CLF 2016 Strategy Delivery

Current sales potential
£2,290m
Growth to 2030 of
£10,200m

UK SUPPLY CHAIN MANUFACTURING CLUSTERS AND PRODUCTS

- Low volume, high performance
  - Nacelles, Single Axle Wings, Wide Body Wings
  - Land Systems, Military Aircraft, UAVs
  - Motorsport

- High volume, high performance
  - Engine Blades, Brackets, Propellers, Rotors
  - Weapons
  - Spooleable Pipes
  - Interiors
  - Components, High Volume
  - Interiors
  - Fittings, Pipes / Systems

- High volume, low cost, semi structural
  - Medium Volume, Luxury Vehicles, Bus
  - Lineside Furniture, Cantilevers, Vehicles / Modules
  - Functional Panels, Tunnel Linings, Modular Bridges
  - Cabin Modules, Leisure Craft
  - Equipment, Pressure Vessels
  - Wind Blades, Nacelles, Marine Turbines

- Mid volume, structural
  - Naval Vessels
  - Platform Systems, Trackbed
  - Custom Bridges
  - Work Boats, Super Yachts
  - Modules, Protection

- Large, low volume, structural
  - Supply Chain Capability
  - Increased Productivity, Products & Services

Growth to 2030

- Aerospace
  - £3,520

- Defence
  - £770

- Automotive
  - £3,110

- Rail
  - £1,100

- Construction
  - £1460

- Marine
  - £150

- Oil & Gas
  - £1,080

- Renewables
  - £510

Figures in billions
Vehicle weights have increased to 2006 and have now started gradually coming down...

...however global emissions targets are reducing aggressively over the next 10 years.

OEMs are working on programmes to significantly reduce weight in their vehicles in order to meet future emissions legislation.

Only the adoption of composites and other materials in multi-material structures, components and panels will provide the necessary level of weight reductions.
The global premium automotive sector has high fleet emissions so has an urgent need to adopt lightweight materials.

The UK has a very large premium sector globally, which is driving UK vehicle output growth to 2.24m vehicles by 2018.

A recent study has estimated the UK demand for automotive composites could grow from £380m in 2015 to £3.5bn in 2030.
High demand identified for affordable composite structures from UK OEM’s

UK has world leading capabilities in production of composites for low volume, high performance applications such as Formula 1 and aerospace.

Big opportunity to build a UK based global hub for automotive composites R&D and production.
Lightweight vehicle and power train roadmap

Source: Automotive Council Technology Group 2013
Why lightweight with composites?

• **Weight saving** – composites substituting for steel where appropriate
  • Composites (thermoset, thermoplastic, CF and GF)
  • *Hybrid multi-material structural components.*
  • 100kg weight reduction = - 6 g CO₂/km

• **Cost saving** – through life compared to steel
  • Part count reduction through component integration
  • Component cost competitive with existing benchmark plus “on cost per kg saved”
  • Use of appropriate fibre reinforcement – GF or CF?

• **Performance improvement**
  • Improved vehicle dynamics
  • Increased design freedom

*Weight saving*
• *reduces fuel consumption*
• *reduces CO₂ emissions*
Where can we reduce weight in automobiles?

**Mid – Volume (3k – 100k parts pa)**

- **Most OEMs develop in-house**
- **High barriers for change – BIW line investment**
- **Safety critical**

**Composite Technologies**

- CF Thermoset
  - GF Thermoplastic
- Hybrid mult-material
  - Including Thermoplastics

**Market factors**

- Tier 1 sourced
  - Incremental change opportunities -
  - Tier 1 sourced
  - Incremental change opportunities
- In-house and outsourced
  - CF panels luxury/sports
  - Move towards structural composite modules and systems
- Tier 1 sourced
  - High existing use of polymers

**Where can we reduce weight in automobiles?**

- Mid-Volume (3k – 100k parts pa)

- **BODY IN WHITE**
  - % of car weight: 35%
- **CHASSIS**
  - 20%
- **STEERING and SUSPENSION**
  - 17%
- **CLOSURES**
  - 10%
- **INTERIOR**
  - 18%

**Composite Technologies**

- CF Thermoset
  - GF Thermoplastic
- Hybrid mult-material
  - Including Thermoplastics
- Hybrid multi-material
  - Pressing
  - HP-RTM

**Fibre reinforced thermoplastics**
Pictures: Mondial de L´Automobile Paris 1 - 16 Oct 2016 M. Remp
Powertrain Opportunities

Electric vehicle battery cases and LNG/CNG gas tanks are significant opportunities for UK

Spillover benefits in establishing UK capability and capacity in manufacturing will maximise future UK share of value chain.

Composites (including CMC and MMCs) and advanced multi-material solutions can improve efficiency of Internal Combustion Engines
Affordable Composites Group

• The ACG was set up by the Automotive Council (Manufacturing Group) and the Composites Leadership Forum with the purpose:
  • “to facilitate development of UK technology capability and supply chain capacity to deliver high productivity manufacturing of globally competitive, higher volume composite structures and components”.
• It is chaired by Philip Bruce and contains representatives from supply chain and funding bodies.
• ACG has mapped out the supply chain development required and is identifying, and seeking to fill, gaps that could restrict future development.
• It is working with Government and funding bodies to identify funding mechanisms to facilitate all of this.
Programme

Stream 1 - “Affordable Composites Programme”
• Supply chain producing high volume parts cost effectively by 2021. Focus on current materials and manufacturing technologies.
• Post 2021, ramp up capability above this, potentially using new materials.

Stream 2 – Innovative Materials and Modelling

“National Composites Materials Centre”
• Develop UK composite materials development and manufacturing capability to bring about the step change in cost and production technology to deliver higher rate affordable production.

Both cover Technology, Supply Chain and Skills development.
Affordable Composites – High level roadmap

- Qualification trials for existing materials, including recycled, for shortlisted production technologies
  - Component to demonstrator

- Development of new materials (inc functional integration) specifically to optimise production technologies
  - Access to HPC for material modelling

- Mapping of production technology suitability envelopes – leading to Best Practice Guides
- Development of appropriate production technology for OEM requirements focusing on manufacturing technologies, joining technologies and sustainability
  - Manufacturing Processes
  - Joining Technologies
  - Sustainability

- Development of design simulation and validation tools (including multi-materials & functional integration)
  - Component to demonstrator – design, simulation & validation

- Accessible data storage and knowledge capture platform
  - Capture of data, understanding and knowledge
  - Shared database

DEVELOP technologies and supply chains to capture market opportunities

- Retain UK position as world class in composites innovation
- Ensure UK supply chain delivers composite product to international market
Why is automation the solution?

• Protects and expands existing UK composites capabilities
• Expands UK manufacturing capacity with economies of scale
  • Accelerated adoption of automated high rate manufacturing processes
  • Improved material utilisation
  • Increased productivity
  • Repeatable processes – higher quality & improved optimisation

• Secures future value

• “Aggregate demand – to develop investment cases”
  • “Standardise processes – to accelerate understanding and acceptance”
  • “Commoditise knowledge – through CAE tools and training”
Accelerating Investment Cases ....

Hitting the target for Investment Readiness: Application of Knowledge

- Supply Chain Readiness Level
  - “Leverage & transfer knowledge capture, risk & cost trade offs”

- Composite Manufacturing Processes
  - “Process understanding”

- Simulation & Virtual Engineering
  - "Materials, Methods & tools"

- Prototyping & Physical Testing
  - “Know-How”

- Skills Readiness Level

- Tech Readiness Level

- Manuf Readiness Level
Collaboration, co-ordination and standardisation?

Combine cross sector volume
Shared knowledge/data
Platform?
Accelerate material characterisation?
- Aggregate

Best practice
Pre-standards
Standards
Training
- Standardise

Make it easier to specify composites

Creating functional market
For Affordable Composites
- Commoditise
Stream 1 – Affordable Composites

Aggregate demand around manufacturing processes, suitable for up 100k components per year and maturing quickly to achieve SOP in 2021

**PROCESSES**

- Press based
  - Wet Compression
  - HP-RTM
  - SMC
  - TP Laminates & Tapes

- Low/medium pressure
  - RTM
  - RIFT

- Injection Moulding
  - Overmoulding

- Semi-continuous
  - Braiding
  - High speed tape laying

**Joining**

**ENABLERS**

- Virtual Engineering
  - Inc design, analysis and simulation

- Sustainability
- Materials
- Training

© National Composites Centre. All rights reserved. Confidential and proprietary document. NCC-TMP-038-v4
Aggregate demand around manufacturing processes, suitable for up 100k components per year and maturing quickly to achieve SOP in 2021.
High Efficiency Preforming – an enabling step

Aggregate demand around manufacturing processes, suitable for up to **100,000 components per year** and “mature by 2017”

**Key technology previously not covered by funded projects**

**Additional critical technologies/capabilities**

**Critical press-based impregnation technologies**

**ENABLERS**

- Virtual Engineering Inc design, analysis and simulation
- Sustainability
- Materials
- Training – knowledge capture

**PRESSSES**

- Press based: Wet Compression HP-RTM, SMC, TP Laminates & Tapes
- Low/medium pressure: RTM, RIFT
- Injection Moulding: Overmoulding
- Semi continuous: Braiding, High speed tape laying

**Joining**

**Preforming**

© National Composites Centre. All rights reserved. Confidential and proprietary document. NCC-TMP-038-v4
Affordable Composites and allied initiatives

**Affordable Composites**

Greater shared knowledge and understanding of composites design and manufacture leading to significant adoption of composites in the automotive supply chain by 2021 and widespread use in new products by 2025.

**NCMC**

NCMC will deliver the right composite materials capabilities to be able to anchor the composite products supply chain in UK and increase GVA impact of composite products in UK.

**High Efficiency Preforming**

“To develop a range of technologies suitable for the production of affordable composite preforms for application to the automotive sector by 2019 in line with sector requirements.”
Federal Investment Will Catalyze a Composites Ecosystem in the Heart of US Manufacturing

- $70M - DOE
- $180M+ - Other
- 122 - Member Consortium
- 6 Core Partner States
- Strong Leadership
- 5 Technology Areas

- CFRP production cost: - 50%
- CFRP embodied energy savings: - 75%
- Greenhouse gas avoidance: - 75%
- FRP recycled and/or reused: 95%
- Jobs: 75%
- Production capacity: 95%

USA - IACMI

© National Composites Centre. All rights reserved. Confidential and proprietary document. NCC-TMP-038-v4
Leading Edge Cluster MAI Carbon

Goals

- 90% Process cost reduction
- 50% Material cost reduction
- 60% - 80% added value in Germany
## ACG Roadmap Objectives – Under Discussion

<table>
<thead>
<tr>
<th></th>
<th>US (IACMI)</th>
<th>Germany (MAI Carbon)</th>
<th>UK (Affordable Composites)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>2015</td>
<td>2010</td>
<td>2017 (Manual processing Benchmark)</td>
</tr>
<tr>
<td><strong>Production Cost of finished CF components</strong></td>
<td>Reduce by 25% (2020)</td>
<td>Reduce by 90% (2020) (“processing costs only”)</td>
<td>Reduce by 40% (2020) (including material cost reduction)</td>
</tr>
<tr>
<td><strong>Demonstrate technologies for recyclability</strong></td>
<td>&gt;80% (2020)</td>
<td>80% (2020)</td>
<td>&gt;80% (2020)</td>
</tr>
<tr>
<td><strong>Cycle (takt) time</strong></td>
<td>90s (Thermoplastic 2020) 180s (Thermoset 2020)</td>
<td>60s (2020)</td>
<td>60s Thermoplastic (2020) 180s Thermoset (2020)</td>
</tr>
<tr>
<td><strong>Reduction of process steps</strong></td>
<td>60% (2020)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Material cost reduction in finished CF parts (includes waste reduction)</strong></td>
<td>Reduce by 25% (2020)</td>
<td>50% (2020)</td>
<td>50% (2025)</td>
</tr>
<tr>
<td><strong>Reduction in CFRP embodied energy</strong></td>
<td>&gt;50% (2020)</td>
<td></td>
<td>&gt;50% (2025)</td>
</tr>
<tr>
<td><strong>Local added value % of finished CF component</strong></td>
<td>60-80% (2020)</td>
<td></td>
<td>50% (2020) 80% (2030)</td>
</tr>
</tbody>
</table>
ACG Roadmap Objectives – Implications

**Indicative Cost Reduction (%):**
- 2017: 5%, 2018: 4%, 2020: 3%

**Cycle Time (min):**

**Useable Parts (%):**

**Sustainability** – Data to capture typical embodied energy in processes

**Knowledge management** – socialise status of process envelopes, collaborate on solutions

**Increasing focus on keeping processes in control to drive repeatability and yield**

Data driven closed loop quality assurance
Industry 4.0 – SMART Manufacturing

Intelligent, connected, manufacturing systems

Going beyond condition monitoring (SPC) and fault diagnosis

Self aware and self diagnosing systems

**Need for range of online multiple NDT/SPC datasets to assure process is in control**

- Rapid sensing
- Multiple criteria
- Decision making
Industry 4.0 - Initiatives

Highly efficient composites preforming enabled through manufacturing informatics and in-process verification, truly realising data driven automation in composites manufacturing.

The end-effector houses an embedded heated tool, various grippers, and sensors. The core idea is to load-balance the complexity of forming, using grippers, tooling, and sensors – verifying key characterises in-process.

Automated Preforming Cell & Composites Integrity & Verification Cell – coming soon
Affordable Composites and allied initiatives

2016

Affordable Composites

2021

Greater shared knowledge and understanding of composites design and manufacture leading to significant adoption of composites in the automotive supply chain by 2021 and widespread use in new products by 2025.

2025

NCMC will deliver the right composite materials capabilities to be able to anchor the composite products supply chain in UK and increase GVA impact of composite products in UK.

High Efficiency Preforming

“To develop a range of technologies suitable for the production of affordable composite preforms for application to the automotive sector by 2019 in line with sector requirements.”