

Preface

In 2001 I published ‘Computation of Unsteady Internal Flows’. This text was largely based around incompressible flow solver methods and hence typically lower speed flows. The key premise behind the original text was that, in some sense, most engineering flows are intrinsically unsteady (even if just due to turbulence). However, because of computational expense, this aspect is often ignored. Of course computing power continues to rise. The use of Graphical Processor Units for number processing is showing promise with rival technologies beginning to emerge.

Detached Eddy Simulation and related eddy resolving methods have added impetus to the use of unsteady Computational Fluid Dynamics. Simulations that potentially rival tremendously expensive rig/wind tunnel tests are now appearing. A notable shoot from this emerging era is work around 2007 at the US Airforce Laboratory, who performed DES for a F/A-18 fighter configuration. Tail buffet was explored and successful comparison made with real flight data (in terms of spectral shape of surface pressure data). This situation was not unforeseen. Around 1975, Chapman, Director of Aeronautics at NASA, proposed, using well founded scientific arguments,¹ that when computers reached 10^{14} flops, eddy resolving simulations that could rival aerodynamic tests would emerge. Modern high performance computing provision now exceeds Chapman’s expectations, reaching Peta scale and beyond. Hence, now the ability to directly predict turbulence, for complex engineering systems, without recourse to accuracy reducing assumptions becomes ever closer—even if advances in solver technology have not been as extensive as perhaps expected by Chapman. The current text focuses on aerospace. Hence, unlike the former, it also includes discussion of compressible flow technology.

With the projected demand for air transport set to double the world aircraft fleet by 2020 it is becoming urgent to take steps to reduce environmental impact with respect to noise and other emissions. Hence, the current text, hopefully, will contribute, in some sense, to the quest to use computers to improve aircraft

¹Note, Chapman’s outer boundary layer scalings are optimistic but this aspect is less critical than the inner scalings.

and thus impact on this pressing environmental need. To make major technological breakthroughs, ultimately, extremely close airframe and engine integration will be needed. This gives the requirement for coupled engine-airframe simulations. Also, increasingly multi-physics simulations will be required. Such endeavors do not marry well with the obvious accuracy benefits provided by making turbulent eddy-resolving simulations. Hence, this text attempts to explore these tensions.

In preparing the text, great effort has been made to remove errors of a typographical nature. Apologies for the errors that are doubtless found.

I would like to express my gratitude to past Researchers who have helped run many of the simulations contained in this text. Especial thanks are due to my longest serving team members—Drs. R. Jefferson-Loveday and J. Tyacke.

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