namely optimal input design and multistep input design – are described, with the author helpfully using illustrations to make his point wherever possible. An overview of the motion variables required for the analysis and guidelines for choosing appropriate sensors to measure these variables are also given. This rest of the chapter contains an interesting account of the practical aspects of flight testing, with the author describing his own experiences and highlighting possible pitfalls in the procedure.

While the third chapter is short in length, the material it covers is crucial for the chapters which follow. The aim of this section is to introduce various forms of the mathematical models that can be used to describe aircraft dynamics, with the emphasis being on state space representations and nonlinear equations. In particular, the author calls attention to modifications which have to be applied to the equations when faced with issues arising due to practical problems with flight test data. These include extensions of the model structure to account for systematic errors in the measurement of motion variables and control inputs, as well as the presence of time delays.

The core of the text considers the time domain parameter estimation techniques used to obtain numerical values for the parameters within the equations of motion. The first three algorithms to be developed are the output error method, filter error method and equation error method, which can all be used post-flight to analyse the measured data. Chapter 7 turns its attention to approaches for real-time, or recursive, parameter estimation, including techniques based on the extended Kalman filter. The subsequent two chapters focus on more specialised topics, with chapter 8 discussing the use of artificial neural networks and chapter 9 describing parameter estimation for unstable aircraft. It is in chapters 4 to 9 that the virtue of including companion software really becomes apparent. The opportunity to implement the various techniques utilising real flight test data allows the user a greater insight into the application of each algorithm. The link between theory and practice is further enhanced by the fact that the author has painstakingly annotated every key equation in the MATLAB files with the corresponding equation number as given in the book. This is particularly advantageous for the Filter Error Method, which is by far the most complex algorithm used for aircraft parameter estimation.

Chapter 10 returns to the issue of instrumentation by describing the data compatibility check, or flight path reconstruction, used to remove systematic errors from the measurements and verify their kinematic consistency. Although this step is carried out prior to the parameter estimation phase, the author delays its discussion until after the chapters covering parameter estimation, as the procedure utilises the output error method or the extended Kalman filter explained earlier.

After a chapter detailing how the parameter estimates can be validated, the final section provides a collection of interesting case studies from DLR in which system identification has been applied. These include the modelling of wake vortex encounters, analysis of unsteady aerodynamic effects and the identification of the Phoenix reusable launch vehicle demonstrator.

Overall, this is a first-rate book, which should appeal to those new to the field as well as anybody already actively involved in the subject area. The author has managed to strike a delicate balance between a theoretical and a practical treatment of the subject. Mathematical descriptions of the various techniques are detailed but concise. At the end of each discussion, the author goes out of his way to comment on which methods, based on his experience, have worked well in practice and the inclusion of the software tools enhances the value of this publication no end. On top of this, it is clear that a huge amount of effort has gone into the preparation of the material, and this ultimately makes the book an enjoyable read.

Stephen Carnduff, Affiliate

Aircraft System Identification: Theory and Practice

V. Klein and E.A. Morelli

American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, USA. 2006. 484pp. Illustrated. $84.95 (AIAA members), $119.95 (non-members). ISBN 1-56347-832-3.

This text on aircraft system identification is based on the considerable experience of the authors at NASA Langley, which has been an eminent authority on the subject over the last three decades. Vladislav Klein is one of the best known names in the field having been responsible for many key developments in aircraft system identification. Eugene Morelli is also a renowned expert on the subject and has analysed various aircraft including the de Havilland Canada DHC-6 Twin Otter, the Tu144LL supersonic transport aircraft and the X-43A (Hyper-X).

The scope of the book is fixed-wing, rigid body aircraft dynamics and, as indicated by the title, the objective is to deliver an account of the subject's theory, while reinforcing the concepts using practical examples. To assist in conveying the practical aspects of the system identification to the reader, a MATLAB software toolset known System IDentification Programs for AirCraft (SIDPAC), written by Dr Morelli, is included in the publication. The flight test data from the case studies is also provided.

The opening two chapters, as would be expected, introduce the principles of aircraft system identification and provide a brief outline of the subject's history. The theoretical background is laid out with a discussion of the mathematical modelling of dynamic systems and system identification in general.

The focus on aircraft begins in earnest with chapter 3, which looks at the mathematical models used to describe aircraft dynamics. In 46 pages the authors have managed to concisely develop the mathematics, starting from Newton's Second Law of Motion, and cover a range of topics including the linearisation of the equations and modelling of unsteady aerodynamic effects. This chapter will be particularly useful for readers who, like me, are schooled in the British system of flight dynamics notation and less familiar with the notation used in the US.

Parameter estimation techniques, used to obtain numerical values for the derivatives within the equations of motion, are the topic of chapters 4 to 8. Firstly, a general introduction to estimation theory is given. This is followed by chapters describing time domain techniques based on regression analysis and maximum likelihood estimation. Chapter 7 then concentrates on frequency domain parameter estimation and chapter 8 discusses techniques for performing the process in real-time. The treatment of the theory in these chapters is thorough, with each of the methods derived from first principles as far as possible. At the same time, practical examples from the authors' experiences at NASA Langley are used to illustrate their arguments and the reader has the opportunity to repeat the analysis using the software and data provided. The pros and cons of each approach are also outlined in detail.

Having discussed the theoretical aspects of parameter estimation, the remainder of the book focuses mainly on the practical issues to ensure the measurements from the aircraft are of sufficient quality. Firstly, the design of flight tests to gather data is considered and covers the selection of suitable data acquisition systems and sensors, as well as the design of control surface inputs. The following chapter describes the data compatibility check. This is an important pre-processing step which is used to remove systematic errors from the measurements and ensure the data is kinematically consistent. Further methods of data analysis are then explored in chapter 11, with a focus on techniques for filtering, smoothing, interpolation and numerical differentiation. Software is again provided to carry out many of the operations described in chapters 9 to 11, and the book's final chapter is dedicated solely to the MATLAB programmes accompanying the text. A useful addition to the software is the inclusion of a nonlinear simulation of the F-16, which allows the reader to generate data and perform the subsequent analysis using SIDPAC.

This is an excellent book which achieves its goal of providing a detailed account of both the theoretical and practical aspects of aircraft system identification. The authors' arguments are well illustrated by case studies and practical examples from their research experiences. The availability of the SIDPAC toolset and flight test data is crucial to the text because, as stressed throughout the book, a complete understanding of system identification can only be achieved through practical experience. In comparison to the two other textbooks available on aircraft system identification (*Aircraft and Rotorcraft System Identification: Engineering Methods with Flight Test Examples* by Mark B. Tischler and Robert K. Remple, and *Flight Vehicle System Identification: A Time Domain Methodology* by Ravindra V. Jategaonkar) the mathematical derivations in this publication begin at the most fundamental level and it is also the only one of the three to cover parameter estimation in both the time and the frequency domain. For these reasons, this book is probably the most suitable for readers completely new to the subject. At the same time, there is much in this text that will interest practicing engineers already engaged in the field.

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Flight Performance of Fixed and Rotary Wing Aircraft

A. Filippone

Elsevier Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford OX2 8DP, UK. 2006. 565pp. £39.99. ISBN 0-7506-6817-2.

This is a big book, but worth its cost. Apparently, if size matters, it was decided that the inclusion of both fixed- and rotary-wing aircraft (along with V/STOL) in one book was worthwhile. Perhaps many readers will use their familiarity with one to augment an understanding of the other, not to suggest that the same performance criteria and standard relationships are used for both.

Readers will not be surprised that an academic author would treat this subject and produce text that has an analytical basis – but the text is nicely interspersed with historical and practical anecdotal remarks. For efficiency in the use of pages, lengthy derivations are left to other books, and occasionally the reader has to deduce the contents of gaps in developments, but explanations and definitions are generally very clear.

Those who are of a computational bent will be pleased with five appendices containing aircraft models, prior to nine simulation programmes (Fortran/MatLab), though these programmes require some personal coding for completion – and there are web-based supplements available, even for the staff who use the book. Whilst the book is analytical in its foundation, it is still quite numerical in many places, frequently resting on tabulated data and often quoting 'algorithms' in the form of a procedural list of operations. Whatever the reader's passion, the 500-odd References should assist any topic-pursuit that occurs, including many of the data-sources used.

The book would be a commendable purchase for students and industrial practitioners.

D.L. Birdsall, MRAeS

Computational Functional Analysis – Second edition

R.E. Moore and M.J. Cloud

Horwood Publishing, Coll House, Westergate, Chichester, West Sussex PO20 3QL, UK. 2007. 180pp. Illustrated. £27.50. ISBN 978-1-904275-24-4.

This book is unlike most texts on functional analysis, in the sense that it surveys the most important facts in this field from the perspective of numerical analysis. It is also unlike most texts on numerical analysis, in the sense that it reaches to deeper mathematical foundations of the numerical methods we are all using.

Functional analysis provides an abstract and concise framework in which quite different numerical techniques widely used today in science and engineering can be derived from a few very general principles such as orthogonal projections, fixed-point iterations, etc. *Computational Functional Analysis* does a good job reviewing the fundamental facts of functional analysis and then showing how they come into play in the design and analysis of modern numerical methods. The authors start by surveying different types of spaces, different notions of convergence and various types of operators encountered in applications. One topic usually appearing in introductory texts on functional analysis, but absent from the present book, is measure and integration theory. On the other hand, the authors offer a fairly thorough treatment of interval analysis, a topic rarely addressed in introductory textbooks on functional analysis.

The review of the basic concepts is followed by a discussion of topics more directly related to numerical analysis, namely eigenfunction expansions, Galerkin's, fixed-point and Newton's methods, etc. Another interesting, and nontraditional, topic discussed in the book is the continuation and homotopy methods. The text ends with a chapter illustrating how the different techniques introduced earlier can be blended together in order to solve a challenging problem involving a partial differential equation with a free boundary.

The book is written in a fairly readable style with all important developments accompanied by numerous exercises that the reader will find useful for solidifying his/her understanding of the material. My overall positive impression is not offset by the fact that I found the title a bit misleading: with the adjective "computational" in it, I expected a somewhat larger number of computational examples illustrating the different ideas in the book.

This text should be a valuable reference for post-graduate students with an interest in the foundations of computational mathematics. While it treats the subject with a degree of mathematical sophistication, it should also be accessible to engineering students with a good command of mathematics and keen on exploring abstract mathematical ideas behind applicable numerical methods.

Dr Bartosz Protas

Undergraduate research projects

A research project is often an important part of many university undergraduate courses. The Royal Aeronautical Society is occasionally approached regarding publication of papers from such projects in *The Aeronautical Journal*.

Our policy is that we welcome papers from any and every source, including papers resulting from undergraduate projects. In this case we would normally expect the papers to be submitted jointly with the supervisor and they would be exposed to exactly the same refereeing process as all the other papers received.