The EPSRC Future Composites Manufacturing Research Hub Industry Day
16.06.23

Agenda

- 1000: Welcome and introduction
- 1015: Hub research overview
- 1030: Industry engagement and impact
- 1045: Outline of the new Hub
- 1100: Online feedback session
- 1130: Future Hub engagement
- 1140: Centre for Doctoral Training (CDT) in Sustainable Composites Engineering
- 1150: Closing remarks
- 1200: Close

Welcome and Introduction

James Whyman
Business and Research Development Manager
University of Nottingham

Welcome and Introduction

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Future Composites
Manufacturing Research Hub

- Purpose of the event is to inform industry stakeholders of:
  - Progress of the Hub’s current research
  - The Hub’s research impact on industry
  - Outline future Hub plans
  - Gather feedback and encourage active engagement from industry stakeholders

Hub Objectives

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Research — Promote a ***step change*** in composites manufacturing science and technologies

Technology — Create a ***pipeline of next generation technologies*** addressing future industrial needs

Training — ***Train the next generation*** of composites manufacturing engineers

Partnerships — Build & grow the ***national & international communities*** in design & manufacture of high performance composites

Timeline and Research Themes

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EPSRC Innovative Manufacturing Centre in Composites (CIMComp) July 2011	EPSRC Future Composites Manufacturing Research Hub (CIMComp2) January 2017	**Under Review** **EPSRC Future Sustainable Composites Manufacturing Research Hub April 2024**
• Novel Approaches to Manufacture of Complex Geometries • Innovated Multi-material and Multi-architecture Preforms • Structural Joints using Novel Embedded Inserts • Multi-scale Modelling to Predict Defect Formation During Resin Infusion	• High Rate Deposition and Rapid Processing Technologies • Design for Manufacture via Validated Simulation • Multifunctional Composites and Integrated Structures • Inspection and In-process Evaluation • Recycling and Re-use	• Integrated Design & Manufacture for Circularity • Optimised Energy-Efficient Materials & Processes • Sustainable Integrated Structures

Academic Partners – 16 Spokes

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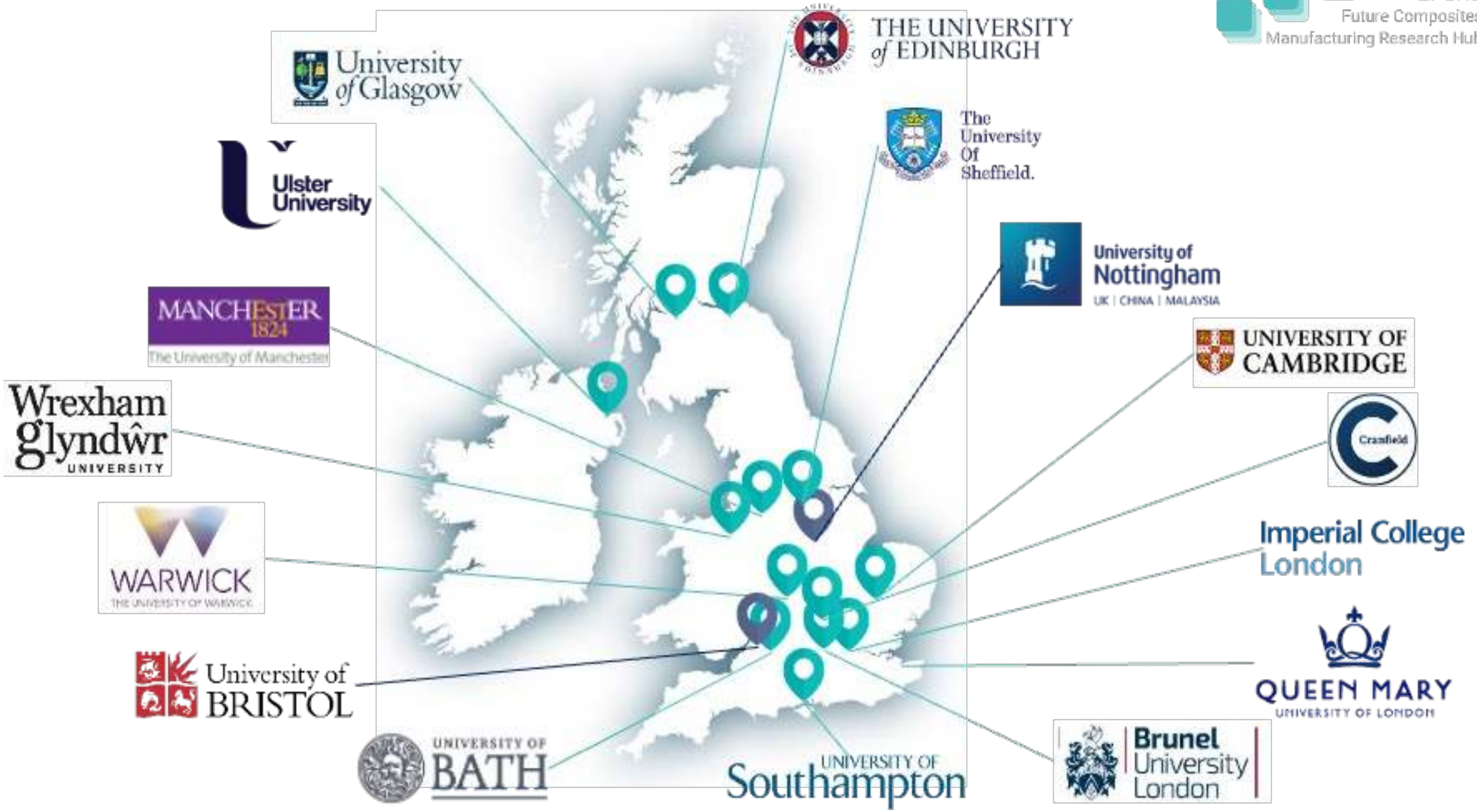

HVM Catapult Partners – 4

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NATIONAL COMPOSITES CENTRE

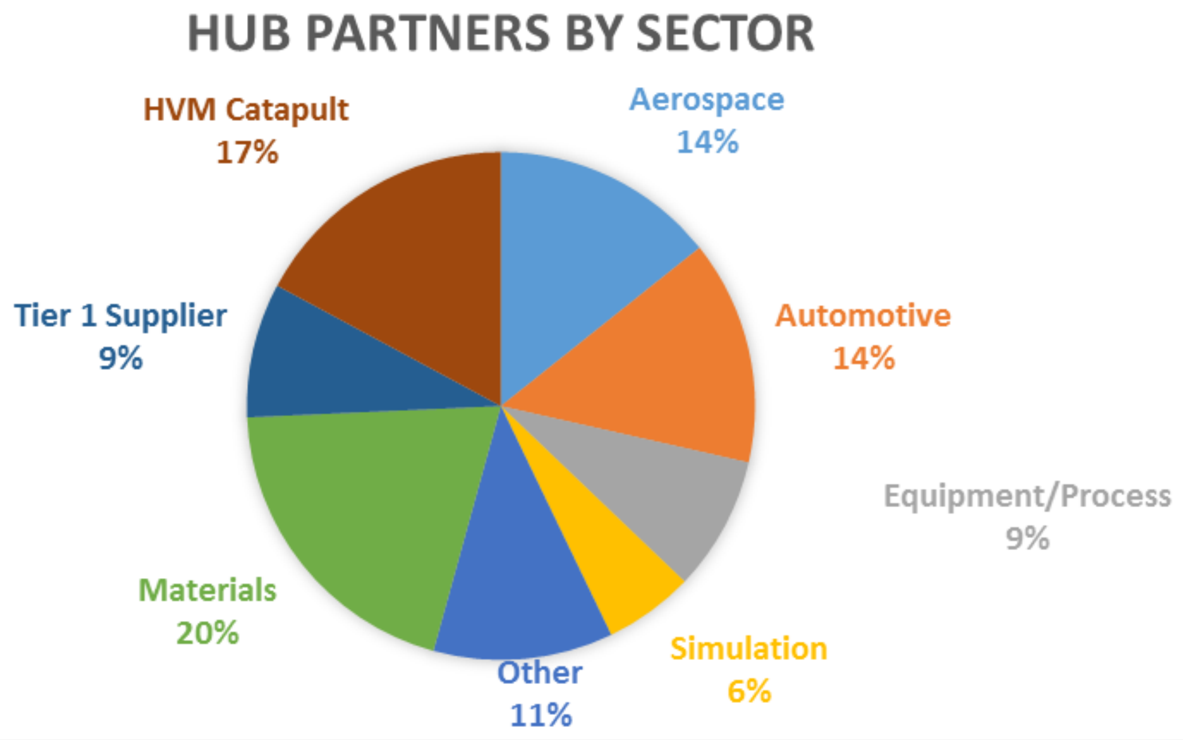
The University Of Sheffield. AMRC Advanced Manufacturing Research Centre

mtc Manufacturing Technology Centre

WMG THE UNIVERSITY OF WARWICK

Industrial Partners

- AIRBUS
- ASTON MARTIN
- BAE SYSTEMS
- BENTLEY
- Bitrez
- COMPOSITE INTEGRATION
- CORIOLIS composites
- DASSAULT SYSTEMES
- esi get it right®
- European Thermodynamics Limited
- FreiLacke
- GE Aviation
- GKN AEROSPACE
- GORDON MURRAY DESIGN
- HEXCEL
- LMAT
- LUXFER GAS CYLINDERS
- M. Wright & Sons Ltd. Engineered Textile Structures
- NetworkRail
- PAC GROUP
- PENTAXIA
- Rolls-Royce
- SCOTT BADER
- sigmatex
- TORAY Innovation by Chemistry
- SHD composites



Research Themes

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- **High Rate Deposition and Rapid Processing**
- **Design for Manufacture via Validated Simulation**
- **Multifunctional Composites and Integrated Structures**
- **Inspection and In-process Evaluation**
- **Recycling and Re-use**

- Proposed in 2015 in conjunction with Industry Partners
- Revisited in 2019 as part of Hub Roadmapping Activity, CiRCL

Projects

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Feasibility Studies

- Up to £50k
- 6 months
- Can lead to a Core Project (36 months

Synergy Promotion Funds

- Up to £100k per academic institution
- 12 months

Core Projects

- Up to 3 years
- Between £375k - £700k

Innovation Fellowships x3

- 2 years
- Up to £250k

Original Objectives of the Hub

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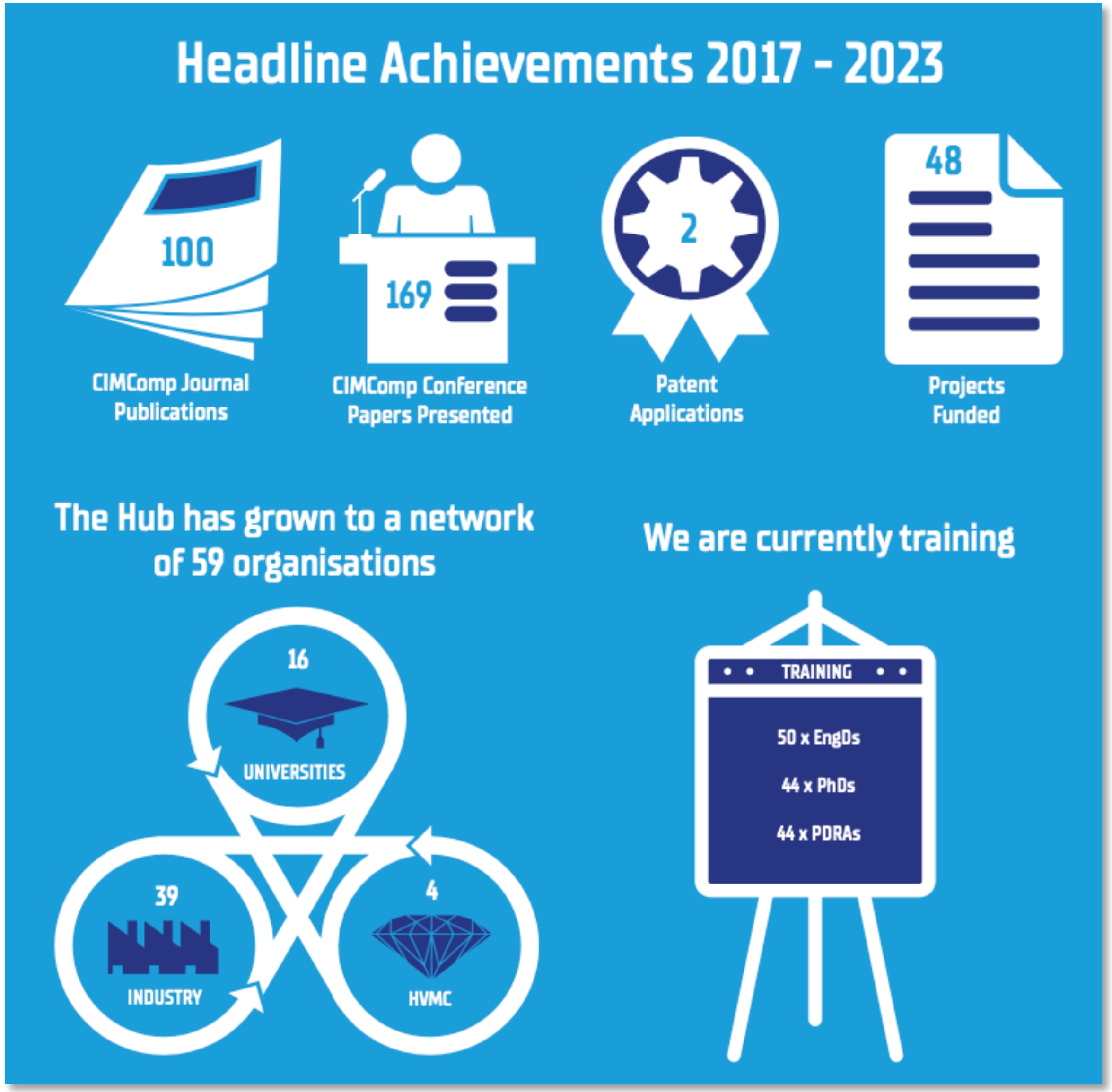
Training

Currently providing training to:

- PHD students
- EngD students
- Postdoctoral researchers

- Engage with the Industrial Doctoral Centre
- Staff Development Policy
- External partner training course

Metrics



- >£2M Institutional support
- >£3.6M Industry support (LoS)
- >£20M Additional leveraged grant Income
- >£3M Additional industry-leveraged income
- New collaborative research activities
- 15,000 people engaged through Public outreach and STEM activities

Hub Research Overview

Prof. Ole Thomsen

Co-Director of BCI, NCC Chair in Composites Design and Manufacture

University of Bristol

Hub Research Portfolio

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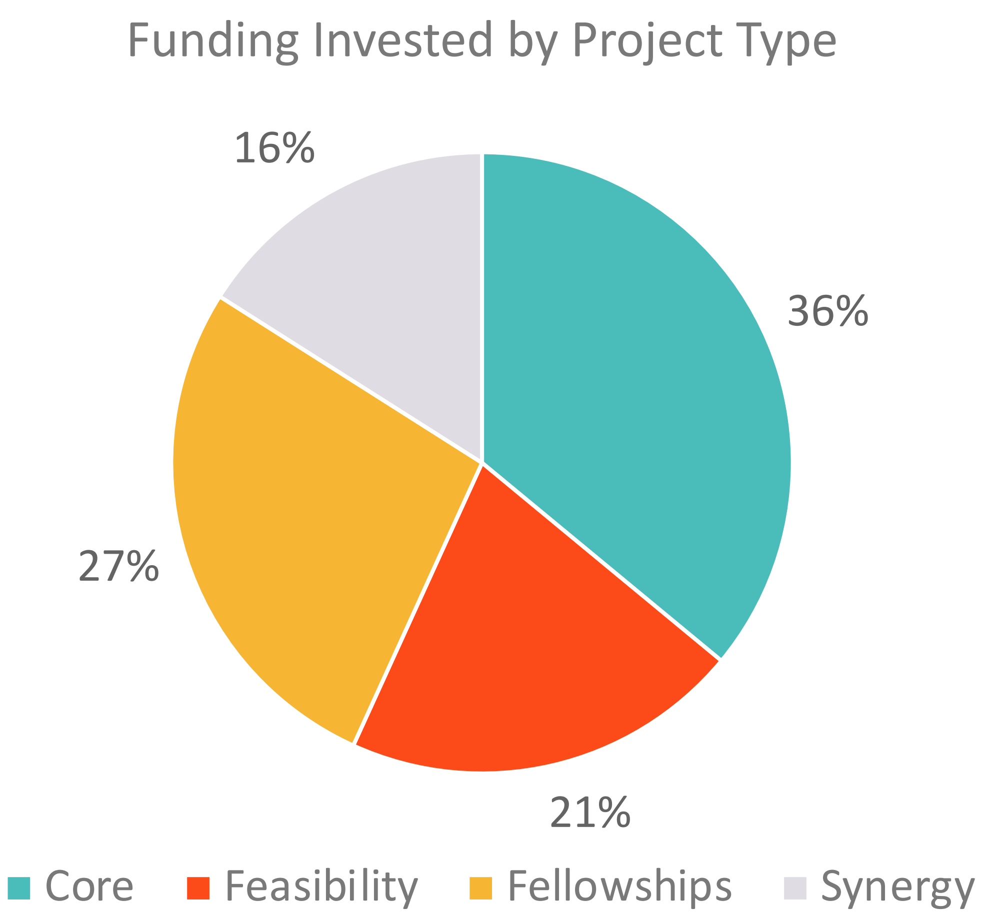
- 16 UK Universities
- 43 Hub-funded projects
  - 6 Core Projects
  - 25 Feasibility Studies
  - 6 Fellowships
  - 6 Synergy Projects
- 35 investigators
- 44 PhD Research Students
- 50 EngD Research Students (via the IDC)
- 44 Post Doctoral Research Assistants



Hub Projects by Research Themes

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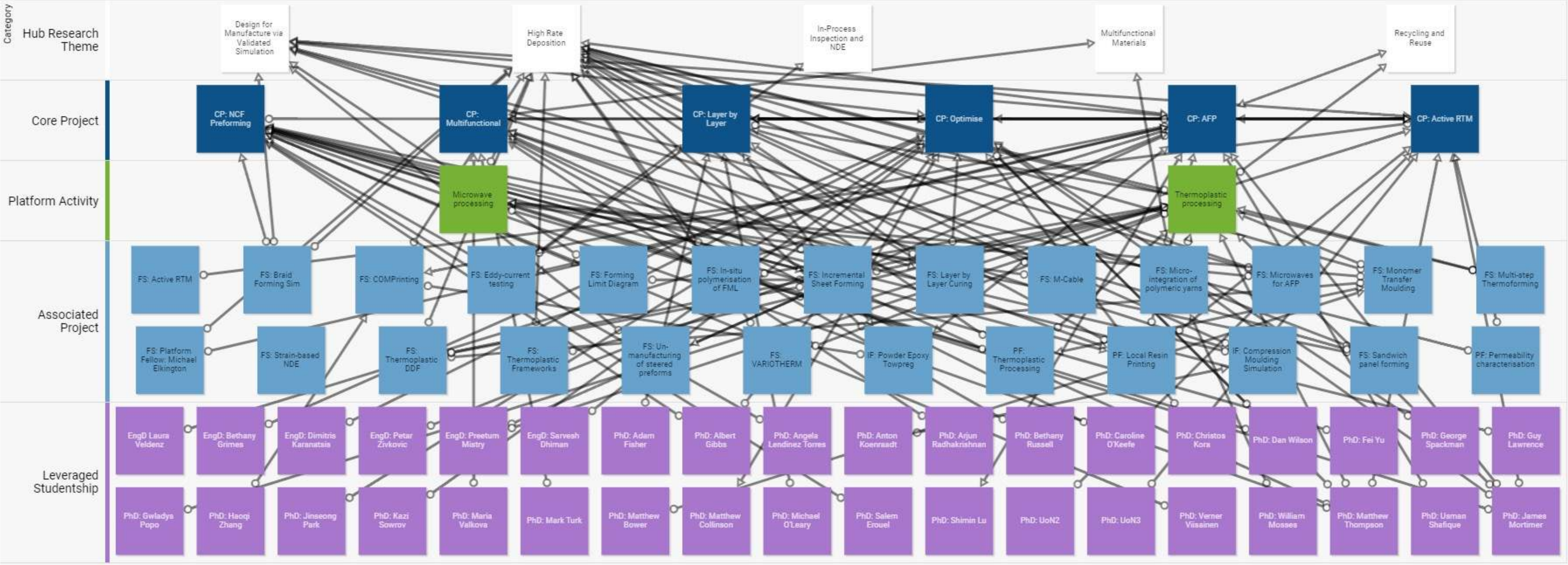

Research Themes

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- High Rate Deposition and Rapid Processing Technologies
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- Multifunctional Composites and Integrated Structures
- Inspection and In-process Evaluation
- Recycling and Re-use

High Rate Deposition and Rapid Processing

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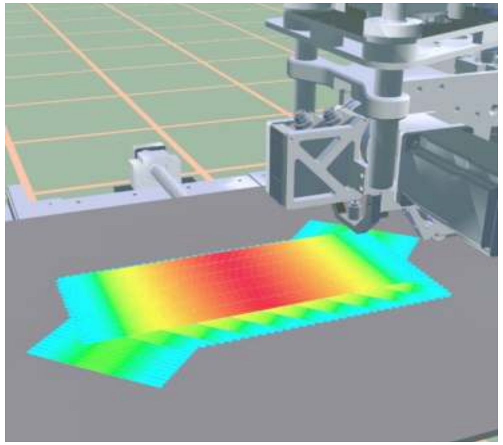
Core Projects	4
Platform Fellowships	4
Innovation Fellowship	1
Feasibility Studies	12
Synergy Projects	3
Industry Partners	17
Industry Leveraged Income	£245K
Academic Leveraged Income	£272K
Grant Leveraged Income	£10.1M



Digital twin of the Automated Dry Fibre Placement machine at the University of Nottingham

Layer-by-Layer (LbL) Curing

Aims of the Project

- Develop a 3D simulation of LbL process
- Create constitutive models for conventional and snap curing systems.
- Optimise the process for toughness, duration, and residual stress control.
- Develop tailored process setups for complex geometries/components.
- Minimise defects in the entire process chain.
- Demonstrate applicability through lab/pilot scale implementations.
- Develop hybrid components and laminates with tailored residual stress.

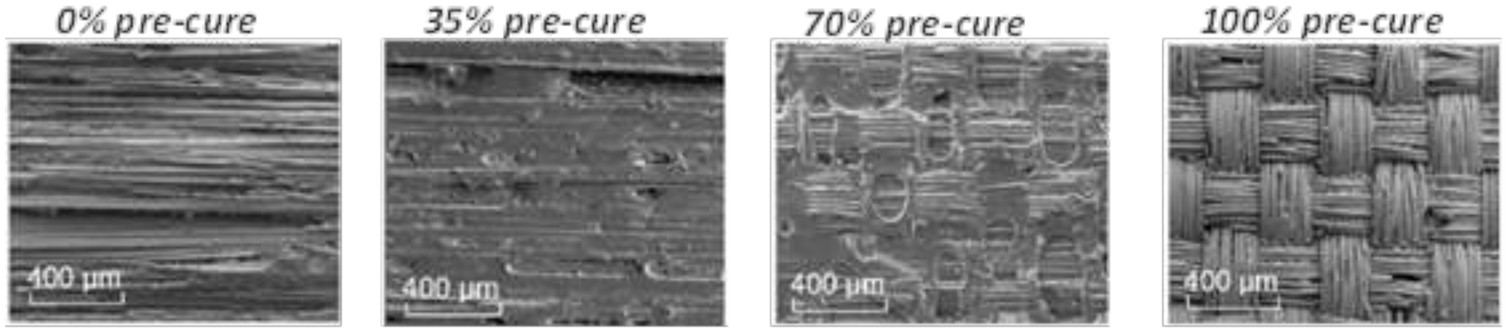
- Team: Cranfield University, University of Bristol
- 5 Industry partners

Industry Support

- PhD co-funding x2
- EngD co-funding
- Technical support
- Access to facilities

Project Outputs

- Cycle time reduction
- Able to manufacture ultra-thick structures using fast curing materials



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Research Themes

- High Rate Deposition and Rapid Processing Technologies
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Design for Manufacture via Validated Simulation

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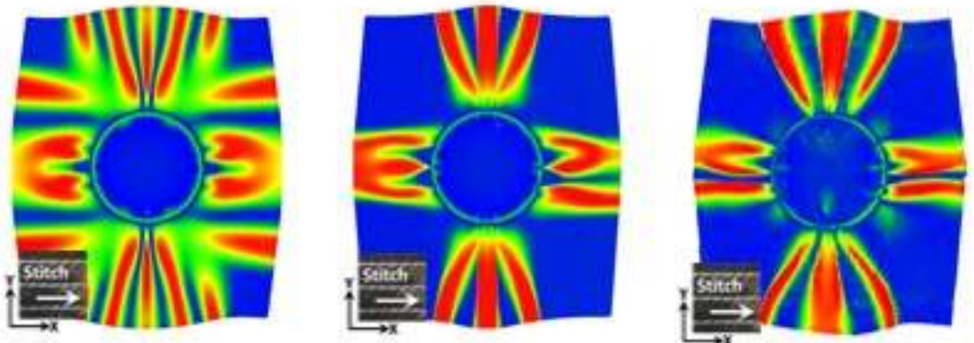
Core Projects	4
Platform Fellowships	1
Innovation Fellowship	1
Feasibility Studies	4
Synergy Projects	1
Industry Partners	9
Industry Leveraged Income	£870k
Academic Leveraged Income	£360k
Grant Leveraged Income	£1.4M



Constant bending stiffness

Nonlinear bending stiffness

Exp.

Technologies Framework for Automated Dry Fibre Placement & Fibre-Steered Forming Technology

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- Team: University of Nottingham, University of Bristol,
- 15 industry partners
- 3 journal publications

- Consequent Hub feasibility study on virtual un-manufacturing of fibre-steered preforms

<u>Aims of the Project</u>

• Develop a rapid, sustainable manufacturing process for complex composite parts.
• Develop fast numerical tools for optimal fibre paths based on part design.
• Produce highly-aligned discontinuous fibre tapes for automated processes.

<u>Project Outputs</u>

- Virtual forming/unforming simulation
- High-rate manufacturing of complex geometry composite parts
- Waste minimisation via steering

Research Themes

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- High Rate Deposition and Rapid Processing Technologies
- Design for Manufacture via Validated Simulation
- Multifunctional Composites and Integrated Structures
- Inspection and In-process Evaluation
- Recycling and Re-use

Multifunctional Composites and Integrated Structures

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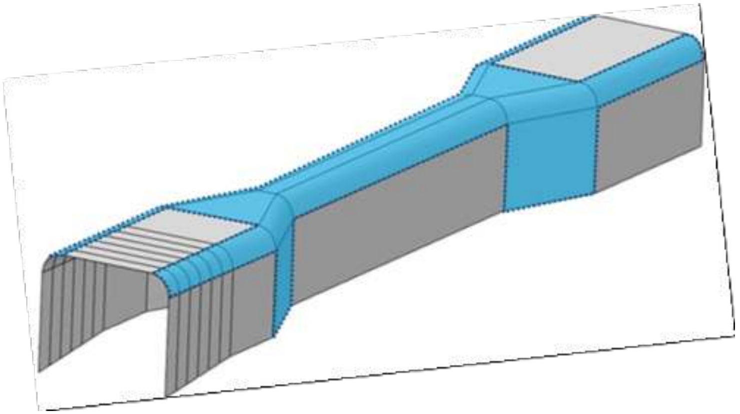
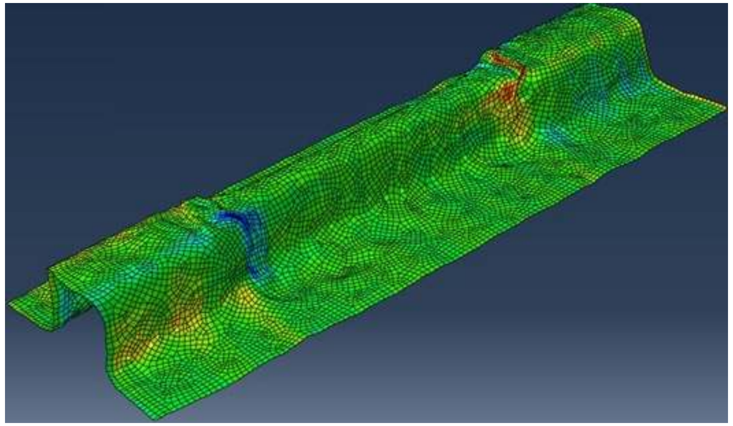
Core Projects	1
Industry Partners	6
Industry Leveraged Income	£25k
Academic Leveraged Income	£388k
Grant Leveraged Income	£1.9M





Multifunctional composite structures have the potential to replace power systems, wiring, actuators, health monitoring systems and control systems, significantly reducing complexity and weight of assemblies.

Manufacturing for structural applications of multifunctional composites

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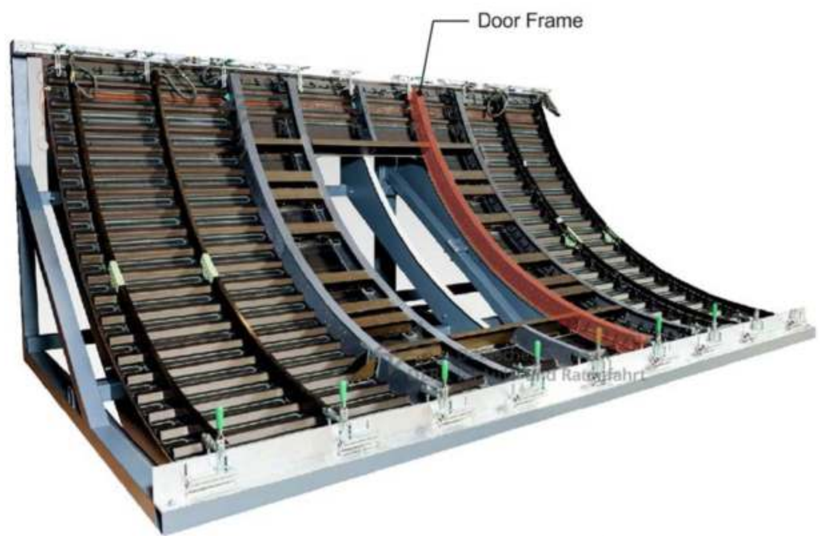
<u>Aim of the Project</u>

Develop reliable, cost-effective manufacturing methods and design practices for using multifunctional composites in various industrial sectors.

<u>Support</u>

- X2 Faculty funded PhD students directly on project
- Support from Airbus to use DEPS as demonstrator

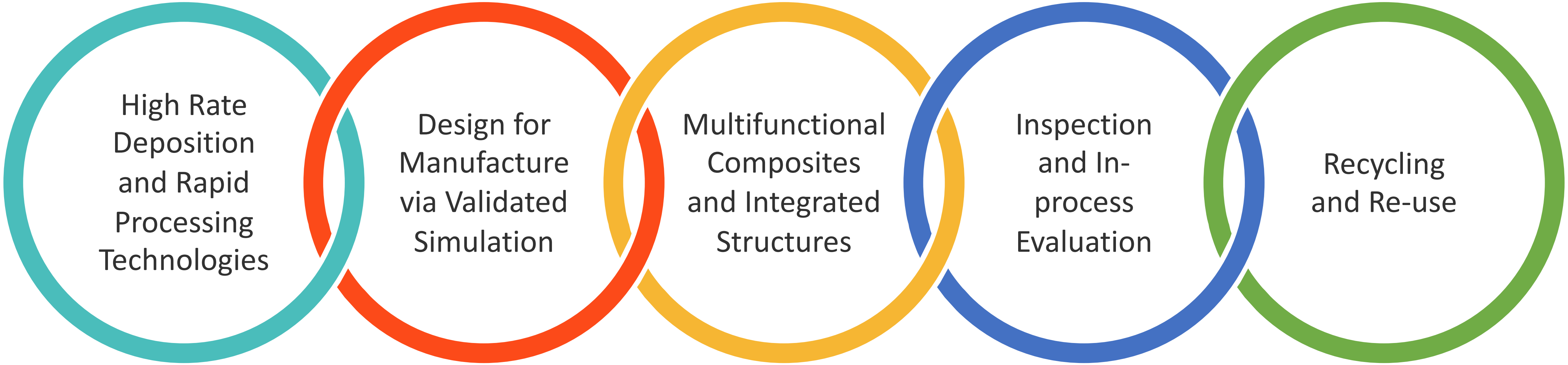
- Team: Imperial College London, University of Bristol
- 4 industry partners
- 6 associated research grants awarded worth £4.4M
- 22 journal publications



<u>Deliverables/Outcomes</u>

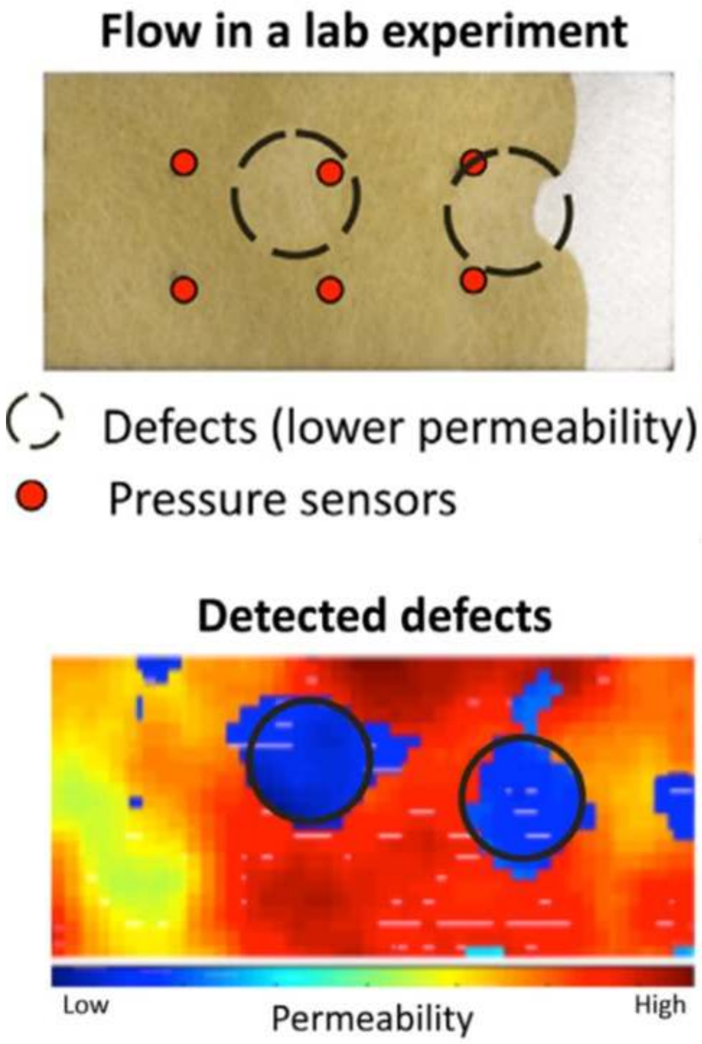
Completed manufacture of a full-scale demonstrator component (multifunctional Airbus fuselage C-beam).

Research Themes



Inspection and In-process Evaluation

Core Projects	1
Feasibility Projects	3
Innovation Fellowships	1
Industry Partners	5
Industry Leveraged Income	£392k
Academic Leveraged Income	£70k
Grant Leveraged Income	£8k



Resin injection into reinforcement with uncertain heterogeneous properties: NDE and control

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Aim of the Project

Develop algorithms for defect detection and closed-loop control to enhance RTM process robustness.

Support

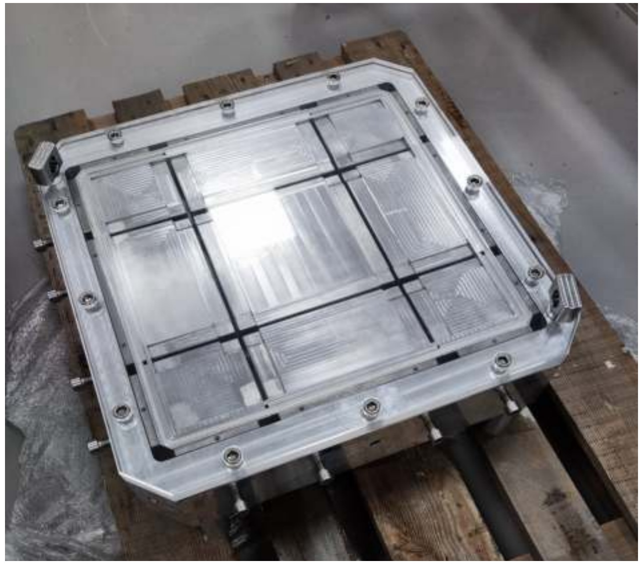
ESI Group committed to co-fund an EPSRC iCASE studentship – ESI withdrew support after restructuring

Sustainability Impact

Through elimination of a trial-and-error approach, closed-loop control of the RTM process will help to minimise

- Raw material consumption
- Scrap rate
- Energy consumption

- University of Nottingham engineering and mathematics co-delivery
- 3 industrial partners
- Developed technology shown to reduce scrap rate



Deliverables/Outcomes

- Validated novel Bayesian algorithm capable of capturing defects
- 10 Journal papers
- £12k in leveraged funding

Research Themes

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- High Rate Deposition and Rapid Processing Technologies
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- Recycling and Re-use

Recycling and Re-use

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Feasibility Projects	6
Synergy Projects	2
Industry Partners	5
Industry Leveraged Income	£392k
Academic Leveraged Income	£425k
Grant Leveraged Income	£8k

Two 10-year-old Boeing 787 Dreamliners are already being scrapped

Rewinding Tape Laying: Can Direct End-of-Life Recovery of Continuous Tapes be a Step-change in the Sustainability of Thermoplastic Composites? (REWIND)

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Aim of the Project

Create a process to recover thermoplastic prepreg from end-of-life parts through a controlled peel process and reuse the plies in new parts with minimal post-processing.

Sustainability Impact

The project is directly aimed at sustainability, developing a process for demanufacturing of thermoplastic composite components that will enable the loop to be closed.

- Led by the University of Nottingham
- 2 industry partners

Deliverables/Outcomes

£12.5k industrial support
£125k additional leveraged grant income
£60k additional industry leveraged income
2 journal papers
2 conference papers

Review of Research Investments

Institutional Support

- 32 PhD students
- University project contributions
- 1 EngD student

Industrial Support

- Advisory board meetings
- Project meetings
- PhD sponsorship
- EngD sponsorship
- Facilities access
- Technology trials
- Materials

Leveraged Grant Income

- Innovate UK - £1.4M
- Clean Sky 2 - £600k
- EPSRC - £18M

Synergy Projects

- Maximum duration of 12 months.
- Maximum grant approximately £100,000 per academic partner.

Titles of Successful Synergy Promotion Projects Chosen for Funding

- Monitoring of Microwave Cure Process using Novel Planar Optical Sensors
- Energy Efficient Composite Tooling with Integrated Self-Regulating Heating and Curing Capabilities based on Recycled Composite Waste (ECOTOOL)
- A Numerical Tool to Aid Design-for- Manufacture of Injection Over-Moulded Composite Parts
- Thermoplastic In Situ Polymerisation (TPIP) and Double Diaphragm Forming (DDF) for Moulding of Complex Parts at Scale
- Zero Waste Manufacturing of Highly Optimised Composites with Hybrid Architectures

- **EPSRC Future Composites Manufacturing Research Hub Annual Open Day**

The Hub is pleased to be hosting its annual Open Day in collaboration with the International Composites Summit on 6 September 2023 at Marshall Arena, Milton Keynes, UK

When and where

Date and time

Wed, 6 Sep 2023 09:30 - 17:30 BST

Location

Stadium MK Stadium Way West Bletchley MK1 1ST

https://www.eventbrite.co.uk/e/epsrc-future-composites-manufacturing-research-hub-annual-open-day-tickets-636421111677?aff=oddtdtcreator

Industry Engagement and Impact

Dr Enrique Garcia
Chief Technology Officer
National Composites Centre

Introduction

Objectives:

- Valuable insights and updates for Round Robin and Hub Research Impact Initiatives:
  - Technology Pull Through
  - Research Impact Project

- Importance of industry engagement

- Aims of the Hub with regard to the academic and industrial ecosystem

- Outline of impact routes for academic research:

  Feasibility study -> Core Project -> External Grants -> NCC Tech Pull-through -> Industry Adoption

Round Robin Project: Tack testing round-robin in support of standard ASTM D8336

Partners: Airbus, Boeing, TU Clausthal, Hexcel, NCC, Northrop Grumman, UoNottingham, NPL, Spirit Aerosystems, Toray, Vestas, WMG.

Aims / Objectives

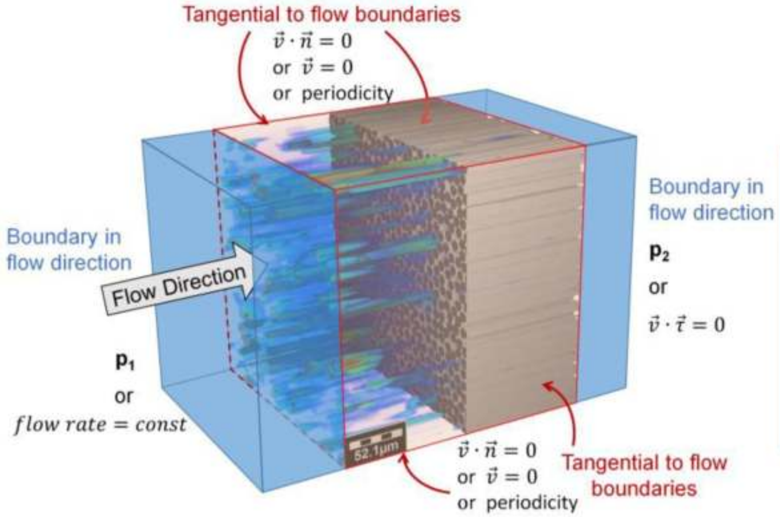
- Assessment of prepreg tack measurement method, using the newly developed ASTM D8336-21, in a Round Robin exercise.

Benefits to industry

- Accurate tack behavior data enables automated processes, such as ATL/ATP, to be finely tuned for better manufacturing efficiency and quality.
- Quality assurance testing of prepreg batches.

Round Robin Project: Image-based prediction of permeability of engineering textiles

Partners: Nantes (Co-Lead), IVW Kaiserslautern (Co-Lead),
14 other universities

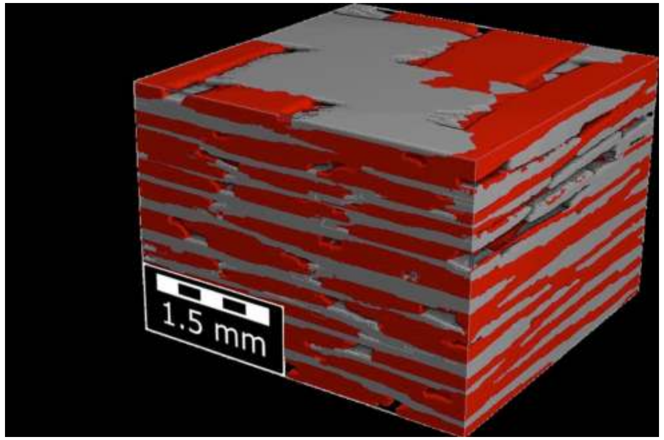


Aims / Objectives

- Develop guidelines for permeability prediction using micro-CT data

Benefits to industry

- Non-destructive testing of materials
  - Best software practice identified



Technology Pull-through Benefits

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- Industrial Implementation
- De-risking and Validation
- Enhanced Readiness for Commercialisation
- Access to Industry Expertise and Resources
- Market-Relevant Solutions

Overview of Hub Research Impact
Technology Pull Through

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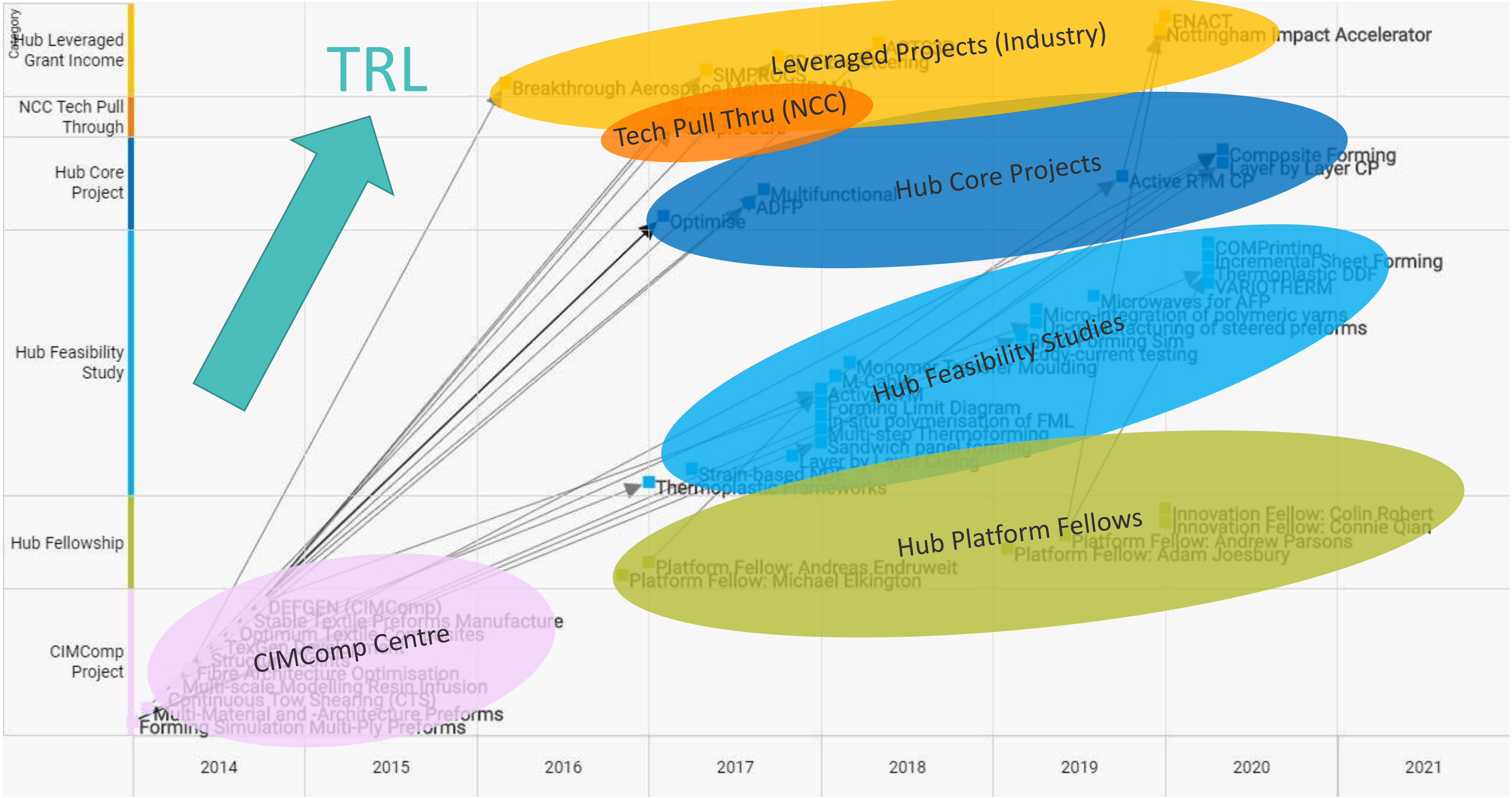
- HVMC Technology Pull Through funding - £1.3m over the life of the Hub
- Aims to transfer suitably mature technologies from academia to industry
- Collaborative projects aimed at increasing Technology Readiness, scaling-up, de-risking
- Projects managed by NCC and offered research space
- Activities include
  - persuasive technology demonstrators
  - examination of the potential for IP protection
  - routes to develop the TRL
  - examination of market opportunities
  - identification of the costs and time to market

Overview of Hub Research Impact
Technology Pull Through

- 2021: Manufacturing Ultra High-Temp CMCs with quicker processing
- 2021: Identifying hazardous products from composite processes
- 2022: Recycling of End-of-Life components through solvolysis
- 2022: Predicting fabric forming defects with quick and efficient simulations
- 2023: Composite assembly repair using vitrimer materials
- 2023: Testing cryogenic hydrogen permeation of materials

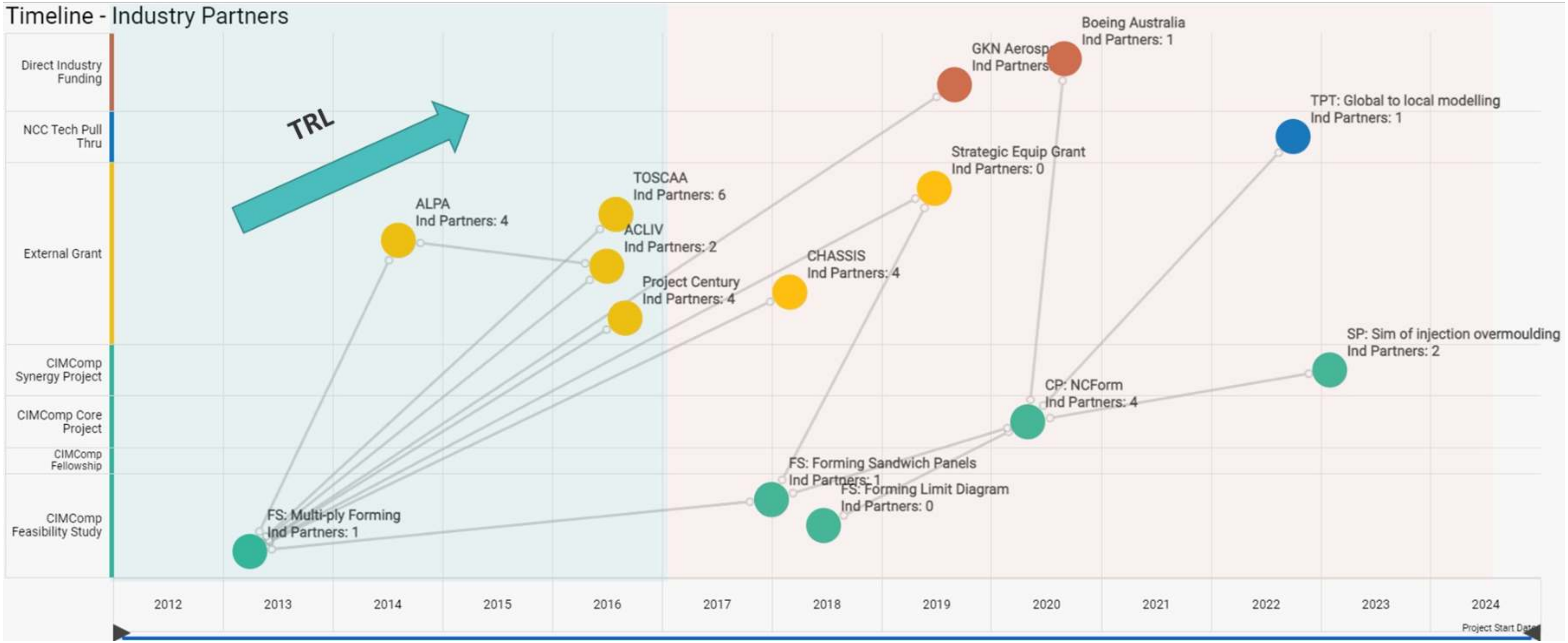


Project Start Date

Core Project: Design Simulation Tools for NCF Preforming

CIMComp Centre

CIMComp Hub



Outline of the New Hub

Prof. Nick Warrior
Director of the EPSRC Future Composites Manufacturing Research Hub
University of Nottingham

Timeline for next Hub

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7th March 2023
- Stage One Outline Opening Date

10th May 2023
- Stage One Outline Closing Date

We are here

3rd July 2023
- Stage One Outline Expert Panel Meeting

11th July 2023
- Stage Two Opening Date

19th September 2023
- Stage Two Closing Date

12th February 2024
- Stage Two Interview Panel

March 2024
- Expected Funding Decision

April - July 2024
- Grant Start Date

Industry-led Challenges

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Industry Challenges

- **IC1 - Environmental** challenges of recycling, re-use of materials, reduction in embodied energy and emissions, reduction in use of non-renewables and elimination of consumables.
- **IC2 - Economic** challenges of sustainable manufacture at competitive costs to meet demand.
- **IC3 - Engineering** and scientific challenges in the design space for sustainable manufacture of high-quality, complex geometries to meet extreme environments of high stress, high endurance, high to low (cryogenic) temperature, high pressure, and high erosion resistance requirements.
- **IC4 - Educational** challenges of meeting skills requirements of future composites manufacturing engineers, trained in circularity and sustainability.

Ambitions

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Ambition 1:
Zero Prototyping

Validated high-fidelity predictive simulations of key energy-efficient manufacturing processes using sustainable materials to eliminate physical prototyping.

Ambition 2:
Zero Waste

Manufacturing net-shaped components via processes with zero wasted energy, incorporating recovered and recycled materials from in-process scrap and end-of-life structures.

Ambition 3:
Zero Critical Defects

In-process sensing, prognostics and the creation of digital material passports to support through-life monitoring, to reduce uncertainty, to maximise product service life and increase structural efficiency to ensure greater weight savings and CO2 reductions.

Ambition 4:
Zero Touch Labour

Automation, robotics and co-botics in key composites manufacturing processes to reduce process variability, to avoid scrap and improve UK competitiveness.

Ambition 5:
Zero Tooling

Tooling strategies across the range of length scales and production volumes for low energy processing, including reconfigurable and recyclable tooling innovations and Additive Manufacturing for novel tooling solutions and tool-less composites.

Research Themes

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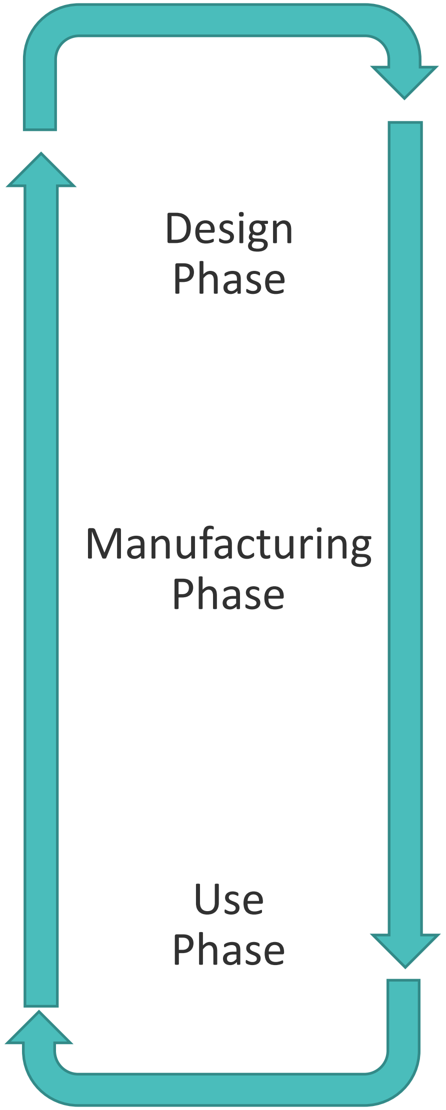

Manufacturing Hub Research Themes

- **RT1 – Integrated Design & Manufacture for Circularity:** Unlocking design freedom by creating new design simulation tools, composite manufacturing processes, disassembly and recycling processes to design out waste and pollution.
- **RT2 – Optimised Energy-Efficient Materials & Processes:** Development of low-emission, minimal energy technologies for precise, recorded fibre deposition and composite moulding, using fibres and matrices (including polymers and ceramics) from sustainable sources (including waste, recycled and bio-derived materials), leading to controlled and optimised architectures, strong interfacial bonds, controlled levels of voids and residual stresses.
- **RT3 – Sustainable Integrated Structures:** Manufacture and disassembly of structural composite components incorporating multi-material, multi-process, multi-functional elements, to provide in-process and in-service sensing, to extend life, facilitate circularity and maximise weight-saving.

Cross-cutting Themes

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Cross Cutting Themes

CC1 – Environmental Profiling - evaluating environmental impact of sustainable composite materials and processes using validated Life Cycle Assessment (LCA) tools. (NCC)

CC2 – Factory of the Future - enhancing composites manufacturing environments, making improvements to factory layout and plant digitisation. (AMRC, MTC)

CC3 – Material Science - developing new sustainable constituent materials. (CPI, NMIS, WMG)

CC4 – Data Science - artificial intelligence and machine learning. (NCC, MTC)

- Research Themes will be underpinned by leveraged contributions from multi-disciplinary partners
- Co-investigators will leverage funding from industrial partners and through open funding calls to augment multi-disciplinary research
- Delivery Partners will not be funded directly by the Hub

The Team

- Led by Universities of Nottingham and Bristol
  - Hub Director – Prof Nick Warrior
  - Deputy/Co-Director – Prof Ole Thomsen
  - Deputy Director for Education and Skills – Prof Janice Barton
  - Deputy Director for Operations – Dr Lee Harper
  - Nottingham – Dr Davide de Focatiis
  - Nottingham – Dr Tom Turner
  - Bristol – Dr Dmitry Ivanov
  - Bristol – Prof Stephen Hallett
- 6 spoke institutions
  - Bath – Prof Richard Butler
  - Cambridge – Prof Michael Sutcliffe
  - Edinburgh – Dr Dipa Roy
  - Imperial – Dr Soraia Pimenta
  - Sheffield – Prof Conchúr O'Bradaigh
  - Ulster – Prof Alastair McIlhagger

Introduction to new Hub Projects

- Develop new technologies to increase sustainability:
  - Constituents: bio-based matrices & low-embodied energy fibres (recovered, natural)
  - Manufacturing process
  - Recovery of materials
- Optimise existing processes to:
  - Increase rate
  - Increase quality – increase precision of fibre placement (avoid wrinkles), reduce voids
  - Reduce inspection
  - Reduce cost
    - Reduce materials costs
    - Reduce capital cost
    - Reduce energy consumption
    - Reduce inspection cost
  - Improve properties

CP Idea 1: Composites de-manufacturing for circularity

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What is the perceived industry problem to be solved?	What will be the project deliverables?

• Currently no de-manufacturing route for large-scale components to maintain value of constituent materials
    • **Fibres are devalued** by chopping to facilitate waste processing
    • **Resins are thermally degraded** or destroyed to enable fibre recovery
	• An end-to-end framework to enable de-manufacture and remanufacture of thermoplastic structures.
	• Development of thermally-assisted methods to deconsolidate thermoplastic laminates, maintaining tow/tape architecture
	• Design of robotic end-effectors to automate fibre peeling
	• Fibre/tow splicing methods to re-join tapes into continuous products

What science will be used to address this problem?	**Who will participate?**
• Continued development from a successful Hub Feasibility Study • Rheology to understand polymer deformation • Establish rheological models to aid process development • Multi-disciplinary support from Chemistry	• University of Nottingham • NCC/AMRC/University of Bristol/Sheffield? • Industry partners ?

CP Idea 2: Large-scale sustainable thermoplastic structures

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What is the perceived industry problem to be solved?	What will be the project deliverables?
• Inability to produce **large thermoplastic composite structures** using out of autoclave/press processes. • Components are either limited in size or quality, limiting the use of **high-performance thermoplastics**. • Wider adoption of thermoplastics over thermosets would unlock more options for processing of in-process waste and end-of-life structures	• In-situ polymerisation manufacturing method to enable use of single-sided tooling and out-of-autoclave processing for thermoplastics • In-situ polymerisation for creating structural joints to produce large assemblies from multiple thermoplastic components
What science will be used to address this problem?	**Who will participate?**
• Design of experiment to understand process parameters for in-situ polymerisation • Hardware development • New material characterisation techniques to confirm degree of polymerisation	• University Nottingham / University of Edinburgh • AMRC + other HVM Catapult partners ? • Industry partners ?

CP Idea 3: Energy efficient manufacturing

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What is the perceived industry problem to be solved?

- Energy efficiency in manufacturing is critical for the cost and sustainability of the produced components.
- Conventional methods are conservative, rely on heavy equipment and tooling with high thermal inertia. The current manufacturing approaches lead to massive energy waste.
- Developing new heating approaches is essential and responds to the call of energy crisis.

What will be the project deliverables?

- The overarching aim is to optimise energy consumption in manufacturing processes, such as curing, consolidation, forming, while satisfying quality requirements.
- This answer to energy challenge will comprise novel approaches to heat supply, tooling, robotics, closed-loop control of process parameters, etc.
- The project will deliver benchmarking assessment of the novel approaches against conventional methods.

What science will be used to address this problem?

- Novel approaches will deal with the major impediment to implementing novel heating strategies: uniformity of heating, flexibility of heat delivery, in-situ control of cure process, elimination of heat losses, lightweight tooling designs.
- The combination of various promising solutions will be brought together in a holistic approach to reduce the embodied energy of composite components.

Who will participate?

- University of Bristol + other academic partners ?
- HVM Catapult partners ?
- Industry partners ?

CP Idea 4: Production of sustainable fibre architectures

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What is the perceived industry problem to be solved?	What will be the project deliverables?
• Cost of producing current textile fibre architectures (laminates or preforms) is prohibitively expensive for complex geometries carrying multiaxial load cases • Material waste levels are high for broad goods in production • Overly conservative designs due to sub-optimal fibre architectures resulting from lack of control over fibre placement and material variability • No commercial route for utilising recovered fibres from end-of-life components	• High fibre volume fraction solutions incorporating recycled fibres for multiaxial structural applications • Methodologies for quality control of both recycled materials and structures to reduce variability/uncertainty • Simulation tools for structures (and their manufacturing process) made with recycled composites
What science will be used to address this problem?	**Who will participate?**
• Understanding the mechanics of filament handling and challenges relating to fibre entanglement in recovered fibre formats. Micro- to mesoscale level modelling of fibre architecture • Theoretical mechanics, surrogate modelling, optimisation techniques	• University partners ? • HVM Catapult partners ? • Industry partners ?

CP Idea 5: Quality control and integrated design with recycled composites

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What is the perceived industry problem to be solved?	What will be the project deliverables?
• The composites industry needs to become circular. • Recycling process for CFRPs are now mature, but recycled CFRPs are still not commonly used. • Currently, quality control of recycled FRPs (through single-fibre testing) is laborious and unreliable. • Engineers lack confidence in the performance of recycled FRPs, as well as suitable design methods.	• Industry-friendly quality control methods and standards for recycled FRPs • Material cards to simulate recycled FRPs in commercial software for process simulation and structural design
What science will be used to address this problem?	**Who will participate?**
• Mechanical characterisation and rheology • Integrated process and structural simulation • Statistical analysis of variability • Development of constitutive models	• Imperial College + UoN or UoB • HVM Catapult partners ? • Industry partners ?

CP Idea 6: Advanced textile composites

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What is the perceived industry problem to be solved?

- It is difficult for industry to exploit advanced textile composites – disconnect between design and manufacture
  - Lack of process to specify a weave style/preform that will meet specific requirement – especially mixed processes
  - At the moment it is mainly trial and error and engineering experience.

What will be the project deliverables?

- Roadmap capturing industry requirements and textile technologies (including combinations) to deliver this
- Integrated modelling software – manufacture (loom) interaction
- Demonstrator of process: Specification –> Design/optimisation –> Manufacture –> Validation/feedback

What science will be used to address this problem?

- Advanced textile manufacturing methods
- Textile geometry modelling software
- Machine – model interaction
- Instrumentation and measurement of manufacturing processes

Who will participate?

- University of Ulster
- University of Bristol
- University of Nottingham
- HVM Catapult partners ?
- Industry partners ?

CP Idea 7: Manufacturing using sustainable fibre and matrix forms

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What is the perceived industry problem to be solved?

- The requirements to sustainability demands deploying (i) recycled fibre, (ii) repairable matrices, (iii) materials sourced from renewable stock.
- These materials exhibit fundamental challenges: alignment of short fibres, cost and processing constraints of matrices, consistency of properties.
- Adaption of these materials require rethinking conventional manufacturing processes and developing new approaches.

What will be the project deliverables?

- The project will explore modular manufacturing routes to produce quality components using reclaimed discontinuous preforms (such as short aligned HiPerDiff preforms) and sustainable matrices (such as vitrimers).
- The project will enhance current design capabilities for sustainable material forms and deploy simulations-driven manufacturing for deposition, forming, impregnation and repair.

What science will be used to address this problem?

- Maintain the integrity of discrete discontinuous material forms and ensure consistency of processes.
- Unveil the potential granted by new architectures, such as formability, steering capacity, flexibility.
- Design consistent manufacturing routes considering more difficult processing characteristics of sustainable matrices.

Who will participate?

- University partners ?
- HVM Catapult partners ?
- Industry partners ?

CP Idea 8: Sustainable integrated structures

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What is the perceived industry problem to be solved?

- Manufacturing of aerospace-quality sandwich structures is cost and energy intensive
- Core materials are expensive and require machining to size, generate waste and limit manufacturing rate
- Open-cell cores restrict composite skin manufacturing options

What will be the project deliverables?

- Integrated composite skin-core manufacturing technology

What science will be used to address this problem?

- Simulation of materials/structures/processes using explicit FE

Who will participate?

- University partners ?
- HVM Catapult partners ?
- Industry partners ?

CP Idea 9: Large-scale digital composites manufacturing

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What is the perceived industry problem to be solved?	What will be the project deliverables?
• Lack of robust composite manufacturing processes for producing defect-free structures • Leading to excessive safety/knock-down factors, conservative designs	• New processes and/or enhancing existing processes: Additive, robotic laminating, filament winding, pultrusion • Digital Twin of major composites manufacturing technologies • Capture the influence of all manufacturing stages to produce a digital passport/record/fingerprint • In-process quality assurance and through-life structural monitoring • Ensure maximum value from recyclates – position of fibres, material composition
What science will be used to address this problem?	**Who will participate?**

• Multi-scale, multi-physics modelling
• Hierarchical data record
    • Processing of large datasets
    • Sensing and live data streaming
• Factory of the future modelling
	• University partners ?
	• HVM Catapult partners ?
	• Industry partners ?

CP Idea 10: Life Cycle Analysis of sustainable composites

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What is the perceived industry problem to be solved?	What will be the project deliverables?
• Lack of confidence in existing LCA tools and data for analysing current composite manufacturing processes and materials	• Robust and transparent accounting processes based on high-quality and repeatable data, exploiting established LCA frameworks • Reliable embodied energy values for a range of composite materials and manufacturing solutions
What science will be used to address this problem?	**Who will participate?**
• A platform activity will underpin all other Hub funded projects to provide relevant LCA data for new sustainable material/process developments	• University partners ? • HVM Catapult partners ? • Industry partners ?

Future Hub Engagement

Dr Simon Quinn
Business Engagement Manager
University of Bristol

Support of your R&D

- Co-creation and co-delivery of pre-competitive low TRL research projects
- To match your medium/long term business goals and drivers
- Active participation in Hub projects and activity, to provide you with quantifiable benefits

Matching the Hub's research ambitions to industrial challenges

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- To ensure the Hub's scientific research is industrially relevant and has exploitation potential
- Links to industry challenges/problems
  - What are the current blockers?
  - What science/engineering break-through or development is required?
  - What needs to be delivered in a low TRL project?
  - Industry partner interest, involving all relevant parts of the supply chain

Modes of engagement

- Co-creation and co-delivery of Hub projects
- Support of doctoral students
- Leveraged funding bids
- Join the Hub community
  - Attend sandpit events to share challenges, interests and ideas for future co-created Hub projects
  - Potential to become a member of the Hub's Industrial Advisory Board (IAB)
  - Receive Hub quarterly newsletters
  - Attend Hub Open Days (for an update on Hub research, exhibit and network with the community)

Co-creation of Hub projects

- Co-development, and co-delivery of a Hub project (Feasibility Study or Core Project)
  - Provision of a use-case (process/part/material)
  - Participation in a pilot trial or field testing
  - Access to data/archive material
  - Secondment
  - Technical advice and support

Leveraged funding

- Support of leveraged funding bids
  - Develop collaborative research ideas for technology pull-through with a Hub academic
  - Engage with academic partner(s) on a collaborative research proposal/project (UKRI (EPSRC), ATI, Innovate UK (including KTP's), Horizon Europe, etc.)

Bid for EPSRC CDT in Innovation for Sustainable Composites Engineering

Professor Janice Barton

Director of the Industrial Doctorate Centre in Composites Manufacturing

The University of Bristol

Overview

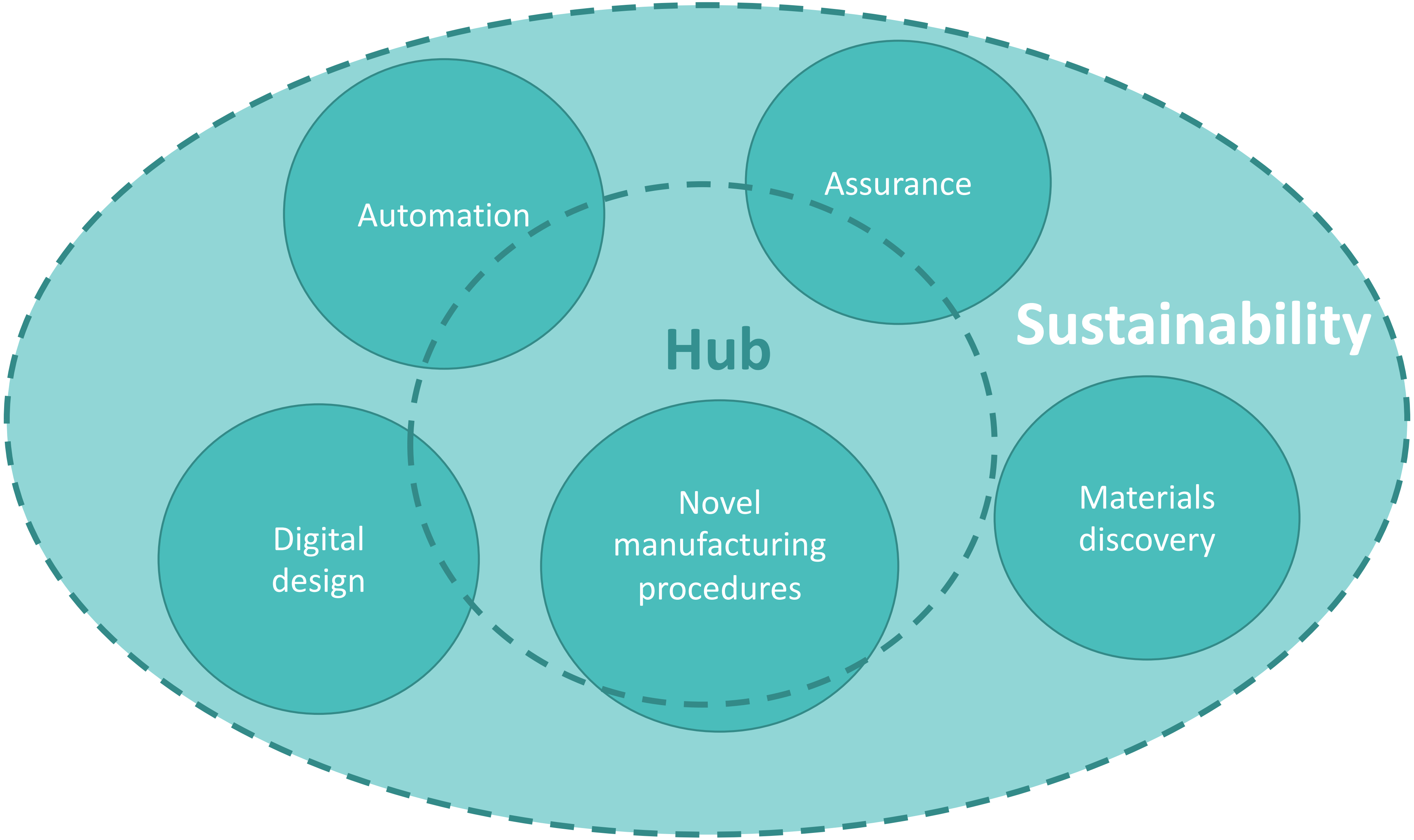
A partnership providing the advanced skills, knowledge, and science creating innovative leaders capable of unlocking the full potential of composites to achieve a sustainable, Net-Zero future.

- Outline proposal submitted in March: a collaboration between Bristol Composites Institute and CIMComp University of Nottingham
- Focus Area of Meeting a User Need: supported by a large investment from NCC
- Target is 80 PhD/EngD students to be recruited over 5 years
- Requested investment from EPSRC is circa £8M
- Bespoke training programme tailored to research projects
- All EngD projects will take place in industry for approximately 75% of student time
- EPSRC received 336 proposals with 124 being invited to full proposal; our proposal has been invited to full proposal deadline is 12th September 2023

Objectives

- Provide a science-based framework for innovative, curiosity driven research
- Provide skills development to facilitate composites as the underpinning technology for a sustainable future.
- Connect TRLs 1-4 providing a transitional pathway from fundamental research through to industrial deployment.
- Offer an agile doctoral educational environment:
  - focused on advanced competencies and skills,
  - tailored to industrial and commercial needs,
  - providing academic excellence
  - encourage innovation
- Provide future leaders with the innovative and entrepreneurial mindset to drive the transition to Net-Zero and support the UK composites sector

Link between the Hub and CDT



- Hub cannot fund studentships
- CDT will require matched funding from industry for studentships
- iCase studentships could be affiliated with the CDT and benefit from training
- Industry staff can enroll for EngD programme

Benefits to industry

- Opportunity to engage in new doctoral training programme that will bring long term benefits to your business and the health of the UK composites industry
- Highly engaged and competent doctoral candidates working on your R&D, located at your company; recruited with, and managed directly by you
- Cutting-edge input into your R&D from academic staff in BCI and UoN
- Access to university facilities, including high performance computing and workshops/laboratories
- Opportunities for your staff to upskill through attendance of the CDT training programmes
- Future recruitment of highly qualified staff trained to meet your needs through the CDT

Online Feedback Session

Padlet Link

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https://padlet.com/leeharper/future-composites-manufacturing-research-hub-lqwbrd55gnjx3acf

- Password: composite

Padlet Responses

What is the biggest challenge your company/sector faces within the next 10 years?

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Environmental

- Legislation & Responsibility for End-of-Life Waste
- Composites' Role in Achieving Net Zero CO_2e
- Shifting to Sustainable Materials & Recycling Solutions
- Improving Collection, Sorting, & Logistics
- Reprocessing Dry Fibre Waste for Valuable Inputs
- Contributions to Net Zero Goals

Economic

- National Collaboration for Domestic Fibre Manufacturing
- Timely Solutions for Customer Needs
- Commercialising Proven Reclamation Technologies
- Managing Costs & Competition

Engineering

- Limited Downstream Processing for Waste Composites
- Scaling up Recycled Fibre-Reinforced Plastics (rFRP)
- Upscaling Ceramic Composites for High-Temperature Needs
- Choosing Between Bio-based Feedstocks & Chemical Recycling
- Optimising Designs for Weight Reduction

Education

- Recruiting Skilled Engineers & Trained Staff
- Considering LCA & Sustainability in Composites
- International Standards for Aircraft Dismantling & Material Reuse
- Ensuring the Supply of Trained Engineers & Robust Supply Chain
- Regulation's Impact on Closed-Loop Recycling & Market
- Educating Customers on Sustainable Practices
- Enhancing Education & Training for Composites Manufacturing
- Addressing Practical Experience Shortage

Padlet Responses

What TRL1-3 science/engineering developments are required to address this challenge ?

- Evaluation of Non-Oil-Based Feedstocks and Their Environmental Impact
- Utilising Reclaimed Resins and Fibres in Composites
- Tagging, Labelling, and Traceability throughout the Product Lifecycle
- Aligning Demand for Recycled Materials with Available Feedstock
- Establishing Standards and Characterization for Recycled Materials
- Optimising Composite Performance through Process-Driven Microstructural Analysis
- Exploring Applications for Recovered Fibres
- Collaborative Projects Involving Stakeholders in End-of-Life Recycling
- Developing Diverse Material Formats from Recovered Fibres
- Industry Education on Sustainable Impact Assessment
- Training Future Leaders in Trade-offs Between Performance and Sustainability
- Bridging the Gap Between Analysis and Practical Implementation on the Shop Floor

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Padlet Responses

Are the outlined Hub research Ambitions appropriate for tackling your industrial challenge?

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Zero Prototyping

- Ambition and cost reduction are important in re-engineering for sustainability.
- Working with customers presents a challenge as they often save problems for later stages.
- Prototyping is essential for improvement and problem-solving.
- Accurate simulation is crucial for the efficient industrialisation of composites.
- The ability to scale quickly is facilitated by simulation.

Zero Waste

- Discussion on sector-specific demonstrator components is important.
- Government involvement is crucial for co-funding facilities and technology pull-through.
- Avoid using the term 'waste'; consider it as material awaiting reprocessing or conversion.
- Emphasise the importance of strong design to initiate waste reduction.
- Identifying opportunities for material hybridisation and its effective utilisation is a valuable outcome.

Zero Critical Defects

- Faster/cheaper inspection. Ability to detect kissing bonds.
- The most straightforward way of increasing composite sustainability in the short-medium term is to extend their service life by having validated methods to assess (and if possible correct) their accumulated damage and residual function. Critical defect detection and correction are key elements in this.

Zero Touch Labour

- Minimal touch even in automation is key to reducing knockdown for subsequent lives

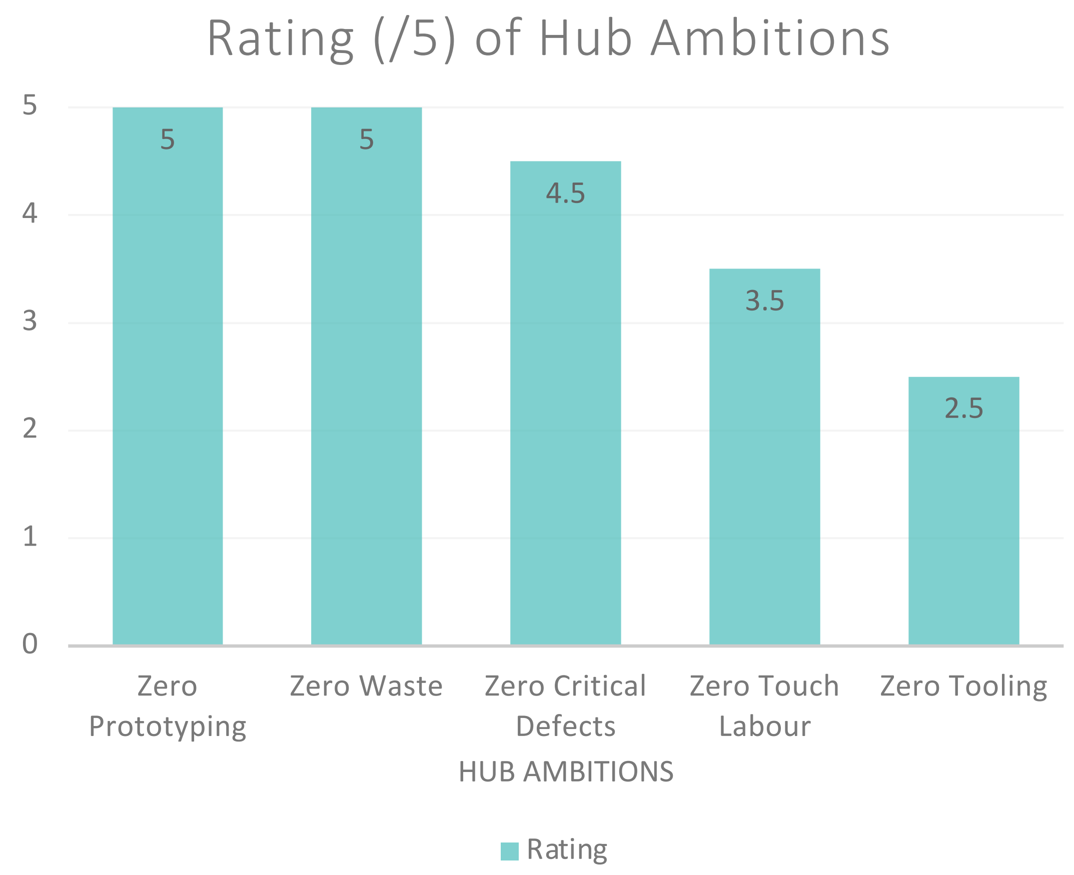
Zero Tooling

- Emphasise environmental impact investigation aligned with UN sustainability goals over the discussed topic.
- Tooling's economic feasibility and waste impact, particularly in lower production volumes, affect composite applications.
- Recovering tooling investment and materials can facilitate composite adoption in certain products.
- Collaboration on a larger scale is needed to implement technical solutions and create infrastructure.
- Lower-cost approaches for direct heating are preferred, as long as they align with industry baselines.
- Assembly and joining are higher priorities than the topic at hand.
- Methods to reduce tooling barriers can promote composite usage.

Padlet Responses

Are the outlined Hub research Ambitions appropriate for tackling your industrial challenge?

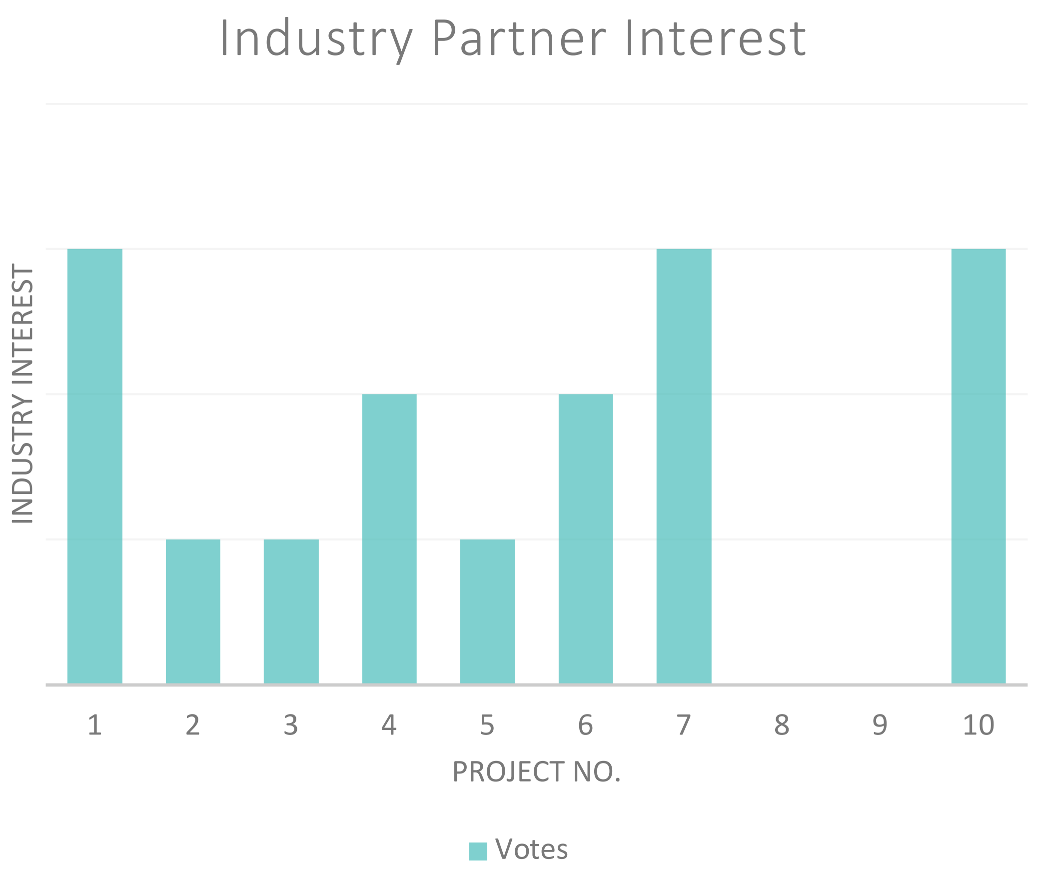
- “They will all feed in to some extent - probably defect stream is most interesting”.
- “Yes largely: Prototyping, Waste, critical defects (to extend service life) are the key ones for me”.
- “Yes, keep me informed of progress”.



Padlet Responses

Which fundamental research project(s) would you like to help co-create as a potential Hub industrial partner?

- CP Idea 1: Composites de-manufacturing for circularity
- CP Idea 2: Large-scale sustainable thermoplastic structures
- CP Idea 3: Energy-efficient manufacturing
- CP Idea 4: Production of sustainable fibre architectures
- CP Idea 5: Quality control and integrated design with recycled composites
- CP Idea 6: Advanced textile composites
- CP Idea 7: Manufacturing using sustainable fibre and matrix forms
- CP Idea 8: Sustainable integrated structures
- CP Idea 9: Large-scale digital composites manufacturing
- CP Idea 10: Life Cycle Analysis of sustainable composites



Which fundamental research project(s) would you like to help co-create as a potential Hub industrial partner?

Additional Ideas for Potential Projects

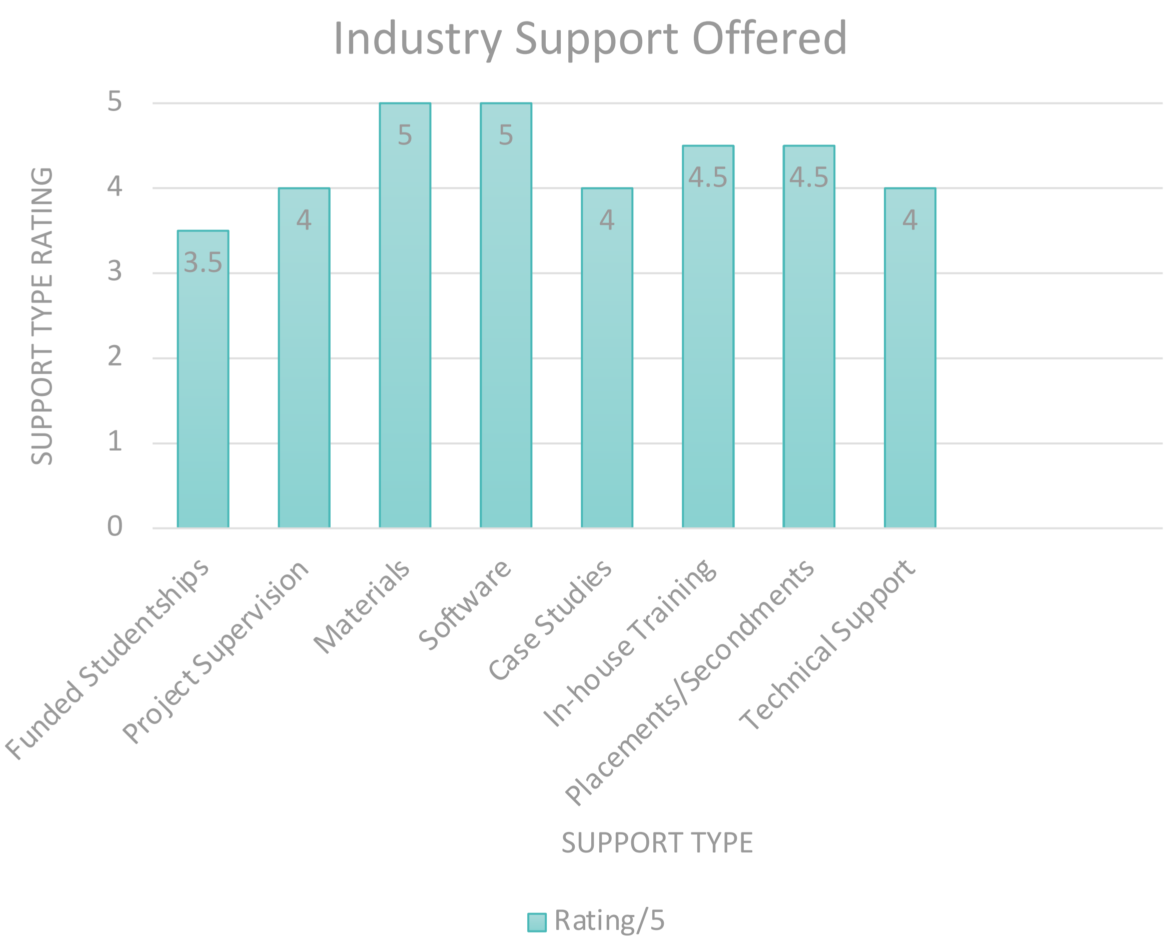
- Next hub's engagement in standards development needs clarification.
- Inquiry into the circularity of bio-composites is required.
- A reassessment of SHM-themed streams' benefits and cost-effectiveness is recommended.
- Identification of composite components suitable for reclamation is necessary.
- Visualise the supply/demand balance with increased use of hydrogen and wind power.
- Emphasise sustainable fibre development, which was overlooked.
- Create a target flying machine concept to explore end-use credibility and design challenges in rotary/EVTOL/fixed wing categories.
- Explore the potential for chemical recycling of epoxy and polyester resins.
- Consider alternative approaches for handling mixed wastes from end-of-life composites.

Padlet Responses

How can you support the co-delivery of these projects? What can you/your organisation offer the Hub?

Examples of Industry Support Offered

- Material data information
- Technical support
- Networking and supply chain access
- Studentship sponsorship
- Expired prepreg materials for fibre recovery studies
- Dry fibre nesting waste
- ABAQUS and other FEA/design tools
- Co-creation of new software
- In-house training e.g., operation of DEECOM
- KTP partnerships



Strengths/Weaknesses for Industry Engagement within the Current Hub

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- Host sandpit events to share challenges/ideas to ensure more projects are co-created between industry and academia.
- Those companies at the smaller end of the SME spectrum are usually, by definition, innovative and forward-thinking but their financial position means that engagement is difficult. This could result in the Hub missing potential opportunities and innovations.
- There are some really great topics in this proposal really great job
- Sustainability is not a challenge that can be solved at a national level. Please consider extensive international collaboration (especially within EU states). This will help build stronger networks, which will support the transitions we need to make.

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UKRI Engineering and Physical Sciences Research Council

Thank you for your participation

University of Bath | University of Bristol | Brunel University London | University of Cambridge | Cranfield University | The University of Edinburgh | University of Glasgow | Imperial College London | Manchester 1824 | University of Nottingham UK | CHINA | MALAYSIA | Queen Mary University of London | The University Of Sheffield. | University of Southampton | Ulster University | Warwick | Prifysgol Glyndŵr Wrecsam | Wrexham Glyndŵr University