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# Book Review

*Publishers are invited to send two copies of new books for review to Dr. I. Michael Ross, Code: AA/Ro, Department of Aeronautics and Astronautics, U.S. Naval Postgraduate School, 699 Dyer Road, Monterey, CA 93943.*

## *Helicopter Flight Dynamics: The Theory and Application of Flying Qualities and Simulation Modeling*

Gareth D. Padfield, AIAA, Reston, VA, 1996, 514 pp., $99.95, ISBN 1-56347-205-8

I have been interested in taking an in-depth look at this book by Gareth Padfield for some time, and for a specific reason. The title of the book mentions a very special topic—flying qualities—that, although critical in today's manned vehicles design, seldom finds adequate space in textbooks.

My curiosity was indeed satisfied because the topic of flying qualities sets the stage in the early chapters and is then discussed in depth in the latter part of the book itself. For this very reason, although aimed at a rotorcraft audience, the work by Padfield is unique. Strangely enough, it does not have a counterpart in the fixed-wing community, perhaps paving the way for a similar text by researchers in this field.

In reading the book, I found two other contributions that I consider worth mentioning that reflect particular care and expertise matured by Padfield over his years of work in rotorcraft research and simulation. The first aspect is the opening to the reader of the research contributions made to the community by many years of cooperation within AGARD. This now formally defunct aerospace research and development arm of NATO has brought together and inspired many activities of researchers across the Atlantic for more than 40 years, and Padfield does a good job in using this knowledge and database for many of the examples in the book. He guides the reader to the specific individuals and organizations that most contributed to helicopter flight dynamics and simulation-applied research in the second half of this century.

The second aspect is the underlining of the importance of basic research and new methodologies throughout the book, together with the obvious need (it is, after all, a book on simulation) for accurate and validated experimental data. This aspect is usually neglected by authors, who tend to keep "academic" and "real world" issues separate. It is important to indicate, especially to the young reader, that theory and practice go together to improve an engineering product, particularly in technology-rich systems, such as aerospace vehicles. There are, of course, always suggestions to be made when reviewing a book, and in this respect I would have welcomed the presence of some sort of software companion with a simulation code (in some ways similar to the book by Stevens and Lewis[1]) to be used in the analysis of flying qualities and in the validation of the important tradeoff between simulation fidelity/accuracy and simulation purpose (see Chapter 3). A second suggestion would be the inclusion of a section devoted to active control technology. Padfield mentions it, making the reader aware of its relevance in future design, but some more detail on levels of automation and implementation of mission-task-elements (MTEs) probably would have brought the reader closer to the not-so-distant future in manned flight vehicles. Perhaps size limitation has played a role, although this (size) appears to be a constant in books on rotorcraft!

The book has seven chapters and a comprehensive list of references, which I found very accurate in referring the reader to the specialized literature in the field. The chapters can be divided roughly into three groups: 1) introductory aspects (Chapters 1–3), where the link between the traditional aspects of aeromechanics, simulation/modeling, and flying qualities is made; 2) flight dynamics (Chapters 4, 5), where static and dynamic stability are described in a traditional sequence but with particular attention to physical implications similar to Ref. 2 and supported by the description of physical characteristics of specific vehicles; and 3) flying qualities (Chapters 6, 7), where specifications criteria and pilot assessment in lieu of new piloting cues are described as seldom found in textbooks.

As I mentioned at the beginning of the review, the style of the book reflects the author's careful attitude (as I remember it) toward precision, and it contains references to people and research experiences, which in an informal tone greatly improve the pleasure of reading, associating the results with the people who obtained them. The technical writing is also clear and well presented. Figures, illustrations, and diagrams are well placed within the text and equations. The necessary formalism in describing helicopter dynamics does not take over, nor is it imposing to the reader. Some of the needed mathematical background is concentrated at the end of the appropriate chapters.

Examining the content in more detail, Chapter 1 serves as a guideline to the book. Chapter 2 presents a general overview of the flight dynamics and flying qualities of the helicopter. The author stresses the interconnection between the two aspects and introduces concepts such as mission task elements, piloting cues, and interfaces, which are essential to the understanding of MIL ADS-33 in the design and compliance phases. Chapter 3 deals with modeling and simulation. Padfield makes a distinction between simulation "levels," although he concentrates on the low-frequency aspects of the vehicle's representation (e.g., main and tail rotors, fuselage, aero surfaces, and flight control system), which are more relevant to the flying qualities engineer and to the low-level flight control system designer. Chapter 4 contains topics relative to static stability and trim. Trim equations and natural modes are presented, and a description of the physical meaning of the major stability derivatives is included. This chapter also contains some numerical data that could be used by a (rather hardworking) student for setting up a computer simulator program. Chapter 5 treats dynamic stability and response to controls and disturbances. Chapter 6 is devoted to a rather detailed description of the rationale behind current military specifications, how they came about, and how they should be interpreted in the overall performance analysis of the vehicle. The information contained in this chapter is not available in any other book, and better information can only be found by reading and applying the ADS-33 itself. Chapter 7 is a companion chapter and describes topics relative to flying qualities assessment (including pilot ratings strategies), design of MTEs, flight test setups for flying qualities, influence of visual cues and inceptors, and relationships between flying qualities variation and cues degradation, a very critical issue for performance and safety at the extremes of the operational flight envelope.

In summary, I found Padfield's book unique in many respects, pleasant to read, accurate, and therefore a primary source of information for those interested in the integration between classical flight dynamical properties and flying qualities of rotorcraft. In my opinion, the reader must have a basic background in dynamics and control and in the way a helicopter operates and flies. I would therefore suggest it as a reference/text for a graduate course in the area, as well as a "must have" for practicing engineers.

**References**

[1]Stevens, B. L., and Lewis, F. L., *Aircraft Control and Simulation*, Wiley-Interscience, New York, 1992.

[2]McRuer, D. T., Ashkenas, G., and Graham, D., *Aircraft Dynamics and Automatic Control*, Princeton Univ. Press, Princeton, NJ, 1973.

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# Errata

## Strapdown Inertial Navigation Integration Algorithm Design Part 1: Attitude Algorithms

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**[J. Guidance 21 (1), pp. 19–28 (1998)]**

EQUATIONS (4) and (44) should be corrected as follows:

Equation (4) should read

$$C_{A_2}^{A_1} = I + \frac{\sin\phi}{\phi}(\phi\times) + \frac{(1-\cos\phi)}{\phi^2}(\phi\times)^2$$

Equation (44) should read

$$\frac{1}{2}\int_{t_{l-1}}^{t_l}\left(\Delta\alpha(t)\times\omega_{IB}^{B}\right)\mathrm{d}t = \frac{1}{12}(\Delta\alpha_{l-1}\times\Delta\alpha_l)$$