



Aircraft Display Systems



Malcolm Jukes

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Series Advisors' Foreword

The field of aerospace is wide ranging and covers a variety of disciplines and domains, not merely engineering but many related supporting activities, all combining to produce exciting and technologically challenging products.

The Aerospace Series is a practical and topical series of books aimed at engineering professionals, operators, and users in the aerospace industry. The range of topics is wide ranging, covering design and development, manufacture, operation and support of aircraft as well as topics such as infrastructure operations, and developments in research and technology. This series will provide a source of relevant information that will be of interest and benefit to all those people working in aerospace.

Aircraft Display Systems is written by a prominent practitioner in the field. Malcolm Jukes has spent most of his working life developing military and civil aircraft displays. The book addresses how the displays system performs a key part of the human-machine interface on modern aircraft and how technology has evolved to meet an increasingly demanding requirement. The topic is covered in a historical, contemporary, and forward-looking treatise that is both easy to read and very informative.

Ian Moir
and
Allan Seabridge

Author's Preface

Aircraft Display Systems is part of a series of books that together are intended to describe the complete set of systems which form an essential part of modern civil and military aircraft.

Aircraft Display Systems is a broad subject, encompassing operational requirements (what the crew needs in order to safely prosecute their task), sensors and data sources (such as flight, navigation, and targeting), and finally the display medium itself.

Aircraft Display Systems provides an overview of the historical development of the civil flight deck and the military cockpit (or crewstation) from the beginnings of manned flight to modern aircraft, highlighting – by specific aircraft case studies – the significant steps in the transitions from mechanical to electromechanical instruments to modern electro-optical displays. In these transitions the interplay between operational need, sensor developments, and display technologies interact. New sensors often drive new displays as much as new display technologies drive new displays, both to satisfy a new operational requirement. Now in the information age, future operational catalysts for change to crewstation displays include the Future Air Navigation Systems in the civil transport arena and Digital Battlespace in the military arena.

Aircraft Display Systems provides an in-depth explanation of current display technologies applied to Head-Down, Head-Up, and Helmet-Mounted Displays and emerging display technologies candidate for use in next generation aircraft crewstations.

Becoming ever more complex and providing as they do the interface between the human and the machine, it is imperative that display systems be developed against the backdrop of proven approaches and techniques that assure safety and integrity. *Aircraft Display Systems* provides an insight into human vision and the perception of display information in the severe airborne lighting environment together with an overview of good design practice and the regulatory requirements.

Aircraft Display Systems is aimed at practitioners in the aerospace environment – researchers, engineers, designers and operators, and crew. It is aimed at a wider audience than engineers and will be of interest to people working in marketing, procurement, manufacturing, commercial, and legal departments. Furthermore, it is intended to complement undergraduate and postgraduate courses in aerospace systems to provide a path to an exciting career in aerospace.

The book will operate at a number of levels:

- provide a top-level overview of aircraft display systems with some historical background;
- provide more in-depth description of specific technologies;
- provide references and suggestions for further reading for those who wish to develop their knowledge further.

I have tried to deal with this complex subject in a straightforward and descriptive manner, setting the context for new technologies into the background of historical display evolution. Though focussed on current display systems, technologies, and design practices I have included a comprehensive overview of potential new technologies and systems appropriate to next-generation aircraft display systems. To meet the challenge of next-generation aircraft display systems designers will require a thorough understanding of the operational needs and the capabilities and limitations of the display technologies available. My hope is that this book makes a contribution to that understanding.

Malcolm Jukes

Acknowledgements

Though I have spent most of my career working in the field of Systems, the more knowledge and experience I have gained, the more I have realized there is to gain. I have been privileged through my employment at Smiths Aerospace, and through the contacts I have made with those in a similar fields in other companies and organizations worldwide, to experience first hand many of the advances made in the transition from electromechanical instruments to the modern 'glass' flight

the entire subject of matching technical implementation to operational need totally absorbing. However, the writing of this book would not have been possible without the encouragement, guidance, and generous support of many colleagues and specialists in those companies.

Particularly I should like to thank Ian Moir, a former colleague at Smiths Aerospace, Professor John Roulston, Technical Director of BAE SYSTEMS Avionics Group, and Robb Brockie, Leon Skorczewski, and my other friends and colleagues of the UK Industrial Avionics Working Group (the IAWG) without whose encouragement I would not have begun to write the book.

My thanks and appreciation also go especially to Christopher Bartlett, BAE SYSTEMS Rochester who, with David Craig and others, provided much of the material concerning BAE SYSTEMS display products and concepts.

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DASA	Texas Instruments
Duxford Imperial War Museum	Thales
eMagin	The Boeing Company

Aircraft controls and display technology have developed apace. The advent of compact, high-power, rugged digital devices has allowed a major shift from dedicated instruments to multi-function displays. *Aircraft Display Systems* covers all aspects of this vital field of avionics. All elements from simple fuel monitoring, through to the displays associated with complex fly-by-wire and navigational systems, are explored. Covering civil and military aircraft, large and small, essential information is provided for those who need to have a clear understanding of aircraft display systems.

- Written by an internationally recognized authority
- Lavishly illustrated with photographs – some in full colour
- Detailed, comprehensive coverage
- Easily accessible style
- Excellent source of valuable information
- Everyday professional reference and study text

Display systems are the vital indicators which monitor the various avionics, environmental, and electronic systems that keep aircraft in the air. *Aircraft Display Systems* introduces the reader to the means by which information is presented to the crew, enabling them to carry out their tasks safely and successfully. Topics covered include:

- Transport aircraft
- Military fast-jet and rotorcraft
- Electro-mechanical instruments
- Head-Down Displays
- Head-Up Displays
- Emerging display technologies
- Advanced display formats
- Display systems architectures
- Visual performance
- Helmet-Mounted Displays

Aircraft Display Systems provides an assessment of the current and potential future information needs in civil and military flight decks. It also offers the reader an appreciation of the technologies available to the display engineer in order to provide solutions that meet those needs. As such, this volume will be an invaluable source of information to all those involved in aircraft design, build, testing, and investigation.

About the Author

Malcolm Jukes BSc, FRAeS, FIEE has over 35 years' experience in the aerospace industry, mostly working for the Smiths Group at Cheltenham, UK. Among his many responsibilities as Chief Engineer for Defence Systems Cheltenham, Malcolm managed the design and experimental flight trials of the first UK Electronic Flight Instrument System (EFIS) and subsequently the development and application of shadow-mask CRT technology for multi-function Head-Down Displays on the F/A-18, AV8B, Eurofighter Typhoon, and EH101 aircraft. In this role, and subsequently as Technology Director, he was responsible for product technical strategy and the acquisition of new technology for Smiths UK aerospace products. One of his most significant activities was the application of AMLCD technology to civil and military aerospace applications. Malcolm was also a member of the UK Industrial Avionics Working Group (IAWG).

Malcolm is now an aerospace consultant operating in the areas of displays, display systems, and mission computing. He is the author of an important chapter in *Civil Avionics Systems* – a book by Ian Moir and Allan Seabridge, also published by Professional Engineering Publishing.

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