ROYAL AERONAUTICAL SOCIETY
LOUGHBOROUGH BRANCH

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Final Year MEng Aircraft Design Projects
Loughborough University
Department of Aero and Auto Engineering

An edited, 70-minute video of the proceedings is also available on the branch website. These notes briefly summarise the principal content of the four projects described.

1. NERODIA - fire-fighting aircraft

The Nerodia team provided a splendid description of the requirements for airborne firefighting, having gathered data on 24 existing types used in this role. They showed a primary list of performance objectives and considered a range of possible configurations. Their initial concept choice was akin to the Fairey Rotodyne but when specific targets were analysed interest moved to a more conventional design.

Key requirements included a 6,000 gallon fire retardant payload, and the most suitable design was with an underslung fuselage with twin booms, associated to the inboard engines ahead of the wing leading edge, and extending to the tips of a single horizontal tailplane. The powerplant choice was four PW150A turboprops, with a 15,000kW rating, and a bespoke propellor with six blades was selected. A six-wheel main landing gear was to be stowed in each boom, aft of the engine.

After introducing the aircraft configuration the presentation outlined the flight-deck and equipment, the design of several retardant fuel tank options and explained why 14 internal baffles were necessary to moderate centre of gravity movements. There was considerable information provided too on costs, manufacturing and operations, and revealed that this was expected to be a $7bn development program that would need sales of at least 62 aircraft for the project to reach break even. The design team faced complex objectives, and they stitched technology and commercial aspects in a well-balanced manner.

2. MISSION TO VENUS – Orbiter, Blimp and Lander (Aeroshell)

This design and assessment of options required to create a credible solution for a system that will land on Venus required a team with a wide range of interest in fundamental aspects, e.g.: astrophysics, aeronautics, materials, sensor capabilities, and more than just a touch of philosophy.

The presentation was a multi-staged description of the way the team allocated tasks to three design elements: orbital, blimp and an 'aeroshell' lander, the latter assessed to weigh 644.2kgs. The complete payload was designed to be an acceptable payload that could be carried from Earth to Venus using a modelled trajectory that showed a 176-day journey (and detail was such that the expected window of opportunity will be possible with a launch on 21st February 2036. The requirement is possible using an existing Space X Falcon rocket.

Considerable data was provided and the three elements described in detail included :

Orbiter – would have 5 instruments: a high-gain antenna, magnetometer, radar sounding, spectrometer and NIR camera.
Blimp – this is a 'balloon' shaped and designed to meet expected 'atmosphere conditions, and would have a 2kW solar-battery and a heading and altitude controller. There was also a nitrogen replenishment system (used once every 8 days).
Aeroshell – would be the only element planned to land on the planet's surface. A region already mapped is the proposed landing area (about the same area as England)

Overall, this was a very demanding objective, and the processes presented did provide a thorough explanation (minimised here) of the reasoning that converted the objectives into a complex solution that was justified and well presented.

The photograph shown below is from a video that showed the major regimes of the launch from Earth, to the sequence of moments when the payload was released from the rocket, then the moments when the orbiter, blimp and aeroshell units were released and orientated as retracted elements were extended. An excellent example of what can be achieved when a motivated team finds appropriate skills to apply modern design support software.

3. ACHELOS – UAV able to support RNLI

This project considered requirements based on RNLI operations data based on incidents at sea. The team analysed response, endurance, operations radius, weather/corrosion, cost and capability requirements, and considered aspects relevant to large or small vessels

The Royal National Lifeboat Institution (RNLI) uses lifeboats and crews that will respond to a mayday message. An RNLI station is usually within 10nm of an incident, and the response to an alert is expected to have a lifeboat at the scene within 30mins. Weather conditions play a big part, with wind, particularly, and sea states affected by the climate.

The design team looked for a waterproof design with high corrosion resistance, sought a low cost solution, and considered three possible configurations. They chose to have a simple wing attached to a rectangular section fuselage. It was to have a propeller at the front, and wings attached atop the fuselage. Using Lithium Sulphur batteries there was adequate power to meet duration requirements. The airframe was made of aluminium and carbon fibre and could be readied and launched from a lightweight rail launch that could be assembled and located quickly. It was adaptable, had a short turn-round capability and was easy to store. It had a fuel endurance of 3 hours and an operational radius of 15nm. Four cameras: one for low level (light), plus electric optical, LED optical and infra-red cameras.
The design was assessed with regard to:

(1) Attaining quick response
(2) Endurance in excess of 3 hours
(3) Operational radius exceeding 15 n.m.
(4) Weatherproof and corrosion resistant
(5) Low cost
(6) Adequate search capability

4. HY500 – the future of sustainable aviation fuel (SAF)

It is likely that the specification used on this project will have been similar to that already in use by many airliner design teams.

The student team has taken on a design that looks very conventional at first sight. But the details reveal innovative and justified details.

The design presentation presented their work under the headings that follow, and used here as they provide a route through their work.

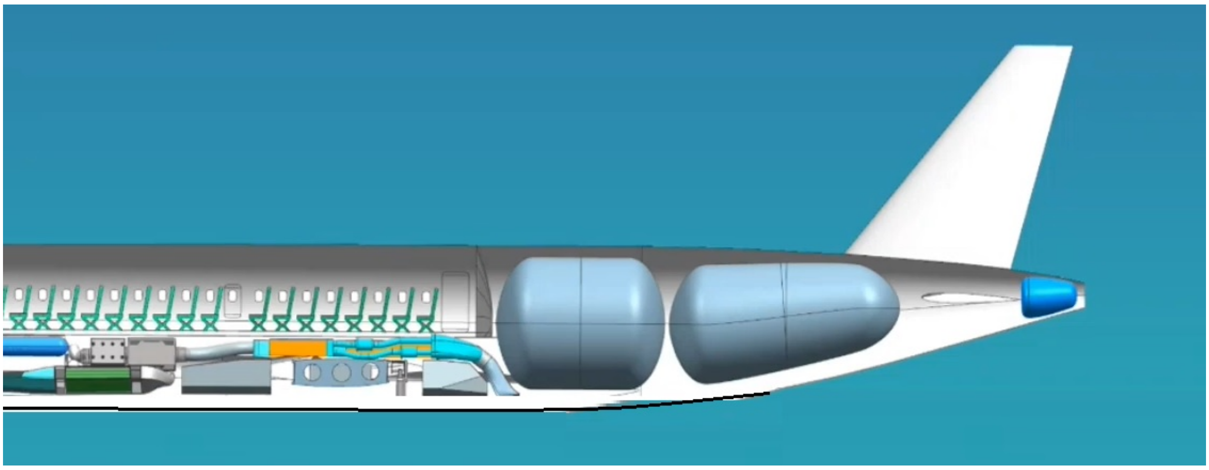
1. Motivations
An overall target was that aviation should not account for more than 3.5% of all effluence radiation, and that is to be 12% of all transport emissions. The most significant targets are to eliminate CO_2 and NO_2 gases in aircraft effluence. Analysing all-electric aircraft using Sustainable Aviation Fuels (SAF) and Hydrogen were considered to still create considerable production of CO_2 gases.

2. Competitor Aircraft
Three categories - Turboprop, Blended Wing Body and Turbofan – were regarded as bench marks that needed to be bettered. Their adopted targets were to consider a 154seat airliner and were to attain 724n.m. range, with a maximum payload of 16,200kg. Cruise speed was to be Mach 0.78 to 0.80 at 30,000 to 32,000ft cruise altitude. Take-off and landing distances were 2,499m and 1,800m and meet ICAO and FAR requirements.

3. Key requirements
There were to be no emissions of CO_2 and NO_2 gases, a 50% reduction of contrail emission (based on yr2000 data), and perceived noise was to be 65% of the accepted current level throughout taxiing and in flight. The team believed a blended wing body (BWB) would be suitable, but the potential low-drag expected of such a design was offset by estimated costs ($5.75 billion development cost) and production cost of $70 million per aircraft. Ticket cost per seat was also higher than for a conventional aircraft.

4. Final design (HY500)
MTOW 69,173kg, OEW 47,045kg Max payload 16,300kg
Max fuel 5,800 kgs - two H_2 tanks in rear fuselage plus small water tank for trim
Available power 30.8 MW fuel cell and Licerion battery system
Max range (city pair) 1,159/724 n.m.
Max cruise altitude 30,000/33000 ft cruise speed (Mach) 0.75 to 0.85 cruise speed
Max take-off length 818m. Max landing length 1.020m

Enter service date 2040



Rear fuselage showing liquid H_2 fuel tanks and small water trim tank (far right)
Beneath passenger cabin, in wing root are two 5-unit battery power packs

5. Technical data

Fuselage – 45m long, and a design that creates a laminar flow. This provides a 25% drag improvement compared to conventional airliner fuselage designs.

Passenger seating - is twin aisle, 2-2-2 and 2-3-2 row configurations, all 29in seat pitch. The design included service, access and emergency doors that meet ICAO requirements.

Wing - wing area 144m^2 dihedral 7^0, Aspect ratio 10, span 37.5m, root chord 7.5m, tip chord 1.87m (there are folding wing tips that reduces span when parked).

Fuel: - liquid H_2 stowed in two aluminium (spec 2219) tanks (each 2,964lb capacity)

Powerplants – there are four units, two slung under each wing (port and starboard) leading edge. They look similar to existing gas-turbine nacelles, but within each is a duct designed to contain the motor and an electric fan.

Trim tank – water at end of fuselage – 2m^3 volume.

With larger teams and a smaller number of projects, and very well planned presentations that have used the scope available using visual aids, this group pf designs has blended information, presentation and enthusiasm very well. One has to wonder if this is just another step …. Roll on next year!

Presentation notes written by Mike Hirst