Book Reviews

Damage Growth in Aerospace Composites

Edited by A. Riccio

This book records the activity of a GARTEUR Action Group (AG-32) whose objective is to develop integrated numerical and experimental methodologies to assess the growth of damage in composite structures. Part 1 is focussed on the development and validation of detailed methods while Part 2 investigates the use of fast numerical tools. Finally, in Part 3, the main results of experimental test campaigns are presented.

There is a need for improved understanding of the influence of damage on residual strength of composite structures and for predictive methods that can be used to (a) reduce test requirements and (b) improve damage tolerant design. This collection of contributions presents the status of some methods that can be used for (a).

The majority of numerical methods presented use standard cohesive zones to simulate the process of delamination growth. These methods require the user to define an array of parameters, relating to the strength, toughness and stiffness of the material. They also require some user-defined features, such as mode-mixity functions and unloading characteristics, which are not assessed in terms of their influence on results.

Unfortunately, the book does not provide clear comparison of numerical and experimental data for the more challenging problems, relating to the influence of damage at the structural (semi-monocoque) level, nor are all the problems described with sufficient clarity and detail to allow the reader to reproduce results. However, some interesting observations of intra-laminar damage are presented, along with methodologies for capturing the influence such damage. The simplified methods look interesting but the methods are not assessed in terms of comparison with actual experimental data.

Aerospace engineers need to understand the influence of damage on semi-monocoque structures, in order to reduce testing, eliminate conservatism and improve design. This book describes some numerical methods that might be of benefit, along with some evidence that these methods might reduce empiricism.

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Unsteady Computational Fluid Dynamics in Aeronautics

P. G. Tucker

The book is part of the ‘Fluid Mechanics and its Applications’ series, edited by Andre Thess, and is very timely, covering an area ‘under rapid development’. It is beautifully written and presented, comprising over 400 pages, split into eight chapters each of which, excepting the final chapter which is a future outlook text, is presented as a self-contained review paper. Each has an introduction and background section, main technical sections and a concluding remarks section, plus extremely thorough citation lists. This makes the book easy and enjoyable to read and this is further aided by the excellent choice of results and illustrations used to complement the text.

The median level of the series is stated as first year graduate student and this book is at
least at that level, but is so comprehensive it is
doubtful there is an upper level of experience,
either academic or practitioner, where this book
wouldn’t present something of interest and this
is quite an achievement by the author.

The introductory chapter is primarily focused
on engine and airframe integration and each area/concept is introduced with sufficient information
to understand the implications. This reads as a
history of the evolution of high-fidelity CFD,
covering unsteady flow sources, typical flow
features and frequencies and limitations of RANS
modelling, making the requirement for LES clear.

Chapter 2 covers fundamental aspects of
numerical methods, including pressure-based
and density-based schemes, spatial and temporal
derivatives and low- and high-order approaches,
preconditioning, aliasing and smoothing control,
mesh-related issues and boundary conditions.
Again detailed background is provided.

Chapter 3 introduces turbulence and its
modelling, covering URANS, DES and LES
models, mesh requirements, zonal and hybrid
methods and various grid-based filters. This is
complemented with some nice discussions of
relevant flow physics and flow field inputs for
typical propulsive system simulations.

Unsteady modelling methods are considered
in Chapter 4, primarily for turbomachinery
cases. A hierarchy of methods are presented
and discussed, from linear harmonic up to DNS,
related to different physics, for example stall
and inflow distortion, eddy distortion and shock
buffet and discussing more specific methods such
as deterministic stress modelling.

Chapter 5 is more applied, focusing on the
application of various model formulations to numerous
test cases, from two-dimensional aerofoils, to
turbomachinery and complete aircraft. The results
here are particularly enlightening and the accom-
panying text (both here and in later chapters) is
essential reading for any early stage researcher
in the applied CFD field. Excellent histories and
summaries of relevant work are provided in terms
of authors, citations, methods, Reynolds numbers,
mesh size and validation level for both various
engine zone cases and various external flow cases.
There are further summaries provided, again for
engine and external cases, in terms of data, source,
comments and validation level.

Computational aeroacoustics is considered
in Chapter 6, which begins with a hierarchy
of noise source, modelling methods, and wave
propagation methods. This is followed by a
thorough review of various modelling equations
detailed validation results. Again historical
summaries are provided for eddy-resolving
methods in aeroacoustics, and validation data
sources.

The final technical chapter covers coupled
computational aerodynamics methods, including
mesh movement schemes for unsteady flows,
coupled CFD-CSD approaches for aeroelasticity,
conjugate modelling, and coupling of different
models for different zones of a turbomachinery
problem. A further historical summary table is
provided here. The book is completed with a
future outlook, including a discussion of indus-
trial simulation and design requirements.

In summary, this book is an excellent read; it
is probably the most technically detailed book
I have read in computational aerodynamics
(in terms of higher-level concepts, rather than
fundamentals) and also the most interesting
and enjoyable to read. This an extremely
hard balance to achieve. The book would make
essential reading as a thorough historical review
of and introduction to high-fidelity CFD for
graduate students, and an enjoyable and inter-
esting read for experienced academics and
practitioners in state-of-the-art computational
aerodynamics. The author should be congratu-
lated on his efforts.

Professor C. B. Allen, MRAeS
Progress in Aeronautics and Astronautics Vol 245

R. V. Jategaonkar

Since its use in the analysis of flight test data began in the 1960s, many institutes have been actively involved in researching the science of aircraft system identification. In recent decades, however, few organisations have been as prominent in the field as the Institute of Flight Sciences at DLR in Germany and few individuals have been as prolific in the field as the author of this book, DLR’s Ravindra Jategaonkar.

This Second edition of Dr Jategaonkar’s text, which was originally published in 2006, continues to focus, as the title suggests, on system identification methods formulated in the time domain. The aim is to provide as much mathematical detail of the methods as is necessary while also offering guidance on practical aspects of the subject based on the author’s considerable experience.

As with the First edition, the book is accompanied by an array of MATLAB software tools, along with real flight test data, to illustrate the methods and provide the reader a practical understanding of the subject. No new chapters have appeared in the Second edition and the layout of the text remains the same. However, the author has updated the software provided (particularly for the Output Error method described in Chapter 4) and additional examples and real life case studies have been included.

The book begins by outlining the principles of system identification for dynamic systems in general before discussing the reasons why mathematical models of aircraft dynamics are required in aircraft development. After a brief historical review of the subject, the author then introduces the systematic approach to aircraft system identification routinely used today.

The majority of Chapter 2 is concerned with the selection of appropriate flight test manoeuvres. An overview of flight testing concepts and common manoeuvres, such as wind up turns and steady heading sideslips, is given before approaches for designing manoeuvres specific to aircraft system identification are described. The flight test instrumentation and measurements typically needed for system identification applications are also introduced. Chapter 3 then outlines the mathematical models used in the remainder of the book to describe the aircraft dynamics, describing how some of the practical difficulties associated with real life flight test data are dealt with, such as measurement noise, measurement errors and time delays.

Chapters 4 to 6 focus on three of the most widely-used time domain methods for parameter estimation, namely the Output Error, Filter Error and Equation Error methods. For each method, a thorough mathematical description of the technique is provided before the MATLAB software for the method is outlined. There then follows some practical examples, typically using flight test data from DLR’s VFW 614 ATTAS, where the relative
pros and cons of the particular method are highlighted.

The following three chapters then touch on some advanced topics. Firstly, in Chapter 7, recursive parameter estimation is discussed, the practical application of this approach being the ability to perform parameter estimation in real time, rather than offline post-flight (which the methods of Chapters 4 to 6 are geared towards). An interesting overview of Artificial Neural Networks is then given in Chapter 8. Their capability of estimating stability and control derivatives from flight test data is illustrated, although it is noted that the use of Artificial Neural Networks for estimating aircraft aerodynamic or stability and control parameters have not yet become widespread. System identification of aerodynamically unstable aircraft is the subject of Chapter 9, which describes some of the practical challenges of estimating open loop stability and control parameters from aircraft, such as highly manoeuvrable fighters, that can only be flown with closed-loop stability augmentation. The challenges are illustrated with data from the X-31A aircraft.

In Chapter 10, the important process of data compatibility is outlined. This step in the process ensures that the measured data feeding into the parameter estimation algorithms, described in Chapters 4 to 9, are kinematically consistent and free of systematic errors that could bias the resulting parameter estimates. The chapter touches on mathematical models for sensor errors and outlines how these errors can be estimated. Chapter 10 concludes with some interesting descriptions of common aircraft data system flight test calibration methods, such as static pressure port calibration and tower fly-by measurements. Model Validation is the subject of Chapter 11, providing an overview of methods for assessing the reliability of the parameter estimates obtained and the capability of the identified mathematical model to accurately predict the aircraft behaviour for other manoeuvre sets.

The final chapter of the text is a collection of advanced examples, where system identification has been used by DLR researchers. This includes the effects of control surface malfunctions on the Dornier 328, the modeling of speed brake effect on the Transall C-160 and modelling of aerodynamic time lag effects. For the Second edition of the text, a case study on flexible aircraft modeling has been added, which utilises flight test data from the SB 10 glider. There have also been updates to the case studies on quasi-steady stall modelling and wake vortex modelling provided in the First edition.

As with the First edition, this text provides a well-ordered balance between the theoretical and the practical aspects of the subject. It will appeal to those new to the subject looking for detailed mathematical descriptions behind each of the methods, while access to the accompanying MATLAB software will provide valuable insight into how the methods are implemented in practice. Experienced practitioners working in the field will also find the book an indispensable reference. The text complements the two other excellent texts on the subject – Aircraft System Identification: Theory and Practice by Vladislav Klein and Eugene A. Morelli (AIAA. 2006) and Aircraft and Rotorcraft System Identification: Engineering Methods with Flight Test Examples by Mark B. Tischler and Robert K. Remple (AIAA. 2012 – Second edition) – and continues to be a must-have resource for anyone with an interest in aircraft system identification.

Dr Stephen Carnduff, AMRAeS
Fundamentals of Aerospace Navigation and Guidance

P. T. Kabamba and A. R. Girard


This book sets out to provide a description of the navigation and guidance of modern aerospace vehicles, in both atmospheric and space flight. It has a structure that progresses logically from a very readable introduction, through deterministic and stochastic systems theory to the main topics of navigation and guidance. However, the balance of the book is skewed toward guidance which accounts for almost two thirds of the book whilst systems theory and navigation take a back seat.

The book explains that it has several intended audiences – undergraduates, those embarked on self-study, practicing engineers and researchers. With proofs that are left to the reader (albeit with some hints), some good illustrations and interesting problems set for the reader, this could well be used as an undergraduate or self-study text. Commenting on the value of this book as a reference text for engineers and researchers is more difficult. I believe that it would not be of significant value as a reference text to engineers working in systems theory and navigation because of the necessary omissions from a work of this length. The areas that are not adequately addressed include: frames of reference; geodesy; sensors and their characteristics; Kalman Filter mechanisation, implementation, stability and pitfalls; satellite navigation systems; inertial navigation error mechanisms and their effects; and calibration. The coverage of guidance however is much more satisfying and for that it is valuable as a reference text.

To summarise, navigation and guidance are two very large and complex topics and this book tries to cover this ambitious range. Unfortunately the result is unsatisfying in some areas. However, if you view the book as an advanced discussion of guidance with some scene setting, it makes more sense. As this book is not comprehensive – and the reader will need access to more comprehensive texts – the price tag of £75 may be prohibitive for individuals but the book would be useful in a library or small collection where its discussion of guidance can give a useful perspective on the subject.

Geoff T. Henderson, BSc, MEng, PhD, CEng, MIEE

Damage and Failure of Composite Materials

R. Talreja and C. Veer Singh


The book is a welcome addition to the literature. Numerous books treat separately the mechanics of composites and failure of materials: very few combine them together and in such a coherent and comprehensive manner. One of the two authors, Prof Ramesh Talreja, is a renowned researcher in the field of composites. Currently, he is Tenneco Endowed Professor in the Department of Aerospace Engineering at Texas A&M University. He served as Associate Editor of Mechanics of Materials and was an Editor in-Chief of the International Journal of Aerospace Engineering. The second author is Professor Chandra Veer Singh, an Assistant
Professor of Materials Science and Engineering at the University of Toronto.

The book is light on mathematics, which makes it accessible even to undergraduate Engineering students in their last year of studies. It would make a valuable course textbook for advanced and specialist courses at a graduate level, either Masters or PhD. It may also serve as a basis for short professional development courses for engineers working in the aerospace and automotive industry. Of course, a background in mechanics is recommended, but not entirely necessary. In fact, Chapter 2 gives an ‘as-brief-as-possible’ revision of the needed concepts of mechanics of materials underlying the development of the book. It is commendable that the authors managed to summarise concisely and effectively these concepts in only one chapter. They are able to blend the classical laminates theory with the fundamental ideas of linear elastic fracture mechanics.

Chapter 3 defines (from the authors’ perspectives) the subtle differences between fracture, damage, failure, structural integrity and durability. It then proceeds in describing the leading ‘damage’ mechanisms occurring in composite laminates. The authors seem indeed to prefer the term ‘damage’ to ‘fracture’, as the following Chapters 4 and 5 illustrate the two categories of damage theories in composites, the MIcro-Damage Mechanics (MIDM) and MAcro-Damage Mechanics (MADM). MIDM (which is now known more generally as Micromechanics) studies damage at the micro-scale level. For example, it includes the theories of mechanics of dissimilar interfaces, micro-cracks formation and fibre-matrix debonding, like the ACK theory (for single and multiple fractures), the Shear-Lag Theory and its recent extensions and various variational methods.

The fourth chapter ends with a summary of computational methods, which, unfortunately, lacks the latest developments of numerical techniques for fracture, such as Extended Finite Element Methods, Meshfree Methods and the Peridynamics Theory. MADM instead (Chapter 5) introduces the concept of Continuum Damage Mechanics (CDM), where failure is seen principally as a degradation of the stiffness properties of the composite, albeit in a rigorous and thermodynamically consistent manner (following the footsteps of the pioneering works of Kachanov).

Chapter 6 describes the progression of damage of ply-cracks, both from experimental and modeling points of view. This chapter is less theoretical than the previous ones, yet a helpful reference to the practical aspects of fracture testing. Chapter 7 is instead reserved to fatigue problems, one of the Prof Talreja’s fortes, having authored a book on Fatigue of Composites (Technomic Pub. Co. 1987).

Finally, the eighth and conclusive chapter, illustrates the future directions of composites, or at least in the opinion of the authors. The emphasis is posed, rightfully, on the needs of improving the community’s understanding according to a multiscale framework. The concept of ‘Synergistic Damage Mechanics’ (SDM) (introduced by Talreja) is central to this chapter, which opposes to the more traditional ‘hierarchical’ approach.

The book is very well written, and provides a wealth of relevant descriptions and examples of typical failure mechanisms encountered in fibre-reinforced composites. However, in some passages it does reflect (inevitably) the personal preferences (and history) of the authors towards Continuum Damage Mechanics (CDM). In CDM fracture is still seen as a continuum, but with degraded mechanical properties. This aspect might disappoint the readers with a formation in fracture mechanics, where
a fracture is seen as a discontinuity in the displacement fields. As a consequence, the book neglects the recent developments in advanced numerical methods for fracture.

From a didactic point of view, it does provide the minimal knowledge that everyone in the field should possess, and for this reason, it is a recommendable read.

Dr Ettore Barbiei


J. Gundlach


The First edition of this book, published in 2012 (and reviewed in The Aeronautical Journal September 2012), was praised for its truly comprehensive nature. This Second edition retains all of the original chapter content covering areas from traditional aircraft design such as aerodynamics, structures, propulsion and avionics each tailored for the specifics of each class of Unmanned Air System (UAS). This edition now adds a new dedicated and quite timely chapter for conventional rotorcraft, ducted fans, multicopters and airships.

The second section of the book covers topics specifically relating to UAS such as launch and recovery, command and control, communications systems and the physics of remote sensing. This also includes a pivotal chapter on Mission Systems Integration, which states ‘The UAS only has value with proper payload integration’. The book is completed with chapters on reliability and maintenance, multidisciplinary design and cost analysis. This Second edition adds a final chapter noting the challenges associated with export control, airspace integration and societal attitudes towards ‘robot ethics’ and privacy.

In writing the book the author has leveraged his significant experience in the UAS field working at Aurora Flight Sciences, Insitu Inc. and the Naval Research Laboratory. Many of the examples used within the book are from his own work, although there are many more and varied designs besides. It would be unreasonable to expect any significant additional content in this second edition published a mere two years after the original. The author does note, however, that ‘perhaps the future will be brightest for civil and scientific applications of unmanned systems’. With this in mind I would suspect that these new applications will feature strongly in future editions.

Aimed at academic study and conceptual design, this breadth will no doubt prove useful for single discipline design engineers, experts in their own field, requiring knowledge of other design areas and their associated interdependencies. The analysis methods presented will also prove useful for future procurement studies and the technical narrative will certainly provide a handy single volume reference for acquisition specialists. Indeed such an all-inclusive book would make a very worthy addition to the bookshelf of anybody whose technical profession even touches upon the UAS domain.

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