Department of Aerospace Engineering
University of Kansas
AE 510 Aerospace Materials and Processes
Design Problem: High Performance Aircraft Wing Torque Box
Fall, 2003

Problem Statement

The overall goal of this design problem is to form a design team and recommend manufacturing processes for the wing torque box of a high performance aircraft. Ten competing designs have undergone preliminary sizing, but have not yet had weight or cost assessments because the specific manufacturing techniques are not yet established. Your team's job is to design alternative manufacturing processes you feel are economically feasible, at acceptable technical risk to the project. Your marketing department is looking for potential customers, but can not yet accurately determine the optimal production rate. Assume that the production rate for this wingbox will be 120 or 600 per year and recommend the preferred approach for *each* of these production rates. Be prepared to alter your recommendations based upon modified production rates.

Each design team will be responsible for reviewing all ten design concepts, and providing justification for a more detailed examination of at least three. As a minimum each team will be responsible for performing a detailed assessment of one concept from at least three of the following groups:

A) Monolithic (unstiffened) carbon-epoxy skins, hat-stiffened carbon-epoxy skins
B) Aluminum honeycomb skins, carbon-epoxy honeycomb skins
C) Two-sheet, three-sheet or sandwich skins
D) I-stiffened, blade-stiffened or Z-stiffened skins.

Teams or individuals can examine additional concepts for extra credit, but only one integrated report will be accepted per team. Quantity does not directly relate to quality, and teams should be cautious about exploring too many options. Again, you must provide sound reasons for your selection of the three concepts, and these reasons should be based on preliminary (less detailed) analyses of weight, cost, and technical risk. Your more promising designs shall be examined in more detail, leading to selection of the preferred concept. Hybrid concepts are certainly acceptable, if it is determined that certain processes are more suitable to the upper skin than the lower skin.

You must design your process using only the equipment you know to be available at major aircraft manufacturers like Boeing, Raytheon or Cessna. The only drawings and dimensions available are those attached. Details on adhesives, fasteners, scrim, surface treatment, paint, etc. are left to your team to recommend as a course of the design. Your time, cost and weight estimates must include all materials, tooling, fixtures and expendables required for your process. Work with your customer to refine requirements for this vehicle as needed. Use any references available to you, including your instructor who will serve as A) your VP of manufacturing B) your representative from the strength team, who performed the initial sizing and C) your vendor representative (if actual data can not be located). Feel free to add structural members, or modify existing members to be more manufacturable, supportable or cost-effective. All design modifications, however, must have an approval signature of the strength team representative.

Note that the purpose of this design project is to use your knowledge of manufacturing processes to devise a concept for building a feasible and competitive aircraft wingbox. The idea is to be creative within the bounds of available manufacturing capability.

Schedule

Your effort must be well integrated from the beginning due to the extremely short time period allowed. As such, you must make certain that a schedule is followed – one which requires and allows each individual to be gainfully employed. We will hold team meetings at every regularly scheduled class time, and you may (should) have additional meetings outside of class. Each team meeting must end with a list of deliverables (action-items) required of each team member for the next meeting, and a list of deliverables delivered by each team member at this meeting. The schedule for all deliverables must allow each team member to be successful, so it must recognize other legitimate time commitments. Each team member must be clear on their personal schedules to make them known to the team. One *possible* schedule is as follows:

20 November	Determine team organization and select integrator Discuss competing parts manufacturing and assembly processes Assess cost, weight and technical risk of all preliminary concepts
25 November	Conceptual design briefs describing concept down-selection to at least three Propose competing manufacturing processes for all parts, including tooling Propose competing assembly processes, including tooling and floor schedule
2 November	Choose individual parts processes & give detail to tooling and machine scheduling Choose assembly process & give detail to tooling and floor scheduling
4 December	Preliminary design review Formalize report requirements and responsibilities
9 December	Coordinate written sections (common figure and table numbering)
11 December	Final design review. Team presentation of manufacturing plan (20-30 minutes/team). Turn in written design report before 5:00 PM.

Detailed Submission Requirements

Only one report will be accepted per group, however each member of the group must write a distinct portion of the report. Authorship of each section must be clearly identified. Groups that submit a well-integrated report will be richly rewarded. The report may be in any format, but must as a minimum include:

A) Executive summary
B) Explanation of choice of three concepts from original ten
C) Detailed process descriptions for alternative processes on the three preferred concepts, including cost, weight and technical risk assessment.
D) Identification of preferred concept(s), and rationale for choice
E) Appendices for items like time estimates to make fixtures, and notes from design team meetings.

The written report should be a stand-alone proposal to make the wingbox for an airframe manufacturer. It should clearly show that many processes were explored, and the ideal one was chosen for the optimal blend of affordability, quality, risk and schedule.

Individual Efforts

Each member of the team, except the integrator, must "own" at least one manufacturing or assembly process. As an example, the group could establish process ownership as follows:

Member	Process
1	honeycomb upper and lower skins two-sheet upper and lower skins
2	hat stiffened carbon-epoxy upper and lower skins z-stiffened upper and lower skins
3	caps, spar webs, and box assembly integrator.

Each "owned" process must be described in great detail. All competing processes for manufacturing the part must be described, and the reason for selecting or not selecting that process must be described in detail. You must describe the parts flow through the factory, and a time estimate for each process.

You may need to design or describe specialized tooling, both for individual parts and for final assembly. No specific tolerances are called out yet, but you can expect that extremely rigid fixturing is required for most final assembly processes. Such tooling shall be designed and at least sketched. In addition, the number of tools required to accommodate the highest production rate of 600 wingboxes per year must be specified.

The integrator will be responsible for overall integration, especially in the design of the manufacturing floor. They will also be responsible for scheduling, and team communication and relations. The integrator will be expected to chair each team meeting, and keep minutes for inclusion in the final report.

Evaluation

Group grade: 100 points
(final recommendation, design choices, integration of concepts, team effectiveness and communication, schedule)

Individual grade: 100 points

- All but integrator:
  - Organization and flow (15)
  - Manufacturing processes (50)
    - detailed process description
    - time, cost and risk estimation
  - Tooling design (25)
    - detailed drawings
    - time, cost and risk estimation
  - Schedule (10)
    - accomplishment of tasks on time

- Integrator:
  - Organization and flow (25)
  - Introduction (10)
  - Summary (40)
    - manufacturing facility diagram (20)
    - parts flow diagram (10)
    - time, cost and risk summary by production rate (10)
  - Minutes of meetings (25)
    - notes from team meetings
    - deliverables, by member
    - accomplishments, by member