Aeronautical Engineering
Group Design Project Presentations
Joint event with Loughborough University, Department of Aero and Auto Engineering
Tuesday 7 June

This was the third consecutive year in which the branch collaborated with the university to provide a public platform from where the final year students on the MEng Aeronautical Engineering course could present their final Year projects. Again it attracted a large audience and this year also required a sub-set of projects to be presented as only 4 out of 6 teams could be accommodated on the timetable with full-presentations.

Departmental summaries and illustration of each project are appended to these notes.

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The **Surge** project considered the design of an electric aerobatic racer, and was jointly conducted by Loughborough University and Virginia Tech. It introduced the audience to the details of Red Bull Air Races, and the challenge of addressing the power requirement, in terms of quality and endurance, in an all-electric aircraft. They handled queries about the efficiency and limitations of current and emerging power-storage convincingly, and were open in their reticence at having to admit limitations. Overall they were pragmatic and balanced in their assessments of the compromises that held them in check.

"Surge" Electric Aerobatic Racer

Project "Surge" is a collaborative project between Loughborough University and Virginia Polytechnic Institute and State University (Virginia Tech). The aim is to design an electric aerobatic racer to compete in Red Bull-style air races. By using a revolutionary electric motor developed by Siemens, capable of 260 kW of sustained power output at a mass of only 50 kg, the aircraft, "Ion Storm", can reach speeds of 200 knots and withstand instantaneous accelerations of up to ±12g. Over 4 000 lithium ion cells afford a total flight duration of 45 minutes.

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Project Lazarus considered an engineered solution to a natural phenomenon (meteors, asteroids or comets) that, if they impacted on Earth, could engulf mankind. The project, as the title suggests, presumes a power to escape death. It was a unique and very ambitious space project involving the launch of a 130 tonnes payload (shown to be compatible in terms of mass and dimension with the NASA SLS launcher) into low Earth Orbit (LEO). It comprised a core unit (Soteria) which would carry up to five separate payload units (Hades). These would be the units that travel deeper into space and use high-energy means (e.g. lasers or nuclear warheads) to disintegrate the hazardous object. The design work described exhibited a wide range of technical analysis, and the dilemmas of a product that attracts technical and ethical questioning were explored too. The presentation received well-earned applause for the quality of debate.

"Lazarus" Planetary Defence System

Project "Lazarus" is a planetary defence system to protect Earth from near-Earth potentially hazardous objects (PHOs) such as asteroids or comets. The system includes five Hazardous Asteroid Deflection System (HADES) modules docked to a mothership, "Soteria", which orbits Earth-moon Lagrange Point 1. HADES modules will travel to the targeted PHO. Each HADES module consists of two bodies that separate via a deployable boom. The fore body acts as a kinetic impactor which creates a crater and larger surface area ready for the aft body which carries a nuclear explosive to detonate within. The aim is to split PHOs into smaller non-hazardous pieces. The feasibility and range of the HADES has been tested by running scenarios on three near-Earth asteroids known as TX68, Paethon and Apophis. The Soteria mothership also includes a scientific research module to test an experimental laser ablation deflection method on a 4-m-diameter asteroid known as 2012 BX112.

Hummingbird was a very unconventional linkage of the old (an airship) and the new (solar-generated power). There was no holding back on being 'impressive' and the project, aimed at being a positive influence for future generations, had esoteric as well as technical requirements: Educate – Demonstrate – Inspire. The team described aerodynamic, buoyancy, propulsion and accommodation issues with some candour, in that many of the cross-discipline issues were uncomfortable partners, but in respect of making models to test assumptions, and evaluating a full-scale gondola layout (entertainingly presented with video/ music) they capably melded enthusiasm and technical rigour. The concept, although largely seen as a zero-emissions 'round-the-world' flagship was shown to have other than just an ambassadorial role, with capabilities that could be applied in humanitarian and militaristic situations, and as such was as innovative as it was eye-catching.

"Hummingbird" Solar Around-The-World Airship

"Hummingbird" is a zero-emissions airship that has been design to travel around the world. As a technology demonstrator, the aim is to educate the general public about zero-emissions possibilities in aviation, demonstrate emissions-free technologies on an airship in the present day and inspire future generations to promote environmental awareness. The design of Hummingbird is radically different to traditional airship designs: It generates 67% of its lifting force from buoyancy, with the remaining 33% being aerodynamic due to its profile. Hummingbird is powered by two different zero-emissions fuel sources: hydrogen fuel cells and solar power. The fuel cells are responsible for providing power to the engines and the solar cells on the upper surface of the airship provide power for auxiliary systems. The airship will begin its maiden voyage around the world in 2020. The voyage will start from the former airship base in Cardington UK and include Abu Dhabi and Chengdu.

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Providence was the final presentation of the evening and did not fail to give the house a good finale. This sought to demonstrate a commercially-resilient solution to providing surveillance of illegal Tuna fishing in the Pacific Ocean, and was a collaborative study with the University of the South Pacific, in Fiji. The requirement called for long-range and great endurance, and was determined to require an autonomous solution to meet cost constraints. They used a 'donor' airframe (F3J glider) for mainplane and tail surfaces, adopted available 'booms' a 2.3KW electric motor and fuel cells, and designed a centre-section and fuselage to carry the payload. The aircraft was on display, and film was shown of it being flown on test. The fuselage had a full range of navigation, communication and flight-control units (it used a combination of commercial receiver/ transmitter units and a Raspberry Pi processor). Sensors had been defined and their accommodate assured, but were not in the demonstrator. This was an enormously practical and very well managed project to have achieved so much, and to have spawned the appropriate reports for assessment in one academic year.

"Providence" Unmanned Aircraft System

Project "Providence" is an unmanned aircraft system (UAS) to provide the government of Fiji with autonomous low-cost marine surveillance to safeguard the Pacific Ocean against the Illegal, Unregulated and Unreported (IUU) fishing of tuna. It is estimated that in the South Pacific area, revenues of around 400M USD are lost to illegal tuna fishing. The design integrates the latest UAS avionics and communications with an off-the-shelf F3J glider airframe. The 16.5 kg aircraft is designed for a 1500 km autonomous mission to the outskirts of Fiji's waters, to transmit live video of illegal fishing for use as judicial evidence, and to cost approximately 40 000 GBP. To prove that an F3J glider can be adapted to a viable UAS solution, a demonstrator has been built and flown in less than 2 months with a cost of just 1 200 GBP.

Due consideration to the two teams who presented on stand only:

The **Multi-role Transport Aircraft** was as close to 'conventional' as any of the projects, but this was a very strenuous exercise in compromise across a wide range of potential applications. This reflects what many customers ask of manufacturers, but whose own musings are cloaked in 'confidentially.' There will probably be covert interest in this project from many real-world design teams, and the confidence that was clear (in reflection of the lessons learned, and the decisions that were hard to swallow) was testimony to a project that had pitted academic rigour against youthful enthusiasm.

Multi-Role Transport Aircraft
(Poster and model only)

As defence budgets get smaller and the nature of modern warfare more complex, many countries may look to consolidate their military transport aircraft fleets into single type aircraft capable of fulfilling a variety of missions and roles. The multi-role transport (MRT) project aims to satisfy this demand by designing an aircraft that can fulfil many different roles either at the same time or by means of a rapid role change via an innovative Module Payload System (MPS). Initial MPS configurations include: aerial refuel, ground surveillance, aeromedical evacuation, and troop and cargo transport. Novel techniques have been used to meet an MTOW of 250 000 kg, an operational radius of at least 5 000 nmi and an in-service date of 2040. In particular, the propulsion system comprises 4 electrically-driven fans. These are powered by 2 turboshaft engines with a competitive SFC of 0.35 lb/lbf/h at cruise. The aircraft will also incorporate an advanced fuel cell system design for auxiliary power that will replace the RAT to allow green taxiing and provide on-demand power for the MPS.

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Project Auxilium was a 'real-time' project, in that the team had taken on the IMechE UAS Challenge to demonstrate a fully autonomous system capable of dropping two 1kg aid packages at a distance (line-of sight), and required adherence to a constrained vehicle mass. Launch and recovery has to be fully autonomous, and the vehicle had fulfilled many (perhaps all) of its requirements in trials on the day of the presentation. The team brought the aircraft to the meeting and were hardly at rest, impressing many attendees on their stand. It was with admiration that many expressed kind wishes for success to the team in their final show-down against other challengers next month.

"Auxilium" Unmanned Aircraft System
(Poster and aircraft only)

Project "Auxilium" is Loughborough University's unmanned aircraft system (UAS), developed for the IMechE UAS Challenge, which tasks teams of university students to develop a fully autonomous system to carry out a representative humanitarian aid mission. System requirements include the ability to autonomously take off, identify a target drop zone using image recognition, accurately drop two 1 kg aid packages within the identified area, and land. The fixed wing design has a maximum take-off mass (MTOM) of 6.9 kg and must operate within visual line of sight (VLOS). Some highlights from Loughborough's design include a modular air-frame, and experimental carbon composite manufacture. Simulation and physical testing has allowed for comprehensive design verification, ensuring that the UAS meets its intended performance targets and operational limits. The flying competition will be in early July 2016.

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As a Branch event this was from newcomers rather than steeped professionals, but was no less invigorating as any of the presentations of the past season, with good presentation skills complementing high-quality material and debate. We take this opportunity to thank the students, and to wish them well for the future. We have to thank too Chris Harvey, Gary Page, James Knowles and Polina Chernukha who oversaw the students' projects throughout the year and rounded them up on the night, and John Newton who coordinated the presentation arrangements. Once again, a very fitting final session enjoyed in a large auditorium that was amply filled.

Presentation notes by Mike Hirst