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# UNDERSTANDING AERODYNAMICS

Arguing from the Real Physics

DOUG McLEAN



# **UNDERSTANDING AERODYNAMICS**

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# UNDERSTANDING AERODYNAMICS

## ARGUING FROM THE REAL PHYSICS

**Doug McLean**

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# Foreword

The job of the aeronautical engineer has changed dramatically in recent years and will continue to change. Advanced computational tools have revolutionized design processes for all types of flight vehicles and have made it possible to achieve levels of design technology previously unheard of. And as performance targets have become more demanding, the individual engineer's role in the design process has become increasingly specialized.

In this new environment, design work depends heavily on voluminous numerical computations. The computer handles much of the drudgery, but it can't do the thinking. It is now more important than ever for a practicing engineer to bring to the task a strong physical intuition, solidly based in the physics. In this book, Doug McLean provides a valuable supplement to the many existing books on aerodynamic theory, patiently exploring what it all means from a physical point of view. Students and experienced engineers alike will surely profit from following the thought-provoking arguments and discussions presented here.

John J. Tracy  
*Chief Technology Officer*  
*The Boeing Company*  
*September 2012*



# Series Preface

The field of aerospace is wide ranging and multi-disciplinary, covering a large variety of products, disciplines and domains, not merely in engineering but in many related supporting activities. These combine to enable the aerospace industry to produce exciting and technologically advanced vehicles. The wealth of knowledge and experience that has been gained by expert practitioners in the various aerospace fields needs to be passed onto others working in the industry, including those just entering from University.

The *Aerospace Series* aims to be a practical and topical series of books aimed at engineering professionals, operators, users and allied professions such as commercial and legal executives in the aerospace industry, and also engineers in academia. The range of topics is intended to be 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. The intention is to provide a source of relevant information that will be of interest and benefit to all those people working in aerospace.

Aerodynamics is the fundamental enabling science that underpins the world-wide aerospace industry – without the ability to generate lift from airflow passing over wings, helicopter rotors and other lifting surfaces, it would not be possible to fly heavier-than-air vehicles as efficiently as is taken for granted nowadays. Much of the development of today's highly efficient aircraft is due to the ability to accurately model aerodynamic flows using sophisticated computational codes and thus design high-performance wings; however, a thorough understanding and insight of the aerodynamic flows is vital for engineers to comprehend these designs.

This book, *Understanding Aerodynamics*, has the objective of providing a physical understanding of aerodynamics, with an emphasis on how and why particular flow patterns around bodies occur, and what relation these flows have to the underlying physical laws. It is a welcome addition to the Wiley Aerospace Series. Unlike most aerodynamics textbooks, there is a refreshing lack of detailed mathematical analysis, and the reader is encouraged instead to consider the overall picture. As well as consideration of classical topics – continuum fluid mechanics, boundary layers, lift, drag and the flow around wings, etc. – there is also a very useful coverage of modelling aerodynamic flows using Computational Fluid Dynamics (CFD).

Peter Belobaba, Jonathan Cooper, Roy Langton and Allan Seabridge