AE 508 -- Aerospace Structures II
Final Design Problem
R.D. Hale, Spring, - '04

We are working with the National Science Foundation to develop requirements for a UAV remote sensing aircraft for operation in Polar regions (Antarctica). A preliminary vehicle arrangement is shown below. An AeroCADD file containing this geometry is available, and will be e-mailed to you on request.

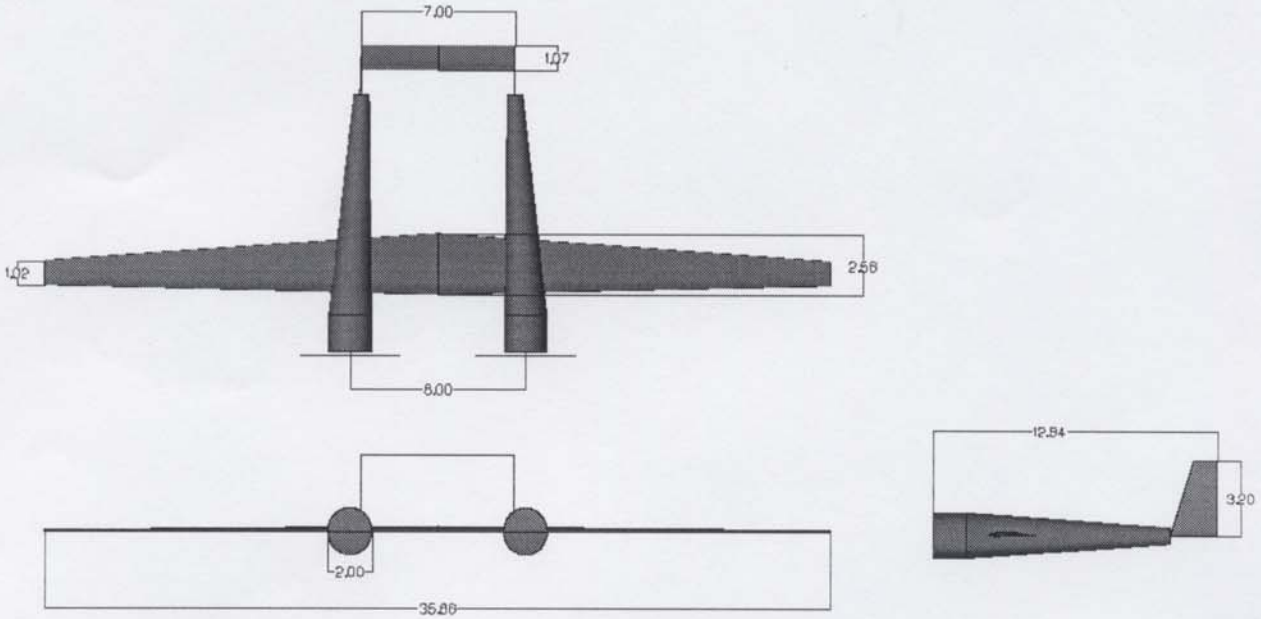

Figure 1. Antarctic Remote Sensing Aircraft Conceptual Design

You are required to perform a preliminary design and analysis of realistic wing geometry for the inboard and outboard wings. The wings are required to support a maximum gross weight at takeoff of 1607 lb. and a load factor of 3.

The basic construction technique shall use aluminum sheet assembly. Use a two spar concept, with the forward spar between 20-25% chord and the aft spar between 60-70% chord. For your design, use standard thickness 2024-T3 aluminum sheet for skins, spar webs and the aft spar caps, 5052-H32 aluminum sheet for the ribs and rib caps, and 2024-T3 unequal angle stock extrusions for the forward spar caps and stringers. Material properties are available in the MIL-HDBK-5 (or from me). Minimum gage for substructure shall be 0.025", for skins 0.04". Maintain a rib spacing of approximately 12", and assume you will have at least one stringer in the upper and lower skins (more are likely required in the inboard torque box upper skin). Assume an end fixity coefficient of 1.5 for longitudinal members. Assume no buckling or crippling at yield, and use a F.S. of 1.5 for ultimate. You may assume that the spars are fixed at the boom attachment.

The identified design limit loads may be applied to the wing finite element model by a distributed, constant load along the forward and aft spars of both wings (such that you will not be required to map a pressure distribution). Assume the forward spar assumes 80% of this load, and the aft spar assumes 20% of this load. The drag is assumed to be 10% of the lift distribution, and is applied as a distributed load along the forward spars. Follow the progressive failure design process of AE 507, as described in Section 8.2 of "Analysis and Design of Aerospace Structures" (Ewing, 1998).

As a minimum, I expect the following analyses:

1) For one wing section between two ribs you feel is critical in each of three identified wing sections (mid boom, inboard, outboard) perform the following analyses:

- •Upper skin buckling
- •Lower skin sizing
- •Spar web shear buckling
- •Rib web shear buckling
- •Upper skin stringer crippling/buckling
- •Lower skin stringer sizing
- •Upper spar cap crippling/buckling
- •Lower spar cap sizing
- •Fastener spacing along spars/ribs (assume 1/8" solid 2024-T31 rivets, with an allowable of 500 lbs shear per rivet)

2) Compute the expected weight of the wing.

You may work in teams of up to three persons. A final report documenting your geometry, finite element model, materials, analysis methods and results is due by 5:00 PM Wednesday, 12 May, 2004. Recall that I have placed a representative stress report on reserve in the library. One report shall be accepted per team, and each team shall work with a single finite element model (though if possible each team should perform a convergence analysis to assess the accuracy of that model).

Your final report shall consist of the following:

1) An executive summary that describes the problem, the design decisions made, the validity or expected accuracy of the finite element model, and which refers to your design summary table

2) A design summary table which identifies critical margins of safety for each major structural element

3) Drawings of the geometry modeled

4) Identification of external loads

5) Documentation of design parameters used for determining internal loads in your analysis

6) Documentation of your finite element model, and of necessary critical internal loads

7) Sample calculations for margin of safety on critical elements

8) Conclusions for the validity of the design, and recommendations for further analysis or design modifications.

Clearly identify the individual or individuals responsible for each section and each analysis. As always, a uniform report format will be rewarded.

Finally, consider that although one can perform the analyses of the existing material gages and satisfy the requirements of this project, the true measure of success are the recommendations for structural modifications. You are encouraged to modify the model as required to accomplish a structural design that is efficient.