András Sóbester
Alexander I J Forrester

Aircraft Aerodynamic Design
Geometry and Optimization

Aerospace Series
Editors Peter Belobaba, Jonathan Cooper and Allan Seabridge

WILEY

Aerospace Series List

Aircraft Aerodynamic Design: Geometry and Optimization	Sóbester and Forrester	October 2014
Theoretical and Computational Aerodynamics	Sengupta	September 2014
Aerospace Propulsion	Lee	October 2013
Aircraft Flight Dynamics and Control	Durham	August 2013
Civil Avionics Systems, Second Edition	Moir, Seabridge and Jukes	August 2013
Modelling and Managing Airport Performance	Zografos, Andreatta and Odoni	July 2013
Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes	Torenbeek	June 2013
Design and Analysis of Composite Structures: With Applications to Aerospace Structures, Second Edition	Kassapoglou	April 2013
Aircraft Systems Integration of Air-Launched Weapons	Rigby	April 2013
Design and Development of Aircraft Systems, Second Edition	Moir and Seabridge	November 2012
Understanding Aerodynamics:	McLean	November

Arguing from the Real Physics		2012
Aircraft Design: A Systems Engineering Approach	Sadraey	October 2012
Introduction to UAV Systems, Fourth Edition	Fahlstrom and Gleason	August 2012
Theory of Lift: Introductory Computational Aerodynamics with MATLAB and Octave	McBain	August 2012
Sense and Avoid in UAS: Research and Applications	Angelov	April 2012
Morphing Aerospace Vehicles and Structures	Valasek	April 2012
Gas Turbine Propulsion Systems	MacIsaac and Langton	July 2011
Basic Helicopter Aerodynamics, Third Edition	Seddon and Newman	July 2011
Advanced Control of Aircraft, Spacecraft and Rockets	Tewari	July 2011
Cooperative Path Planning of Unmanned Aerial Vehicles	Tsourdos et al	November 2010
Principles of Flight for Pilots	Swatton	October 2010
Air Travel and Health: A Systems Perspective	Seabridge et al	September 2010
Design and Analysis of Composite Structures: With applications to aerospace Structures	Kassapoglou	September 2010
Unmanned Aircraft Systems: UAVS Design, Development and	Austin	April 2010

Deployment		
Introduction to Antenna Placement and Installations	Macnamara	April 2010
Principles of Flight Simulation	Allerton	October 2009
Aircraft Fuel Systems	Langton et al	May 2009
The Global Airline Industry	Belobaba	April 2009
Computational Modelling and Simulation of Aircraft and the Environment: Volume 1 – Platform Kinematics and Synthetic Environment	Diston	April 2009
Handbook of Space Technology	Ley, Wittmann and Hallmann	April 2009
Aircraft Performance Theory and Practice for Pilots	Swatton	August 2008
Aircraft Systems, Third Edition	Moir and Seabridge	March 2008
Introduction to Aircraft Aeroelasticity and Loads	Wright and Cooper	December 2007
Stability and Control of Aircraft Systems	Langton	September 2006
Military Avionics Systems	Moir and Seabridge	February 2006
Design and Development of Aircraft Systems	Moir and Seabridge	June 2004
Aircraft Loading and Structural Layout	Howe	May 2004

Aircraft Display Systems	Jukes	December 2003
Civil Avionics Systems	Moir and Seabridge	December 2002

AIRCRAFT AERODYNAMIC DESIGN

GEOMETRY AND OPTIMIZATION

András Sóbester and Alexander I J Forrester
Faculty of Engineering and the Environment, University of Southampton, UK

WILEY

This edition first published 2015

Registered office
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com.

Library of Congress Cataloging-in-Publication Data

Sóbester, András.
Aircraft aerodynamic design: geometry and optimization/András Sóbester, Alexander Forrester.
pages cm – (Aerospace series)
Includes bibliographical references and index.

ISBN 978-0-470-66257-1 (hardback)
1. Airframes. 2. Aerodynamics. I. Forrester, Alexander I J. II. Title.
TL671.6.S58 2014
629.134′1–dc23

2014026821

A catalogue record for this book is available from the British Library.

ISBN: 9780470662571

CONTENTS

List of Tables

List of Illustrations

Chapter 3

reached the end of the 1 km segment) of the disturbance created by the aircraft in that point. The aircraft has no effect on the free stream outside of the cone defined by the wavefronts.

Figure 8.10 Eurofigher Typhoon – the Mach 2 cone of the nose superimposed upon the planform of the aircraft $(\mu = \arcsin(1/2) = 30°)$.

Figure 8.11 The angle of attack envelope of the X-29 forward swept-wing research aircraft (angle of attack versus airspeed at a range of load factors) and the aircraft in high angle of attack flight (as shown by the smoke generated for visualization purposes) – both courtesy of NASA, plot from Bauer et al. (1995).

Figure 8.12 Panavia Tornado ADV (F3), a Mach 2.2 long-range variable-sweep interceptor with its wings at Λ = 67°, their highest sweep setting, the lowest being Λ = 25° (photograph by A. Sóbester).

Figure 8.13 NASA oblique wing aircraft: OWRA (Oblique Wing Research Aircraft) unmanned demonstrator (left) and the AD-1, a subsonic, manned research aircraft from 1979 (NASA images).

Figure 8.14 Swept-wing aircraft turning on a taxiway around its port main landing gear (MLG). The space required is greater than the span of the aircraft, by a margin known as *swept-wing 'growth'*.

Figure 8.15 Typical constraint diagram reflecting the initial climb requirement. The curve separating the feasible (white) and the infeasible (grey) region of the thrust-to-weight versus wing loading space is the nominal constraint boundary. The additional boundaries show the impact of changes to the nominal (target) values of some key parameters on the location of this boundary.