

The Grand Designers

The airplane has experienced phenomenal advancement in the twentieth century, changing at an exponential rate from the Wright brothers to the present day. In this ground-breaking work based on new research, Dr. John D. Anderson, Jr., a curator at the National Air and Space Museum, analyzes the historical development of the conceptual design process of the airplane. He aims to answer the question of whether airplane advancement has been driven by a parallel advancement in the intellectual methodology of conceptual airplane design. In doing so, Anderson identifies and examines six case histories of “grand designers” in this field, and challenges some of the preconceived notions of how the intellectual methodology of conceptual airplane design advanced. Filled with over one hundred illustrations which bring his words to life, Anderson unfolds the lives and thoughts of these grand designers.

DR. JOHN D. ANDERSON, JR. is currently Curator for Aerodynamics at the National Air and Space Museum, Smithsonian Institution, and Professor Emeritus at the University of Maryland. Dr. Anderson has published eleven books including *A History of Aerodynamics* (Cambridge University Press, 1999). He is a member of the National Academy of Engineering, an honorary fellow of the American Institute of Aeronautics and Astronautics, and a fellow of the Royal Aeronautical Society.

Cambridge Centennial of Flight

General Editors

John D. Anderson, Jr., *Curator of Aerodynamics, National Air and Space Museum, and Professor Emeritus, Aerospace Engineering, University of Maryland*
Von Hardesty, *Smithsonian Institution*

The series presents new titles dealing with the drama and historical impact of human flight. The Air Age began on December 17, 1903, with the epic powered and controlled flight by the Wright brothers at Kitty Hawk. The airplane rapidly developed into an efficient means of global travel and a lethal weapon of war. Modern rocketry has allowed heirs of the Wrights to orbit the Earth and to land on the Moon, inaugurating a new era of exploration of the solar system by humans and robotic machines. The Centennial of Flight series offers pioneering studies with fresh interpretive insights and broad appeal on key themes, events, and personalities that shaped the evolution of aerospace technology.

Also published in this series

Jeremy R. Kinney, *Reinventing the Propeller: Aeronautical Specialty and the Triumph of the Modern Airplane*
Von Hardesty, *Camera Aloft: Edward Steichen in the Great War*
Asif A. Siddiqi, *The Red Rockets' Glare: Spaceflight and the Russian Imagination, 1857–1957*
Michael B. Petersen, *Missiles for the Fatherland: Peenemünde, National Socialism, and the V-2 Missile*
Scott W. Palmer, *Dictatorship of the Air: Aviation Culture and the Fate of Modern Russia*

The Grand Designers

The Evolution of the Airplane in the 20th Century

JOHN D. ANDERSON, JR.

Smithsonian Institution

and

University of Maryland



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press & Assessment
 978-0-521-81787-5 — The Grand Designers
 John D. Anderson Jr
 Frontmatter
[More Information](#)



CAMBRIDGE
 UNIVERSITY PRESS

Shaftesbury Road, Cambridge CB2 8EA, United Kingdom
 One Liberty Plaza, 20th Floor, New York, NY 10006, USA
 477 Williamstown Road, Port Melbourne, VIC 3207, Australia
 314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
 103 Penang Road, #05-06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of Cambridge University Press & Assessment,
 a department of the University of Cambridge.

We share the University's mission to contribute to society through the pursuit of
 education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9780521817875

DOI: 10.1017/9780511977565

© John D. Anderson Jr. 2018

This publication is in copyright. Subject to statutory exception and to the provisions
 of relevant collective licensing agreements, no reproduction of any part may take
 place without the written permission of Cambridge University Press & Assessment.

First published 2018

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging-in-Publication data

NAMES: Anderson, John D., Jr. (John David), author.

TITLE: The grand designers : the evolution of the airplane in the 20th century /
 John D. Anderson, Jr., Smithsonian Institution and University of Maryland.

DESCRIPTION: New York : Cambridge University Press, 2018. |

Series: Cambridge centennial of flight | Includes bibliographical references.

IDENTIFIERS: LCCN 2017039156 | ISBN 9780521817875 (hardback)

SUBJECTS: LCSH: Airplanes—Design and construction—History—20th century.

CLASSIFICATION: LCC TL671.2 .A58 2018 | DDC 629.134/10922—dc23

LC record available at <https://lccn.loc.gov/2017039156>

ISBN 978-0-521-81787-5 Hardback

Cambridge University Press & Assessment has no responsibility for the persistence
 or accuracy of URLs for external or third-party internet websites referred to in this
 publication and does not guarantee that any content on such websites is, or will
 remain, accurate or appropriate.

Contents

<i>Preface</i>	<i>page ix</i>
1 Introduction: Before the Beginning	1
2 The Beginning: The Wright Brothers and Their Design Process	10
3 Setting the Gold Standard: The Design Methodology of Frank Barnwell	44
4 Products of the First Design Revolution: Arthur Raymond and the DC-3	68
5 Design for Speed: R. J. Mitchell and the Spitfire	116
6 Design Perfection: Edgar Schmued and the P-51 Mustang	156
7 Defying the Limits: The Jet Airplane, the Second Design Revolution, and Kelly Johnson	187
8 Airplane Design and the Grand Designers: The End Game	282
<i>Appendix A: Calculation of Change in Maximum Velocity of the Spitfire: Elliptic Wing versus a Straight Tapered Wing</i>	289
<i>Appendix B: Thrust Available: Comparison of a Piston Engine/Propeller Combination with a Jet Engine</i>	293
<i>Index</i>	297

Preface

The evolution of the airplane is one of the most important technical developments of the twentieth century, and the evolution of the intellectual methodology for airplane design is part of this development. This book is focused on that intellectual methodology, how it came about, and some of the key people who advanced the methodology. It is a story of rapidly advancing technology, used ingeniously by a few people, all of whom were different. They had various backgrounds and different personalities, but fashioned out of whole cloth some of the most spectacular airplanes in history. How did they do it? This book is aimed directly at readers, both nontechnical and technical, who want to know the answer. If you are simply interested in airplanes and have a nontechnical background, this book is for you. If you are an engineer or scientist, this book is also for you. This story is one of the most fascinating in the history of technology, and it is built around two basic thoughts, as follows.

Thought one: The design of a new airplane starts by someone or some group taking out pages of blank paper (or a blank computer screen), and beginning an intellectual process called *conceptual* airplane design. After a very short period of time (weeks, or at most months), a crude configuration layout emerges showing the overall shape and size of the new airplane. After this baby, so to speak, is born, it enters a much more sophisticated and complex phase called preliminary design, where only relatively minor changes are made to the configuration layout; a lot of attention is paid to structural and control system analysis. At the end of this preliminary design phase, a major decision is made whether or not to commit to the manufacture of the airplane. If the decision is “go,” the detail design phase starts – the “nuts and bolts” phase that readies the

airplane for fabrication. But it is the “baby stage,” the conceptual design phase on those first few pages, which dictates the very genes of the airplane.

Thought two: Anyone looking at the progress made in the advancement of the airplane sees an exponential change over the past 100 years. Just compare the image of the 1903 Wright Flyer, flying at 30 mph at about a 10-foot altitude, with the image of the spectacular Lockheed SR-71 Blackbird flying at Mach 3 plus, at 90,000 feet, or even the image of the Airbus 380 carrying over 600 passengers at near Mach One at 40,000 feet. Clearly, the airplane has experienced a phenomenal advancement in the twentieth century.

Question: Why? In particular, since the first step in the intellectual process in airplane design is conceptual design, has this exponential advancement in the airplane been due to an exponential improvement in the intellectual methodology of conceptual airplane design? This book is devoted completely to an investigation of the answer to that question. It looks at the historical development of the design process and uses six case histories of specific airplane designers, starting with the Wright brothers. I have identified these six designers as “grand designers” because they were all exceptional and different, and they make this history come alive. They are not by any means the only grand designers, but they suffice to help answer the question.

The answer itself turns out to be quite surprising, at least to me. As I progressed through the case histories, my preconceived perception of how conceptual design advanced was totally turned on end. Continue to read on; the lives and design thinking of these grand designers will unfold for you.

I wish to give credit to my colleagues at the National Air and Space Museum for many stimulating conversations on the subject of the history of aeronautical engineering, and to my wife Sarah-Allen Anderson for living with my research and thoughts on this book. Credit also goes to Dr. Von Hardesty, Senior Curator and Chair of the Aeronautics Department at the National Air and Space Museum (now retired) for suggesting the general idea of this study. Also, thanks go to Brian Riddle, Chief Librarian of the Royal Aeronautical Society in London. I spent many weeks in this library researching the topics in this book, and Brian was indispensable to me in finding material very relevant to my study. Finally, I give thanks to my longtime friend and scientific typist Susan Cunningham for typing the manuscript.