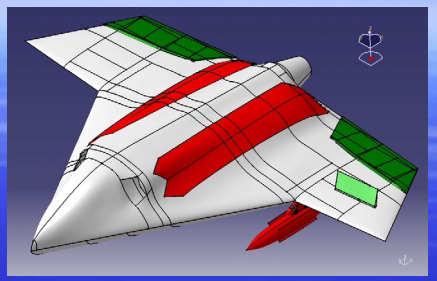
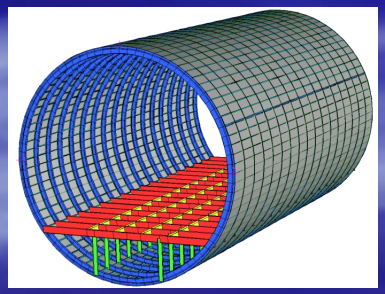
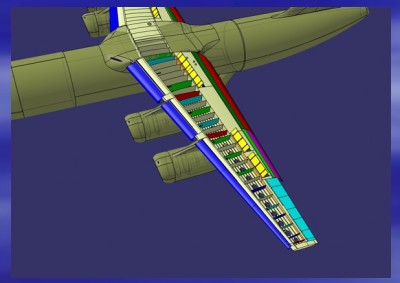
MSc Aerospace Vehicle Design



The Teaching of Aerospace Vehicle Design At Cranfield University



Mr. Phillip Stocking
Course Director



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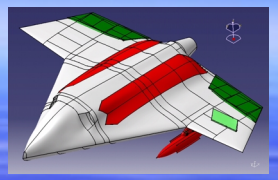

Course Director
Personal Background

- Undergraduate Apprenticeship with British Aerospace Filton, Bristol (1974-1979)
- BSc in Aeronautical Engineering Hatfield Polytechnic (1978)
- Stress Engineer with British Aerospace (1979-1984)
- MSc in Aircraft Design, Cranfield (1980-1981)
- Senior Stress Engineer, Cranfield (1984)
- Chief Stress Engineer, Cranfield (1990)
- Chief Designer Cranfield Aerospace Ltd (2001)
- Course Director MSc in Aerospace Vehicle Design (2003)

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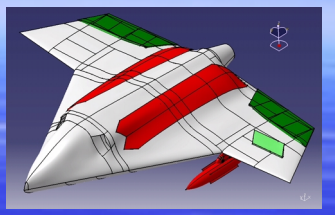
MSc Aerospace Vehicle Design

Presentation Contents

- Course History
- Course Aims
- Learning Outcomes
- Teaching/Learning Methods
- Assessment
- Course Structure
  - Taught Component
  - Group Design Project
  - Visits to Industry
  - Individual Research Project
- Student Destinations
- Conclusions



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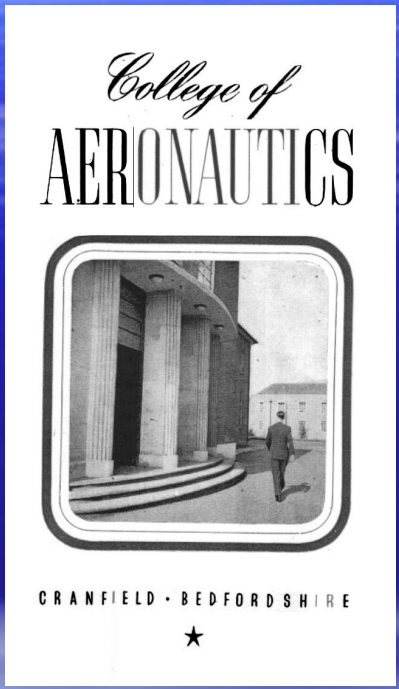

- **Course History**
- **College of Aeronautics established 1946**

'The College of Aeronautics has been set up by His Majesty's Government in the United Kingdom to provide high-grade engineering, technical, and scientific training in aeronautics to fit students for leadership in the aircraft industry, civil aviation, the Services, education and research'

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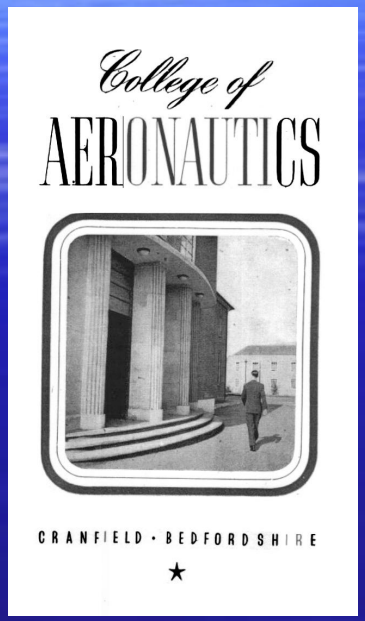
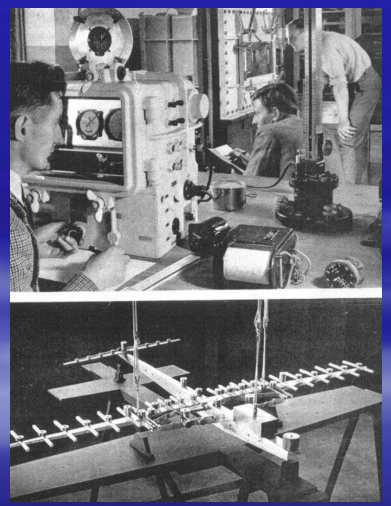
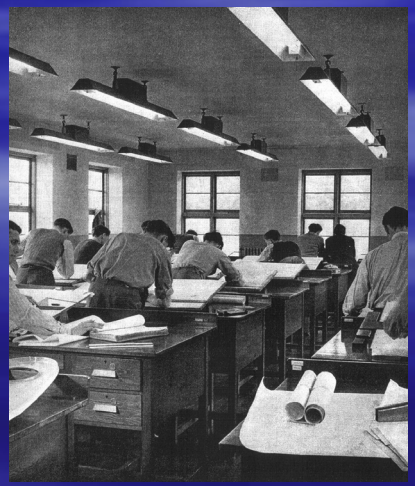
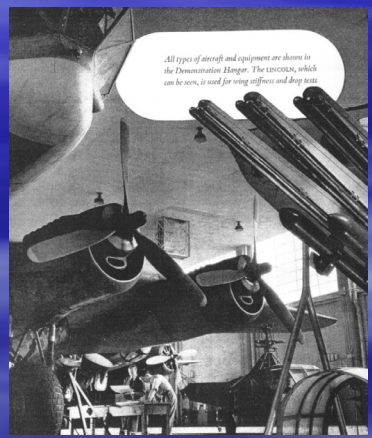


- **Course History**
  - **First Course in Aircraft Design 1946**
  - **Diploma of the College of Aeronautics**
  - **MSc in Aircraft Design (late 1970's)**
  - **MSc in Aerospace Vehicle Design (mid 1980's)**







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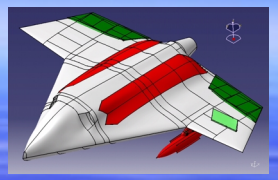

Course Aims

- To build upon the student's knowledge gained in their first degree
- To provide teaching that integrates the range of disciplines required by modern aircraft design
- To provide students with the opportunity to work in a Virtual Industrial Environment
- To enable students to undertake a piece of individual research

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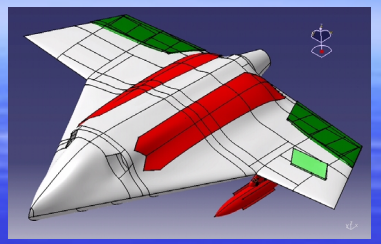
Intended Learning Outcomes (1) (Knowledge and Understanding)



- On successful completion of the course the student will be able to :-
  - Implement the principles of aerospace design related to aircraft performance, structures and systems
  - Understand up-to-date design techniques used in industry
  - Apply airworthiness requirements to aircraft design
  - Demonstrate a working knowledge of
    - stress analysis, fatigue & fracture
    - aerodynamics and loading
    - aircraft systems design and integration
    - structural design
  - Demonstrate the ability to undertake independent research on a subject relevant to aircraft design

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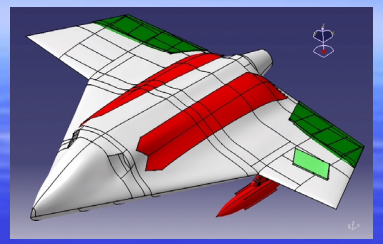
Intended Learning Outcomes (2) (Personal Skills)



- On successful completion of the course the student will be able to :-
  - Communicate effectively in a group environment
  - Plan, execute and manage projects
  - Undertake independent learning
  - Apply analysis tools to solve engineering problems
  - Present clearly proposals & results to a variety of audiences
  - Critically evaluate technical literature and data
  - Demonstrate a practical approach to solving design problems
  - Work effectively under time pressure
  - Seek employment with confidence

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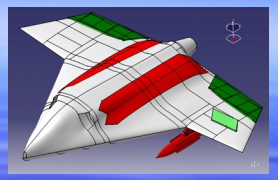

Teaching / Learning Methods And Strategy

The transfer of knowledge, the understanding and application are achieved through :-

- **Lectures, case studies, group exercises, computer based demonstrations & exercises**
- **Group Design Project and Research Project Thesis**
- **Lectures from industry specialists**
- **Visits to industry**

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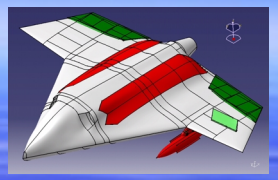

Assessment

- **Written examinations**
- **Group Design Project Thesis**
  - **Peer Assessment**
- **Individual Research Project Thesis**
- **Oral Examinations**

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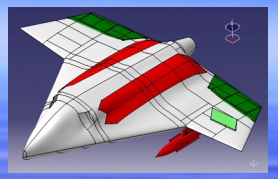

Course Structure

Aerospace Vehicle Design – Group Project Option

Taught Component	10%
Group Design Project	50%
Individual Research Project	40%

Aerospace Vehicle Design – Structural Design Option

Taught Component	20%
Individual Research Project	80%

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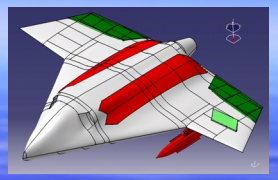
Taught Component



- **Lecture Modules**
  - **Core Subjects**
    - **Loading Actions**
    - **Aerodynamics & Performance**
    - **Stress Analysis**
    - **Composite Materials**
    - **Fatigue & Fracture**
    - **Aeroelasticity**
    - **Design for Manufacture & Operation**
    - **Initial Aircraft Design**
    - **Airframe Systems**

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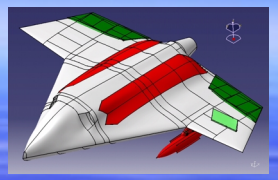
Taught Component



- **Lecture Modules**
  - **Optional Subjects**
    - **Computer Aided Design (CATIA)**
    - **Finite Element Methods (NASTRAN/PATRAN)**
    - **Structural Stability**
    - **Accident Investigation**
    - **Crashworthiness**
    - **Avionic System Design**
    - **Powerplant Installation**

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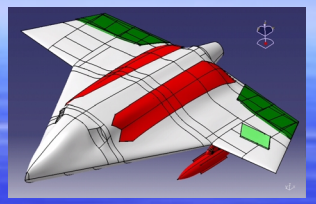
Taught Component

Tutorials & Flight Laboratory



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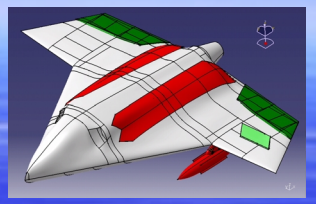
Taught Component



Flight Simulator Tutorials

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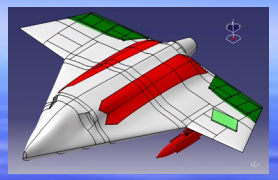
Group Design Project



A Problem Based Learning Environment

and

A Virtual Industrial Learning Environment

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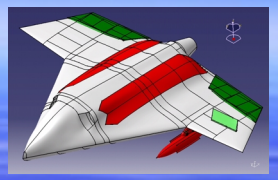
Group Design Project



A Problem Based Learning Environment……

- **The Group Design Project is a real and engaging problem**
- **Students are given the problem before they have the skills to solve it**
- **Students have to actively acquire the knowledge they need to solve the problem, and then apply it**
- **Students are learning to learn**

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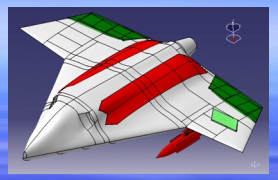
Group Design Project



A Virtual Industrial Learning Environment……

- **Made as authentic as possible**
- **Places the student group in the professional role as aerospace design engineers**
- **Industry standard software**
  - **CATIA**
  - **NASTRAN / PATRAN**
- **ESDU, MMPDS, MIL-STD, JAR's, DEF-STAN, CS**
- **Rapid Prototype / Wind Tunnel Testing**

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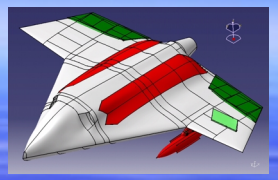
Group Design Project



Design Process

The Group Design Project

- Conceptual Design Phase
- Preliminary Design Phase
- Detail Design Phase
- Manufacture

Work completed by Cranfield University Staff

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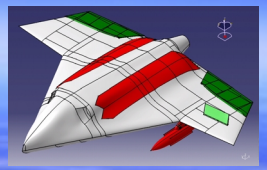
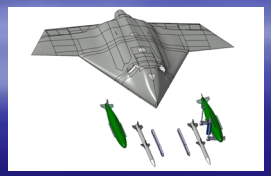
Group Design Project

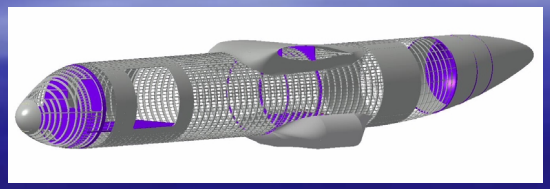


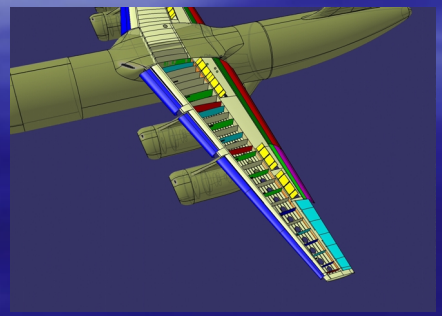
Aircraft Conceptual Design Specification

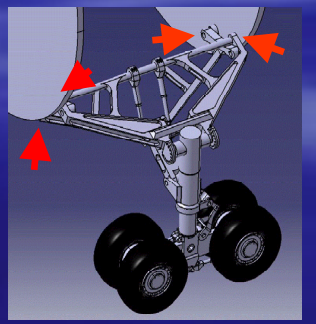
Lecture Modules → **Group Design Project** ← **Visits to Industry**

Lectures from Industry Specialists









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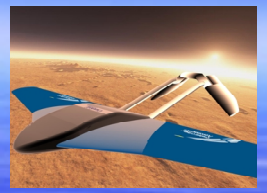
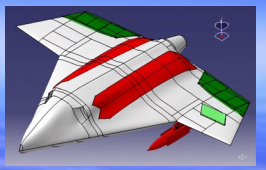
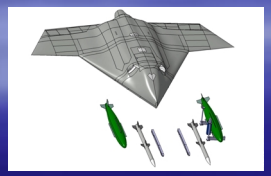
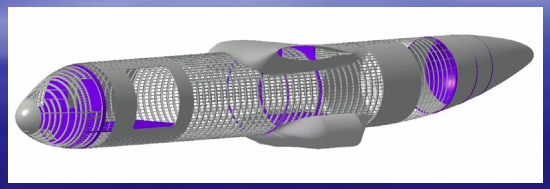
Group Design Project

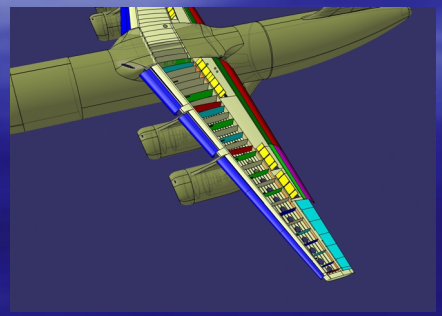


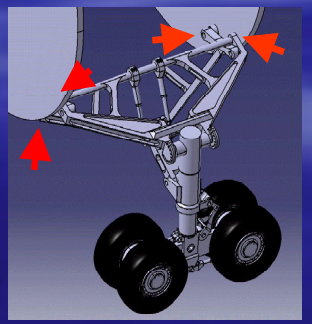


- Aerodynamics & Performance
- Fatigue & Fracture
- Airframe Systems
- Loading Actions
- **Group Design Project**
- Design for Manufacture & Operation
- Stress Analysis
- Composite Materials
- Aeroelasticity
- Initial Aircraft Design









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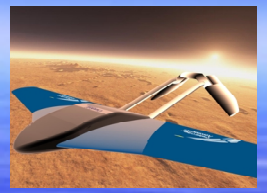
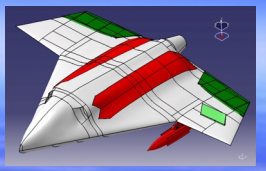
Group Design Project





Group Presentation to External Examiners Preliminary Design Review

Individual Viva Examination

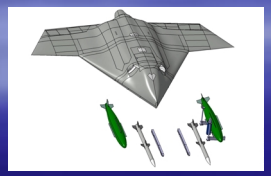
Group Presentation To Industry Critical Design Review

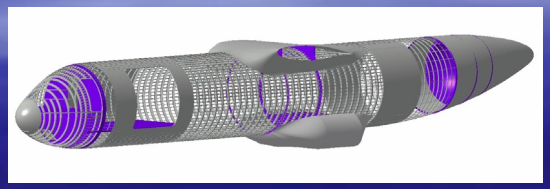
Individual Project Design Theses

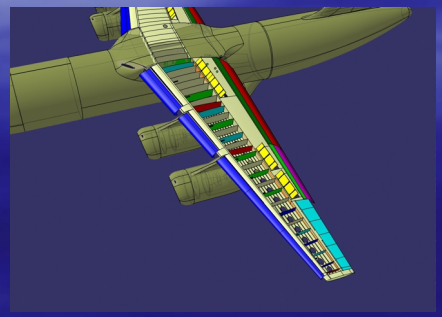
Group Design Project

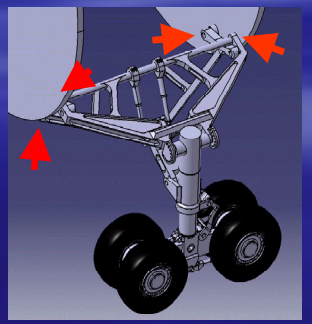
34,000 man hours
27 GB of data
6,600 pages of text
60 Engineering Drawings

Wind Tunnel Model And Test Results









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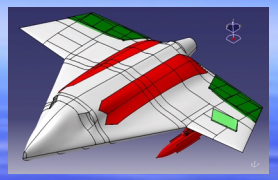

Design Organisation

Chief Engineer
Deputy Chief Engineer

Structures Design Group

1) Symmetrical loading team
2) Asymmetrical loading team
3) Wing, Aileron & Flap loading team
4) Landing Gear loading team

Systems Design Group

1) Fuel, ECS, Propulsion, Hydraulics & Secondary Power team
2) Flight Control and Avionics team
3) Cabin, Flight Deck, Synthetic vision team
4) Performance & Cost, R&M, Laminar Flow team

Additional Design Tasks Group

1) Project Monitoring team
2) CAD team
3) Wind Tunnel Model and Testing team

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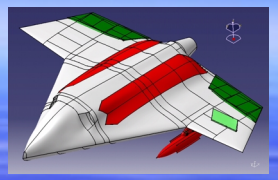

Weekly GDP Meetings Typical Agenda

- Project Monitors Presentation — **Project Plan, risk register, Interface Issues, List of Actions**
- CAD Team Presentation — **Configuration Control of Aircraft Master Model**
- Wind Tunnel Model Team Presentation — **Progress, Wind Tunnel Problems, Test Results**
- Structures Design Group → Student Individual Presentations
- Systems Design Group → Student Individual Presentations — **Student presentations**

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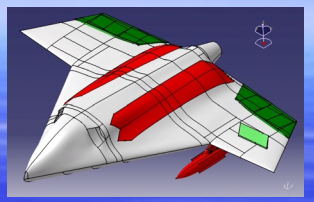
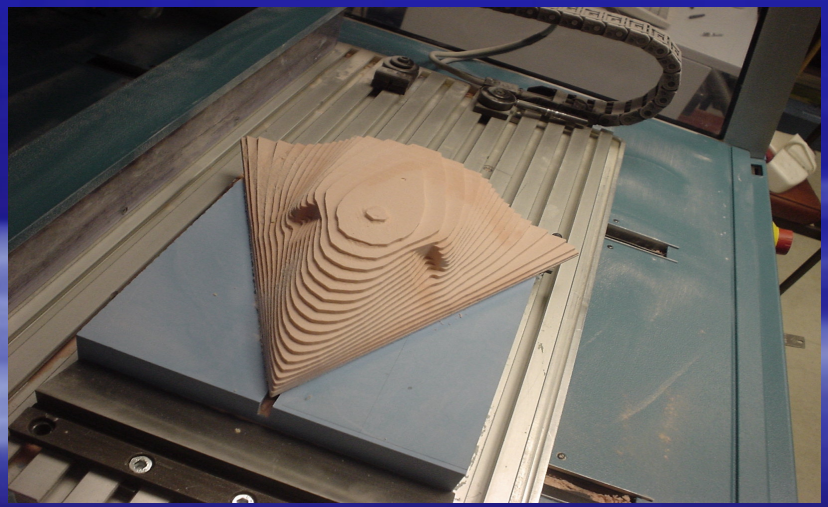
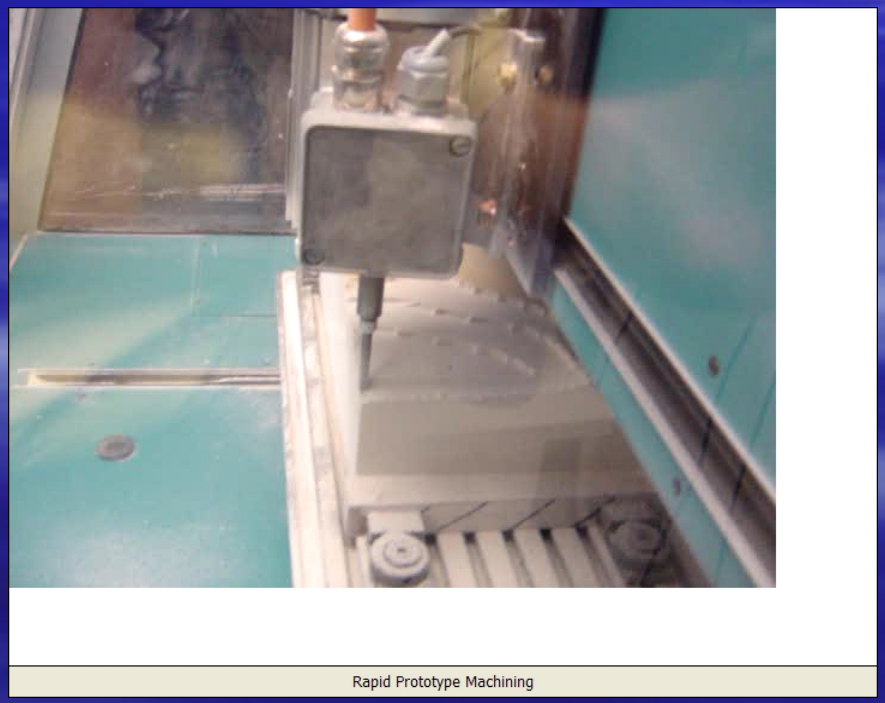
Group Design Project



- Rapid Prototyping Facility
- Manufacture of Wind Tunnel Models
- CATIA to Machining





Rapid Prototype Machining

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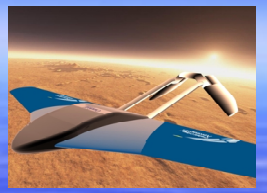
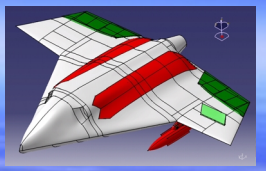
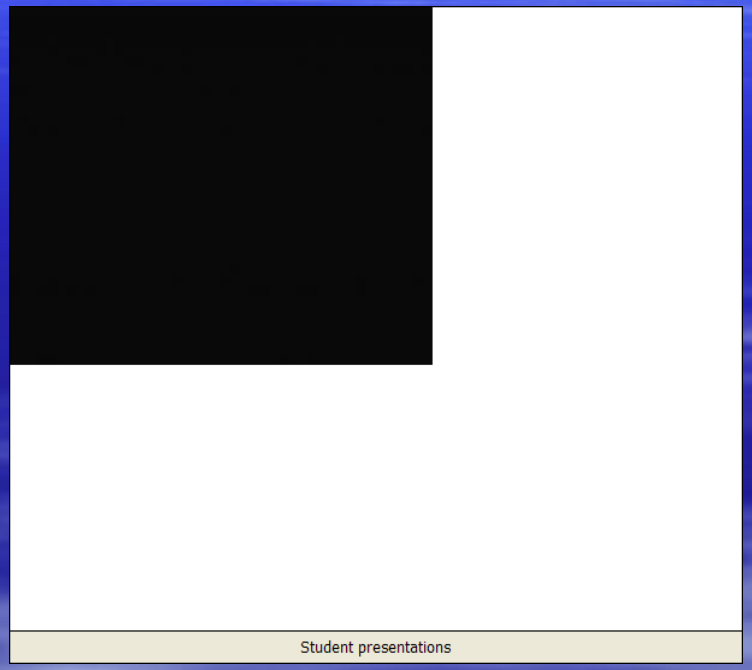
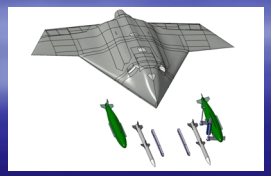
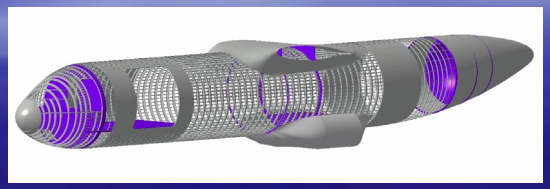


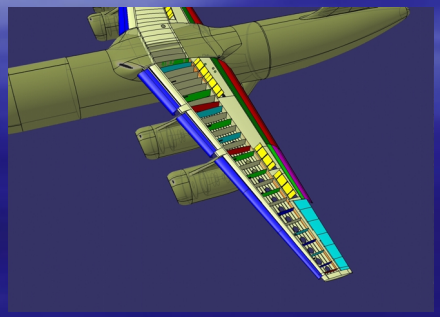


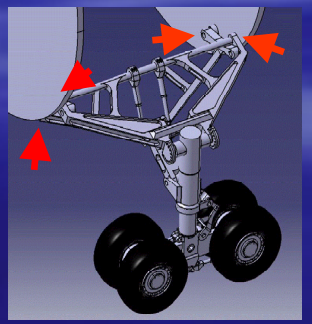
- 2002/03 Large Civil Cargo Aircraft
- 2003/04 Unmanned Combat Aircraft
- 2004/05 MARS Flight Vehicle











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Group Design Project 2002-2003

F02 Civil Freight Aircraft

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Group Design Project 2002-2003
F02 Civil Freight Aircraft

- Civil Version of the A400M
- 30 to 40 Tonne payload
- 2000 nm range
- MTOW 116500kg

- M0.7 Cruise at 10km
- Designed to JAR 25

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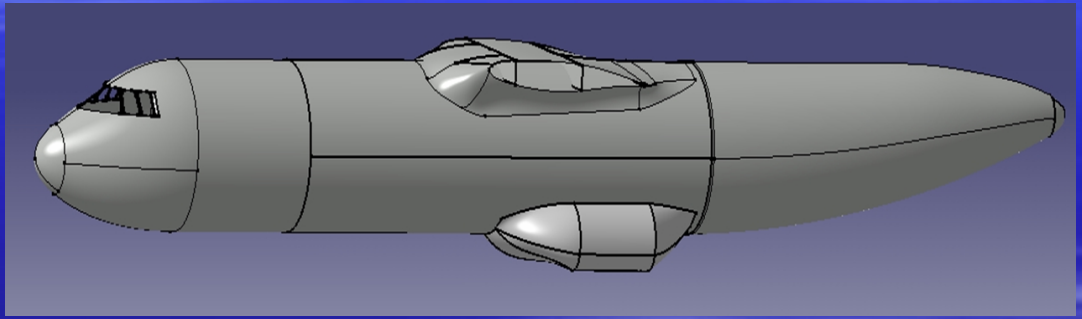
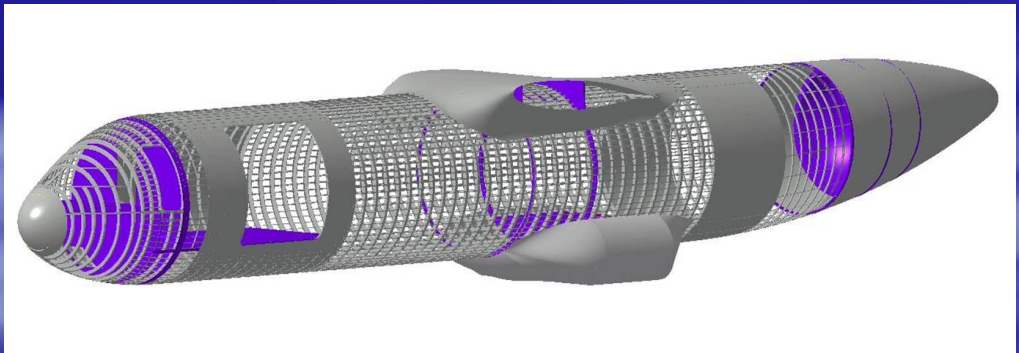
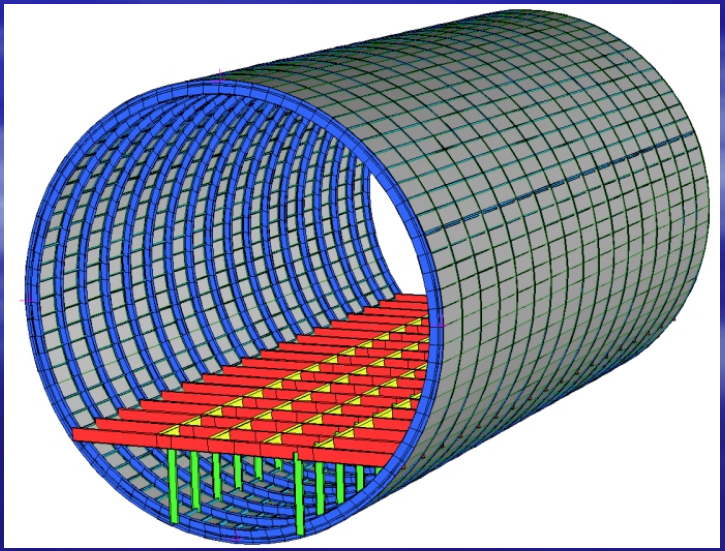
Group Design Project 2002-2003
F02 Civil Freight Aircraft

- Fuselage Length 41 m
- Freight hold Length 28 m
- Fuselage Diameter 5 m







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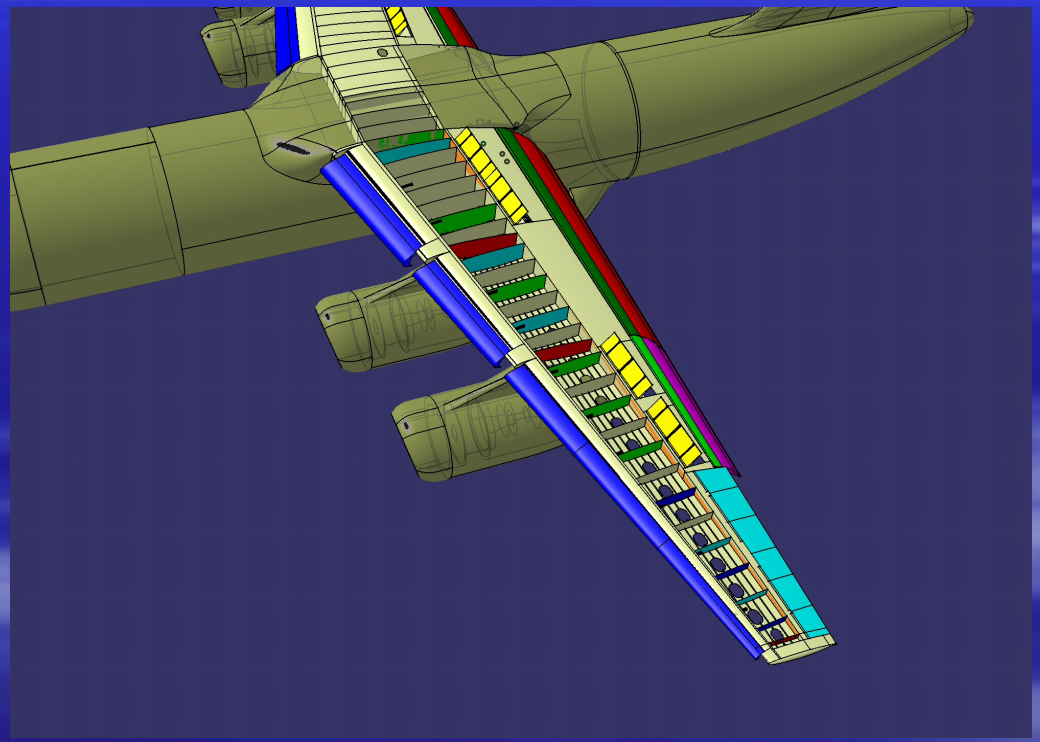
Group Design Project 2002-2003
F02 Civil Freight Aircraft

- Wing Span 47.4 m
- Propulsion
  - Rolls Royce BR 715-58 Turbofan



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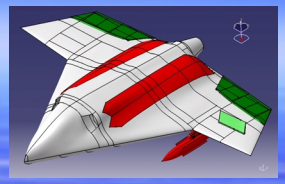
Group Design Project



- Wind Tunnel Testing

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Group Design Project 2003-2004

U-3 ‘Spectre’ Joint Services Unmanned Combat Air Vehicle

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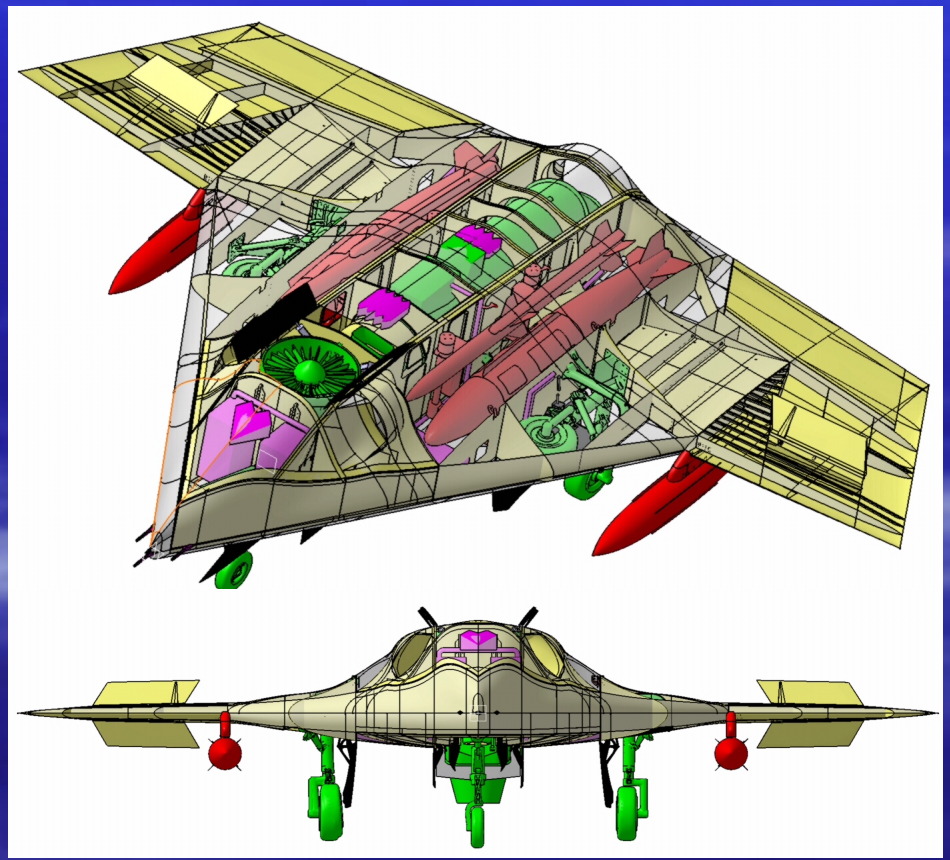
Group Design Project 2003-2004
U-3 ‘Spectre’ Joint Services Unmanned Combat Air Vehicle



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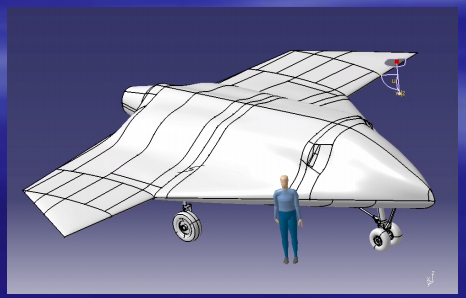
Group Design Project 2003-2004
U-3 ‘Spectre’ Joint Services Unmanned Combat Air Vehicle

- Intended for service with all branches of the military
- Mixed fleet operations
  - 1 JSF to 3 UCAV’s
- Three aircraft variants
  - CTOL
  - STOVL
  - CV



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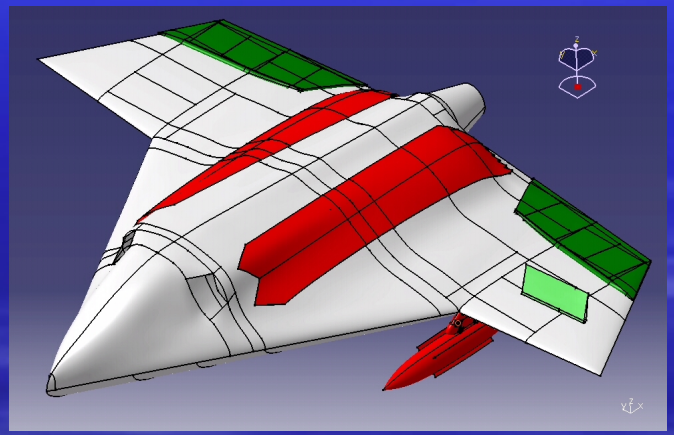
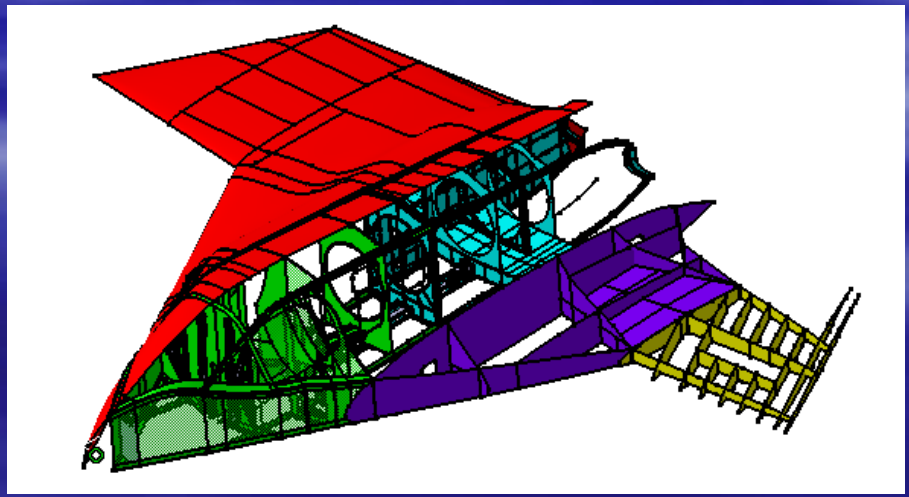
Group Design Project 2003-2004
U-3 ‘Spectre’ Joint Services Unmanned Combat Air Vehicle

- VLO Strike / SEAD
- Persistence Mission
- Surveillance / Targeting

- M0.85 at 250 ft
- Ceiling > 40,000 ft
- Wing Span 10 m
- MTOW 11780 kg





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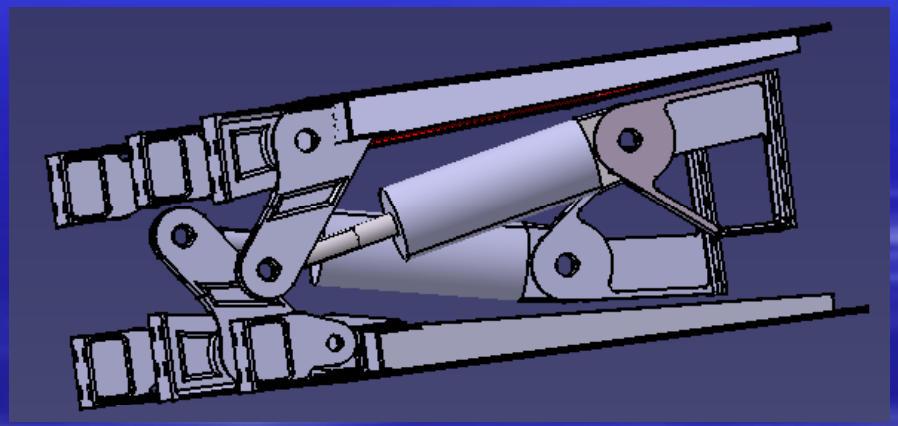
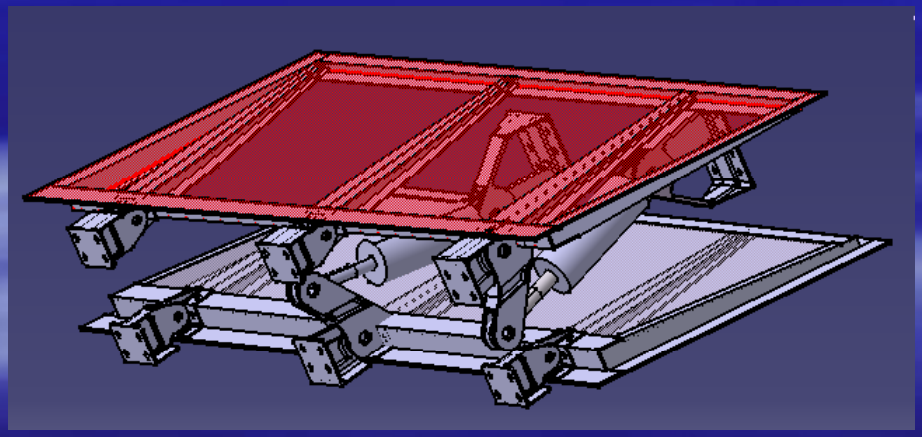
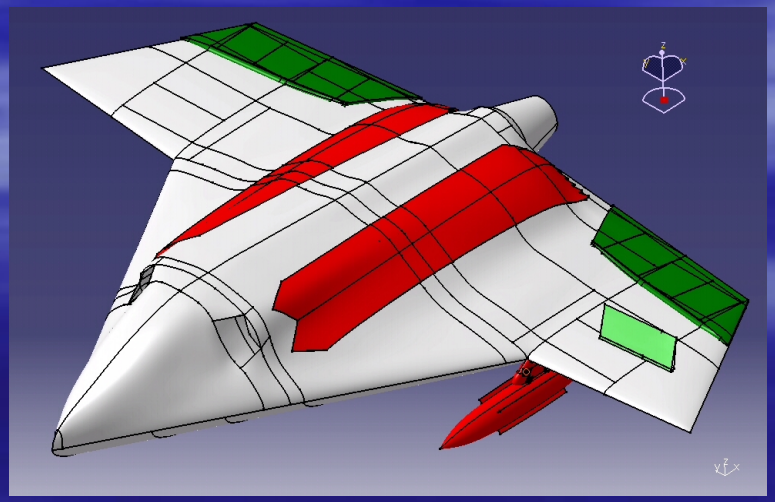
Group Design Project 2003-2004
U-3 ‘Spectre’ Joint Services Unmanned Combat Air Vehicle

- Inlayed Control Effectors (ICE)
- Type – Plain Spoiler
- Movement 60 deg







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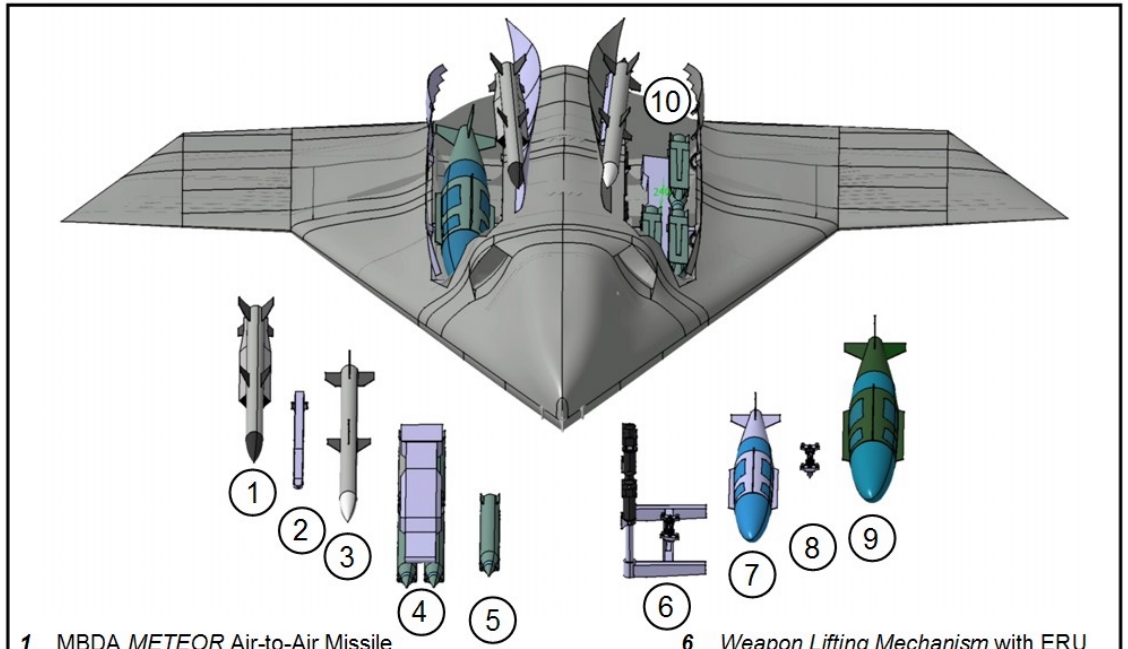
U-3 'Spectre' Joint Services Unmanned Combat Air Vehicle

U-3 Weapons System



1	MBDA *METEOR* Air-to-Air Missile	**6**	*Weapon Lifting Mechanism* with ERU
2	LAU-128A Digital Launch Rail	**7**	GBU-32 *JDAM* (1,000 lb)
3	AIM-120C *AMRAAM* Air-to-Air Missile	**8**	ERU
4	BRU-61/A Quadruple *Small Diameter Bomb* Carrier	**9**	GBU-31 *JDAM* (2,000 lb)
5	GBU-39/B *Small Diameter Bomb*	**10**	Triple GBU-39/B SDB installation

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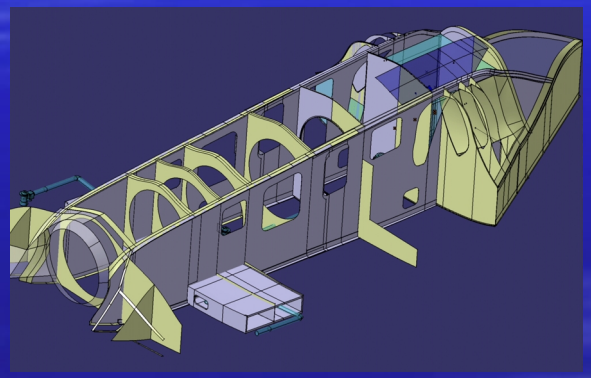
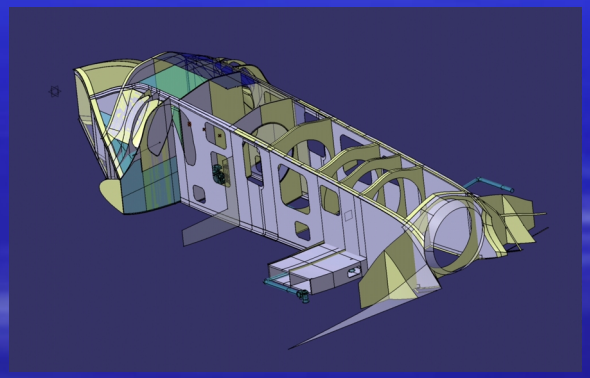
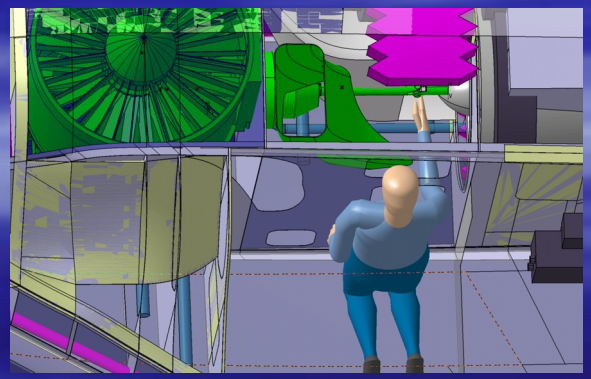
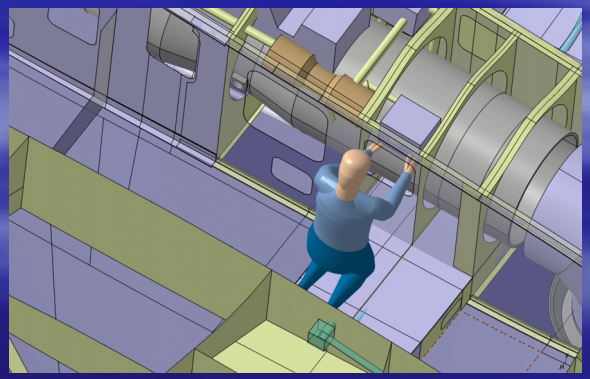
U-3 ‘Spectre’ Joint Services Unmanned Combat Air Vehicle

Systems Accessibility And Maintainability









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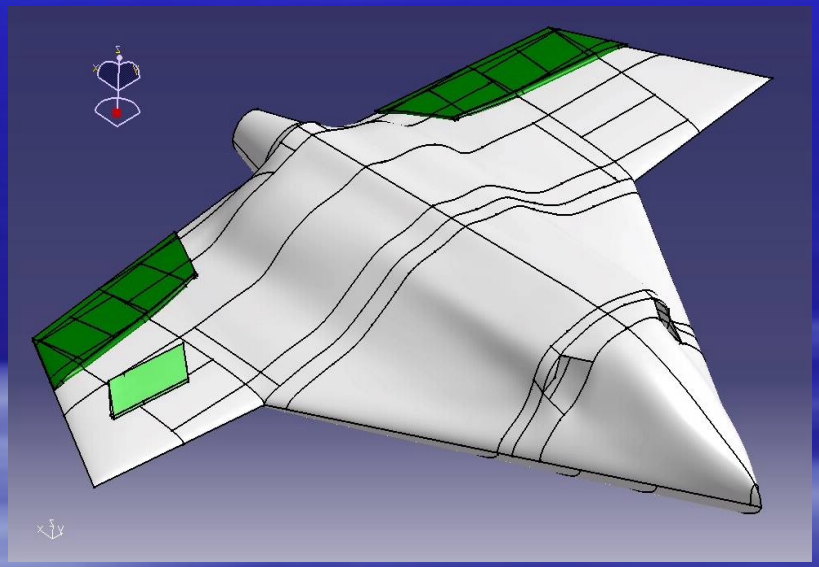
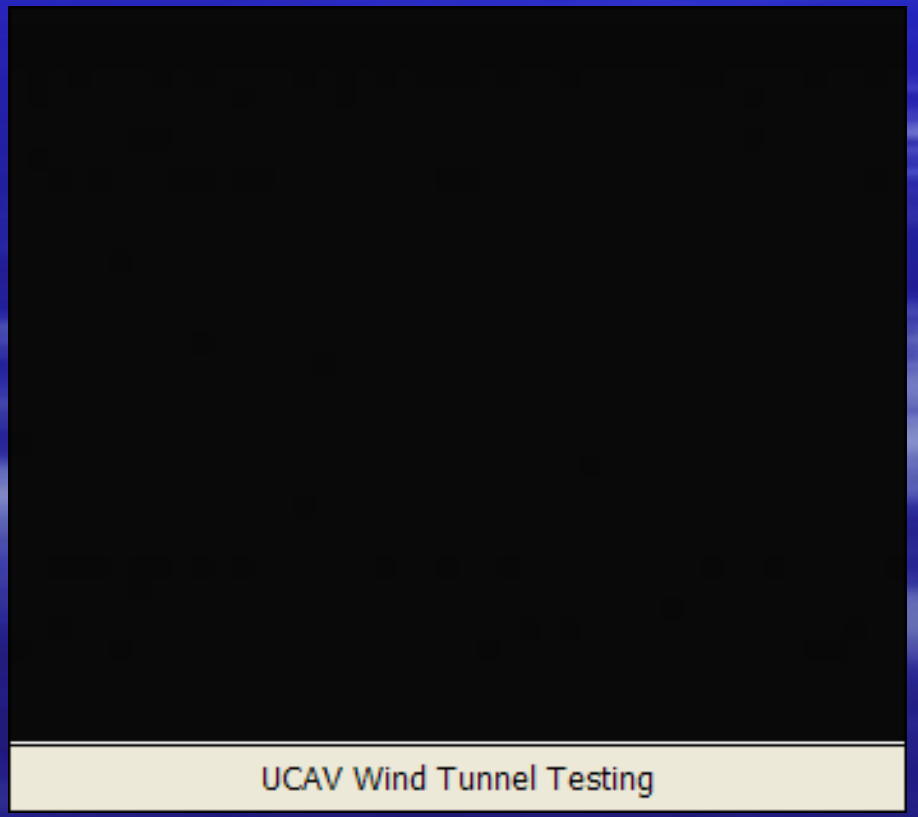
U-3 ‘Spectre’ Joint Services Unmanned Combat Air Vehicle

Wind Tunnel Testing





UCAV Wind Tunnel Testing

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Group Design Project 2004-2005

M4 Martian Atmospheric Flight Vehicle

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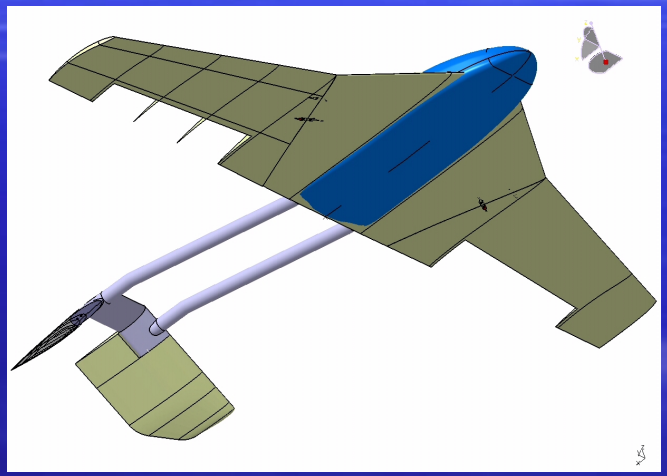
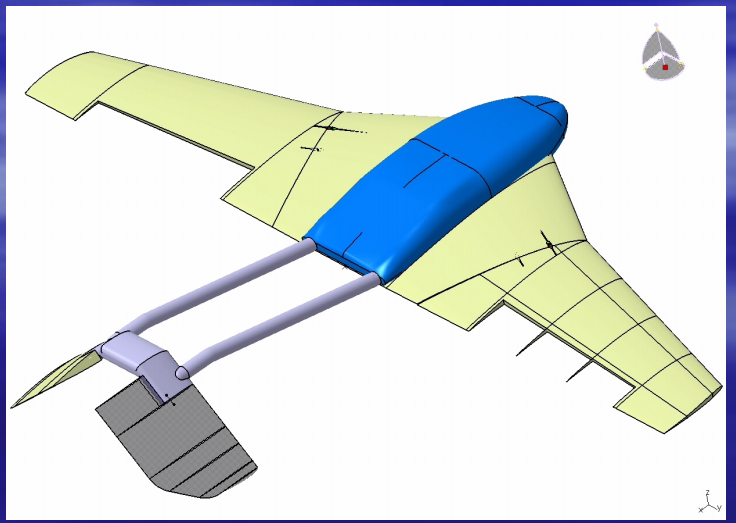
Group Design Project 2004-2005
MARS Atmospheric Flight Vehicle

An Atmospheric Flight Vehicle for The Robotic Exploration of Mars



- Designed to fill the gap between Orbiters and Landers
- High resolution mapping from low altitudes



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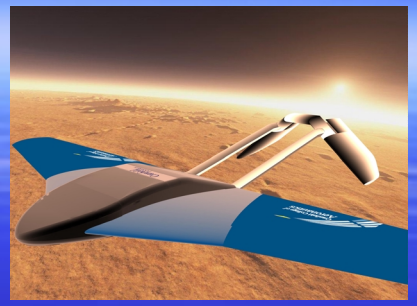
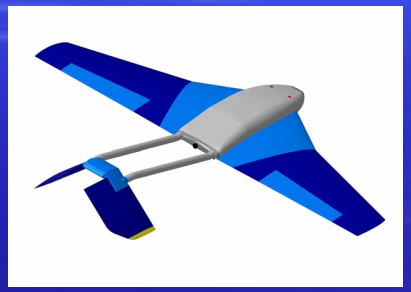
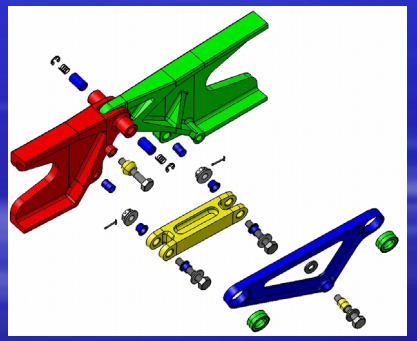
Group Design Project 2004-2005
MARS Atmospheric Flight Vehicle

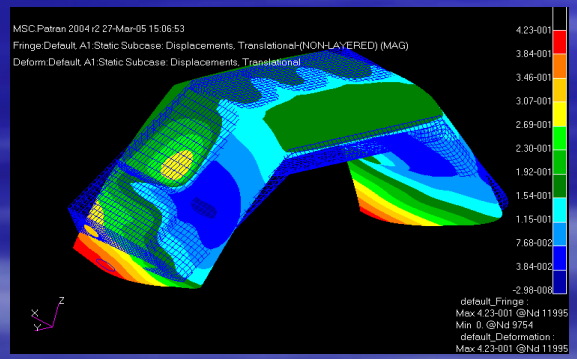


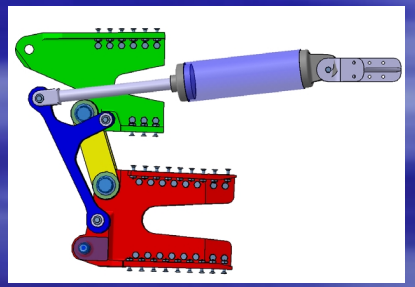
- Launch Vehicle – Delta II
- 10kg science payload
- Up to 6km altitude
- Endurance up to 75 minutes
- Range up to 620km





- Length 4.4m
- Wingspan 6.18m
- Design Launch Mass 141.5kg
- Propulsion – Aerojet reaction control thrusters





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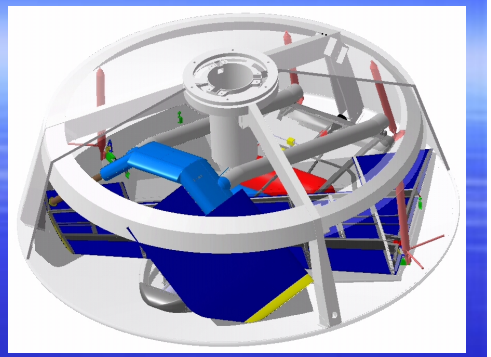
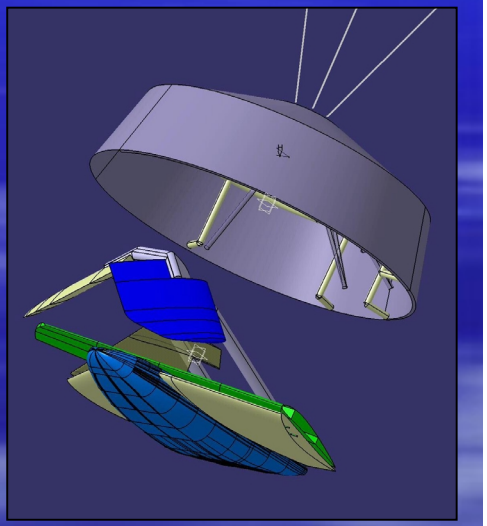
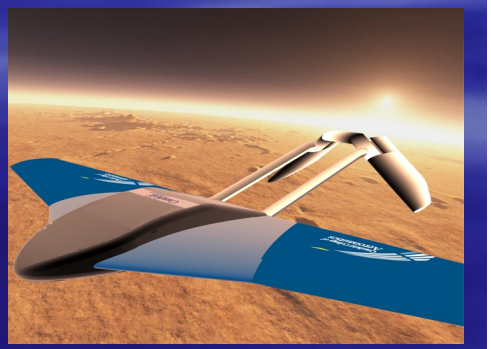
MARS Atmospheric Flight Vehicle







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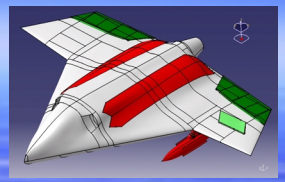
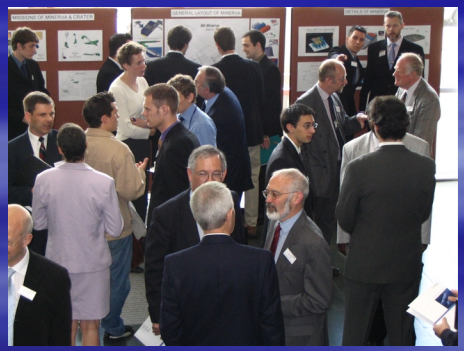
Group Design Project



Presentation to Industry



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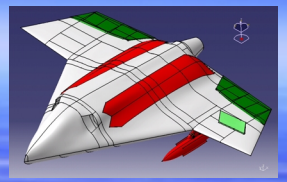
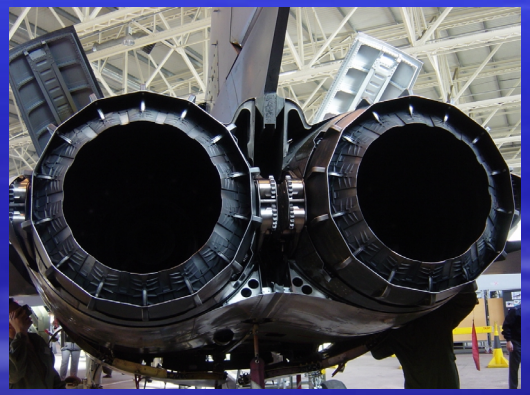
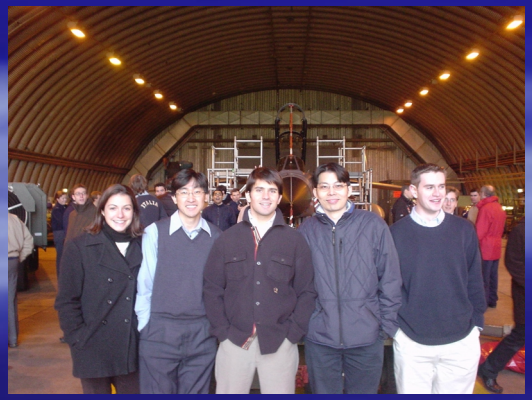
Visits to Industry



Visit to RAF Marham – Tornado Squadron





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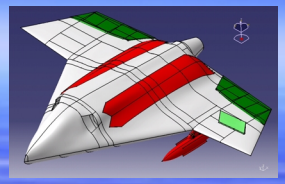
Individual Research Project



Thesis Topics

- **Conceptual Design**
- **Structures**
- **Systems**

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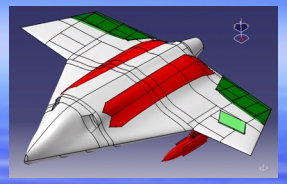
Student Destinations



Upon successful completion of the course,
Typical student destinations include :-

- BAE SYSTEMS
- Airbus (UK and Europe)
- Dassault
- Messier Dowty
- Royal Air Force
- Royal Australian Air Force
- Royal Australian Navy
- Royal New Zealand Air Force
- Greek Air Force
- Doctorate PhD programs

- FLS Aerospace
- Canadian Air Force
- Rolls Royce
- STRAND Engineering
- Magellan Aerospace
- Marshall Aerospace
- UK MoD
- Air France Engineering
- Air France Pilot
- MEDYSYS

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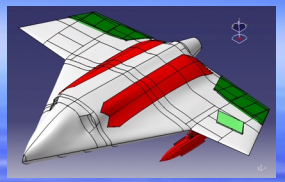
Conclusions



- **The Group Design Project provides……**
  - **An example of Problem Based Learning at Masters Level for the teaching of Engineering Design**
  - **An Authentic Virtual Industrial Environment**
  - **A ‘hands-on’ learning experience of interacting with and working on an Aircraft Design Project**
  - **Enjoyable, self-motivated and enthusiastic student participation in all aspects of the course**
  - **Students with the confidence to seek employment and make an immediate contribution to the work of an employer**

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