Introduction to Aircraft Design

This book provides an accessible introduction to the fundamentals of civil and military aircraft design.

Giving a largely descriptive overview of all aspects of the design process, this well-illustrated account provides an insight into the requirements of each specialist in an aircraft design team. After discussing the need for new designs, the text assesses the merits of different aircraft shapes from micro-lights and helicopters to super-jumbos and V/STOL aircraft. Following chapters explore structures, airframe systems, avionics and weapons systems. Later chapters examine the costs involved in the acquisition and operation of new aircraft, aircraft reliability and maintainability, and a variety of past aircraft projects to see what conclusions can be drawn. Three appendices and a bibliography give a wealth of useful information, much not published elsewhere, including simple aerodynamic formulae, aircraft, engine and equipment data and a detailed description of a parametric study of a 500-seat transport aircraft.

Introduction to Aircraft Design is a useful text for undergraduate and graduate aeronautical engineering students and a valuable reference for professionals working in the aerospace industry. It should also be of interest to aviation enthusiasts.

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Whilst his personal research, teaching, and consultancies are in the areas of aircraft design, reliability and maintainability, he is the College of Aeronautics' Business Manager for Continuing Professional Development. A well-known lecturer in aircraft design, Professor Fielding has given lecture courses in the Netherlands, the People's Republic of China, Indonesia, Belgium, South Africa, Poland and the USA and has published more than 60 technical papers.

Since 1991, Professor Fielding has been visiting Lecturer at the University of Texas, and is external examiner at City and Limerick Universities in the UK. He is on the editorial board of two Aeronautical Journals, and is a member of the technical committee of the American Institute of Aeronautics and Astronautics.

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Dedication

This book is dedicated to the late Prof. David Keith-Lucas, C.B.E, and Prof. Denis Howe, both of whom were the author's immediate predecessors as Professor of Aircraft Design at the College of Aeronautics, Cranfield University, The author gained much of his knowledge of aircraft design, much encouragement and good role-models from these elder-statesman of aircraft design education.

Contents

Preface

This book acts as an introduction to the full breadth of both civil and military aircraft design. It is designed for use by senior undergraduate and post-graduate aeronautical students, aerospace professionals and technically-inclined aviation enthusiasts.

The book poses and answers pertinent questions about aircraft design, and in doing so gives information and advice about the whole aircraft design environment. It asks why we should design a new aircraft and gives examples of market surveys and aircraft specifications. It then answers the question 'why is it that shape' and gives the rationale behind the configurations of a wide range of aircraft from micro-lights and helicopters to super-jumbos and V/STOL aircraft, with many others in-between. Having examined the shape, the book then examines and describes what is under the skin in terms of structure, propulsion, systems and weapons. Later chapters answer questions about aircraft costs and conceptual design and draw lessons from past projects and then look into the future. A major part of the book answers the question 'what help can I get?' It is a combination of bibliography, lists of data sheets, computer tools and 100 pages of appendices of design data vital to aircraft conceptual designers (most of it previously unpublished).

The book concentrates on fixed-wing civil and military aircraft, with some reference to light aircraft and rotorcraft, but does not address the design of sailplanes, airships, flying boats or spacecraft. While these are fascinating and important subjects it was decided that the current scope of the book is sufficiently wide and further extension would make it unwieldy, although information about references which address the design of aircraft in the excluded categories is provided.

Much of the material has been developed for use in Preliminary and Masters' courses in aircraft design at Cranfield University. Many of the examples and illustrations have been produced as part of Cranfield's unique Group Design Project programmes. With the Cranfield method, conceptual design is done by the staff, thus enabling the students to start much further down the design process. They thus have the opportunity to get to grips with preliminary and detail design problems and become much more employable in the process. This method also allows students to use modern design tools such as CAD, finite elements, laminate analysis and aerodynamic modelling. The group design project is undertaken by all the aerospace vehicle students and is a major feature of the M.Sc. course, accounting for almost half of the final assessment. Each year the students work in a team on the design of a project aircraft. A substantial part of the airframe, a system, an installation or some

performance aspect is allocated to each student at his or her own responsibility. The aircraft chosen as the subject for the work are representative of types of current interest to industry. They usually incorporate some feature which extends the bounds of existing practice, as an applied research activity. This excites the interest, enthusiasm and ingenuity of the students and forces the staff to keep up to date. Civil and military aircraft are investigated in alternate years, so that the whole of the industry is catered for. Recent examples of design projects included large and small business-jets, a number of medium-sized jet transports and a 500-seat short-haul airliner. The latter aircraft is described in Chapter 10 and Appendix B of this book. Military aircraft have also been designed, including basic and advanced trainers, close-air support aircraft, an advanced tactical fighter, V/STOL supersonic strike aircraft and military transports.

There are many textbooks available that cover the conceptual design phase and others that provide the more specific information appropriate to the detailed design phase. This book has been written to fill the gap between these two stages, utilizing the experience gained from all the projects carried out at Cranfield and from other industrial projects.

Acknowledgements

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The book contains some 200 illustrations and large amounts of data. Much of this has come from the author's and colleagues' work at Cranfield University, but many other organizations have helped. The following individuals, companies and organizations have provided data, drawings and photographs.

Airbus Industrie: Figs 3.4, 3.5, 3.10, 5.13, 6.12, 8.1, A9.2, A9.8, A9.11, A9.12, A9.13.
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Fairchild Aircraft Company: Figs 4.9, 6.11.
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