Foreword to JPAS Special Issue on Applied Computational Aerodynamics and High performance Computing in the UK

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Use of large scale computational fluid dynamics (CFD) models in aircraft and aero-engine design has grown rapidly in recent years as parallel computing hardware has become available. Computational aerodynamics is now one of the largest areas of use of high performance computing facilities worldwide. This has been fuelled by the need for more efficient designs for aircraft and aircraft engines in shorter design times. The need for continued research in this area is stronger than ever. A number of reviews of the aerospace industry [1,2] have identified the need to increase its rate of technology development to meet future targets for safety, noise, and emissions. For example, the Advisory Council for Aeronautics Research in Europe (ACARE) targets for 2020 are to reduce CO₂ emissions by 50%, NO_x emissions by 80%, and perceived noise levels by 50%. These are very challenging targets.

This special issue describes some of the work done in this area within the UK Applied Aerodynamics Consortium. The UK Applied Aerodynamics Consortium was formed in 2004 following a successful application to the Engineering and Physical Sciences Research Council (EPSRC) for time on the UK's then high-end computing machine, HPCx, and continued in 2008 with a second successful bid for time on the current super-computing service, HECToR. The consortium brings together many of the UK's leading research groups together with a strong involvement from the aerospace industry. The remit of the consortium is to focus on problems featuring recognisable aircraft or engine components. These problems typically have a complex geometry, high Reynolds number, and often involve aero-elasticity or other multidisciplinary approaches.

The technical programme of the consortium is divided up into four themes: fixed wing aircraft aerodynamics; helicopter aerodynamics; propulsion systems; and hypersonic aerodynamics. The fourth of these, hypersonic aerodynamics, was added when the 2nd consortium was formed. The contributions in this special issue are representative of the spread of work in the consortium with papers from each of these themes.

The work of the first consortium was described in a special issue of the Aeronautical Journal published in 2007 [3]. Comparing the papers in that special issue to the ones in this, it is clear that significant progress has been made in the last five years and a number of trends are apparent. Increasingly simulations of full systems are now being carried out, rather than simulations of the individual components. In this special issue, Vallespin et al. discuss the use of CFD to predict realistic aircraft manoeuvres using unsteady simulations of an entire aircraft, and Lawson et al. present a survey of their recent progress in helicopter design including simulations of the unsteady interaction of a Sea King helicopter and a frigate.

The ability to model the turbulence in highly complex and separated flows will always be the limiting factor in the use of CFD as a truly predictive design tool. High performance computing is allowing weaknesses in turbulence modelling to be addressed through the use of Large Eddy Simulation (LES) of turbulence. In this special issue, three papers concentrate on the use of LES in turbomachinery design: McMullan and Page demonstrate the feasibility of using LES for a compressor stage design; O'Mahoney et al. use LES to predict the sealing effectiveness of turbine stage rim seals; and Xia et al. use LES to predict the efficiency and acoustic behaviour of realistic engine nozzles.

Finally, two papers describe current work in hypersonics: Redford et al. show state of the art simulations of developing turbulence in the boundary layer of a high Mach number external flow, and

Greenshields and Reese investigate the use of non-equilibrium boundary conditions for rarefied hypersonic flow.

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- [1] A Vision for the Future of UK Aerospace, DTI Aerospace Innovation and Growth Team, May 2003.
- [2] Strategic Research Agenda, Adv. Com. For Aeronautics Research in Europe, Oct 2002.
- [3] UK Applied Aerodynamics Consortium Special Edition. The Aeronautical Journal, vol 111. 2007.