QUB - Mechanical and Aerospace Engineering PhD Project 2019-2020

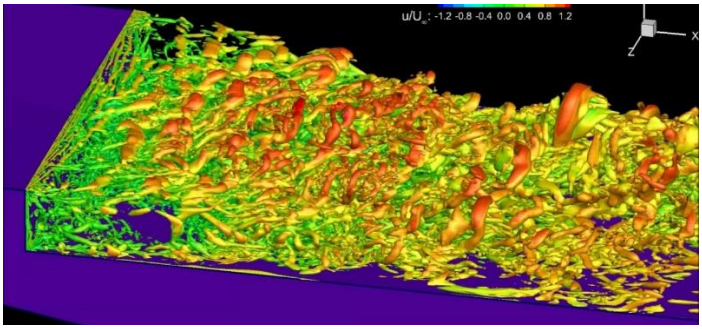
Title:

Flux Reconstruction for Future High Accuracy Aerospace Design Tools

Project Background and Objectives:

Over the past thirty years, computational fluid dynamics has come to dominate the design process in the aerospace industry. From power plants to fighter jets, the use of CFD is ubiquitous. Many of these tools are deeply embedded in the work flows of manufacturers, and, as such, accurate and fast tools are vitally important both environmentally and economically.

The accurate modelling of turbulence remains the last great unsolved problem of classical physics, and the tools currently in use can only be relied upon to be accurate in small, experimentally validated areas of the design space. This necessarily limits and slows the adoption of novel and potentially revolutionary designs – since the predicted physics cannot be assumed accurate. With the increase in computational power, however, new, but hugely more expensive, methods of turbulence modelling have become available, such as Large Eddy Simulation and Detached Eddy Simulation. It has been shown repeatedly that high order-of-accuracy methods are able to outperform the standard second order accurate schemes, achieving equal or superior accuracy using far fewer computational resources.



Unfortunately, the technology of computational fluid dynamics has not kept pace with the developments in computing. Since about 2005, the clock speeds of individual processors have not increased significantly, and gains have instead been made by adding more and more processors. This means that instead of using a single, faster, core to speed up calculations, the work must instead be split over more processors – typically hundreds and occasionally thousands - and a high proportion of time is spent having these processors talk to each other, rather than crunching numbers. This turns out to be particularly true for high order methods, whose performance is far superior on single cores. The problem has got so bad that for very large jobs, the efficiency may be down at the level of 5% of a computer's processing power actually being used for calculation.

More recently, however, a new family of schemes has been developed. Flux Reconstruction is an approach which tries to combine the benefits of high order accuracy with suitability for implementation on modern computational hardware. The purpose of this PhD will be to assess and develop the use of Flux Reconstruction as a computational fluid dynamics tool for industrial use. This project is fundamental research, so the direction it takes will be led by the results, but likely areas of exploration include developing the methods, and applying them to real problems. Since the project is of direct relevance to aerospace companies such as Rolls-Royce, GE, and Mitsubishi, it is anticipated that the industrial applications will involve running simulations on real gas turbine engine geometries, including both turbine and compressor flows.

Key skills required for the post: A minimum degree of a first or a high 2:1 (or equivalent) in one of the following areas is required: Engineering, Science, IT, Mathematics, or a closely related subject area. Candidates with other primary degree areas may be considered if they can demonstrate a high level of suitable relevance and experience to the scope of the project in their primary degree area. Solid computer skills are essential as the project will involve significant computer modelling, simulations and analyses, and it would be desirable if the candidate had some experience of working with computer code, such as Matlab, as there will be a proportion of development as part of the project.	
Key transferable skills that will be developed during the PhD: The key transferable skills that will be developed during this PhD project will be the development of high levels of experience and expertise in CFD, the skills needed to successfully manage complex projects, international collaboration and networking, conference presentation skills, and significant software development ability.	
Lead supervisor:	Dr. Rob Watson, School of Mechanical & Aerospace Engineering r.watson@qub.ac.uk Tel:(+44) 02890974122
Other supervisor(s):	Dr. Marco Geron, School of Mechanical & Aerospace Engineering
Guaranteed stipend:	Remuneration will include a basic stipend paid per annum, for which there may be a conditional top-up. The basic stipend for 2019/20 is estimated to be around £14,925.
Conditional top-up available:	The value of the top-up will depend on the candidate.
Demonstrator hours:	PhD students may also have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to £1,200 per year.
Enquiries:	For informal inquiries, email r.watson@qub.ac.uk
Closing Date for Applications	28th February 2019

Queen's University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.