Dual-role UAVs - a Conceptual Design Perspective

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UTP for design

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1. The Grand Challenge

"To develop technologies for a maintenance free, low cost UAV without conventional control surfaces and without performance penalty over conventional craft."

Within this wider goal of the BAE Systems/EPSRC funded FLAVIIR (Flapless Vehicle Industry Integrated Research) project, part of the remit of the Southampton UTP centre is to look at novel conceptual design technologies to be used in the development of such vehicles.

The airframes considered in the first phase of the project fell into two broad categories. First, HALE-type planforms were investigated, as shown below.

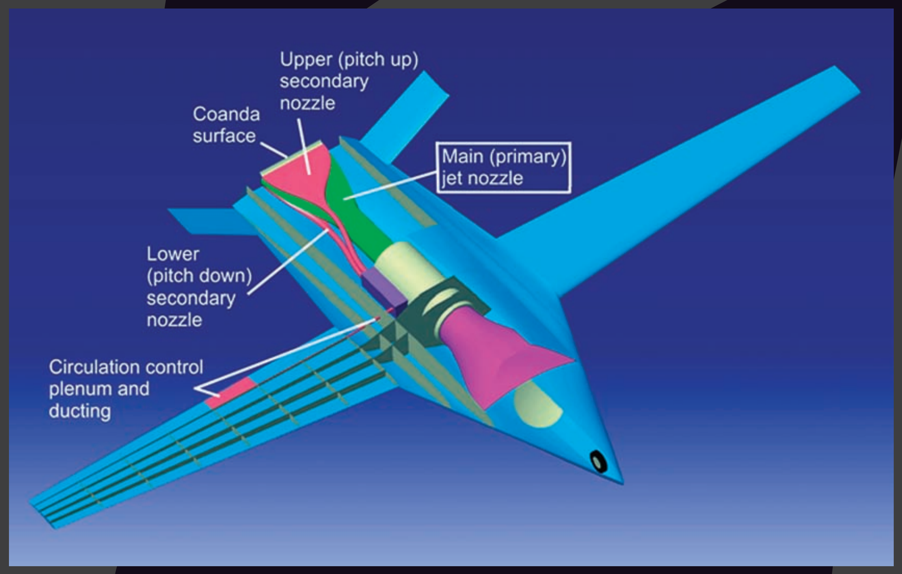

Fig. 1. High Altitude Long Endurance (HALE) UAV model created using the Southampton concept design system.

The second major category was that of combat vehicles, generally designed for high manoeuvrability during short to medium range missions.

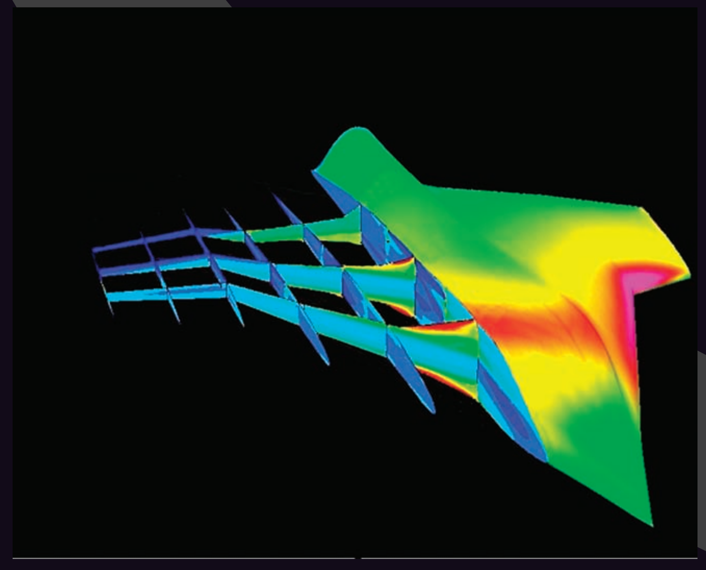

Fig. 2 Results of an MDO study (internal structure stress distribution and surface pressure distribution) on a generic combat airframe.

2. Designing for commonality

Following discussions with BAE Systems and FLAVIIR partners from other UK universities it was felt that the project in general and the Southampton concept design tool in particular should investigate the feasibility of maximising the commonality between airframes designed for HALE and combat missions. This could be done to the extent where the two types of airframe could share everything but the wings - these could be fitted pre-deployment, depending on the mission to be performed that day. Figure 3 depicts such a concept.

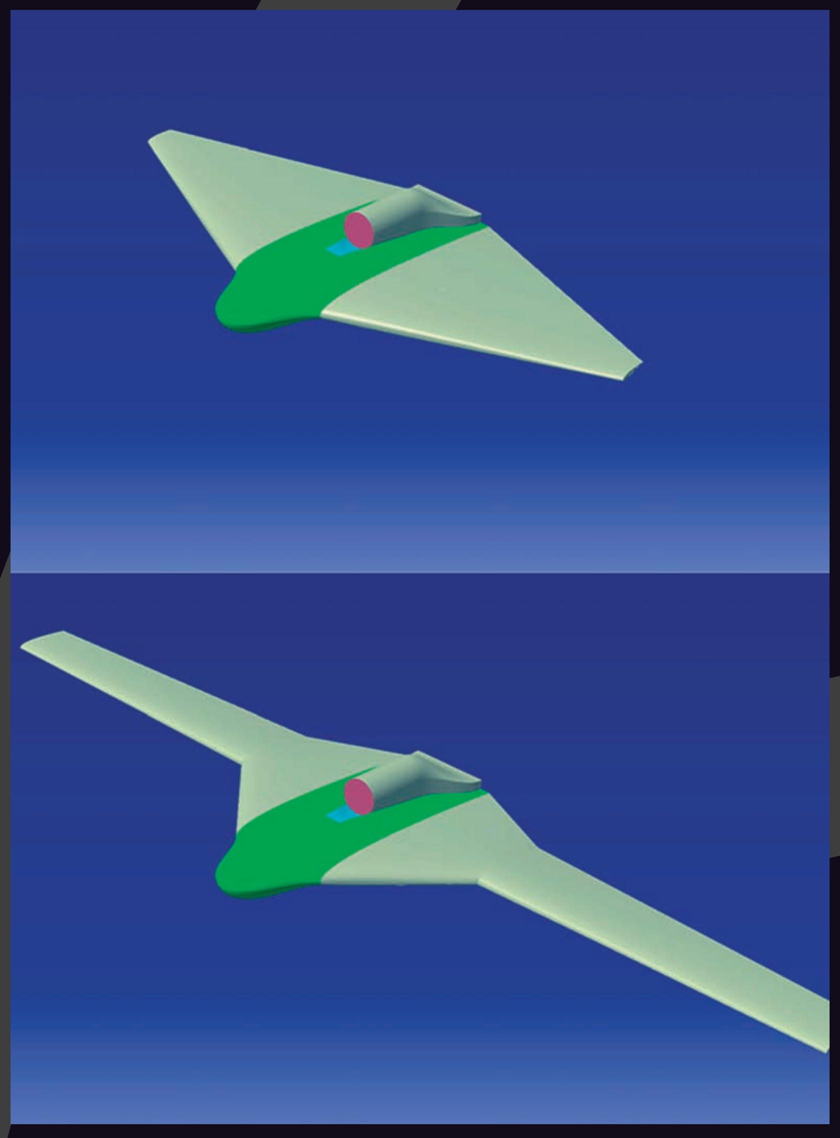

Fig 3. Combat setup (top) and HALE setup (bottom) of a dual role concept, as modelled by the Southampton concept design system.

While the carry-through structure of a UCAV has to withstand high g-loads, the equivalent part in a HALE UAV, while under moderate g-loading, carries a significant bending moment due to its long wingspan. Thus, the common centrebody structure (Fig 4.), if carefully designed, does not have to be over-engineered for either mission.

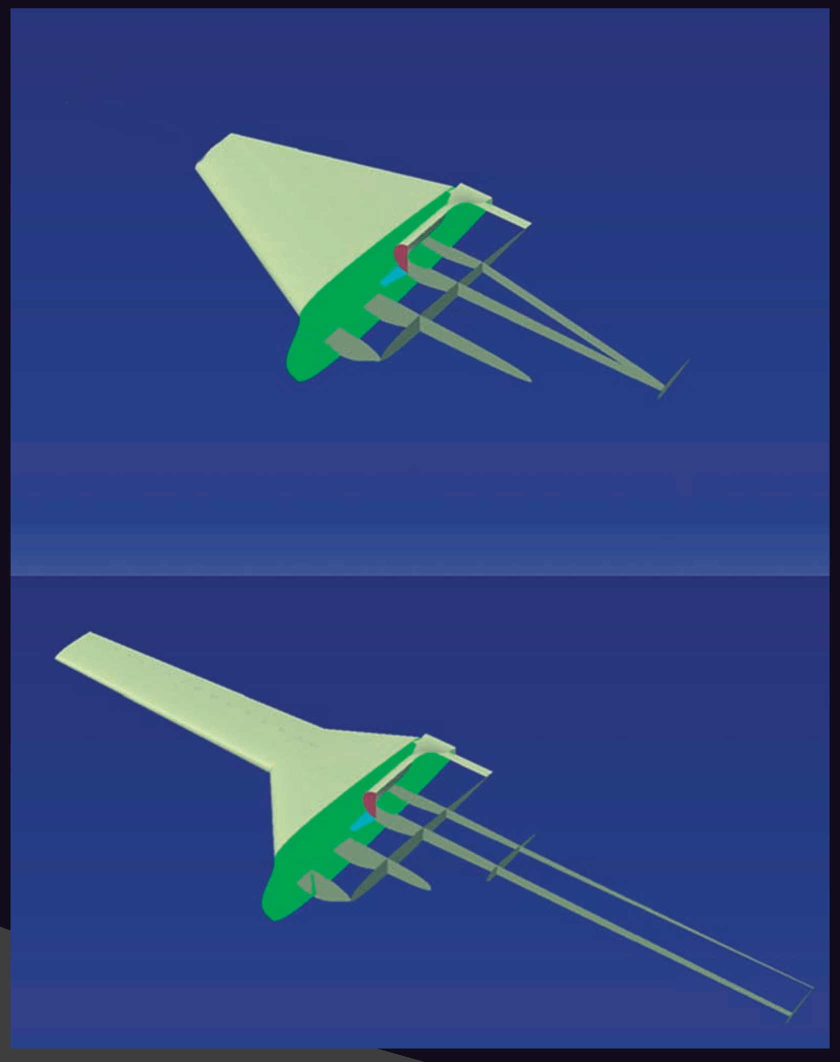

Fig 4. Shared internal structure of the common centrebodies. Also note the common anchor points of the two types of wings.

3. Further conceptual design challenges

Figure 5, showing two screencaps from the stability module of the dual mission airframe design tool, illustrates one of the principal challenges of designing an airframe for two radically different missions: the weight distributions of the two centrebodies will be almost identical, yet the requirements for static margins and mean aerodynamic chords of the two setups will be different.

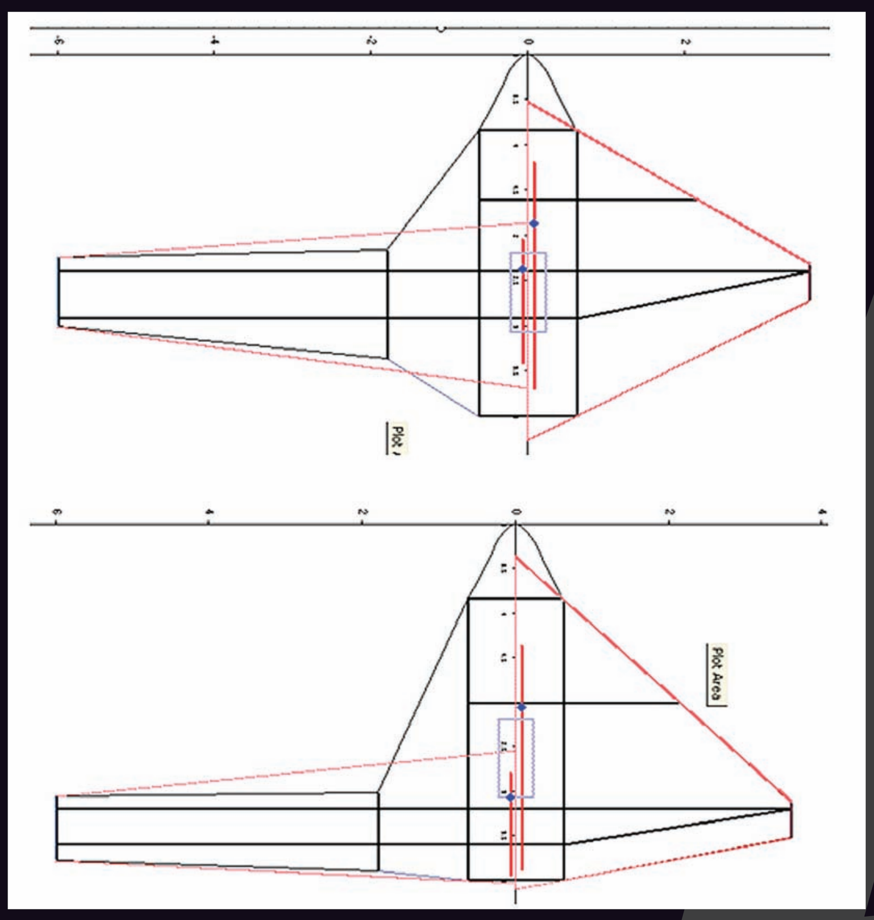

Fig 5. Two possible layouts, with the combat wing on the right and the HALE wing on the left. The red vertical bars indicate the Mean Aerodynamic Chords of the two wings, the locations of the aerodynamic centres are marked by blue dots.

The sizing of the internal structure of a given concept is based on the pressure loads computed at the critical points of the two flight envelopes (also generated by the concept design tool, see Figure 6). Figure 7 illustrates the results of a VSAERO pressure distribution computation.

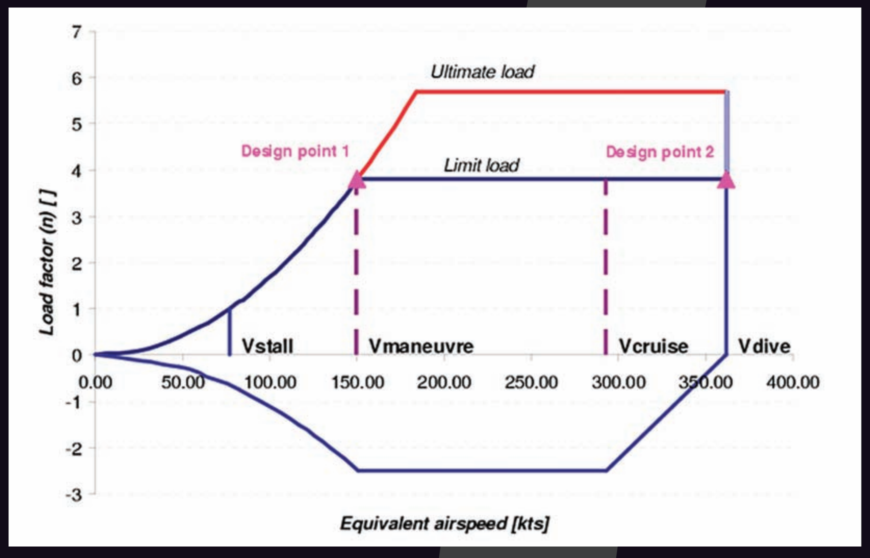

Fig. 6 Flight envelope of a combat concept.

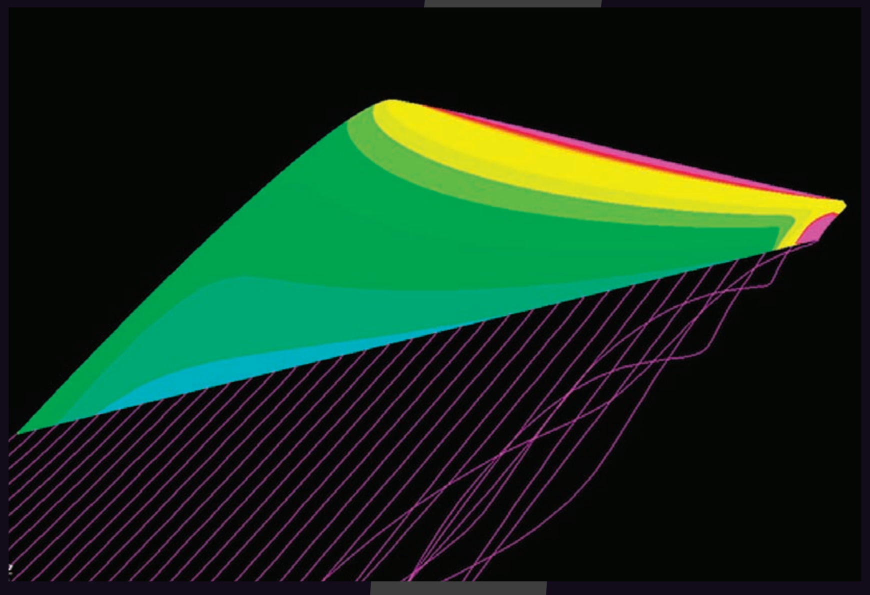

Fig. 7 Pressure distribution and wingtip vortex model generated using VSAERO on a combat UAV wing.

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