On the Use of Aerospace Techniques for the Design and Operation of Unconventional Aircraft and their Extension to Renewable Energy Devices.

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This paper will explore how aerospace design techniques, such as initial sizing, multi-disciplinary optimisation, and the determination of stability and control, must be modified when applied to unconventional aeroplanes. To do so it will use, as a case study, the ultra-long endurance, uninhabited air vehicle 'Phoenix' which exploits a variable-buoyancy propulsion system. This vehicle spends half of its time as a heavier-than-air aeroplane, and the other half as a lighter-than-air balloon, the repeated transition between which provides forward motion, and thus it does not fall neatly into any one conventional Certification Standard. As a prototype and technology demonstrator it was decided to operate at under 150kg thus requiring certification under a Permit-to-Fly with associated Operating Manual and Safety Case. However, at low speeds, the aeroplane (without the benefit of contributions from the aerodynamic surfaces) displays a challenging mix of high manoeuvre inertia (a slow response to self-generated forces such as control inputs) and high sensitivity to disturbances (a fast response to externally-generated forces such as gusts). Additionally, the certification limit of 150kg does not normally include the mass of gas captured within the airframe, however Phoenix contains >20kg of Helium as its lift gas which contributes a significant factor to the energy of the aeroplane in flight. These factors, together with the design of the flight control surfaces and the automatic flight-control system, present departures from conventional aeroplane design processes.

In addition, the paper will explore how the experience and techniques developed for the design of aeroplanes is now being used to inform other sectors, including renewable energy. In particular, it will demonstrate how multi-disciplinary optimisation is being used to size hybrid combined heat-power solutions for new and re-furbished civil engineering projects, and to investigate the opportunities offered by a variety of technologies being investigated for wave-energy devices, including wave-energy converters, power take-off, materials and controls. It will also explore how health-monitoring systems are being used to inform the design and operation of tidal turbine devices, and how the consenting for this technology might be informed by lessons learned from Building Information Modelling (BIM).

This work is supported by a number of projects:

'Phoenix' is funded by Innovate-UK and the partners in the programme are: Banks Sails, IQE, Stirling Dynamics, TCS Micropumps, the National Composite Centre, the Manufacturing Technology Centre, the Centre for Process Innovation, and the Universities of Bristol, the Highlands and Islands, Newcastle, Sheffield, and Southampton.

The renewable energy work is supported by an EU INTERREG VA Programme 'The Bryden Centre' involving Queen's University Belfast, the University of the Highlands and Islands, Ulster University and Letterkenny Institute of Technology, the Agri-Food and Biosciences Institute, Donegal County Council, Dumfries and Galloway Council and with support from Sonas Energy, Wave Energy Scotland and Orbital Marine.