2015 GROUP DESIGN PROJECT PRESENTATIONS
by LOUGHBOROUGH UNIVERSITY AERONAUTICAL ENGINEERING
MEng DEGREE FINAL YEAR STUDENTS

Extending a process inaugurated in 2014, and again attracting many Branch members expressing great contentment, this will surely become a permanent event within our annual programme. The aim is that students are encouraged to showcase their air-vehicle design prowess, and the accompanying goal for the Branch is for our attendees to have an insight into the university's commitment to maintaining world-class levels of attainment.

The 2014/15 class had worked on five design projects – ranging across human-powered flight, an autonomous unmanned aircraft (also built for competition), a general aviation design, airliner of the future and an exploratory space vehicle. They all included innovative content, stimulating those seeing their offerings as drawings and models in a pre-meeting reception area, and then attending the presentations, to share the pride and the confidence that was evident from what had been substantive efforts. For each student the commitment to the project equates to one-quarter of their final year assessment.

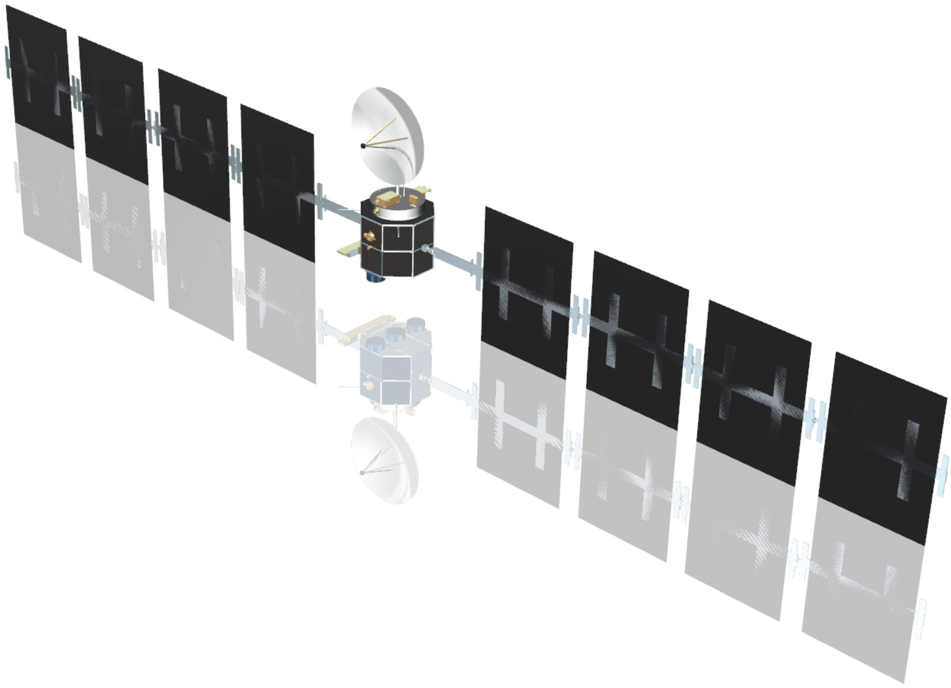
SORA – a General Aviation Jet Aircraft

This was a collaborative project conducted by Loughborough University and Virginia Polytechnic Institute and State University (VirginiaTech) students. As much of the current general aviation (GA) fleet is still based on 1960's technology, the team was tasked to bring a design with technological advancements to the market. They outlined their requirements, which were derived from analyses of surveys and ranged across technical and commercial interests. Collaborative efforts started independently in both teams and they shared configuration concepts through regular video and telephone-conferencing sessions. The developed aircraft had a single jet engine, incorporated fly-by-wire and the latest fully integrated glass cockpit, with traffic and collision avoidance systems to make the aircraft safe and simple to fly. A bespoke mid-bypass turbofan engine was designed with specific design mission objective. The team summarised that upon entry into service in 2020 the aircraft would be at an expected price of $1.5million, and would be capable of carrying four

95 percentile adults (each with 20kg of carry-on luggage) over 520 n.m. and cruising at 245kts. Ferry range capability was 1,193 n.m..

In discussion with the audience the team members opened insights into many conflicting issues they had considered. Their knowledge and willingness to tackle difficult-to-reconcile issues proved they had addressed desire and capability well in reaching their compromises.

ASTERIA – a space craft to explore asteroid 2-Pallas



Again, this was a project based on real-world requirements. The Asteria spacecraft design evolved from the requirements of an existing organisation, Deep Space Industries, to gather data on the viability for harvesting resources (water and carbon) from 2-Pallas, the largest carbonaceous asteroid in the solar system. They had real-time constraints as they considered using a Space X Falcon 9 launch in November 2019 from Cape Canaveral.

Design parameters were driven by the mission profile, which given the asteroid is at 34.8^{O} inclination to the solar ecliptic had to include manoeuvring during the earth-to-asteroid period: a minimum energy time-line was determined with launch on 17 Nov 2019 and arrival at 2-Pallas on 13 May 2028. The satellite would function on expected power availability and requirements until 24 July 2029. A major technical decision was to use a three-unit ion propulsion system, providing long-duration periods of small propulsive thrust, and consuming relatively small quantities of 'fuel.' To determine the composition of the asteroid and its atmosphere a bespoke payload ring was proposed, its location and rotational ability ensuring that the asteroid's atmosphere, surface and subsurface could be observed most effectively whilst maintaining the spacecraft's attitude.

The team had evolved a design with low-cost as an objective, but ameliorating risk where possible too, and in their discussion with the audience their acknowledgements of the difficulty of these decisions was evident and well presented.

Loughborough Environmental Aircraft for the Future (LEAF)

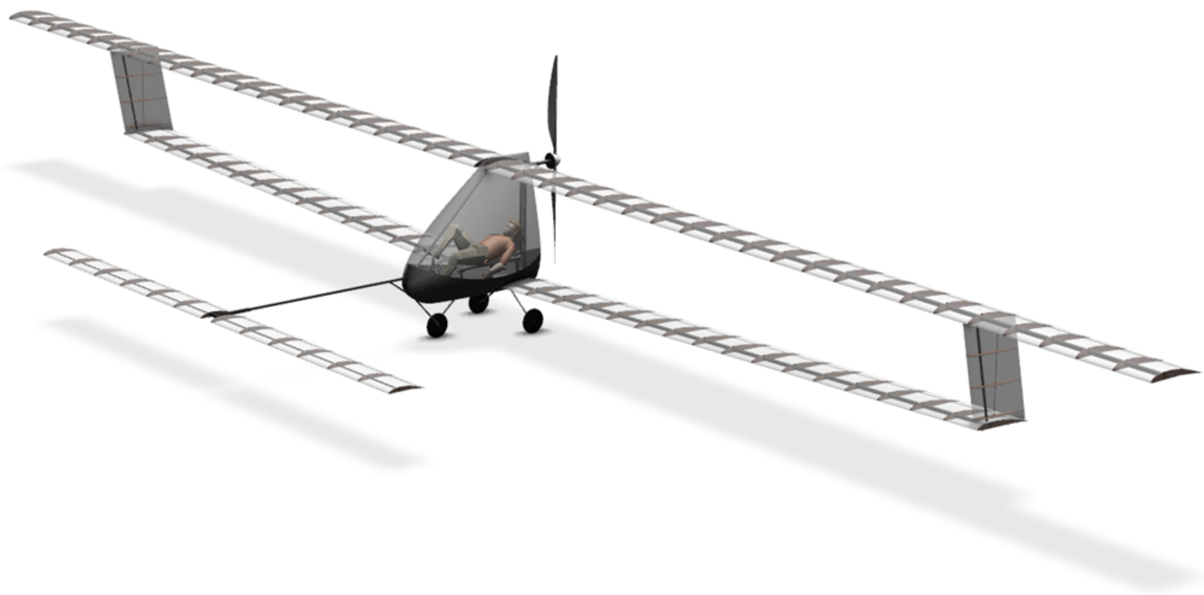
The LEAF project team, as they chose to consider the replacement for the Airbus A321neo and Boeing 737MAX, addressed what is perhaps the airliner design requirement uppermost on the priority list in most major aerospace companies at the current time.

Acknowledging the public expectation that now could be a time for a step-change in aircraft efficiency, the LEAF team took an innovative approach on almost all fronts: they specified a box-wing configuration, selected open rotor engines, and chose to use advanced composite materials. The box-wing was estimated to achieve a 15% reduction in wing profile drag, the open rotor engines (which included a large debris-rejection intake) was expected to improve specific fuel consumption in cruise by 45% (relative to year-2000), and along with a lighter structural mass an overall reduction of 25% in operating costs was predicted.

The baseline design provided a 222-seat (high-density single-class) cabin and could attain 2,500nm range with all seats in use. The range target addressed 75% of all flights operated by this class of aircraft in current-day operations. Multiple cabin layouts in stretch and truncated designs annotated as 'TWIG' and 'BRANCH' alluded to 'family' development. The team quoted market estimates of demand for 26,000 units by 2030, an estimated programme cost of $30bn (relative to 2012), and headline cost per aircraft of $75m.

In debate they received a grilling that any equivalently innovative project team would receive in industry. They defended their choices with robust and well-orientated defence of their unwillingness to be held to traditional values alone, and time will tell if industry assesses the time is so right as this team believed. Meanwhile this was a striking example of a learning opportunity definitely not wasted.

HELIOS - Human Powered Aircraft



Helios is a Human Powered Aircraft designed to meet the requirements of the RAeS Icarus Cup competition. (For non-RAeS members: the Cup is awarded to the winner of a competition conducted occasionally in the UK. In the meeting contestants are awarded points for performance in duration, 100 metre sprint, 1 kilometre race and slalom course trials, plus a take-off and landing accuracy test, and distance around a triangular course).

The Helios team described their approach to the aerodynamics, structures and propulsion, plus systems/pilot controls, and aspects of the operability. The aerodynamic work included CFD modelling of the biplane wing layout to investigate wake effects, the interaction of the fuselage and propeller, and the propeller design itself. These yielded data that suggested a power requirement within the capability of a reasonably-fit (not necessarily athletically-fit) individual. They investigated ways of extracting human power, and chose to use pedals, with a recumbent pilot position. Structural detail had been determined in preliminary design and had been used to justify the selection of materials, configuration and mass estimation.

They conducted analysis of pilot control and display requirements and had established a control design which incorporated several functions in a simple, lightweight and easy to produce unit, and they paid attention to minimising the pilot attention needed to fulfil control needs when in high workload situations. This had included investigating the display requirements of flight path parameters. An Icarus cup regulation is that the design should be transportable in roadworthy unit, not exceeding 11m length, a requirement that had influenced the biplane choice. The team were confident in the viability of their project and showed how they would construct an example in a 12m x 15m workshop space, which is an objective that the university will, funds permitting, be able to carry though in the future.

ZEUS – Unmanned air system

The ZEUS Unmanned Air System (UAS) team has been developing their project for the IMechE University UAS Challenge. This tasks teams to develop a fully autonomous system that is capable of carrying out a representative humanitarian aid mission. It has been

designed and built and was on display before the presentation, but as the aircraft had to be at trials the following day they were having to prepare the aircraft for an imminent departure, and did not present. Their description of the aircraft – illustrated above – is thus:

> System requirements include the ability to autonomously take-off, identify a target drop zone using image recognition, accurately drop two 1kg aid packages within the identified area, and land. The fixed wing design has a maximum take-off mass (MTOM) of 7kg and must operate within visual line of sight (VLOS). A high, straight wing ensures stability and structural rigidity, whilst the twin-boom design increases control surface efficiency at the low flight speeds required for an accurate payload drop. Simulation and physical testing has allowed for a comprehensive design verification, ensuring that the UAS meets its intended performance targets and operational limits.

The aircraft is pitted against designs from 13 other UK universities at trials to be conducted on July 13th at Bruntingthorpe, in Leicestershire. We wish them good luck.