

# Short Course

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## High Performance Composite Structures and Components

### - Materials, Design and Manufacturing Techniques:



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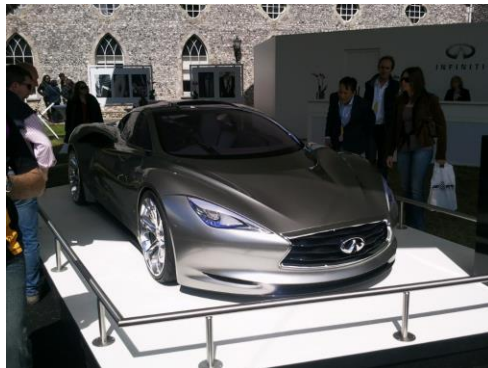
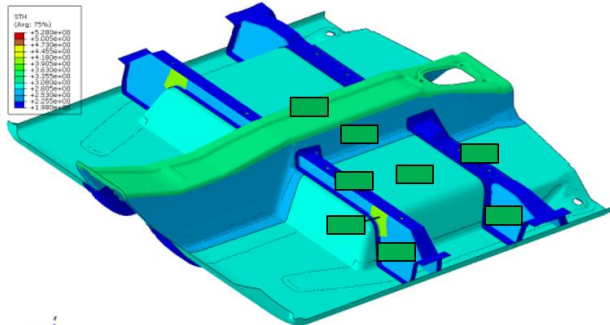


# Scope and Topics:

- Benefits of using high performance composite materials using case studies
- Materials forms – fibres, plastics and core materials
- Processing requirements and targets
- Materials and process technique selection through application requirements
- High rate manufacturing techniques
- Manufacturing techniques for weight optimised high performance structures
- Thermoplastic composites manufacturing
- Materials and process selection engineering tool demonstration with manufacturing cost and weight comparisons
- Joining and assembly best practice - design and techniques
- Mould tool design and materials
- The design process – Demonstration of the stages of structural design from application concept to manufacturing instructions
- Case studies of best practice design and manufacturing from the automotive, motorsport, aerospace, marine, wind energy and sports equipment sectors.
- Laboratory manufacturing process demonstrations - Prepreg lay-up, vacuum infusion, compression moulding.

# Vehicle Light-weighting Projects - Examples of Cranfield designed and developed structures

Expert Design, manufacturing technology & product development partnership through 37 years of lightweight structures engineering research and applications development



# Manufacturing Laboratory

- Autoclave
- Hot Presses
- Ovens
- Collaborative assembly robot
- RTM systems
- Vacuum Infusion
- Polymer ALM
- Polymer injection moulding
- Clean room
- Machining room
- Structural test laboratory





# Cranfield Materials and Process Selection Software Tool

<https://www.prosel.co.uk/>

PROSEL

- **Selection** of suitable composite M&Ps by interactively working through new applications design and manufacturing requirements

PROSEL provides:

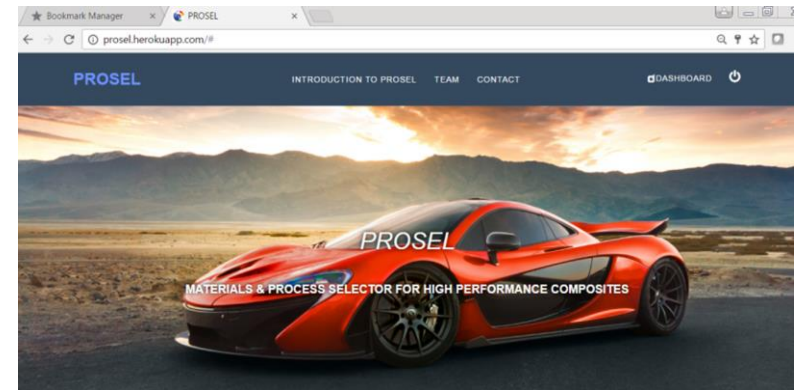
- **Capable materials and processes**
- **Component weight and manufacturing cost comparison** for each recommended M&P option

## 1<sup>st</sup> Stage Design Page

A world-first interactive design tool developed within the UK Composites Industry Cluster CIC



## Home Screen



## PROSEL Output Page Example

### Recommended Materials & Processes – Sports Car Roof

Name	Process	Weight	ToolName	Tool cost	Labour cost	Material cost	Total cost
Automated UD Tape Lay Up: and DGF	730 Prepreg Compression Moulding	3.8	Type6 - Double sided steel press tool - Prepreg or Wet Pressing	£ 6	£ 0	£ 189	£ 200
CFBMC High Fib plus fiber Quantum	Moulding compounds Press Moulding	5.9	Type11 - Hardened matched surface steel - CFBMC	£ 10	£ 2	£ 243	£ 255
Gurt Sprint CB5200	Prepreg Compression Moulding	5	Type6 - Double sided steel press tool - Prepreg or Wet Pressing	£ 6	£ 11	£ 503	£ 520
chopped PP thickness 3mm	Moulding compounds Press Moulding	6	Type11 - Hardened matched surface steel - CFBMC	£ 10	£ 2	£ 153	£ 165
NCF	Compression RTM (aka Gap RTM) with automated preforming	4.8	Type15 - Compression RTM or HP RTM - precision aligned and sealed tools	£ 14	£ 3	£ 99	£ 116
NCF	High Pressure RTM with Automated Preforming	4.8	Type15 - Compression RTM or HP RTM - precision aligned and sealed tools	£ 14	£ 3	£ 102	£ 119
Signatex (reconstituted) Chopped / UD NCF Hybrid 50% 50%	Compression RTM (aka Gap RTM) with automated preforming	5.6	Type15 - Compression RTM or HP RTM - precision aligned and sealed tools	£ 14	£ 2	£ 89	£ 85
UD CF Tape with CFBMC	Moulding compound with UD tape press moulding	4.2	Type11 - Hardened matched surface steel - CFBMC	£ 10	£ 2	£ 108	£ 121
UD Tape HS fibre	Prepreg Compression Moulding	4	Type6 - Double sided steel press tool - Prepreg or Wet Pressing	£ 6	£ 21	£ 203	£ 230
Woven	Compression RTM (aka Gap RTM) with automated preforming	5.1	Type15 - Compression RTM or HP RTM - precision aligned and sealed tools	£ 14	£ 4	£ 126	£ 144



## Previous Automotive Projects

Some examples from un-confidential projects  
– mainly joint industry and EPSRC or Innovate funded collaborative projects

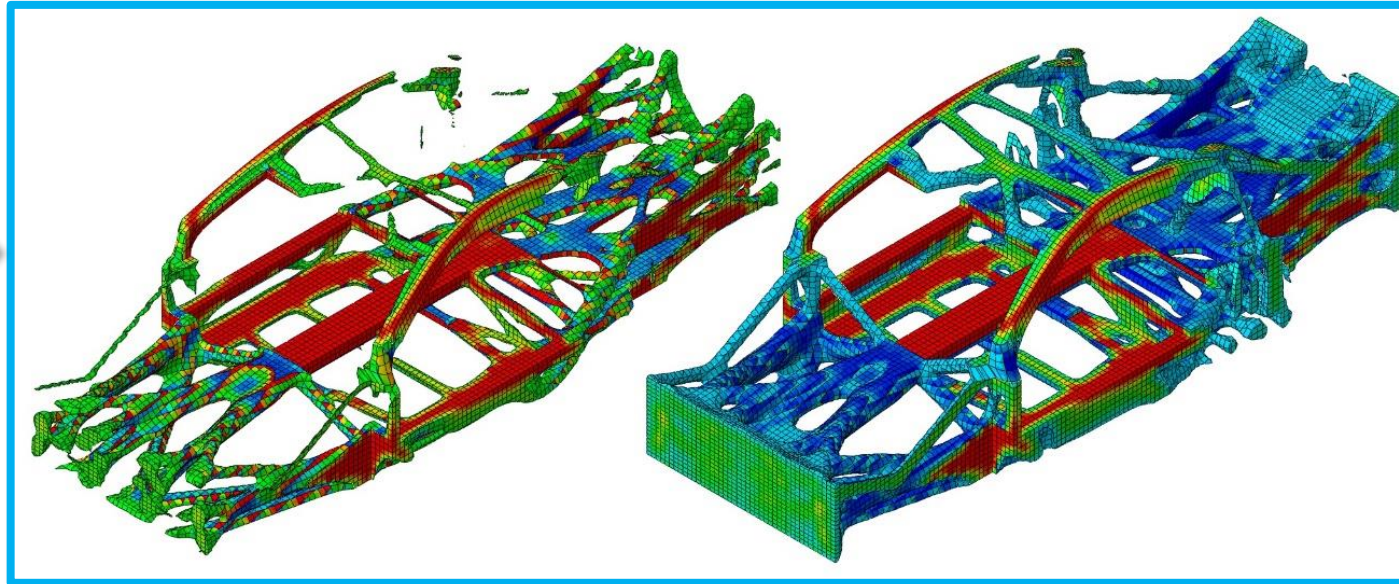
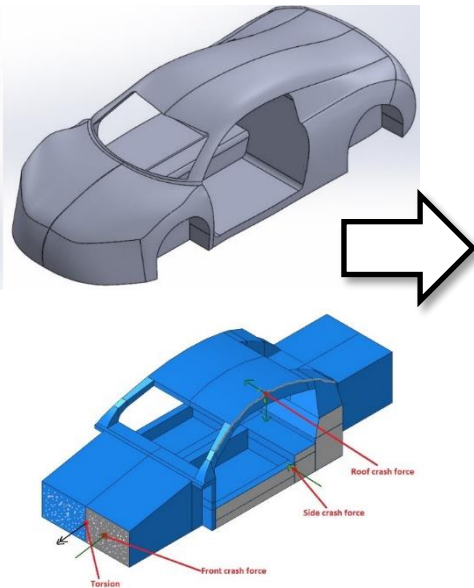
# CFC Sports Car Framework

## Loading and lay out study

### Structural Lay out and Optimisation

Based on the Audi R8 sports car design space

Optimised shape generated from multiple loading scenarios

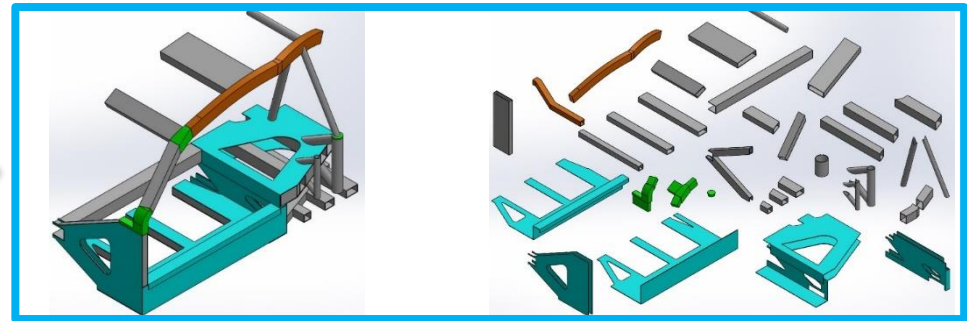


# Sustainable and Light-weight Car Framework

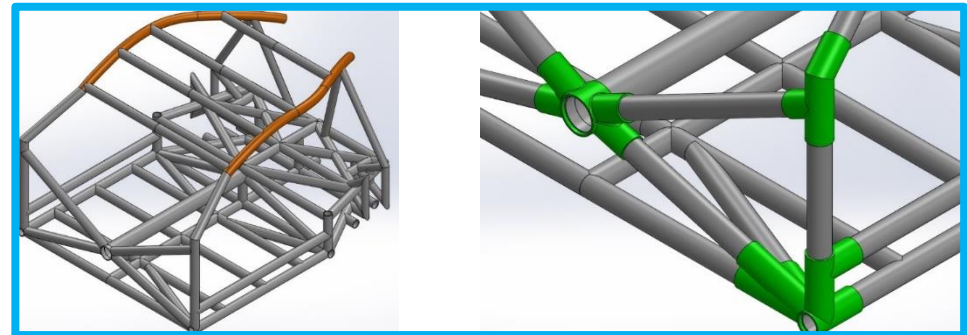
– Thermoplastic CFC Body Structure  
Design and Manufacturing Concepts

## High volume production structural options

### Welded TPCFC Pressings



### Welded TPCFC Tubing and Aluminium Cast Joint Pieces



Both options utilise CF TP matrix laminates and profiles

– constant thickness allowing continuous manufacturing and localised forming

Novel Cranfield conceived TPRC joint welding techniques allow high rate frame assembly without adhesives

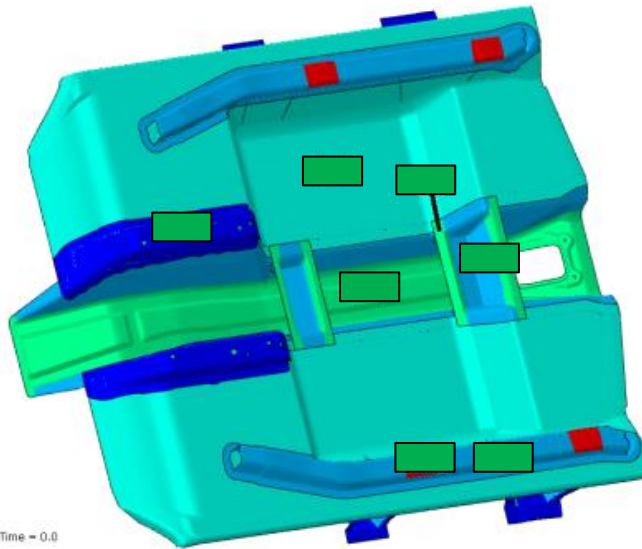
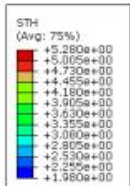


# E-Vehicle Composite Platform Concept

## Innovate UK LX Project

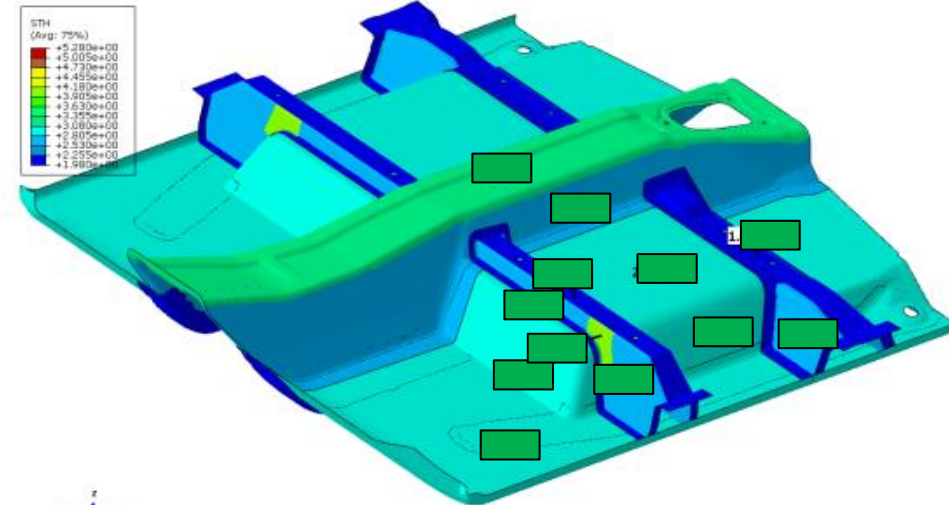


With Engenuity, Liberty  
Composites, Expert  
and Sigmatex



Step: Step-1  
Increment 0: Step Time = 0.0  
Primary Var: STH

OC6: Phase2\_e3\_run.odb Abaqus/Explicit 6.14-3 Tue May 10 16:22:00 GMT Daylight Time 2016



Phase: Phase-1



- This electric car platform was developed for a 50 000 per year rate, automated, manufacture, light-weight and crash safety
- With around 70% lower weight than the current steel design, the mixed recycled chopped and virgin fabric design has a manufacturing cost around 2X that of the steel design, but requires only 45% of the capital investment for equipment and tooling

# Infiniti Emerge – E

- With Nissan, Lola  
Composites and Concept  
Group International



**Upper body design  
using lightweight carbon  
fibre pre-preg**

Weight - 45 kg  
previous GRP body – 115kg



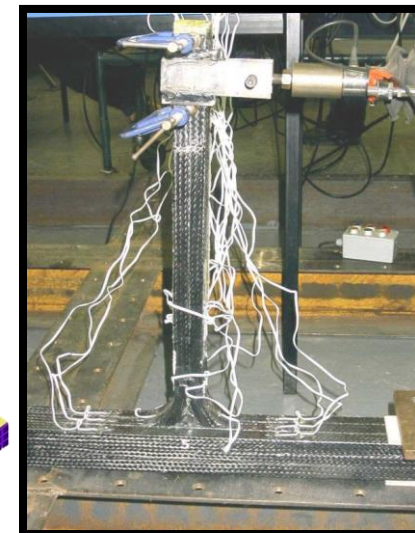
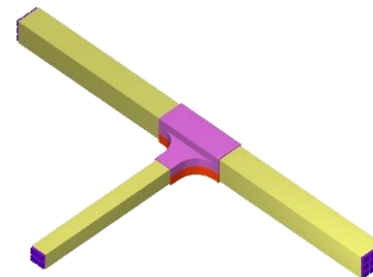
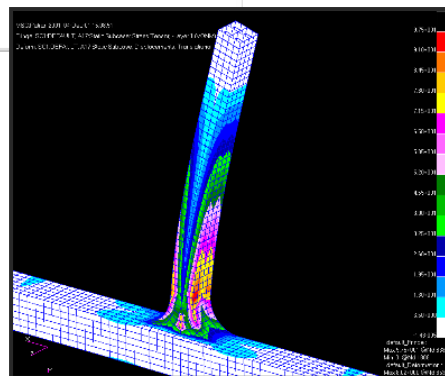
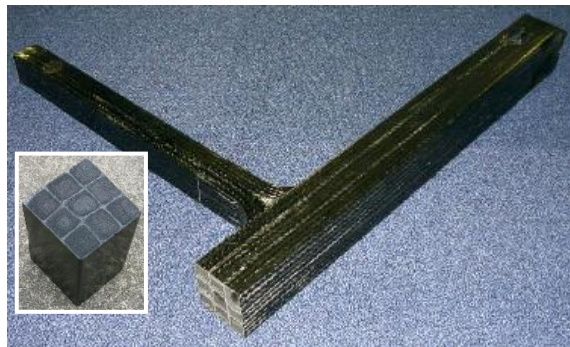
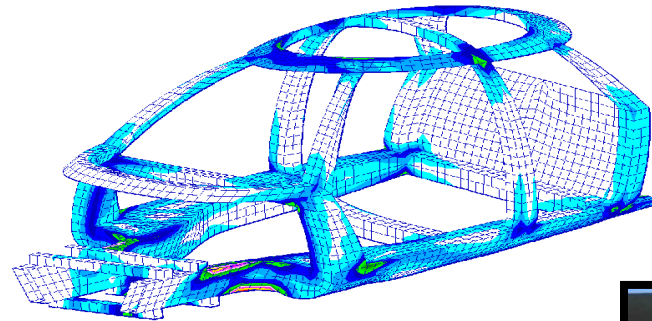
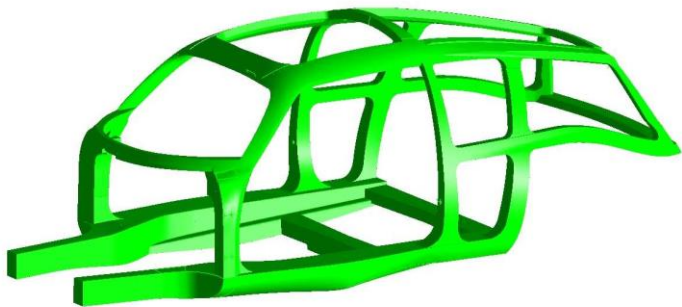
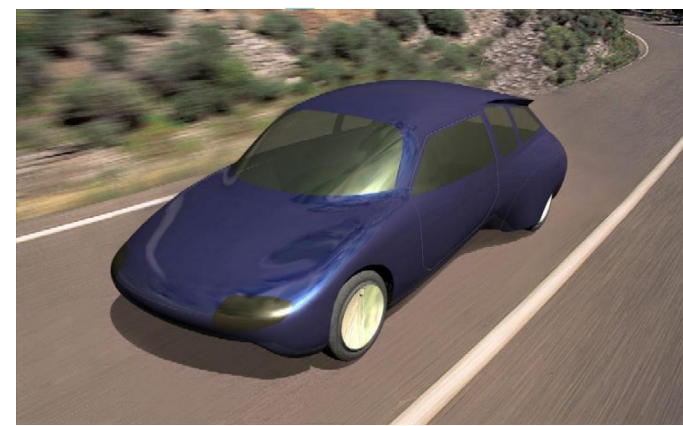
Solvay BPS Prepreg with local foam core stiffening - oven cured body panels

# ASCC Project

## Aero-stable Carbon Car

with Lotus Cars & Reynard Motorsport

Ultra-lightweight demonstrator car  
Body frame design using a novel  
tubular braided carbon fibre  
- Axontex





# Aero-stable Carbon Car

## Platform manufacture

- Single piece CFC

Floor frame manufactured using a low pressure injection process



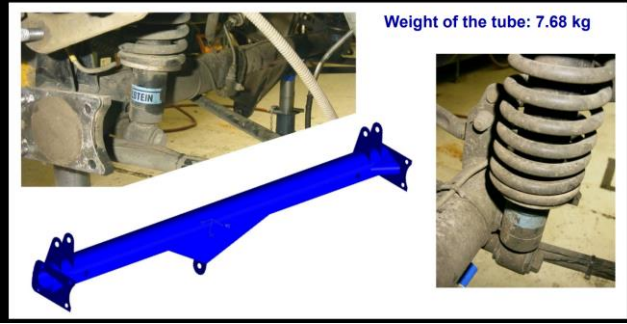


# Caterham 7

## Body Frame and Suspension Beam

Space-frame and suspension beam manufactured using braided and fabric carbon fibre

Caterham 7 De Dion rear suspension



Caterham 7 Cranfield FastFrames Project  
Completed Frame Sections  
(During assembly)



# Bumper Beam Development

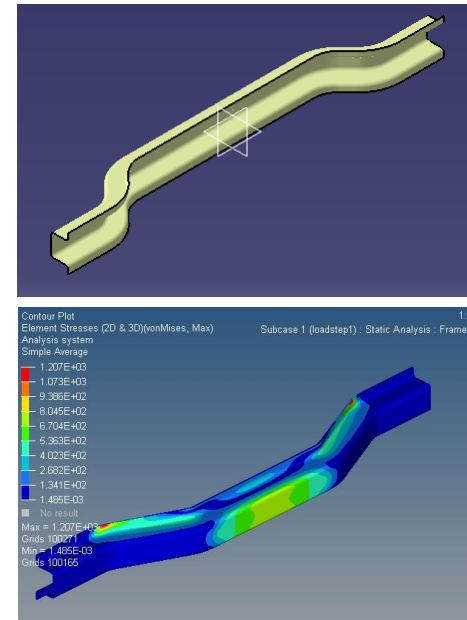
- with FORD UK and a confidential OEM

Ultra-light sports car bumper beam  
manufactured using carbon fibre thermoset  
RTM



CFC beam weight 2.9 kg  
Existing steel design 8.3 kg

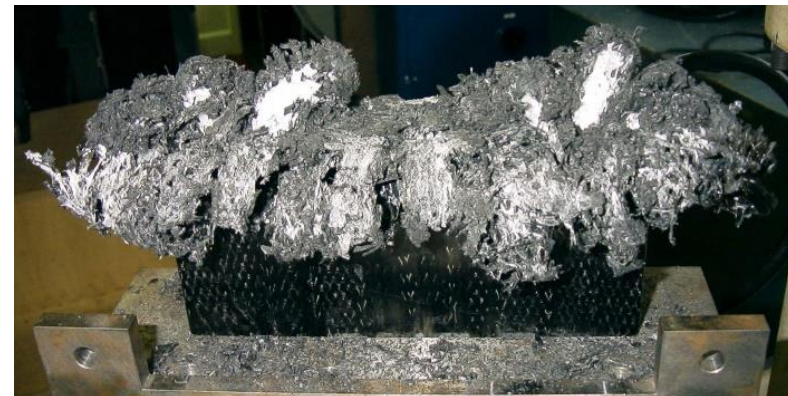
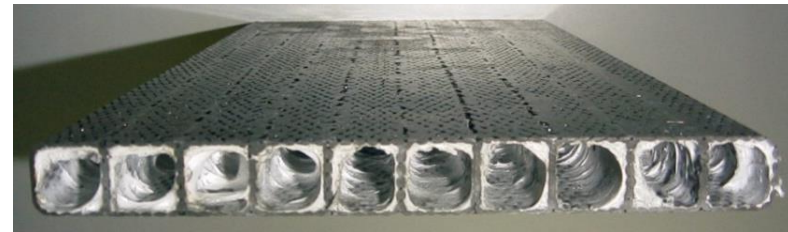
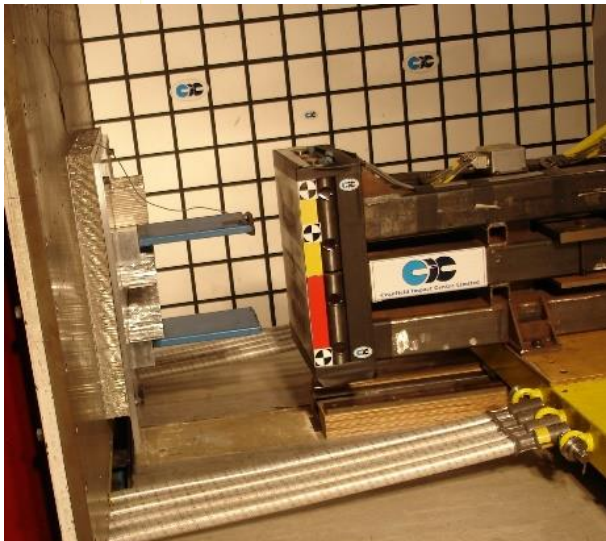
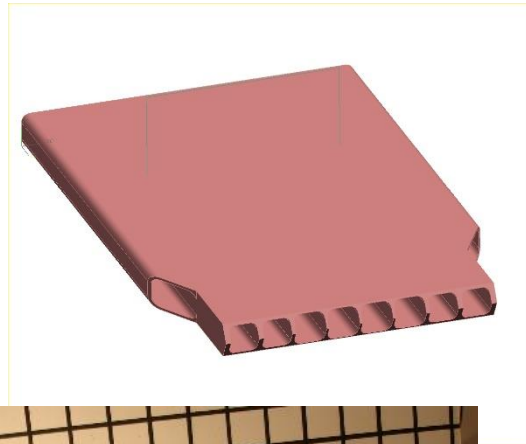
Thermoplastic compression moulding - cost  
and weight study – using glass and carbon  
fibre





# Automotive Crash Safety Structures

Manufactured using braided  
CFC for extreme energy  
absorption and low cost



# Aircraft Structures

AIRBUS UK & British  
Aerospace

**Airbus A320 Aileron**



**Airbus A320 Flap Track Fairing**



**Demonstrator Wing Box for BAE 125 Jet with  
British Aerospace Hatfield**

Outer wing demonstrator



**Jetstream ATP Storage Tank with AIM Aviation**





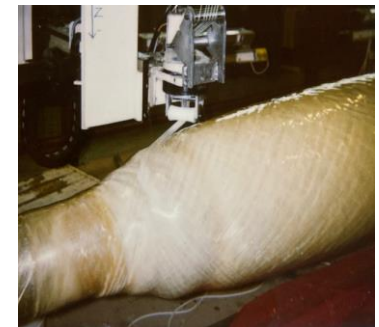
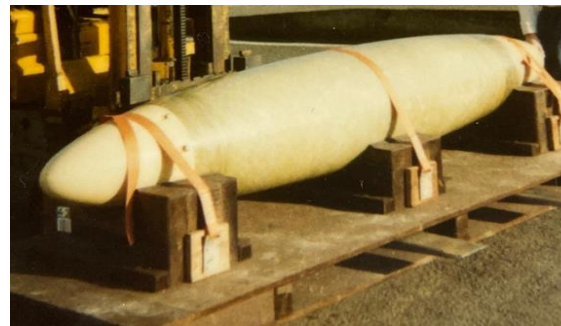
# Aircraft Structures

- AIRBUS UK, Courtaulds, GKN & Bombardier

**Airbus UK Wing Box Demonstrator**



**Experimental High Pressure Fuel Tank**



**RIFT Fan Cowl Door Demonstrator**

*Cranfield*  
UNIVERSITY

With GKN Aerospace



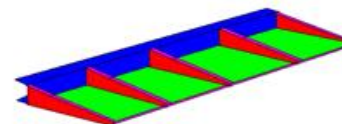
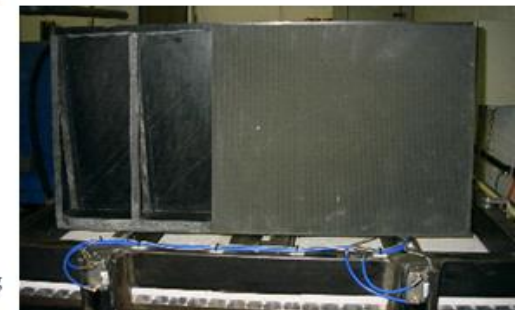
With integrated metallic hinge fittings

**EPSRC AMICC Bombardier Shorts**  
- Aileron Demonstrator

*Cranfield*  
UNIVERSITY

One shot RTM  
moulding

- Investigation and Demonstration of:
  - Integrated moulding
  - Low cost tooling
  - Low cost materials
  - Low labour cost moulding



- Half scale
- Cutaway top skin

# Aircraft Structures

- BAE SYSTEMS

Unmanned Aircraft

FLAVIIR Grand Challenge

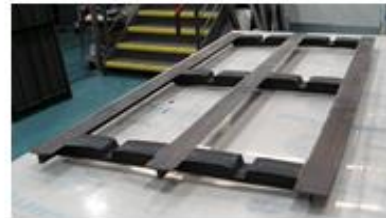
## Demon UAV Airframe



Low-cost, ultra-light airframe manufactured using  
low temperature cure oven cure prepreg  
– 4 metre span – 17kg weight

## Low Cost Wing Box Demonstrator

BAE SYSTEMS Flaviir Unmanned Aircraft Wing Box Assembly 



[www.cranfield.ac.uk](http://www.cranfield.ac.uk)

Low-cost, ultra-light airframe manufactured using  
resin infusion and stitching with bonded assembly  
– eliminating structural bolting  
- 45% cost saving compared to current low-cost  
prepreg design

[www.cranfield.ac.uk](http://www.cranfield.ac.uk)

# Automotive Project Partners



Nissan Europe  
Jaguar Land Rover  
Lotus Cars  
Reynard Engineering  
Caterham Cars  
Ford UK  
Bentley Motors  
McLaren Automotive and Racing  
Red Bull Technology  
HONDA UK  
GKN Wheels and Structures  
Prodrive Composites  
Engenuity  
DASIS  
Automotive Trim Developments  
Cranfield Impact Centre

## Project Partners

### Other Sectors, RTOs and Suppliers

BAE SYSTEMS

Airbus UK

Bombardier (Spirit)

GKN Aerospace

National Composites Centre

Advanced Manufacturing Research Centre

Airborne

SAFRAN

Hexcel Composites

Sigmatex UK

Huntsman International

ELG Carbon Fibre

TWI

Nottingham University

University of Bristol

University of Warwick