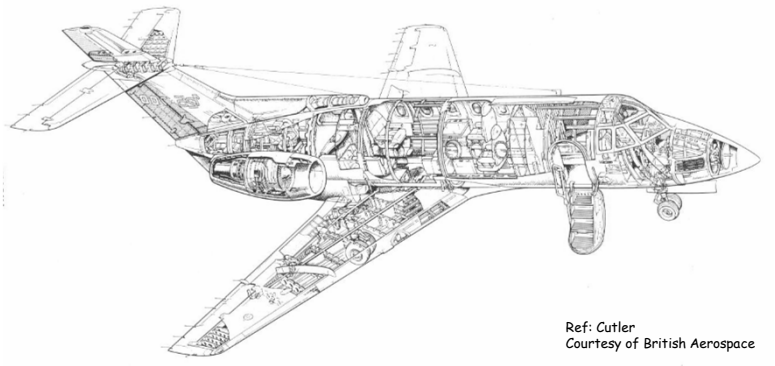
Aerospace Vehicle Design



Ref: Cutler
Courtesy of British Aerospace

Ian Farrow, Tom Rendall, Fabrizio Scarpa, Steve Bullock, Terence Macquart
Ivor Franklin, Raf Theunissen, Sergio Araujo Estrada

Aims & Objectives

Aims:

- To provide basic experience of the design, build and test of a mechanised wing, including aerodynamics, structures, mechanisms actuation and control with written and oral communication of technical design information.

Objectives:

On successful completion of the unit students will be able to:

- carry out the design, build and test of a functioning aircraft wing structure accounting for aerodynamic, structural, mechanism,actuation and control aspects using a wide range of analysis methods.
- cope with the freedoms and constraints of a complex design problem spanning several disciplines.

Aims & Objectives ctd.

- select and analyse aerofoils to achieve the best compromise of aerodynamic performance for different flight phases.
- perform initial sizing and refined checks of a lightweight semi-monocoque structure for stiffness, strength and stability at part, section, element and detail levels.
- understand the function of various types of mechanisms within mechanical and aeronautical systems; apply analytical and graphical methods and calculate idealised mechanism load transfers.
- gain experience of mechanism actuation and control.
- understand the organisation and management of teams
- clearly document and present technical design, build and test information.

Bb Information

- General
- Aerodynamics
- Structures
- Mechanisms
- Actuation & Control

- Methods
- Illustrations
- Design Data

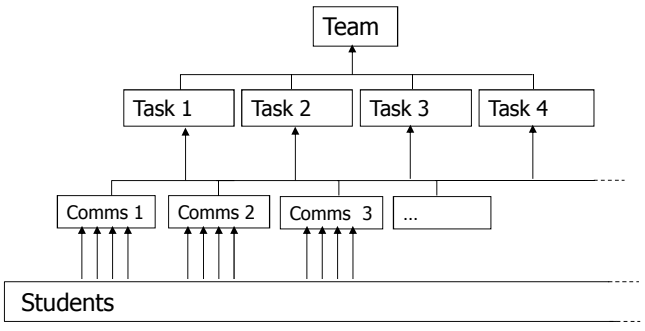
Method of working

- 4 Teams

  Within each team all students must:

  - individually carry out design and analysis in Aerodynamics, Structures Mechanisms, Actuation & Control using an A5 bound Log Book
  - work collaboratively within Comms groups, task groups and the team.

Team Organisation



Task = Task group
Comms = Communications group

Group Organisation

- Comms groups
  = Lab groups
- Task groups, e.g.:
  - Ally build
  - Foam build
  - 3D printing
  - Aero sensors
  - Mechanisms
  - Control
  - CAD & co-ordination
  - Document organisation & Portfolio
  - Etc.

Comms groups
must allocate specialities to members e.g.:
- Aerodynamics
- Structures
- Mechanisms & control
- Manufacture
- CAD & Co-ordination

Comms groups must spread members as widely as possible amongst the task groups

Groups and teams must be self-organised with clear delegation of tasks and responsibilities

Communication

Client : E-mail / Bb Announcements

Team : Social media, fileshare space

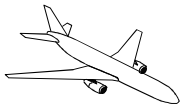
Assessment

- i = 35% Individual assessments
  Online tests on aerodynamics, structures and mechanisms
- C = 20%* Comms group reporting
  Executive summary + Executive review
- T = 45%* Team achievement and documentation
  Wing performance and Team final report

See SAFE for detailed breakdown

* Group and team items also include team member peer assessment

The design process



Stages		**"Concurrent design fields"**		
		Aerodynamics …		
Define		Material, Structure, Manufacture		… Mechanisms
Scheme*		~	~	~
Check	*Initial*	~	~	~
	Refined			
Trade-off		~	~	~

*Each Comms group to select a different initial trial scheme then check

Wing Design, Build & Test

- Based on Requirements for
  - Aerodynamic performance
  - Structural performance
  - Mechanisms, Actuation & Control performance
- See Formal Requirements doc for details

Design - Aerodynamics

Approach:

- Predict lift and drag for attached and separated conditions and consider *L & D* performance for take-off, flight mission and landing phases.
- For initial design use X-foil, an interactive program for the design and analysis of subsonic isolated aerofoils coupled with estimation + intuition
- For refined analysis use ESDU data sheets, based on theory and experiment (empiricism).

Design - Structures

Approach:

- Design for stiffness, strength and stability
- Using simple models at part, section and detail level use trial schemes and checks to confirm appropriate sizing at critical locations. Assess remainder of structure from beam loading distributions and a practical interpretation of local stresses.
- Refine analysis accounting for combined stress interaction, inelasticity and secondary effects at all critical locations.

Design – Mechanisms …

Approach:

- Scheme hinges and basic linkages to obtain required flap deployment.
- For initial design consider hinge lines and trajectory of flap for continuity of profile using CAD and check animation.
- For refined design check stiffness, strength and stability of linkage elements and supporting structure and consider accurate positioning (indexing?) and locking. Consider alignment, friction and losses in deformed loaded structure.

… Actuation & Control

Approach:

- Scheme actuation motors and gearing
- Scheme position sensing method and stops
- Scheme control logic
- Animate using CAD
- Bench test

Design - General

- Trade-off!
- Commit to design
- Retrospectively perform further refined and detailed checks

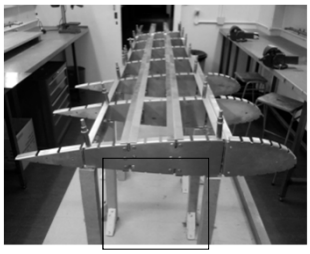
Build

- Assemby jigs
- Metal Cutting, drilling, folding…riveted / bonded assembly
- Hot-wire foam cutting
- 3D printing of mechanisms and fittings
- Laser cutting of mechanisms and fittings

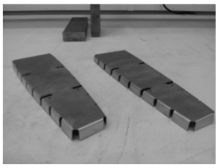
Build - now simplified!

Note, you will be building a starboard wing as shown.

[You may see a port wing prototype in the lab but note the photos here have been flipped to show it as starboard.]



Note, use jig plates connected to rib webs NOT posts connected to rib flanges as shown here



Test

- Aerodynamic
  - Wind tunnel – force cubes and pressure tappings
- Mechanisms & Control
  - CAD animation + bench testing + on-wing operation
- Structures
  - Loading frame – test to failure

Schedule