, in ES and EA modes separately and together, are examined using a number of approaches. The scenarios are viewed by Poisel as typical use of tactical EW systems countering target communication networks. He also notes the results apply equally to ground-to-ground, air-to-air and air-to-ground situations. Chapter 10 presents the results of EW architecture simulations. The engineering performance is first analysed by computer simulation then the results are presented for two operational scenarios – North-East Asia and urban terrain. Appendix A illustrates the specific networks simulated.

To increase military conflict success probability, many nations are moving from distributed land, sea, air and space platforms towards fully integrated, network-enabled capabilities. This book appears a worthwhile reference against this background and the increasingly complex, congested and conflicted electromagnetic spectrum. It is likely to be useful for IW/IO and EW engineers working across these domains and should help engineers and researchers better understand the technical aspects of integrated IW/IO/EW capability.

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Spacecraft Dynamics and Control: an Introduction

A. H. J. de Ruiter *et al*

John Wiley and Sons, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK. 2013. 569pp. Illustrated. £62.95. ISBN 978-1-118-34236-7.

This book provides an introduction to the field of dynamics and control of spacecraft. The book is organised in 26 chapters detailing elementary kinematics and kinetics (1-2), orbital dynamics (3 -10), spacecraft attitude control (11-17), classical control theory (18 -23) and then further topics in spacecraft control including nonlinear control, navigation and practical design issues (24 -26). The book examines a wide range of topics that an undergraduate would need to know to start designing control systems for spacecraft.

In terms of the astrodynamics chapters, the book provides details ranging from the two-body problem to the restricted three-body problem including discussion on orbital manoeuvres and interplanetary trajectories. The notation used for equations is clear and well thought out. Diagrams are however highly minimalist and lack the depth or rigour of prominent texts such as *Vallado Fundamentals of Astrodynamics and Applications* (McGraw-Hill, 1997) where significant effort has been made to make the diagrams full of useful information, yet clear to understand.

The book presents several chapters on classical controls. Whilst the book provides a good overview of these techniques (root locus, bode plots, time and frequency analysis), the book seems to lack sufficient examples for students to fully understand the content. The book is also significantly lacking any problems to work through. In comparison, many core controls texts provide much greater grounding in the subject,

such as Franklin, Powell and Emami-Naeini (FPE) – *Feedback Control of Dynamic Systems* (the source of several of their chapters). For example, the root locus design chapter of FPE, provides at least 12 worked examples of the design process followed by 48 practise problems for students thereby providing a better learning source for students.

In terms of organisation, it would have also helped if chapters had been grouped together into subsets for clarity e.g. Part A: Dynamics and Astrodynamics, Part B: Classical Controls, Part C: Spacecraft Attitude Control etc. Without these parts, the separation between the chapters is confusing on first glance.

In conclusion, this book covers a broad range of areas – including some more in-depth content (stabilisation techniques, practical design issues) – and is best used as an introductory text to the field for latter year undergraduates.

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Deep Space Propulsion: a Roadmap to Interstellar Flight

K. F. Long

Springer. 2012. 367pp. Illustrated. £31.99. ISBN 978-1-46140606-8.

This is a readable, insightful and personal history of interstellar travel thinking with a focus on propulsion ('the author favours the nuclear pulse', page x).

The history takes us from Aviation to possible solutions that Long hopes will progress us to 'thinking of your own ideas for how machines can be propelled across the vastness of space' (page ix).To help with this aim, each chapter has an 'Introduction' providing a short overview of the chapter while the 'practice exercises' at the end are to stimulate discussion.

The book turns into a politely engaged argument that we as a society should support long term engineering and interstellar projects. The central suggestion is 'The Alpha Centauri Prize...to be held every four years. This would allow sufficient time between design studies so as to allow some technological and scientific discoveries' (page 319). At present, this is a very optimistic timescale for this type of engineering. In fact at least since Project Daedalus, some form of nuclear propulsion has been regarded as the technology needed for interstellar missions while actual technology status has faded away. Long is aware of this and argues for a gradual return to nuclear developments as well as for a Pathfinder 'technology demonstrator mission to 1,000AU (Astronomical Unit), the outermost location of the solar gravitational lensing point'(page 318).

Since at least 1987 Claudio Maccone has made such a mission a priority due to its importance to detect weak radio signals from possible intelligences. The effect is estimated to begin at 550AU but even that distance would be a challenge at present. The Kuiper Belt for example is 'only' at 40 to 100AU. In fact Claudio Maccone in 2009 predicted a focus for gravitational waves and neutrinos at 22,45 to 29,59AU (that is somewhere between the orbits of Uranus and Neptune).This prediction with the increasing instrumentation for neutrino astronomy could perhaps be a mission for the more near term.

Long discusses the gravitational lens mission (page 311) and follows it up with three' Challenger Missions' ie. 150-200AU launched 2015-2020; 200-600AU launched 2025-2030; 1,000AU launched 2030-2040.

However, 'the year 2050 for the first star mission seems quite ambitious. Let us think about a scenario that leads to the first launch by the year 2100' (page 321).This illustrates well the problem with any interstellar flight planning: our present society lacks the intellectual and financial

preconditions for such missions. To remedy this Long argues for an Institute that 'would attract academics from the word to come together...The interstellar research community awaits the arrival of such investment' (page 309). In fact Long is himself working to provide this since 'we should have had probes in the Kuiper Belt yesterday' (pages 345 and 346).

The theoretical background presented here by Long deserves to be read and the bibliography deserves to be considered as a starting point for anyone interested in these topics. The colour illustrations are very helpful. Introducing this section Long sums up our paradoxical situation: 'it appears we have started from a position of being bounded in the nutshell that is Earth, but yet can count ourselves the Kings of infinite space' (page 326). Further 'this situation needs to change if we are to ever to become a spacefaring civilisation and join the community of worlds that may possibly exist in this vast universe' (page 347).

For such a change we need a change in engineering demand as well as a change in institutions and most of all a change of perception of what is possible. Read this book and discuss.

Anders Hansson

Stimson's Introduction to Airborne Radar – Third edition

G. W. Stimson

SciTech Publishing (an imprint of the IET), Michael Faraday House, Six Hills Way, Stevenage, Herts, SG1 2AY, UK. 2014. 744pp. Illustrated. £110 ISBN 978-1-61353-022-1.

Since its first issue three decades ago Stimson's *Introduction to Airborne Radar* has been indispensable. The second edition was released in 1998, since when there have been major developments in airborne systems, driven by advances in both RF hardware and digital processing. An update was therefore long overdue and at nearly 30% larger this third edition does not disappoint.

The clear style and extensive use of meaningful diagrams remains, augmented throughout with real examples of radar systems and data. Sections are well structured, with key points tabulated for ease of reference. Every section now concludes with key points, short exercises to test understanding and suggestions for further reading. This will be an invaluable addition for students approaching the subject for the first time. For those using the book as a quick reference the main index, a weakness of previous editions, has been greatly expanded and improved. Key radar equations and relations are conveniently printed inside the rear cover.

All sections have been re-edited and refreshed. Important mathematical concepts are now collected together. For hardware; solid state devices, active electronically scanned arrays, receivers and digitisers are all included. For radar processing; existing sections have been expanded, with SAR processing presented in much more detail, including advanced techniques such as tomography and automatic target recognition.

Less traditional radar techniques are covered in depth. All modes of electronic warfare, including use of the array as a passive sensor and for electronic attack are now covered, mindful of the operation of multifunction radars in a congested and contested spectrum.

For radar experts and amateurs there is much here to expand understanding of the very latest concepts and techniques. The authors clearly understand their audience, and have produced a work that will quickly become essential to anyone wishing to understand airborne radar.

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Bayesian Multiple Target Tracking – Second edition

L. D. Stone *et al*

Artech House, 16 Sussex Street, London, SW1V 4RW, UK. 2014. 293pp. £119. (20% discount available to RAeS members via www.artechhouse.com using RAES2014 promotion code). ISBN 978-1-608-07553-9.

Recently there has been a tremendous interest in tracking multiple targets. The applications are numerous – from cell tracking to surveillance, security, autonomy and communication systems.

The authors present key techniques for multiple target tracking that have been shown their power and that work in many practical systems. Compared with its previous edition, the book is expanded to include recently developed particle filter methods for multiple targets. This edition of the book fills an important gap by integrating motion models and filtering methods, with a special emphasis on dealing with data association, array signal processing and presenting important applications such as multi-static sonar tracking.

The first chapter introduces motion and sensor models, with examples for bearings only tracking, periscope detection by shipboard radar and multiple targets. Chapter 2 presents the Bayesian methodology and likelihood functions as an important inference tool. It is shown how both the presence of information and the lack of information or negative information could be embedded in Bayesian framework and used for decision making. These are illustrated over bearings-only, radar and infrared sensor detection and it is shown how likelihood functions can be used to combine different kinds of information.

Chapter 3 considers the single target tracking problem as a Bayesian inference problem. In the core of the book are Chapters 4-6 which focus on multiple target tracking with an unknown number of targets. Multiple Hypothesis Tracking and Probabilistic Multiple Hypothesis methods are presented in their particle implementations and other data association techniques.

A thorough introduction into Poisson point processes and Probability Generating Functionals (PGFs) is given in Chapter 5 which makes the book a valuable reading both for practitioners and theorists. The intensity filters (iFilters) and the maximum a posterior penalty function technique for multiple target tracking are covered in Chapters 5 and 6. Chapter 7 introduces the reader to the Likelihood Ratio Detection and Tracking (LRDT). This is a problem which is especially important in the presence of high clutter.

One of the main features that make this book valuable is the use of many examples, algorithms and solutions which are extremely important in solving both theoretical and practical problems under a wide range of uncertainties – in the dynamic models, measurements and in complex environments.

I highly recommend this book to graduate engineering students, researchers and practitioners engineers who are working on Bayesian inference problems and especially on multiple target tracking.

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Start by marking â€œModeling And Simulation Of Aerospace Vehicle Dynamics (Aiaa Education Series)â€ as Want to Read: Want to Read savingâ€¦ Want to Read. Currently Reading. Read. Other editions.Â Itâ€™s the wrong book Itâ€™s the wrong edition Other. Details (if other): Cancel.Â This book unifies all aspects of flight dynamics for the efficient development of aerospace vehicle simulations. It provides the reader with a complete set of tools to build, programme and execute simulations. Unlike other books, it uses tensors for modelling flight dynamics in a form invariant under coordinate transformations. For implementation, the tensors are converted This book unifies all aspects of flight dynamics for the efficient development of aerospace vehicle simulations.