NATIONAL COMPOSITES CENTRE

Welcome to the Technology Pull-Through Launch Webinar

We will start shortly after 10.00

29th September 2022

Agenda

10.00	Welcome and introduction to the NCC	Enrique Garcia
10.05	Introduction to TPT and the TPT process	Matt Scott
10.15	Our Sustainability Strategy	Tim Young
10.25	Our Hydrogen Strategy	Marcus Walls-Bruck
10.35	Our Digital Strategy	Marc Funnell
10.45	Other areas for collaboration	Matt Scott
10.50	Break	-
11.00	How TPT helped Dielectric Sensing research reach Meggitt	Alex Skordos
11.10	TPT: An industrially-based researcher’s perspective	Jonathan Belnoue
11.20	Questions, including poll results	Matt Scott
11.35	Conclusions and thanks	Matt Scott
11.45	End	-

NATIONAL COMPOSITES CENTRE

Brief introduction to the National Composites Centre

Enrique Garcia NCC Chief Technology Officer

13 September 2022

High Value Manufacturing Catapult

CATAPULT
High Value Manufacturing

7
centres

17
locations

27
technologies

3500+
people

£800m
assets

Over 2000
projects per year

1/3
government funded

2/3
industry funded

£500m
industry R&D linked to HVMC per year

1. AFRC – ADVANCED FORMING RESEARCH CENTRE – UNIVERSITY OF STRATHCLYDE
2. cpi
3. NUCLEAR AMRC
4. AMRC – ADVANCED MANUFACTURING RESEARCH CENTRE
5. mtc – Manufacturing Technology Centre
6. WMG – THE UNIVERSITY OF WARWICK
7. NATIONAL COMPOSITES CENTRE

Image courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center

Catapult Mission: Bridging the Valley of Death

Early innovation and research

Applied research and development

Technology implementation through to successful operations

TRL 1 TRL 2 TRL 3 TRL 4 TRL 5 TRL 6 TRL 7 TRL 8 TRL 9

Research establishments

NCC

Private sector

The National Composites Centre

Our Vision

The NCC is a world leading authority on composites, bringing together the best minds and the best technologies, to solve some of the world's most complex engineering challenges

Our Purpose

To accelerate the adoption of high value, sustainable engineering solutions in composites to stimulate global growth and enhance capability for the benefit of the UK

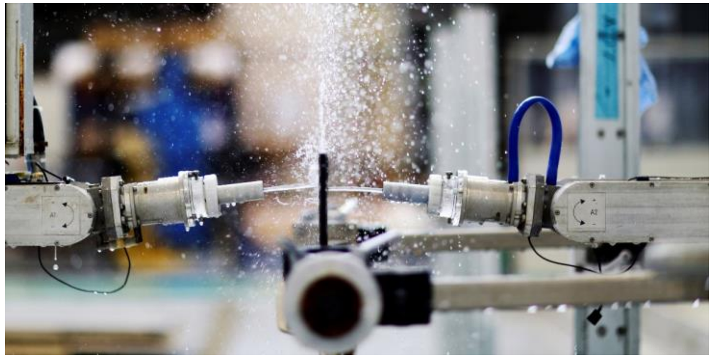
£200m invested in capabilities

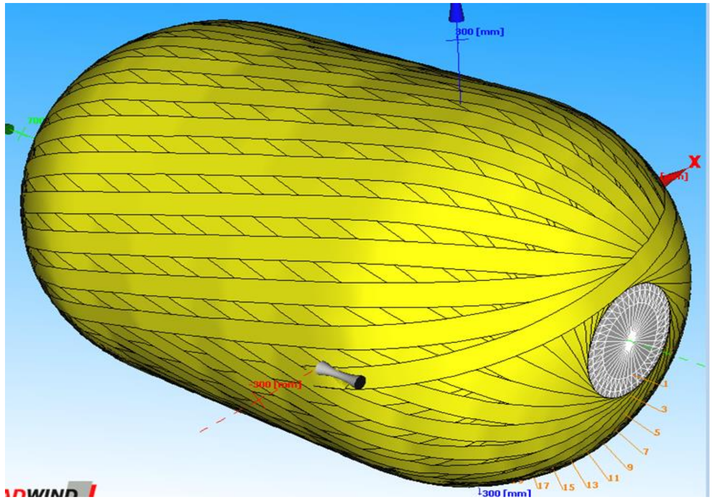
700+ organisations supported

600+ composites specialists

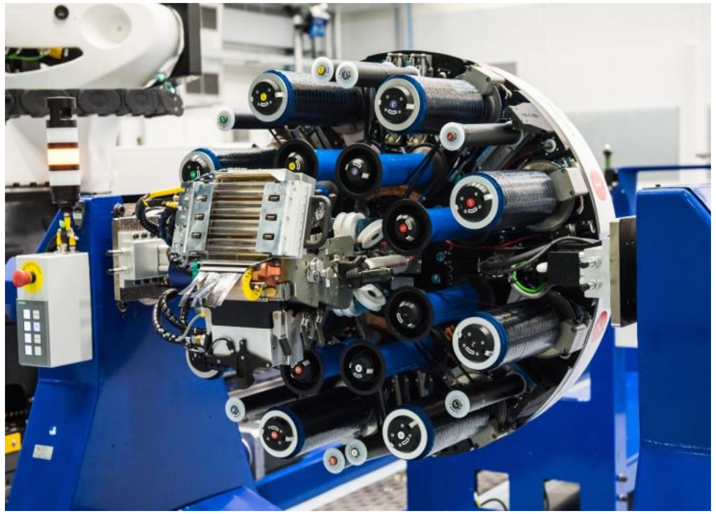
60+ university partners

Capabilities





Europe’s leading composite innovation centre



NATIONAL COMPOSITES CENTRE

NCC Technology Pull-Through Programme: Transitional Research in Action

Matt Scott NCC Chief Engineer for Capability

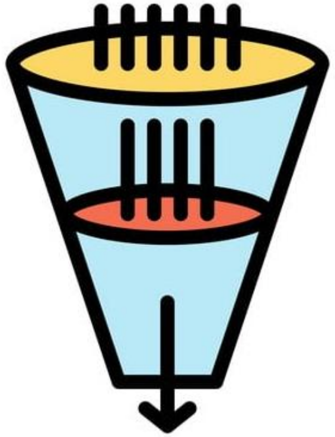
13 September 2022

Technology Pull-Through: What is it?

- A technology development programme to stimulate the transition of suitably mature technologies to industry
- Scope is technologies and methods ready to leave the lab environment (TRL3-4)
- Projects are 12 months long, are funded and managed by the NCC, and conducted primarily by NCC
- Background IP stays with the source universities, foreground IP is shared

Technology Pull-Through: History

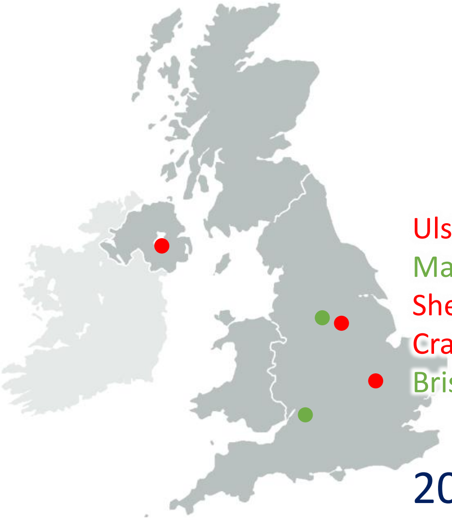
- First programme launched in 2017
- 20+ "technologies" matured – including:
  - Continuous Tow Shearing — University of BRISTOL
  - HiPerDif — University of BRISTOL
  - SimpleCure — University of BRISTOL
  - Dielectric sensors — Cranfield University
  - Dismantlable joints — OXFORD BROOKES UNIVERSITY
  - Bio-derived thermoplastics — UNIVERSITY OF BATH



Down-selection process involves CIMComp and NCC input

~£2m total invested in upcoming technologies over last 5 years

Technology Pull-Through: History



Ulster
Manchester
Sheffield
Cranfield
Bristol (UoB)

2018-19

Highlands
Ulster
Manchester
Cranfield
Bristol (UoB, UWE)
Cardiff
Bath
Oxford
Surrey
Exeter

2019-20

Glasgow
Edinburgh
Sheffield
Chester
Birmingham
Bristol (UoB, UWE)
Bath
London (UCL)
Portsmouth

2021-22

Liverpool
Nottingham
Birmingham
Bristol (UoB, UWE)
London (UCL)
Portsmouth
Exeter

2022-23

- Launched projects
- Applications received

Technology Pull-Through 2022-23

- Two TPT projects kicked off for 2022-23
- Both directly aligned with NCC composites strategy

MARKET PULL ↓

- Market drivers
- Sector trends
- Sector platforms
- Enabling products
- Technology challenges
- Technology themes
- Technologies

TECHNOLOGY PUSH ↑

NCC's current
Technology Challenge THEMES

Digital Sustainability Hydrogen

Global-to-Local Forming Simulation

Digital

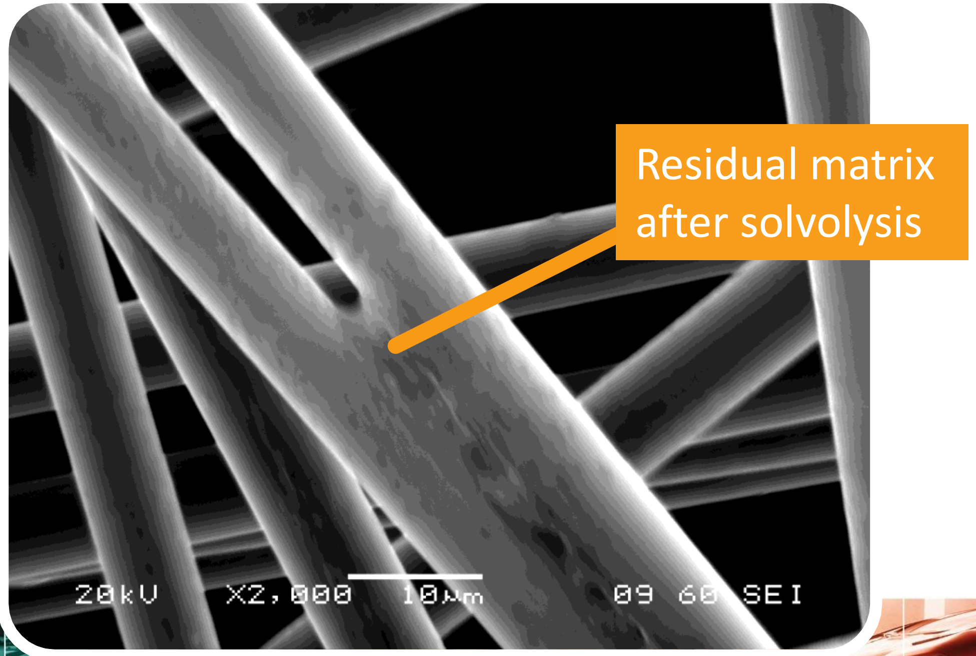
- ✓ Dr Lee Harper @ University of Nottingham working alongside Dr Jonathan Belnoue @ NCC/(UoBris)
- ✓ Key technology contributor to large aerospace manufacturing
- ✓ Will directly support national NCC CR&D project
- ✓ Off the shelf software benchmarking

The University Of Sheffield.

Solvolysis recycling of composites

Sustainability

- ✓ Prof Gary Leeke @ University of Birmingham
- ✓ National expert in solvolysis will help build strong NCC recycling foundation – CPI engaged to partner future exploitation with potential future SME route



UNIVERSITY OF BIRMINGHAM

Technology Pull-Through 2023-24

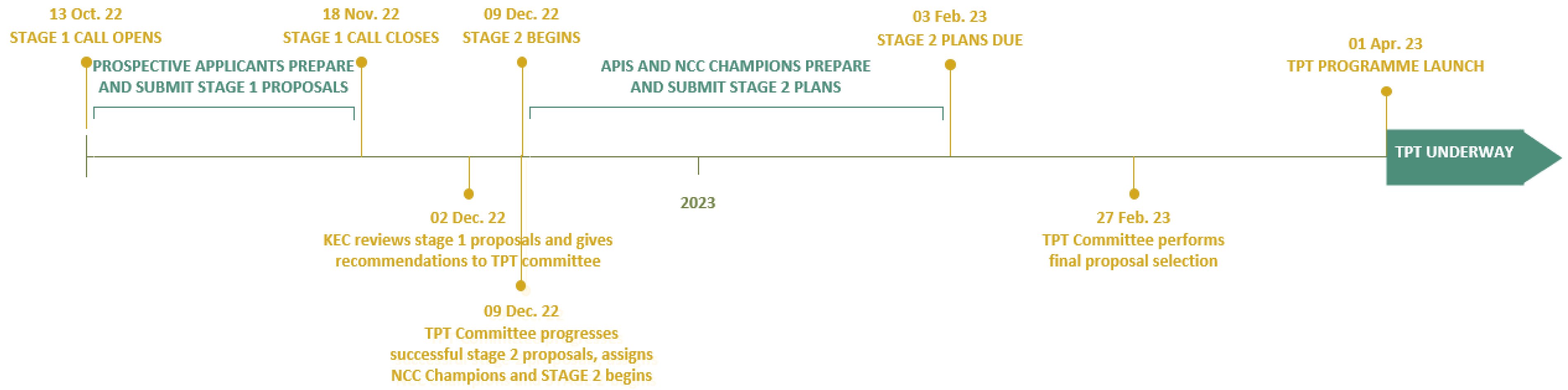
- Next year's programme will CONTINUE with new academic proposals

Digital | Sustainability | Hydrogen | Explorative

- Selection criteria will include:
  - ✓ Technology Readiness Level
  - ✓ Alignment with Technology Challenge Themes
  - ✓ Viability and impact for future industrial application
  - ✓ Intellectual Property and freedom to operate

Technology Pull-Through 2023-24

- Application process to commence in TWO WEEKS: 13 October 2022



- Application page to be circulated on 13th October when call opens

NATIONAL COMPOSITES CENTRE

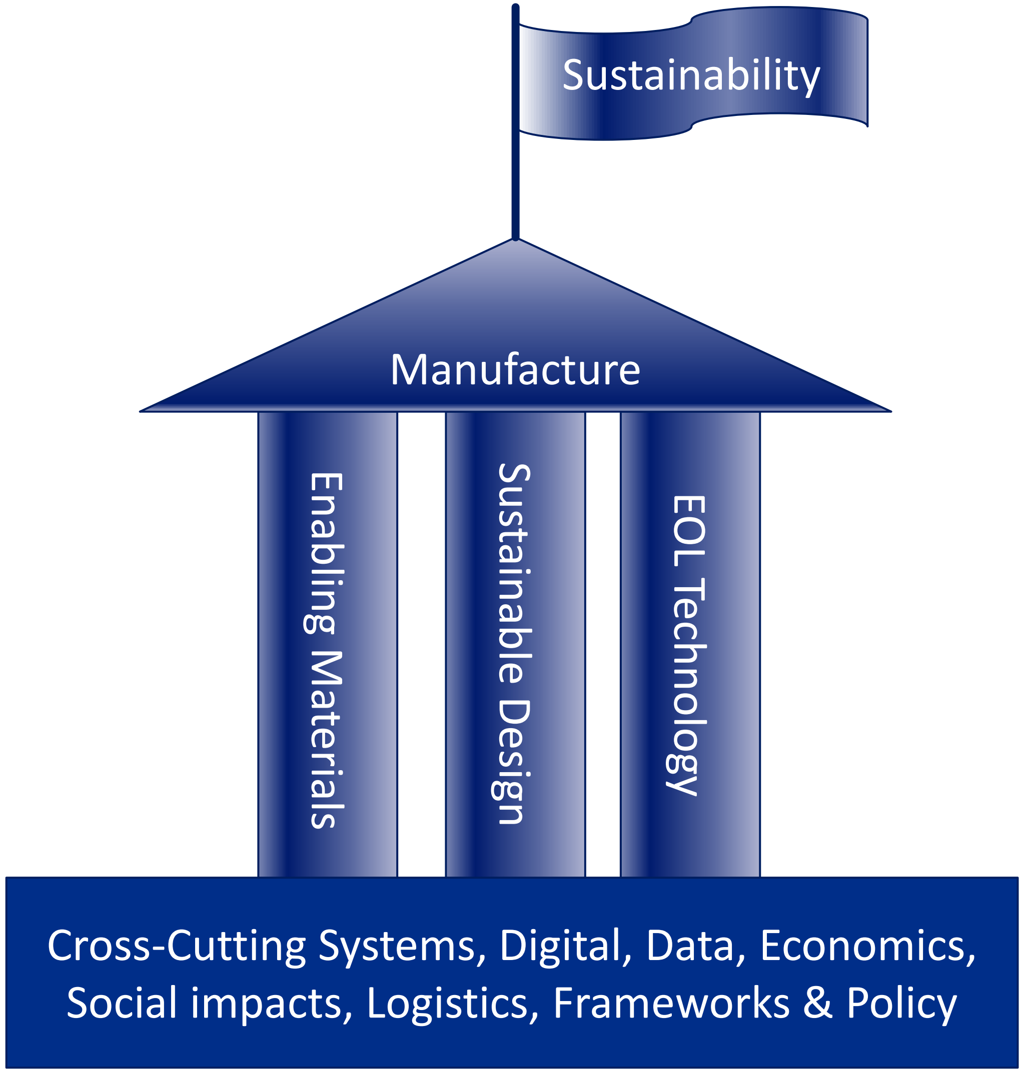
NCC Sustainability Outlook

Tim Young NCC Head of Sustainability

13 September 2022

Sustainability

Sustainability



Transform composite materials, manufacturing, their products and their supply chains into a sustainable and circular industry.

- ✓ Enabling Materials
- ✓ Sustainable Manufacture
- ✓ Design for Sustainability
- ✓ End of Life Technologies

Underpinned by existing network strengths across cross-cutting systems architectures/digital/data and increasing impact of academic excellence with a broadened network in economics & social pillars of sustainability

Sustainability

For the purpose of collaboration, focused flows of activity

- Impact to a product or supply chain
- Demonstrate key technology enablers
- Translation impact into other areas (start on wind blades, exploit across automotive)
- Creates a platform for the partnership as thought leader

Sustainability

Sustainability

Digital
- Make Life Cycle Assessment easier & accessible
- Measure and tracking
- Manufacturing optimisation

Increase confidence in sustainable design
- Credibility assessment (Is it greenwashing? End-of-life viability assessment)

New Materials
- Sustainable materials aimed at specific products (e.g. hydrogen tanks/pipes)
- Materials for end-of-life (e.g. separation, disbonding, recyclability)
- High performance drop-in replacements
- Technologies that increase performance/durability
- Improved processability

Re-lifing technologies
- Requalification
- Post-process technologies (how to handle reclaimed fibres prior to manufacture)
- Re-lifing / reforming of thermoplastics

Manufacture with recyclate & products
- Increased vol fraction & control of rFibre products
- Prediction of short fibre
- “r”intermediates and “r”matrices

Sustainable manufacture
- Remove waste (e.g. consumables)
- Reduce harm (volatiles, toxicity, cleaning products)
- Quantify and reduce energy / costs
- Low energy heating technologies

Underpinning → Design for S → Future Materials → End of Life → Sustainable Manufacture → **PRODUCT IMPACT**

Sustainable design & predictive modelling
- Materials data & appropriate characterisation
- Recycling requirements 4 design
- Designs / disassembly concepts

Recycling Technologies
- Reclamation, of both fibre and matrix
- Waste product identification
- Post reclamation treatment of fibre
- Recyclate quality assurance & categorisation

End-of-life
- Disbonding/dismantling
- Fibre handling & chopping
- Separation & identification technologies

NCC Hydrogen Outlook

Marcus Walls-Bruck NCC Head of Hydrogen

13 September 2022

Hydrogen focus areas at NCC

	Pressure vessels	Cryogenic tanks	Distribution pipes
Why composites?	Mass and volume efficiency, predominantly for mobility applications	Mass efficiency, initially for aerospace applications	Reduced deployment and in-service maintenance costs
NCC ambition	Support creation of supply chain Position UK as future leader through R&D	Support development of UK cryogenic knowhow Identify areas of key IP	Support development of UK supply chain Unlock future markets

Pressure vessels ambition:

Position UK as a future leader in design and manufacture of composite pressure vessels

Hydrogen

Support formation and development of UK supply chain

Position UK as leader in pressure vessel R&D, including development of market disrupting technologies for UK benefit

2021
Concepting and design space exploration

2022
Multi-load case design & certifiable product

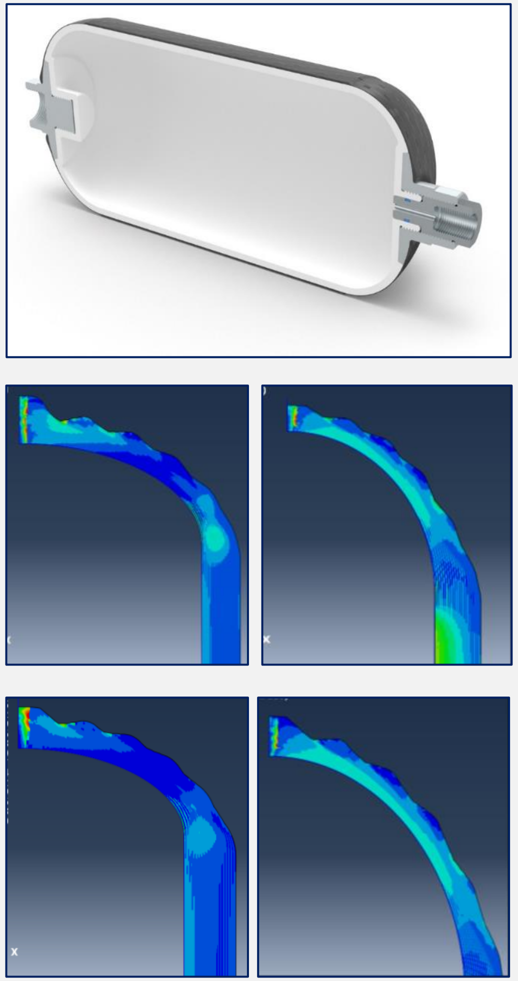
2023
Certifiable product by design, future product demonstrators

2024
Tank that exceeds DOE 2025 targets

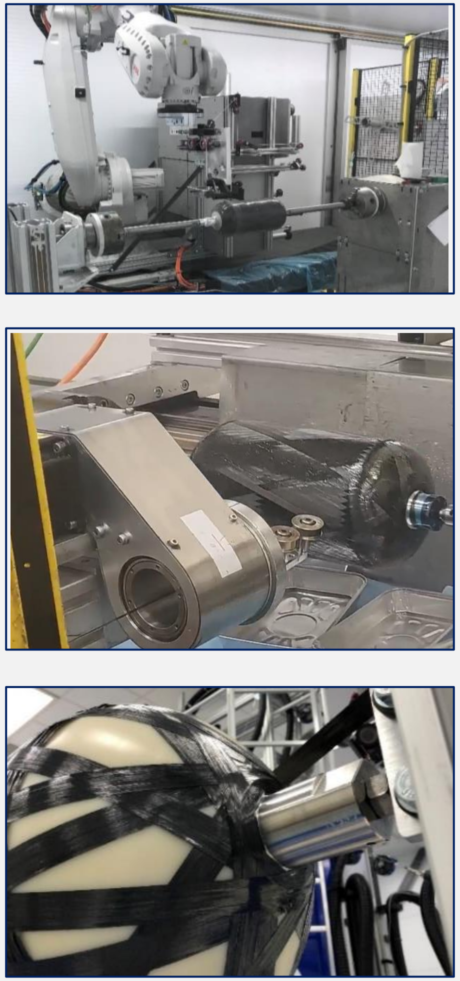
≈2025
MOON SHOT
Sustainable pressure vessels

Pressure vessels: NCC activities

Hydrogen



Design



Manufacture

Test

End of life

Pressure vessels: TECHNOLOGY GAPS

Hydrogen

2021	2022	2023	2024	≈2025
Concepting and design space exploration	Multi-load case design & certifiable product	Certifiable product by design, future product demonstrators	Tank that exceeds DOE 2025 targets	**MOON SHOT** Sustainable pressure vessels

Challenge 1: Reduced variability in pressure vessel manufacture

Variations during manufacture, including fibre placement and tension during winding, can impact performance. Manufacturing variability is a key driver in the high factors of safety used in design, and the variability in final product performance

Challenge 2: Recoverable and reusable liners and matrix materials

Continuous fibre recovery has been proven possible, however the ability to remove and reuse liner and matrix materials is required to achieve the moon-shot of a fully circular pressure vessel

Cryogenic tanks ambition:

Maximise UK opportunity from adoption of H2 in aerospace

Hydrogen

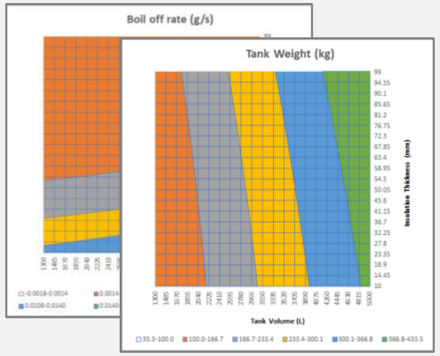
Support development of UK cryogenic know-how and supply chains

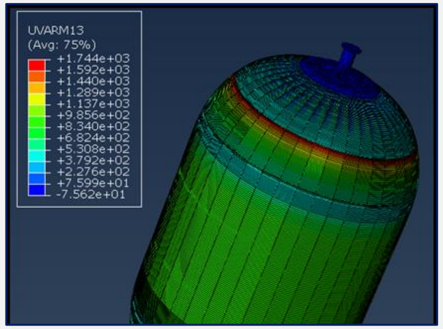
Identification and exploitation of key cryogenic tank technologies for UK benefit

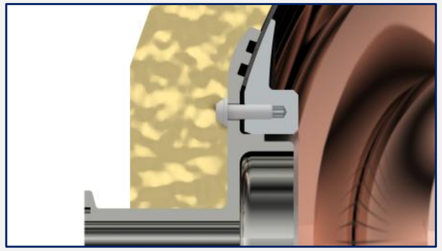
2021	2022	2023	≈2030
Concepting of cryogenic tanks	Ground tested low cycle tank	Flight worthy low cycle tank	Flight worthy high cycle tank

Cryogenic tanks: NCC activities

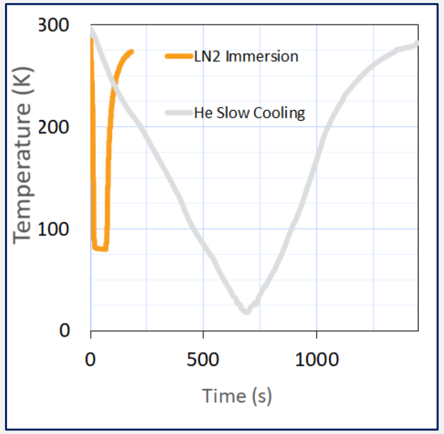
Hydrogen

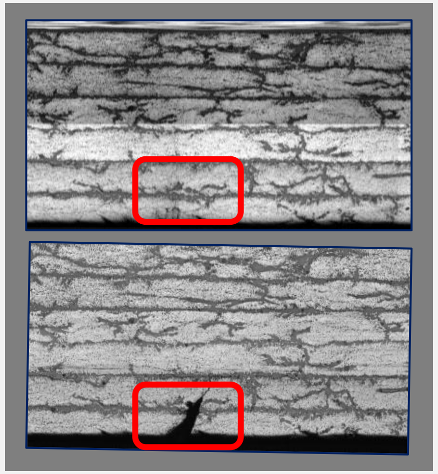




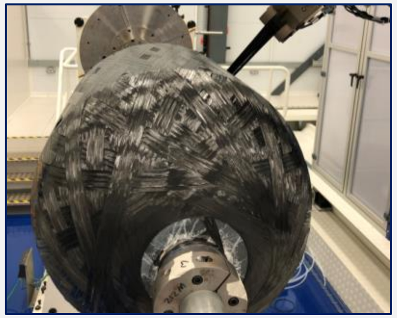


Concepting and design





Materials



Tank testing coming soon

Manufacture and test

Cryogenic tanks: TECHNOLOGY GAPS

Hydrogen

2021	2022	2023	≈2030
Concepting of cryogenic tanks	Ground tested low cycle tank	Flight worthy low cycle tank	Flight worthy high cycle tank

Challenge 3: Permeability liners

Composites are susceptible to microcracking when thermally cycled to LH2 temperatures. A barrier able to remain bonded to the composite surface, without microcracking and preventing escape of either liquid or gaseous hydrogen is required, preferably able to withstand a high number of thermal cycles

Challenge 4: Microcrack resistant matrix materials

To achieve fit and forget tanks, materials that don't suffer from microcracking when thermally cycled are required. Development of matrix materials able to withstand the loads imparted on them during thermal cycling are therefore key to the long term goal of high cycle tanks. <u>Detection of microcracking in-service is also a significant technology gap</u>

Energy distribution pipes ambition:

Minimise barriers to deployment of hydrogen production

Hydrogen

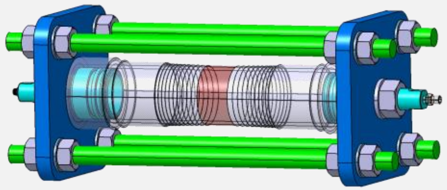
Support development of supply chain by simplified design and path to qualification

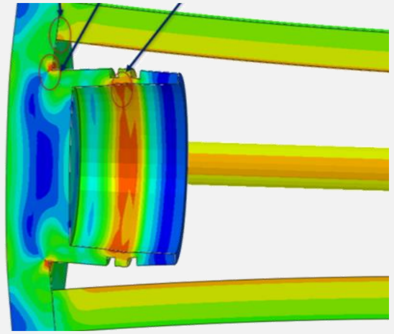
Assets management of composite pipes

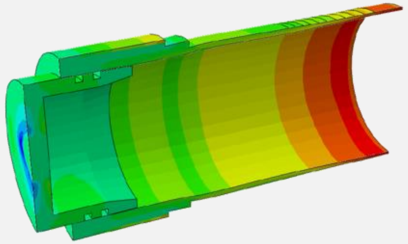
2022	2023	2024	2025	≈2026
Pipe manufacturing and pressure testing capability	Application mapping; Identified role of digital in path to qualification	On-site learning to customer's site transferability	Pipe design & validation - support qualification	**MOON SHOT** Smart pipes and fully digital exploitation

Energy distribution pipes: NCC activities

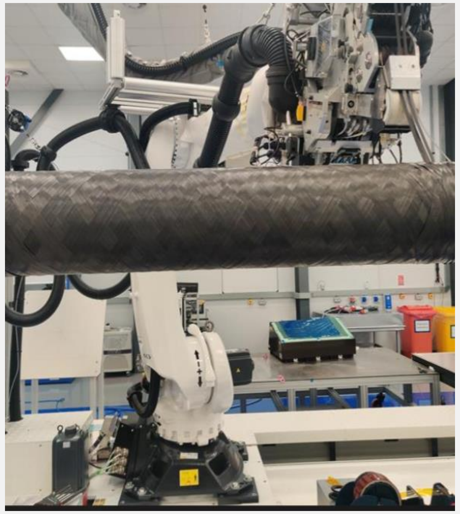
Hydrogen

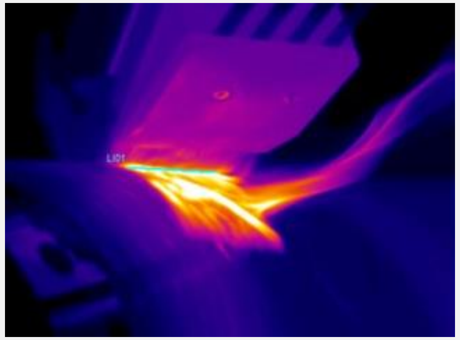






Design





Manufacture

Inspection and Test

Energy distribution pipes: TECHNOLOGY GAPS

Hydrogen

2022	2023	2024	2025	≈2026
Pipe manufacturing and pressure testing capability	Application mapping; Identified role of digital in path to qualification	On-site learning to customer's site transferability	Pipe design & validation - support qualification	**MOON SHOT** Smart pipes and fully digital exploitation

Challenge 5: Sensors for in-service flexible hydrogen pipes

Condition monitoring of composite pipes tends to be limited by the sensor technologies able to detect defects and damage, whilst being able to withstand the manufacturing and deployment processes

NCC Digital Outlook

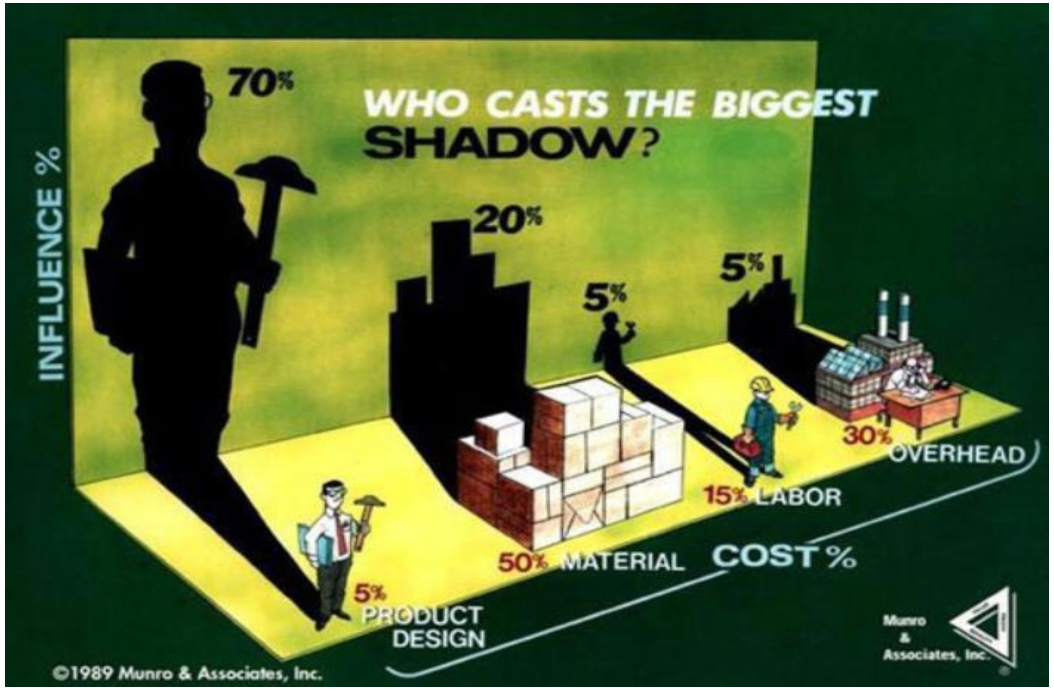
Marc Funnell NCC Head of Digital

13 September 2022

Our Digital Engineering Drivers

Digital

Transforming Product Development



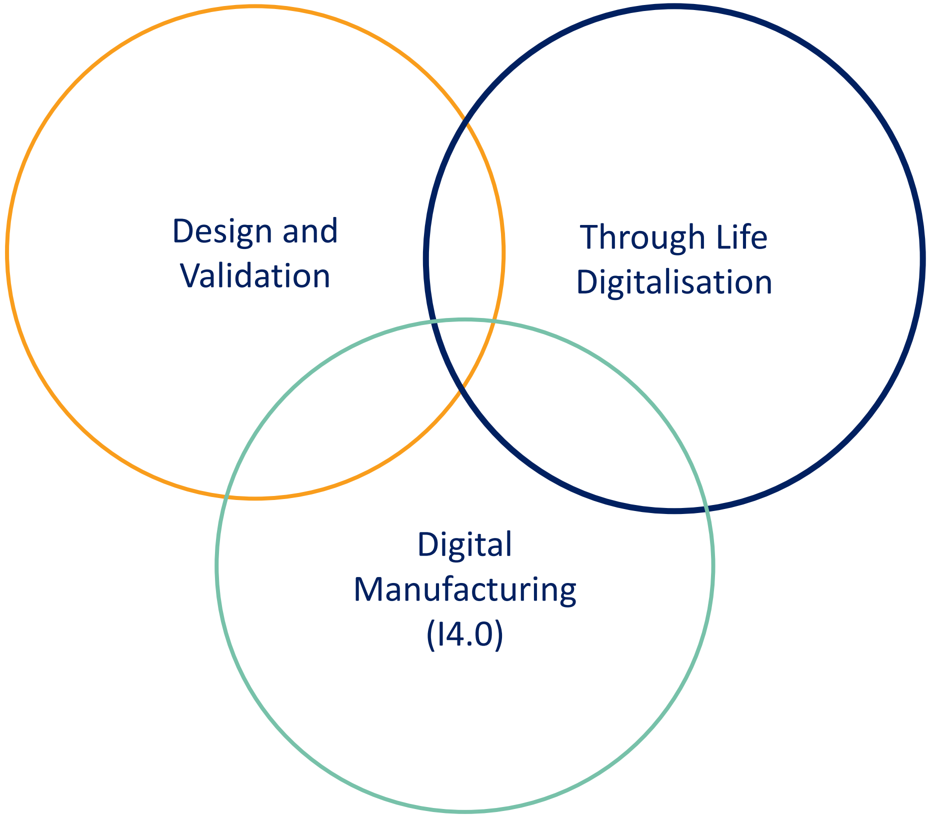
Demonstrating exploitation of knowledge and data to accelerate Product Design and innovative Assurance for net zero solutions

Demystifying Digital Engineering

Services and Demonstrations of ROI and solution architectures inside relevant industrial setting, accelerating transformation and adoption

NCC Strategy for Digital Engineering

Digital



Centre of Excellence for Accelerated Product Innovation

Nurturing a cohort of new engineering companies able to exploit digital techniques to compress the product development cycle – delivering more sustainable solutions to the market in half the time

Digital Innovation Hub for I4.0

Providing open access, industrial testbeds which accelerate innovation, skills and workforce developments and collide digital technology with manufacturing

Digital Demystification Services supporting SMEs

Services which help SMEs to unlock new business models and digital solutions as part of an enterprise supply chain which ensure economic growth, diversification and ultimately business resilience

Customer Scenario:

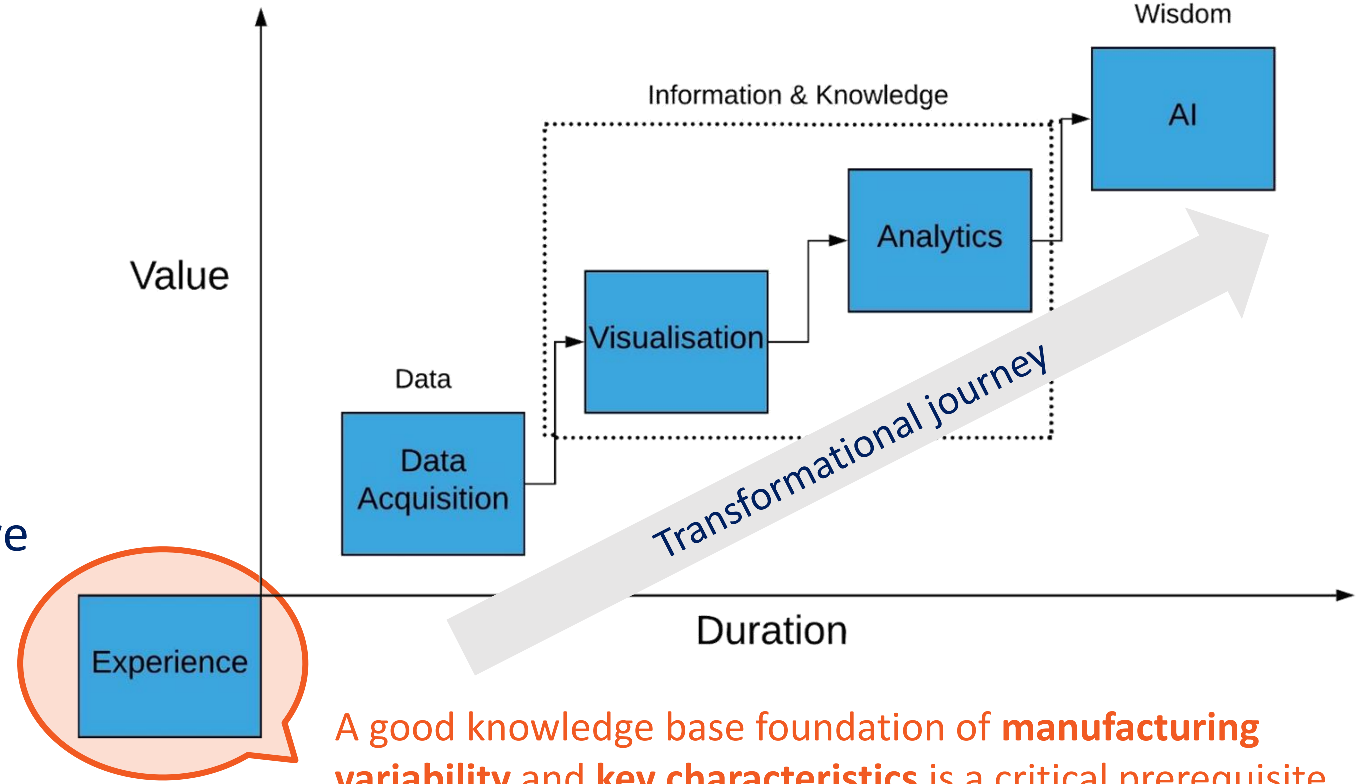
Limited knowledge of where to start or no appreciation of the journey

Understanding Digital & mapping out the transformation journey

(Diagnostics and advisory services)

- What benefits will digital actually offer?
  Where are returns to be expected?
  How long will this all take and at what cost?
- The journey may look too big to grasp and we may not know where to start

Diagnostics Team



A good knowledge base foundation of **manufacturing variability** and **key characteristics** is a critical prerequisite

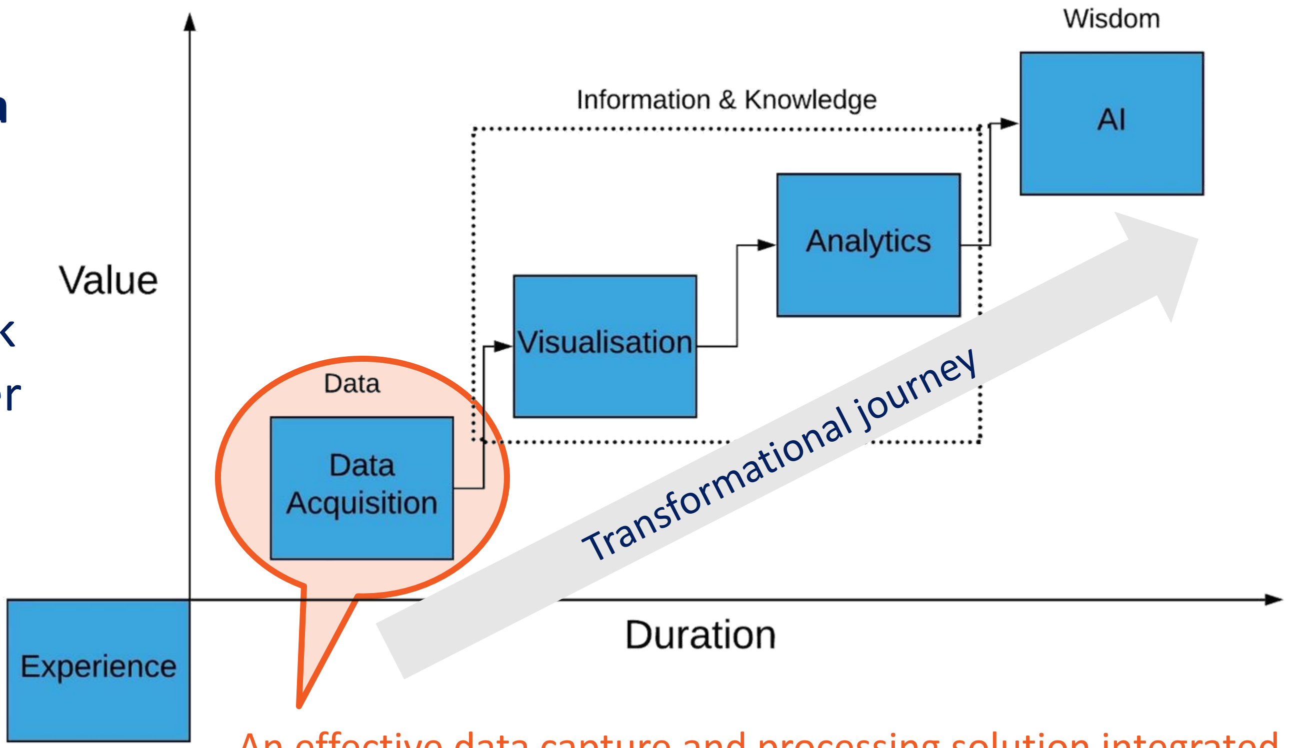
Customer Scenario:

Journey started but limited data available, or no clarity on how to get to or manage datasets

Digital

Acquiring, cataloguing and accessing relevant data

- How do we most efficiently acquire data from our machines? (legacy + new)
- How do we catalogue, categorise and keep track of data collected from multiple sources and over extended periods?
- How do we secure, maintain and configure all this data and at what maintenance cost?



An effective data capture and processing solution integrated to a secure and capable IT infrastructure and system solution is imperative

Data & Information Technology
(IOT, 5G, Cloud, Data Management, Networks)

Operations Technology
(Data Acquisition, Sensors, Vision Systems)

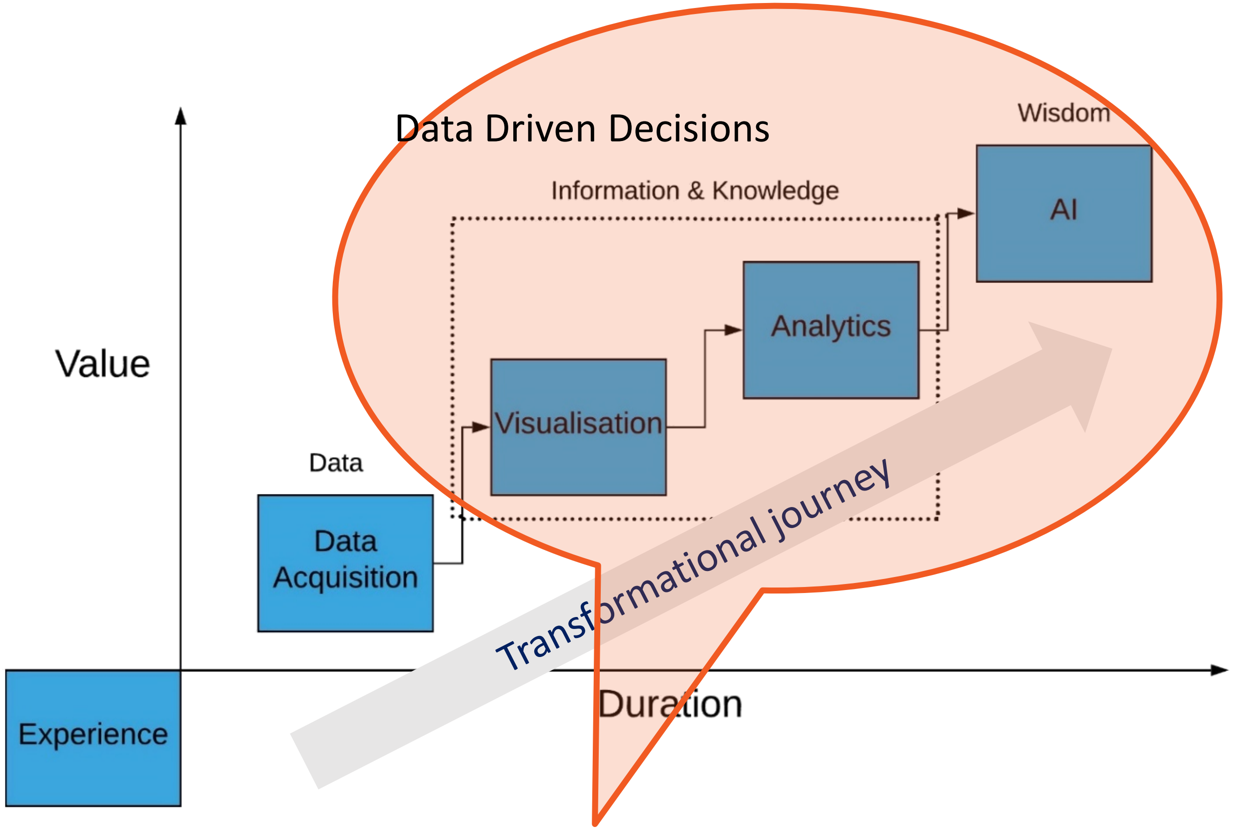
Customer Scenario:

Data available and being collected but limited experience of how to get value from data

Digital

How best to exploit the gathered data and present this to the users

- What is the best AI, Machine Learning or Data modelling/visualisation strategy to ensure success?
- What recourses (computing power, tools and skill sets) do we need to get success and at what cost?
- How do we enable cultural uptake and acceptance of digital ways of working?



Visualisation, Analytics and Data Science (AR/VR, Dashboards, AI/ML)
Model Based Enterprise (PIDO, MDO, Toolchains, PLM-MES)

Tailored user interfaces for key stakeholders with robust software engineering management protocol, underpinned with a tailored change management and skills development programme is core to success

Specific Areas of Interest

- Tracking distinct objects around a busy environment (like a factory/workshop) using various comms scenarios e.g. 5G 4G, Narrow band or WiFi signals — this hasn’t really progressed beyond academia yet
- Human augmentation, visual (in- and post process verification), Audial (Voice control) and physical — there are good examples of exo-skeletons that increase the strength of human operators, but not that significantly increase speed or dexterity
- Machine learning for manufacturing — general AI models for language, image generation etc. are becoming commonplace, but there hasn’t been much progress on general AI for manufacturing. What should this look like, what kind of QHSE and ethical controls should be built in. Especially critical too for limited data sets.
- Interoperability, Resilience and Security in Data acquisition solutions and IOT devices inside the factory
- Manual dexterous task tracking and machine vision verification – hand tracking learning using AR headsets as opposed to laser line scanners, specific HD cameras and other in-process verification capabilities.
- Opportunity for “swarm” Cobot mimicry – based off manual dexterous task tracking and monitoring to increase productivity and consistency
- Model-based Systems Engineering, Integration platforms and digital thread techniques — keeping traceability from Material Development — Design Make, Test and following through life (via digital Twin in operations) and through recycling reuse phases.
- Bringing in attributes from supply chain and shopfloor (e.g. manufacturing capability, energy usage and resilience) into the early design phases as part of the MDO solutions
- Structural Health Monitoring or condition-based monitoring solutions of in-service products using embedded or other sensor solutions e.g. fibre optics to support for Eg H2 — detection of cracking etc in service and other safety considerations

NCC: Other Challenges

Matt Scott NCC Chief Engineer for Capability

13 September 2022

… But that's not all

Explorative

- The NCC has three strategic themes, and these are our main growth areas
- But composites research and development at the NCC happens across the board
- Our technology roadmap covers the full gamut of composites development

Materials

Application & Process Design

Manufacture

Validation & Certification

In-Service

End-of-Life & Circularity

… But that’s not all

Explorative

- Other interesting areas:
  - Polymeric composites for high temperature applications
  - CMCs/MMCs for high temperature applications
  - SiC/SiC composites for nuclear applications
  - Reducing time and cost of structural design certification
  - New, low-carbon concrete solutions
  - Etc.

… Disruptive innovation happens unexpectedly

Agenda

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11.00	How TPT helped Dielectric Sensing research reach Meggitt	Alex Skordos
11.10	TPT: An industrially-based researcher's perspective	Jonathan Belnoue
11.20	Questions, including poll results	Matt Scott
11.35	Conclusions and thanks	Matt Scott
11.45	End	-

Short Break and Poll

FOLLOW THE QR CODE TO THE RIGHT

Or go to menti.com and enter

1108 9014

How TPT helped dielectric sensing research reach Meggitt

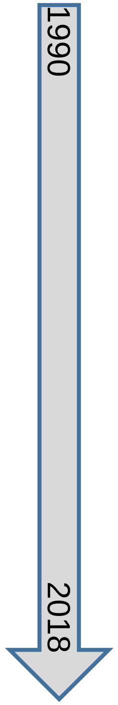
Alex Skordos
Composites and Advanced Materials Centre

29 September 2022

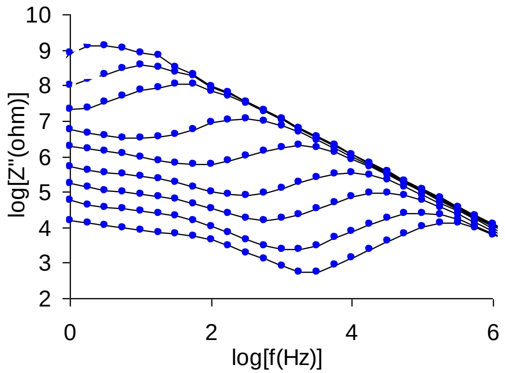
www.cranfield.ac.uk

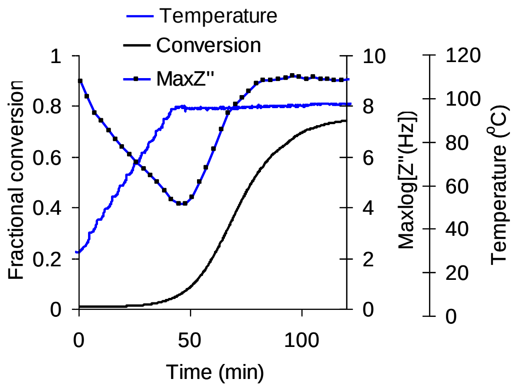
Background – Composites process monitoring at Cranfield

- Work on dielectrics for composites cure started at Cranfield (Partridge/Bloch)
- Application to autoclave cure, RTM (Maistros/Karkanas/Partridge)
- Development of cure monitoring signal interpretation methods (Kazilas/Skordos/Karkanas/Partridge
- Development of dielectric flow sensing for LCM of insulating reinforcement (Skordos/Partridge)
- <u>Development of flow and cure sensing for carbon reinforcement (Tifkitsis/Skordos)</u>



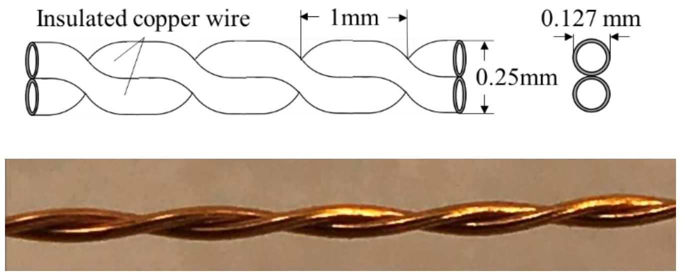
- A number of DTI/ESPRC/EU projects completed
- Cure monitoring implemented by two SMEs (Inasco, Advise-Deta)
- Dielectric cure monitoring used in Bombardier, Augusta Westland

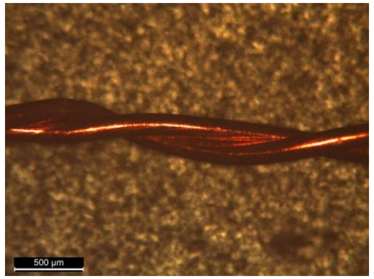


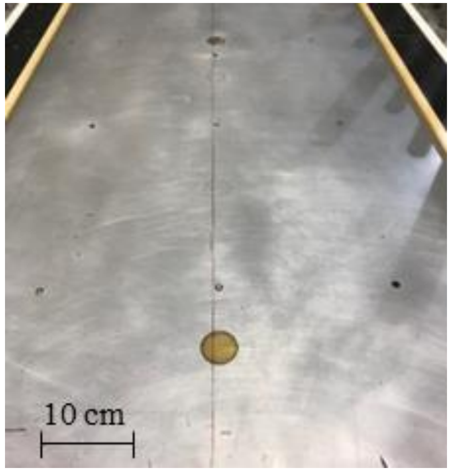


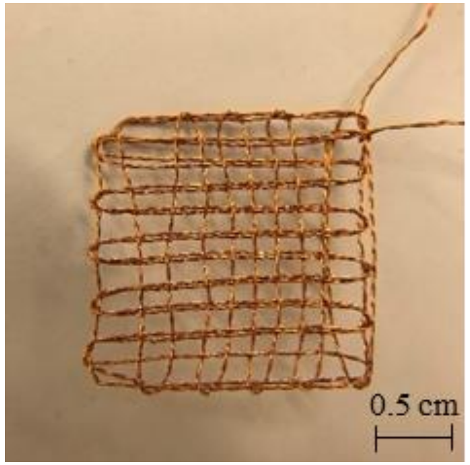
Background – Flow/cure sensor for carbon composites

- Insulated (polyurethane, polyamide) wire twisted pair
- Wires act as electrodes
- Insulation eliminates sorting by carbon
- Electric field goes through resin pockets not screened by carbon
- Implementation as:
  - ✓ Lineal sensor for flow monitoring
  - ✓ Woven sensor for cure monitoring





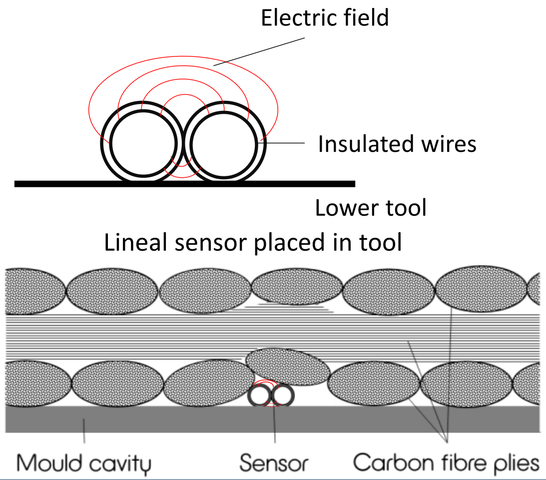


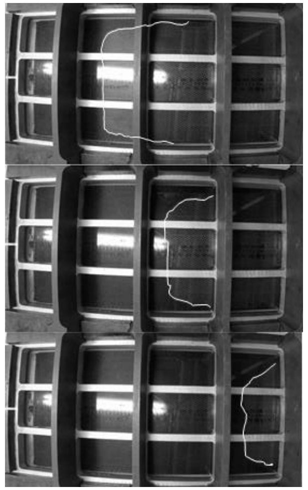


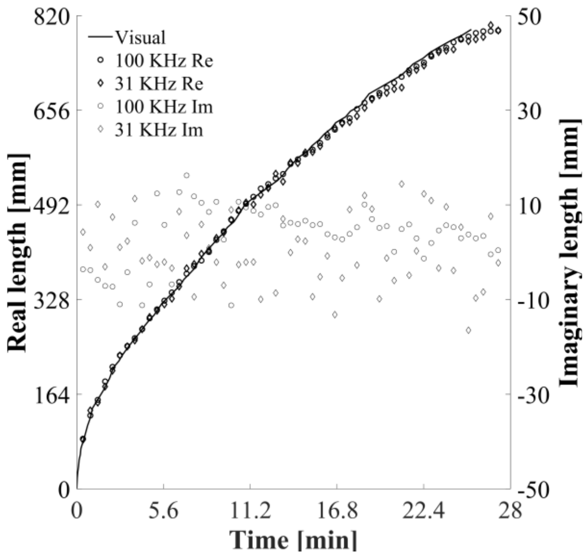
KI Tifkitsis, AA Skordos. A novel dielectric sensor for process monitoring of carbon fibre composites manufacture. Composites Part A: Applied Science and Manufacturing 2019;123:180-189
KI Tifkitsis, AA Skordos. Real time uncertainty estimation in filling stage of RTM process. Polymer Composites 2020;41:5387-5402

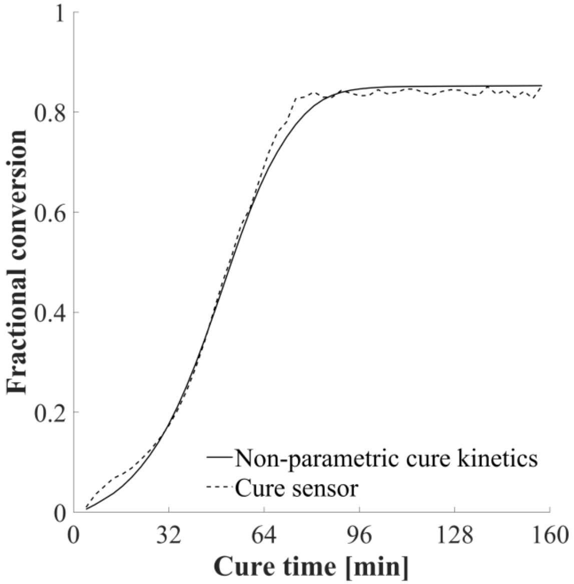
Background – Flow/cure sensor for carbon composites

- Flow monitoring in carbon fibre RTM (3 bar):
  - ✓ Lineal sensor placed on lower tool aligned to main flow
  - ✓ Transparent glass to monitor flow front
  - ✓ Lineal sensor follows closely flow front position at different flow front velocities
- Cure monitoring in carbon fibre VARTM:
  - ✓ Degree of cure measured
  - ✓ Vitrification identified in the signal







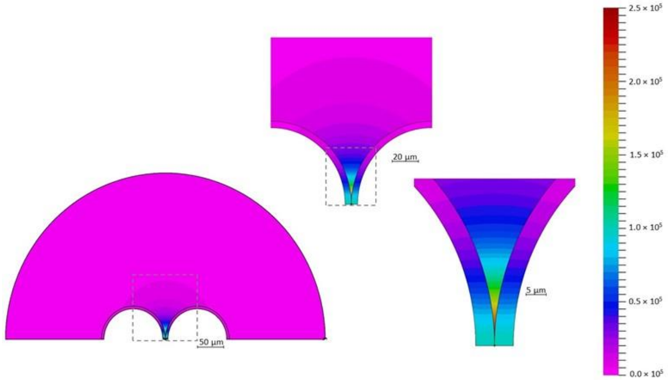


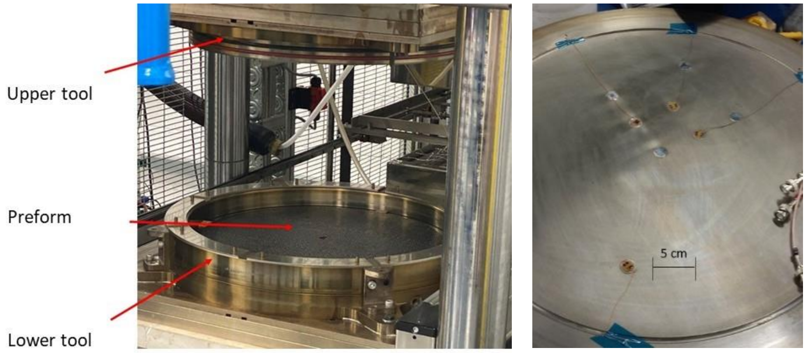
TPT – DiSenc project setup

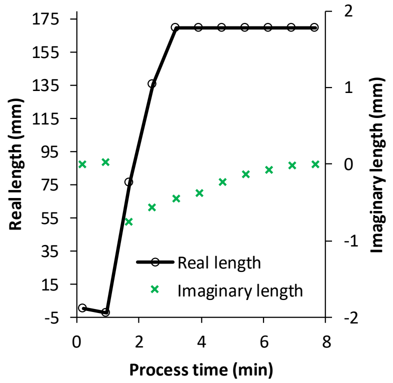
- Technology at TRL3-4 in 2018
- Pull to TRL6-7 required:
  - ✓ Implementation under industrial conditions (7 bar/180°C)
  - ✓ Sensor production at industrial level
  - ✓ Integration with industrial level equipment (ingress/egress), software and control
- Addressed through
  - ✓ Sensor modelling and optimisation (Lead: NCC, Support: Cranfield)
  - ✓ Wire material/type selection (Lead: NCC, Support: Cranfield)
  - ✓ Sensor manufacturing (Lead: Advise-DETA, Subcontractor: AGTEKS)
  - ✓ Connector development (Lead: Advise-DETA, Support: NCC)
  - ✓ Process integration (Lead: NCC, Support: Advise-DETA)
  - ✓ Process trials (Lead: NCC, Support: Cranfield, Advise-DETA)
- Timeline:
  - ✓ Stage 1/2 proposals: April – July 2018
  - ✓ Project: April 2019 – March 2020
- Key people:
  - ✓ NCC: Tassos Mesogitis, Christian Lira, Fillippo Dionisi, Jack Alcock, Leah Rider
  - ✓ Advise-DETA: George Maistros
  - ✓ Cranfield: Mehdi Asareh, Alex Skordos

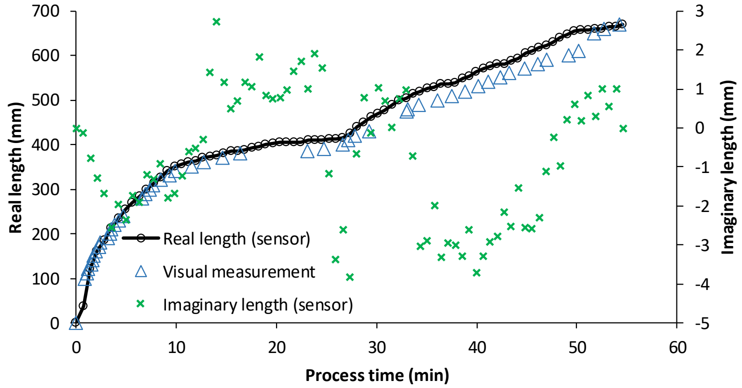
TPT – DiSenc outcomes

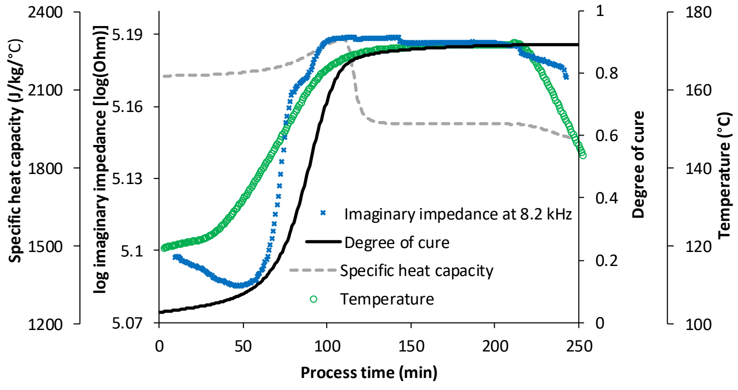
- Optimal material/wire selected
- Sensor produced in km lengths at low cost
- Connection protocol developed and tested
- Interfacing with DETA Scope online system
- Successful operation at 7 bar, 180°C
- Accurate monitoring of flow front
- Use for cure sensing including both reaction motoring and vitrification identification





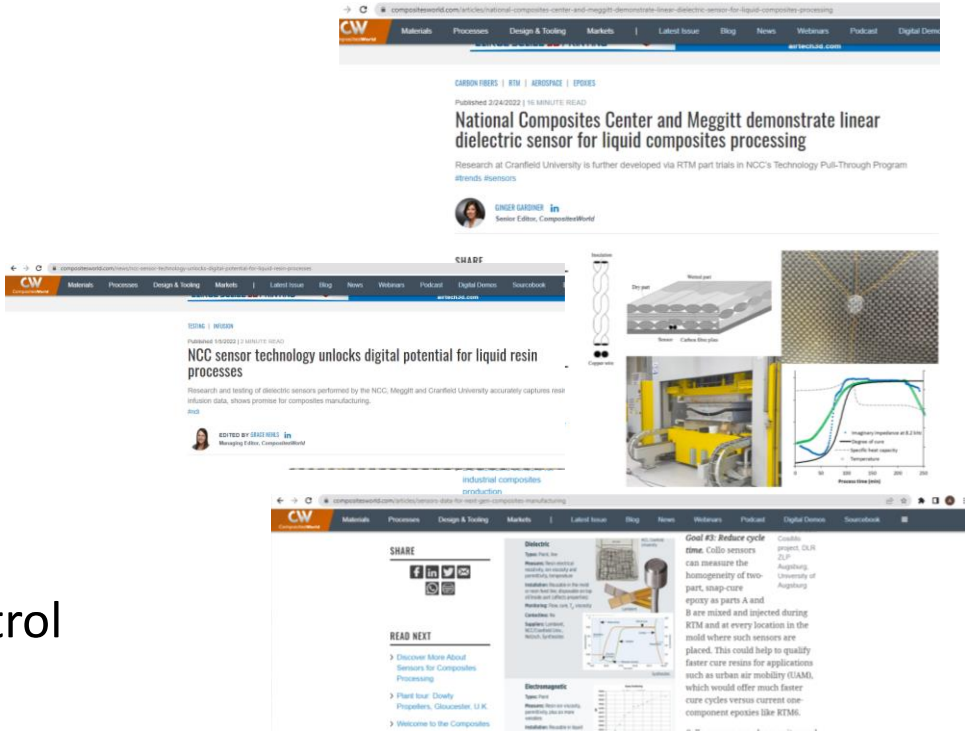






TPT – DiSenc beyond the project

- Research outputs:
  - ✓ TS Mesogitis, GM Maistros, M Asareh, C Lira, AA Skordos. Optimisation of an in-process lineal dielectric sensor for liquid moulding of carbon fibre composites. Composites Part A: Applied Science and Manufacturing 2021; 140, 106190
- Industrial outputs
  - ✓ NCC follow ups with industrial contact
  - ✓ Adoption and successful testing at Meggitt
  - ✓ Subsequent publicity:
    - ➢ *CompositesWorld, 24/02/2022*
    - ➢ *CompositesWorld, 1/03/2022*
    - ➢ *CompositesWorld, 1/05/2022*
- Further testing (RNLI)
- Eureka project HYPERCOMP: Integration in process control
- Low TRL: incorporation tufting



Overall experience

- Significantly faster adoption than standard routes
- Funding flexibility allows easy key external contributor involvement
- Resources focusing on maturing technology
- Research institution concentrating on critical knowledge contributions
- Industrial dissemination element unmatched
- Publications still compatible
- Sufficient flexibility in IP to make the project possible

University of BRISTOL
Bristol Composites Institute

TPT: An industrially-based researcher's perspective

Technology Pull-Through 2023 Launch Event 29/09/2022

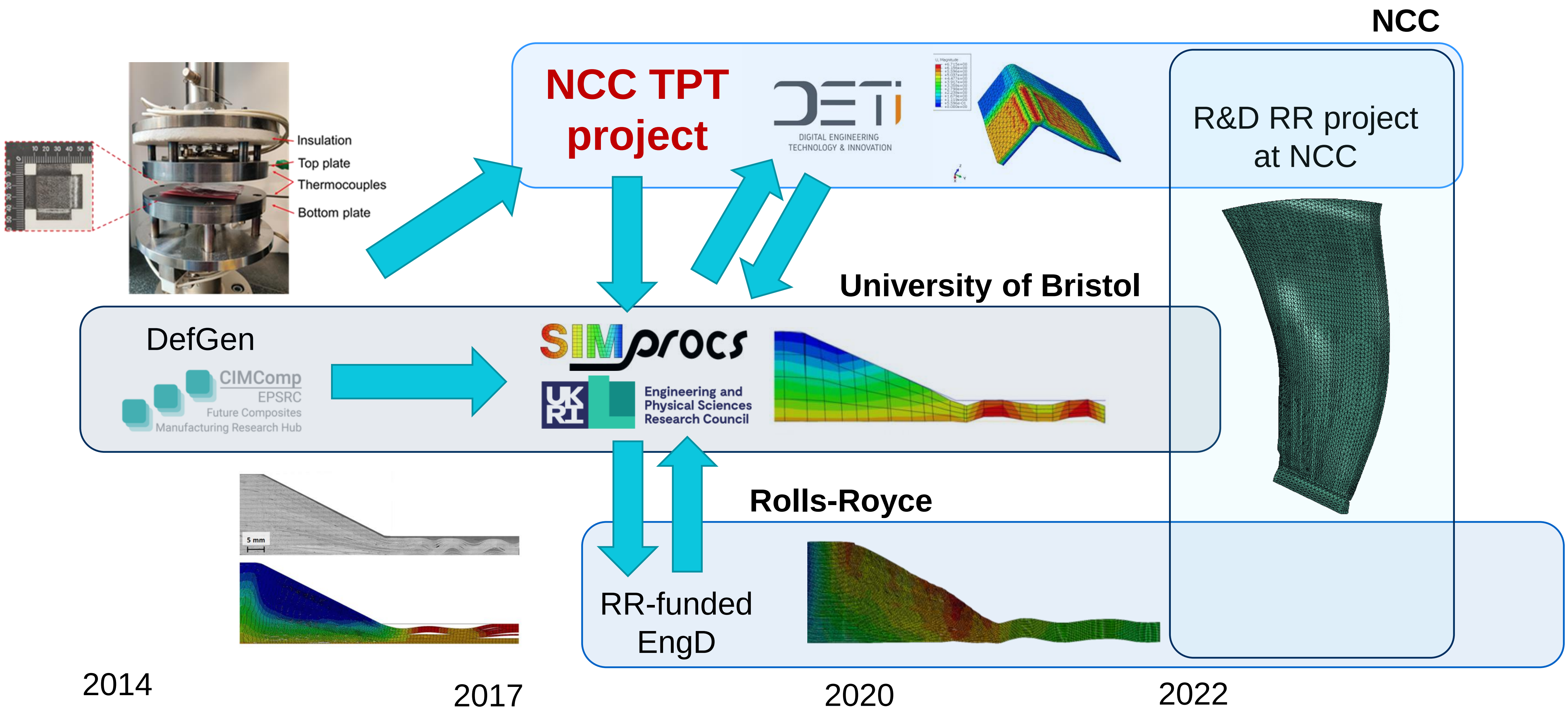
Jonathan Belnoue

NCC Lecturer in Composites Manufacturing Process Simulation

My Experience with the Technology Pull Through program

- Awarded one of the 2 first (“pipe-cleaner”) TPTs.
- Unsuccessful application last year.
- NCC technical lead for one of last year’s project.
- Why apply for a TPT?
  - **Impact** is becoming increasingly important in academia (REF!) and this provides funding for the first steps towards impact.
  - Gives **exposure to industry** challenges (and vice-versa) and can inspire future research.
  - Sometimes what makes for a great idea in a lab environment does not scale-up that well: methods to help **scaling-up** the **technology** can become great low TRL research (see next slide).
  - [Light-touch application that can recycled if unsuccessful].

How an unsuccessful TPT and technology reached Rolls Royce



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NATIONAL COMPOSITES CENTRE

TPT: Summary and Conclusions

Matt Scott NCC Chief Engineer for Capability

13 September 2022

Poll Results

- What topic areas would you currently consider for a TPT proposal?
- If you’re thinking of something beyond the Technology Challenge Themes (the Big Three) – what are you thinking?

So what?

- TPT stimulates the transition of suitably mature technologies from academia to industry
- This gives researchers the opportunity to show the IMPACT of their research (…REF)
- Prior work has shown that TPT gives promising technology the opportunity to progress
- Expressions of Interest open in 14 days – 13th October 2022

Thank you – questions?

matt.scott@nccuk.com