UROP: Undergraduate Research Opportunities Programme (Summer 2020)

A Personal Perspective by Flavio Savarino, Year 3 in 2019-20, MEng Aeronautical Engineering

UROP title: **Commissioning work for Imperial's new Supersonic Wind Tunnel**

The primary reason why I started looking for a UROP was my desire to gain experience in a research environment, which, at the end of my project, I realised how different it is to being an undergraduate doing the typical things of an undergraduate. My UROP was about designing the supersonic nozzles to be manufactured as part of a project involving the construction of the new supersonic wind tunnel facility at the Department of Aeronautics.

As I am sure it is the case in other UROPs, my initial steps, even prior to approaching any member of the department, were very much characterised by a personal research into my academic background and posing questions on what I really wanted to learn in greater detail. As a result of my passion for aerodynamics, which gradually became clearer over my time at the Aero department, and also special interests in compressible flow phenomena, such as shock waves and compressible boundary layers, I chose to introduce my plan to apply for UROP to Dr. Bruce, who is the leading high speed flows researcher in my department.

I was extremely pleased to see his openness to my interests and I did appreciate the level of communication we achieved since our very first chat in one of the common rooms of the department. As a personal point of view, I give great value to informal discussions because they pave the way for extraordinary levels of understanding, which are key to developing any idea. Therefore, I would advise anybody wishing to approach academics for UROPs to first identify possible research objectives; as a second step, to gain more information about the several different research figures within the department, and, finally, to reach out demonstrating initiative, curiosity and, last but not least, kindness. In some cases you might already know your potential supervisor because you met him/her at lectures or tutorials, however, it may well be the case that you have to introduce yourself from the very beginning and so you must know yourself (however obvious this may sound), be able to provide a clear picture of your plans, hopefully hinting at future career steps, and devise the best way to break the ice. Speaking of this, I would strongly suggest reading about your supervisor's research achievements and reflecting on how these may relate to your interests.

It turns out that some career plans do not necessarily follow the direction you hoped for, but sometimes they might still take you to unexpected success. I can honestly say this statement reflects some aspects of my UROP experience; in fact, after Dr Bruce and I agreed on combining some elements of design to experimental testing, the pandemic revolutionised the scope of my project quite substantially, given that access to the facility was no longer possible. Without losing faith on my UROP carrying forward, we adjusted our research to the unforeseen remote working mode, thus recognising the usefulness of computational and numerical tools in the absence of experimental activities.

As a result, my main effort during those 6 weeks of research was coming up with a set of suitable methodologies to design three supersonic nozzle contours, one for each target exit Mach number. I took this opportunity to enhance my understanding of the Method of Characteristics presented in lectures, especially because I focused on its numerical implementation in MATLAB. Being this method valid under the assumption of inviscid flow, I later investigated the effects of boundary layer growth on the nozzle walls and the resulting impact on the exit Mach number. After some literature review based on semi-empirical methods to predict the behaviour of compressible boundary layers, I was able to write a new code to account for geometric corrections dictated by viscosity. Finally, I set up Computational Fluid Dynamics simulations to assess the performance of the nozzle contours with and without the viscous correction. As a final result, it was very exciting to see that the simulations were outputting the desired exit Mach number for all test cases, thus supporting the validity of the analysis.

Reflecting on the significance of this research experience in the wider context of my career goals and personal development, I can say that I have successfully applied my coding skills to compressible aerodynamics problems and derived useful results, gained further experience with fluid flow simulations and proven the effectiveness of engineering methods in the design workflow. From a more general standpoint, I have improved several transferable skills, such as setting a strategic timeframe to my work, discussing any future improvements to the results with Dr Bruce and presenting my findings to his research group of PhDs.

As a concluding element of my work, I have written a technical report I am proud of.

What is the most immediate impact of this UROP on my career?

Well, I am now in the process of securing a PhD position in high speed aerothermodynamics to find out the new features of the next generation space vehicles.