

Book Review

Publishers are invited to send books for review to Dr. I. Michael Ross, Code: AA/Ro, Department of Aeronautics and Astronautics, Naval Postgraduate School, Monterey, CA 93943.

Advances in Aircraft Flight Control

Edited by Mark B. Tischler, Taylor and Francis, Bristol, PA, 1996, 423 pp., \$79.95, ISBN 07484-0479-1

This book emerged as a follow-up to the publication of a collection of papers in a special issue of the *International Journal of Control*.¹ The intent of the book, as stated by the Editor, is "...to provide the flight control engineer with a single comprehensive resource that reviews many of the current aircraft flight control programs from the perspective and hindsight of experienced practitioners." The presentations are typically at the program level by authors primarily from the technical management of the organizations that either developed the control systems or are involved with development of specifications.

The volume is organized into four parts. Part One addresses flying-qualities specifications and validation, and Parts Two, Three, and Four include discussions of modern rotorcraft/vertical short takeoff and landing (VSTOL), transport, and high-performance aircraft flight control systems, respectively.

Part One contains two chapters. The first chapter is an overview of U.S. handling-quality specifications for fixed- and rotary-wing military aircraft. The second chapter explores the use of system identification techniques in the development of flight control systems.

Part Two reviews four advanced flight control programs for rotorcraft and VSTOL configurations, with one program discussed in each of four chapters. More specifically, Chapter 3 describes the development and flight research applications of a rotorcraft in-flight simulator, ATThES, based on a Bo-105 helicopter equipped with a fly-by-wire control system. Chapter 4 reviews the evolution of advanced flight control technology for rotorcraft at the Boeing Helicopter Company, from the TAGS (Tactical Aircraft Guidance System) experimental test bed to the RAH-66 Comanche. Chapter 5 describes a nonlinear inverse controller implementation for the QSRA (Quiet Short Haul Research Aircraft) powered-lift aircraft and an advanced conceptual short takeoff and vertical landing (STOVL) fighter aircraft. Chapter 6 presents the development and testing of the VAAC (Vectored Thrust Aircraft Advanced Flight Control) experimental aircraft, a Harrier I trainer equipped with an advanced fly-by-wire flight control system.

The three chapters in Part Three discuss advanced flight control technology for three different military or commercial transport aircraft. Chapter 7 presents design and flight-test results for the U.S. advanced tactical transport aircraft, the C-17, which features a full-authority,

digital flight control system. Chapter 8 presents an overview of the Airbus fly-by-wire control laws, systems, certification, and development methods. In Chapter 9, enhancements to the lateral autopilot for the Boeing 767 are discussed, including flight-test results.

Part Four includes six chapters that present flight control development methods and flight-test results for advanced, high-performance military aircraft. In Chapter 10, the control design, development, and flight testing of the Lavi aircraft are described. Chapter 11 discusses the development history of the AMX autopilot, along with the control law structure and design approach for the new Eurofighter 2000 aircraft. In Chapter 12, the control law design philosophy and flight-test results for British Aerospace's Experimental Aircraft Programme are presented. Chapter 13 presents the control law design and lessons learned in flight tests of the X-29 forward-swept wing technology demonstrator. Chapter 14 describes the system requirements and control law design methods for the F-15 short takeoff and landing (STOL) and Maneuver Technology Demonstrator. Finally, the control law design and implementation for the X-31A post-stall experimental aircraft are presented in Chapter 15.

Although a variety of control synthesis approaches are represented, the focus of the discussion is generally on the larger issues of meeting design specifications, system architecture, hardware implementation, and system validation. The control laws themselves are typically presented with the use of high-level block diagrams. Synthesis methods cited include nonlinear inversion (Chapter 5), a couple of flavors of linear quadratic regulators (Chapters 9, 14, and 15), and, of course, conventional methods. The techniques have virtually always been used in combination. But again and again we are reminded that the development of such real systems involves much more than exercising control-law-synthesis techniques.

Another clear message from the authors is the critical importance of ground-based simulation and flight testing in the development of flight control systems. Also communicated effectively is the interdisciplinary nature of this engineering enterprise. It is repeatedly pointed out that successful development of these systems requires extensive collaboration among the flight dynamicists, control engineers, test pilots, and simulation experts. Multidisciplinary design challenges discussed include the delivery

of excellent handling characteristics over a wide range of flight conditions, aeroservoelastic interactions, limited control authority, and ever troublesome phenomena such as time delays and actuator saturation.

Because the work is a collection of multiauthored chapters and because of the case-study style, there are some significant differences in notation and terminology between the chapters. The block diagrams, for example, have different formats and are presented at differing levels of detail. Although none of this is surprising for this type of book, with its stated intent, it does make the book

inappropriate for an engineering textbook. However, the book can certainly serve as a valuable reference resource, for both the practicing engineer and the engineering professor.

Reference

¹*International Journal of Control, Special Issue: Aircraft Flight Control*, Vol. 59, No. 1, 1994.

David K. Schmidt
University of Maryland, College Park