CATAPULT
High Value Manufacturing

Welcome to the NCC

AFRC ADVANCED FORMING RESEARCH CENTRE UNIVERSITY OF STRATHCLYDE
Advanced Manufacturing Research Centre
cpi
mtc Manufacturing Technology Centre
NATIONAL COMPOSITES CENTRE
NUCLEAR AMRC
WMG THE UNIVERSITY OF WARWICK

ReDisCoveR Composites

Welcome and introduction – Enrique Garcia, CTO, the National Composites Centre

12th November 2019

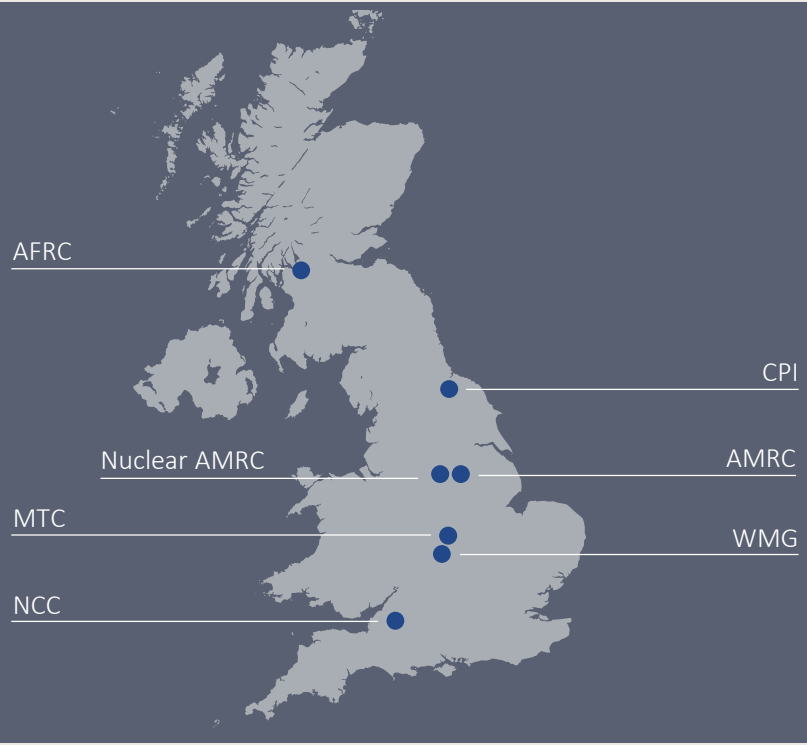
Welcome to the NCC

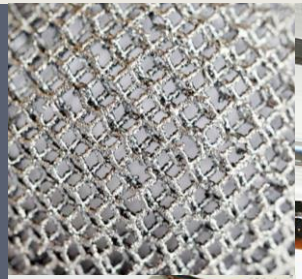
Health and safety

Please note there **will** be a fire alarm test at 12:00pm today, **this is a test**

The High Value Manufacturing Catapult

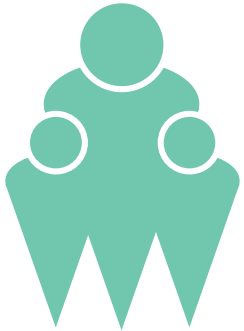
CATAPULT
High Value Manufacturing





Large Transformational Projects (LTPs)

Centre collaboration



Building a community

Typically a year in length

ReDisCoveR began in April 2019

Today's presenters

Welcome:
Enrique Garcia

Introduction and chair:
Graeme Cruickshank

Setting the scene:
Malcolm Hannaby
Nick Cooper

Workshop introductions:
Lucy Eggleston

RDCR

Recycling. Disassembly.
Circular materials. Reuse.

ReDisCoveR Composites

Welcome and introduction – Graeme Cruickshank, CTIO , the Centre for Process Innovation

12th November 2019

What to expect

- Today’s agenda
- Introduction to ReDisCoveR
- The largest value opportunities, as perceived by industry
- ReDisCoveR Composites network
- The next steps
- How the sessions will work

Today's agenda

8:45-9:00 – Arrival and coffees
9:00-9:45 – Welcome and introduction, setting the scene

BREAK

10:00-11:00 – Recycling workshop

BREAK

11:15-12:15 – Circular Materials workshop

LUNCH

13:15-14:15 – Reuse workshop

BREAK

14:30-15:30 – Disassembly workshop
15:30 – Summary and close

RDCR

Recycling. Disassembly.
Circular materials. Reuse.

ReDisCoveR

The aim of ReDisCoveR is to transform the UK's world leading composites end-of-life academic and commercial capabilities into a fully functioning and interconnected supply chain

Research roadmaps and strategies

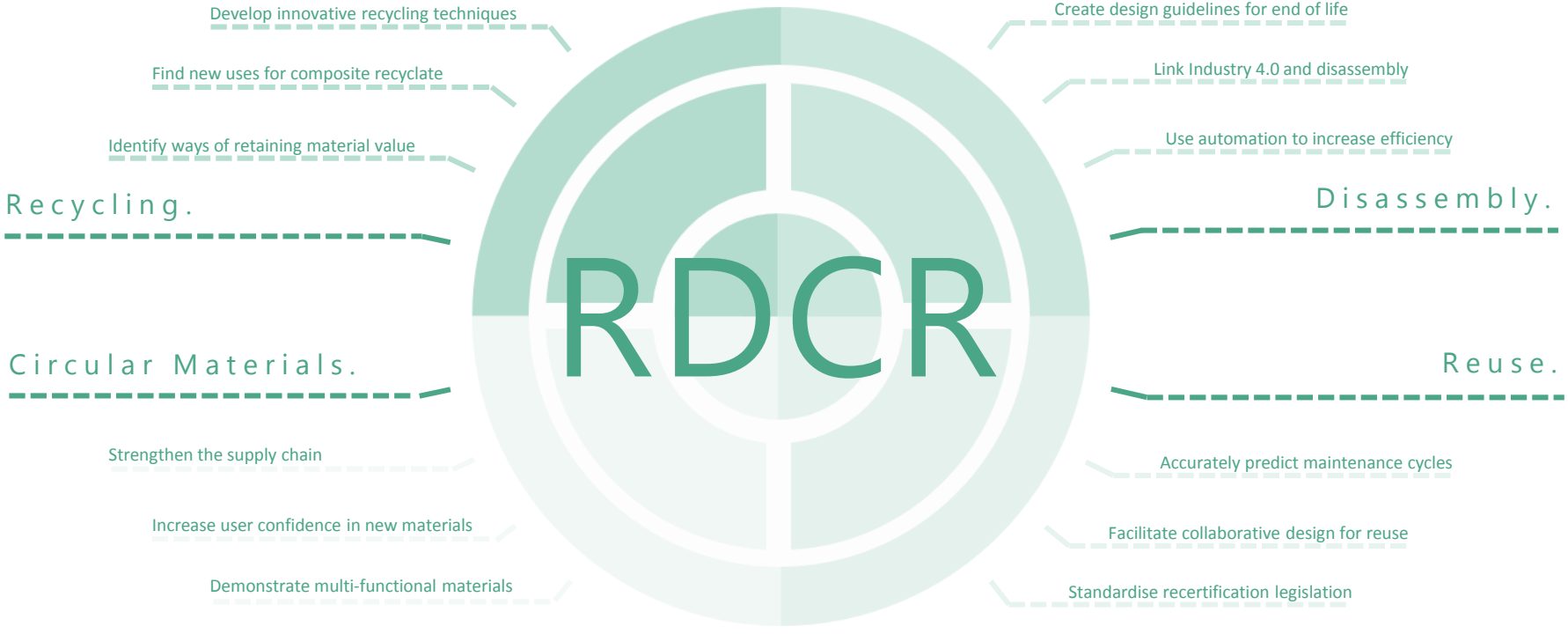
Determine largest perceived value opportunities

Gain feedback from industry and reassess

Determine a suite of projects that capitalise on these opportunities

ReDisCoveR Composites event

Largest perceived value opportunities



Who's involved

CATAPULT
High Value Manufacturing

AMRC ADVANCED MANUFACTURING RESEARCH CENTRE / The University Of Sheffield.

AFRC ADVANCED FORMING RESEARCH CENTRE UNIVERSITY OF STRATHCLYDE

cpi

mtc Manufacturing Technology Centre

NATIONAL COMPOSITES CENTRE

WMG THE UNIVERSITY OF WARWICK

Next steps

The HVMC will drive all project scoping, planning, and bid writing activities
Look out for invitations to focused workshops based on the feedback you give today

Research roadmaps and strategies

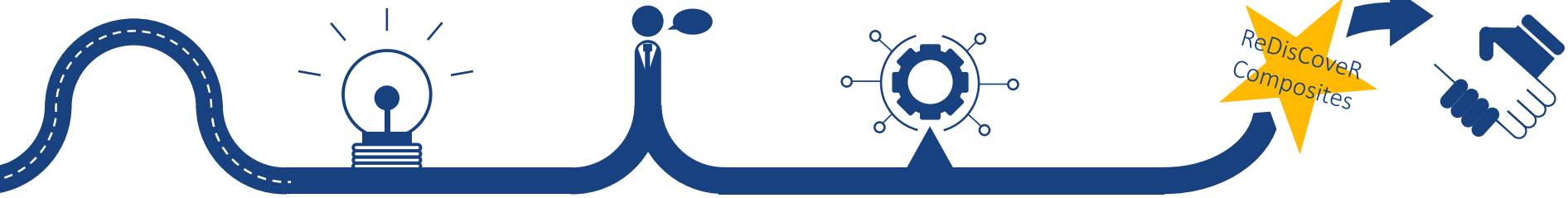
Determine largest perceived value opportunities

Gain feedback from industry and reassess

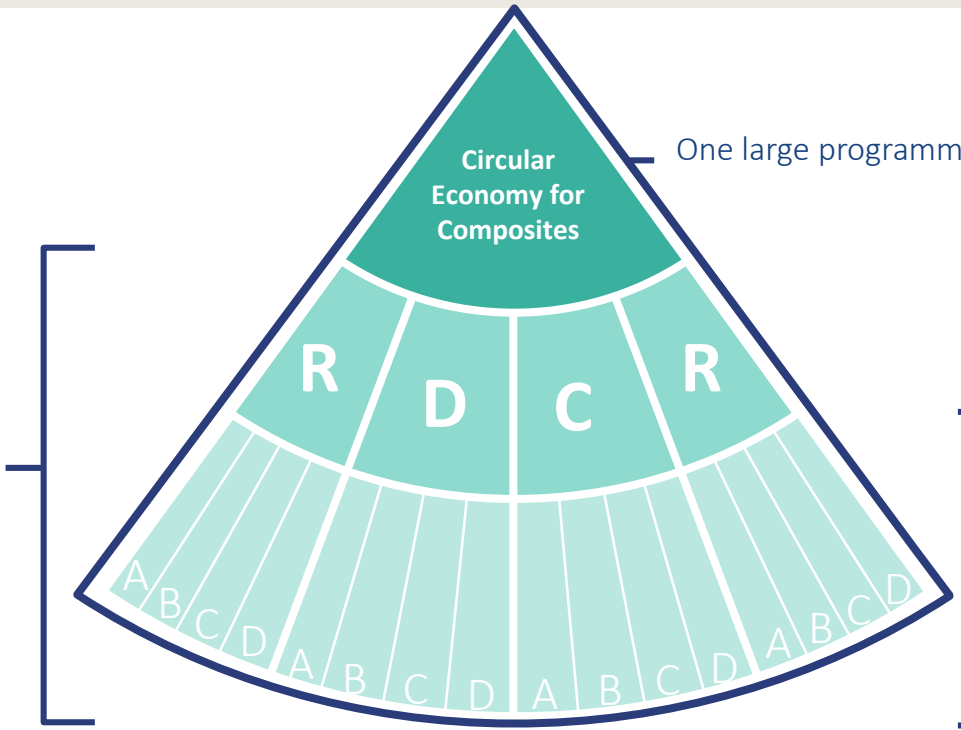
Determine a suite of projects that capitalise on these opportunities

ReDisCoveR Composites event

Focussed workshops, project scoping, and bid writing



Funding



One large programme

Four separate programmes of work, one for each stream

24 Individual projects

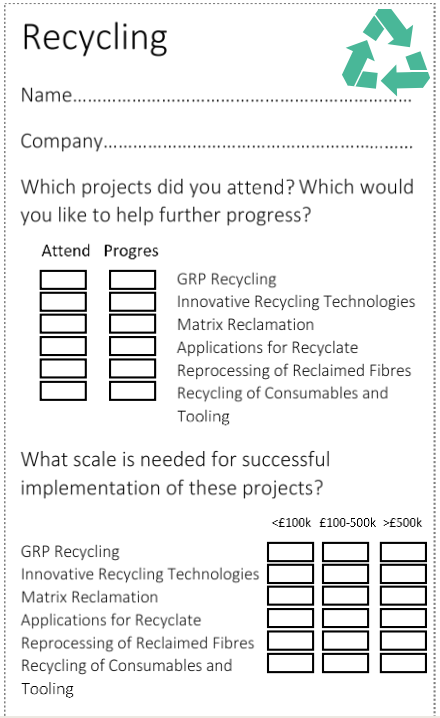
The sessions

10 minutes – Introduction to the stream

40 minutes – Project engagement and workshopping

10 minutes – Stream feedback

- Engage with as many projects as you would like during the 40 minute session
- Use your sticky notes to have your say and help steer the direction of the projects
- At the end of the session, fill out the relevant feedback form in your welcome pack and submit this as you leave the session
- Place your three stickers on the projects of highest priority for your organisation



Recycling

Name.....

Company.....

Which projects did you attend? Which would you like to help further progress?

Attend	Progres	
☐	☐	GRP Recycling
☐	☐	Innovative Recycling Technologies
☐	☐	Matrix Reclamation
☐	☐	Applications for Recycle
☐	☐	Reprocessing of Reclaimed Fibres
☐	☐	Recycling of Consumables and Tooling

What scale is needed for successful implementation of these projects?

	<£100k	£100-500k	>£500k
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Recycling of Consumables and Tooling	☐	☐	☐

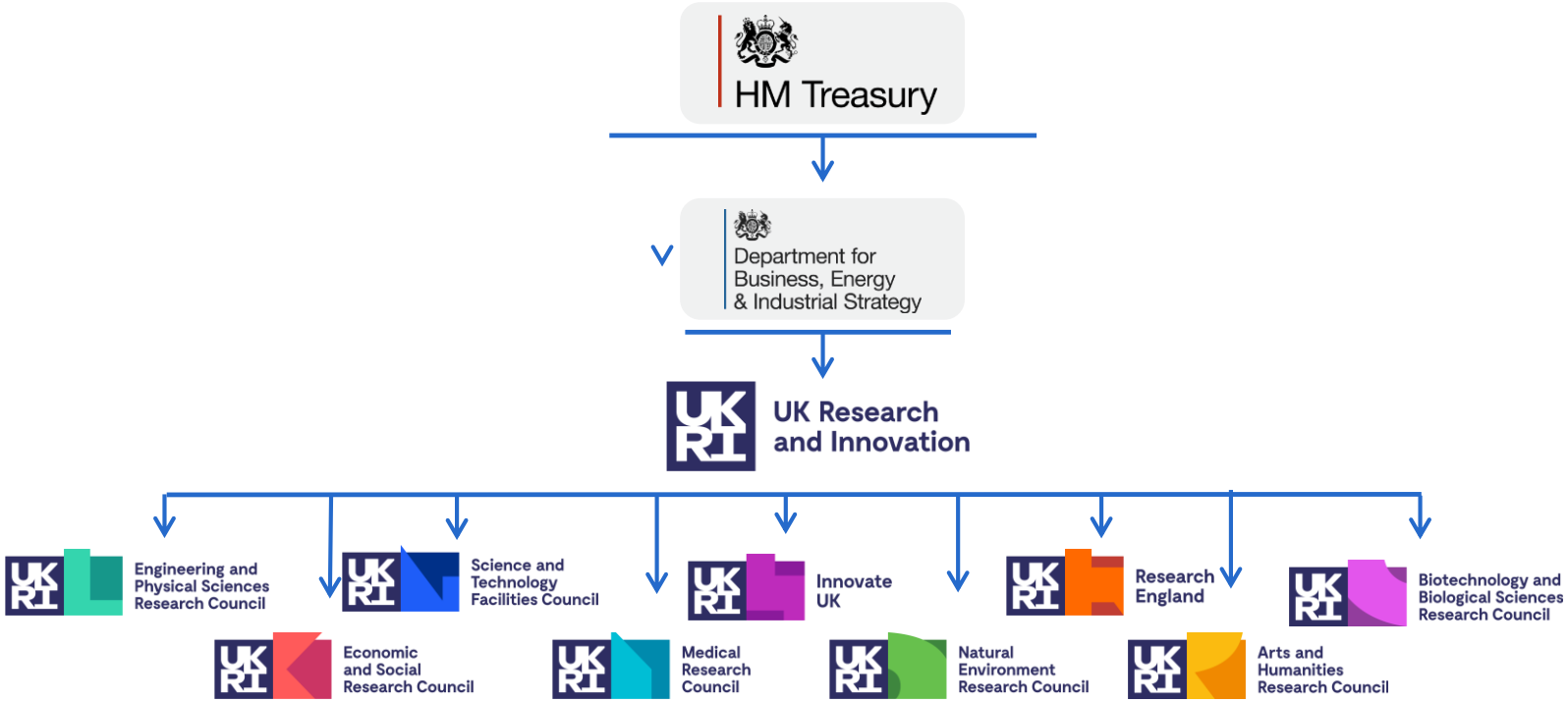
Engineering and Physical Sciences Research Council

EPSRC – funding landscape

ReDisCoveR event, 12 November 2019

Nick Cooper, Senior Portfolio Manager

UKRI Structure



EPSRC vision

- To make the UK recognised as the place where the most creative researchers can deliver **world-leading engineering and physical sciences research**

- To work within the research ecosystem of UKRI, the R&D base within business, SMEs, government departments, charitable organisations and international **partnerships** to identify and tackle new research challenges and **deliver societal and economic impact** from our research base

- To build on our **strong working partnerships with business** to play a leading role within UKRI, particularly working in **partnership with IUK**, in delivering economic prosperity to the UK (and hence the government's target of 2.4% of GDP invested in R&D by 2027)

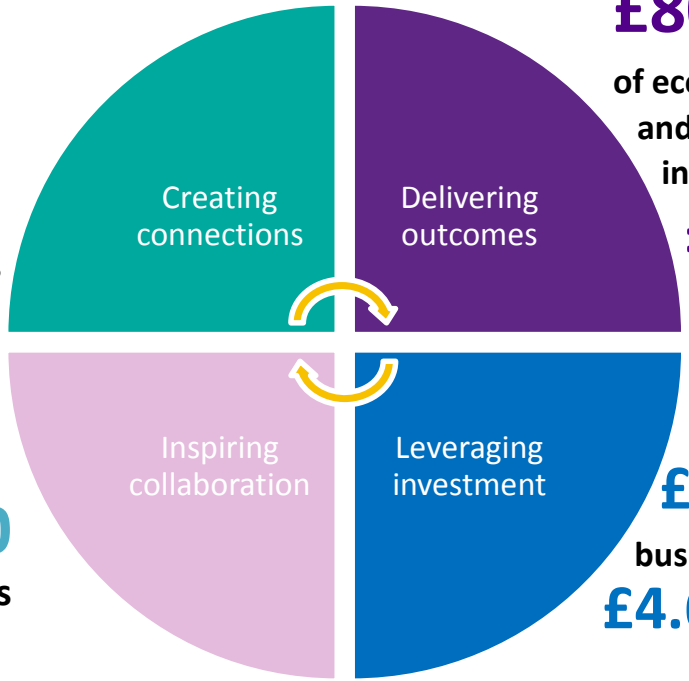
An intelligent investor

£4.6 billion

EPSRC research and training portfolio, of which

£3.4 billion

is relevant to industrial sectors



£80 billion

of economic activity and cost efficiencies from an EPSRC investment of

£7.8 billion

3,800

collaborating organisations

£1.2 billion leveraged from business against a current portfolio of

£4.6 billion

EPSRC Delivery Plan

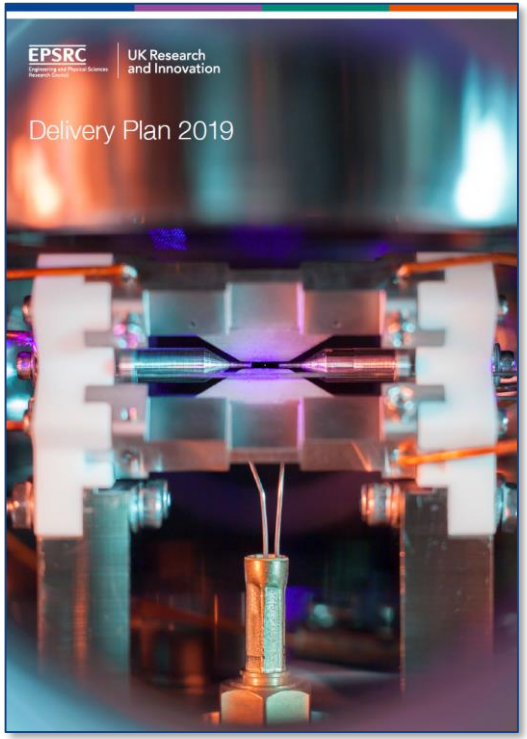
The overarching objectives:

1. Delivering economic impact and social prosperity
2. Realising the potential of engineering and physical sciences research
3. Enabling the UK engineering and physical sciences landscape to deliver

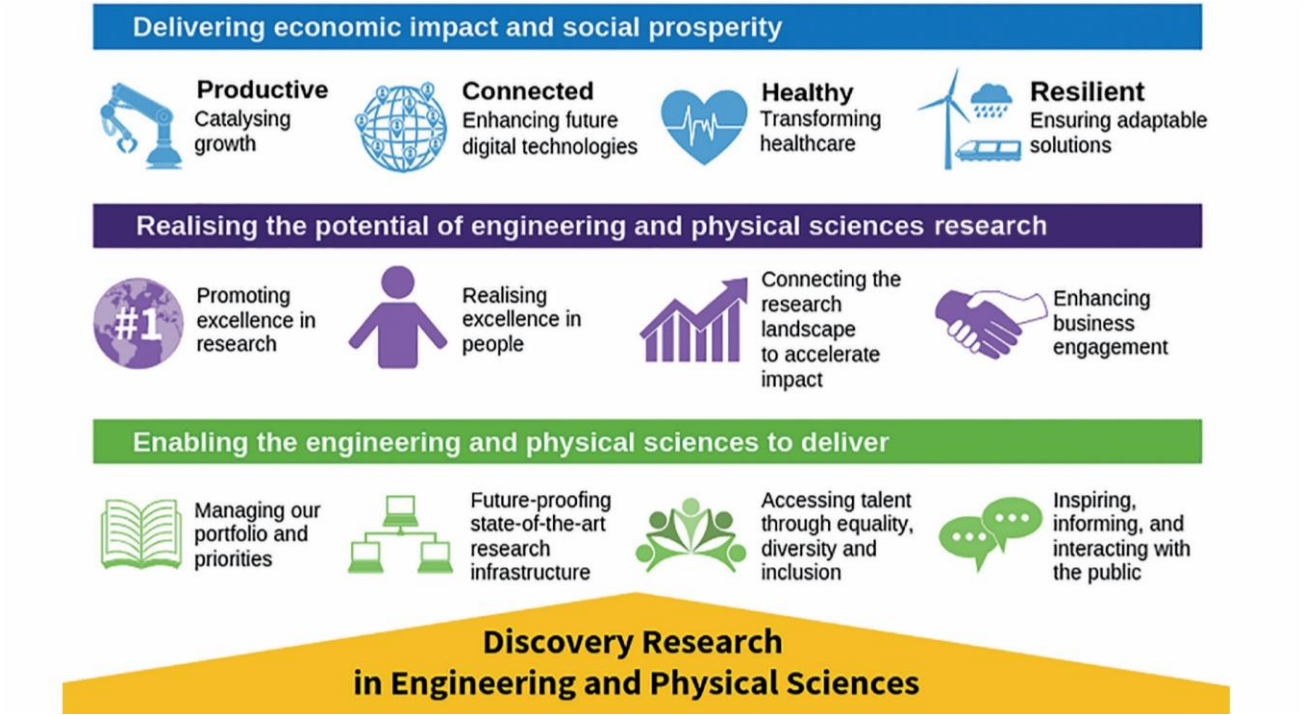
The second objective focuses on stimulating and challenging the research community to open up new areas of science, engineering and technology, and will promote excellence, accelerate impact and provide new ways of working with business to deliver the 2.4% target

The Delivery Plan proposed the formation of a science, engineering and technology board into the EPSRC Governance and Advisory Board Structure, evolving from the 'Big Ideas' initiative.

The proposed board will enable greater transparency and engagement with academic and user communities.



Priority Framework



Putting the Delivery Plan in Context

National Productivity Investment Fund (NPIF)

- Industrial Strategy Challenge Fund (ISCF)
- Strategic Priorities Fund (SPF)
- Talent & Skills
- Strength in Places Fund (SIPF)
- Fund for International Collaboration (FIC)

UKRI cross-cutting themes

- **EPSRC with Innovate UK and Research England**: Commercialisation of University Research
- **MRC**: Future Leaders Fellowships
- **ESRC**: Equality, Diversity & Inclusion
- **STFC**: Infrastructure (Infrastructure Roadmap)
- **NERC**: Grants Funding Service
- **Innovate UK**: ISCF (NPIF)
- **AHRC**: International

Global Challenges Research Fund (part of the UK's Official Development Assistance (ODA))

UKRI Landscape of Activity: Manufacturing

Research and skills

Investing in new growth areas
Chatty Factories

Drawing on emergent research
Catalysis Hub

Supporting skills
Manufacturing Fellowships

Dr Zushu Li
Tata Stell to WMG
now part of SUSTAIN

connected everything.
industrial systems in the digital age

Early stage commercialisation

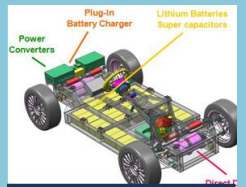
Future Manufacturing Hubs

11 Hubs supporting commercialisation of early stage research opportunities driven by long-term challenges of industry - plus 2 Vaccine Hubs funded by DoH

Continuous Manufacturing and Crystallisation

Vaccines

VaxHub



Electrical Machines

SUSTAIN

Translation

ISCF

- Medicines manufacturing
- MMIC
- Vaccines Centre
- Driving the electric revolution
- Transforming foundation industries
- Manufacturing made smarter

wave 1

wave 3

UKRI Interdisciplinary Circular Economy programme

- This £30m UKRI programme (developed by AHRC, BBSRC, EPSRC, ESRC, NERC and Innovate UK, with DEFRA and BEIS) will build an **interdisciplinary circular economy research and innovation community** that will provide the underpinning research understanding to enable the transition to a more circular economy.

- This will support policymakers and industry with frameworks to make more effective evidence-based decisions, and develop clear implementation pathways.

- The programme will also accelerate innovative solutions needed to enable change, and support strong national leadership and coordination facilitating cross-sector stakeholder engagement.

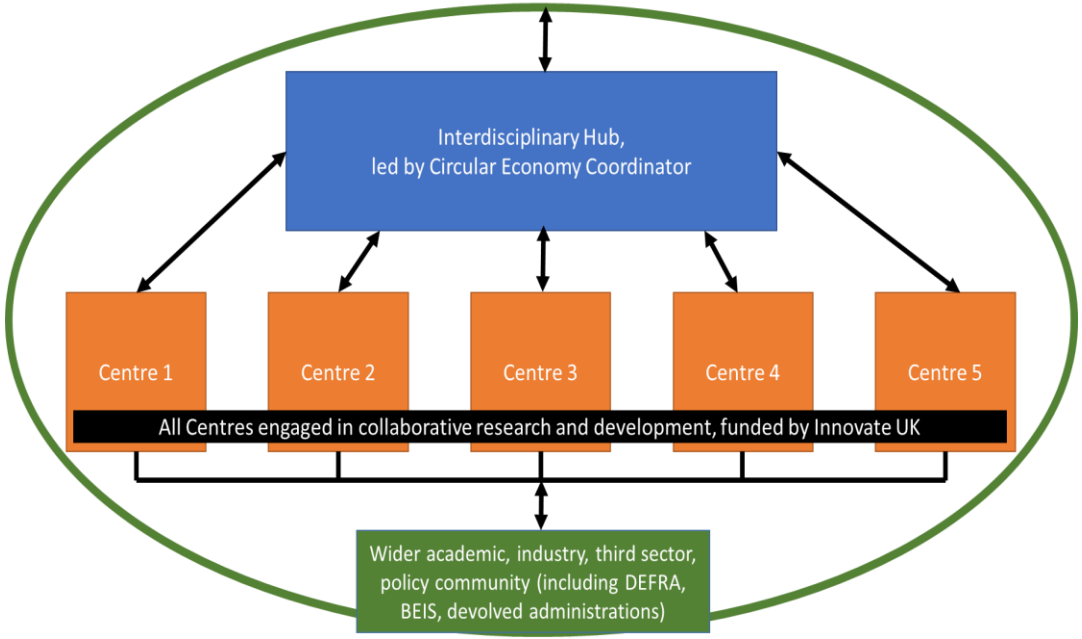
Background

The programme has three key objectives, to:

- Accelerate understanding and solutions to enable circularity of specific resource flows (including related waste streams and uses, and within sector contexts)
- Provide national leadership, coordinate and drive knowledge exchange across the programme as a whole and with policy, consumer, third sector and business stakeholders
- Ensure research is embedded with stakeholders by involving businesses, policymakers, consumers and society, the third sector, and other affected groups and communities at every part of the programme – including provision of funding to enable SME involvement.

Background

The programme objectives will be progressed by £30m of funding for up to five interdisciplinary Centres and an integration Hub led by a Coordinator.



Current calls

- Up to **£22.5M** available (alongside **£2.5M of future funding** to enable small and medium enterprise involvement with Centres) to support **up to five academic interdisciplinary Centres** of up to 48 months, expected to be from October 2020.
  - Outline closing date: 16.00 05 December 2019
  - Full proposals due 21 April 2020

- Up to **£150,000** for **one grant of up to 11 months**, leading to a second stage with a single proposal submission for an **Interdisciplinary Circular Economy Hub**, with up to **£3.3m** available for up to 43 months expected to start January 2021.
  - Coordinator will be announced in (estimated) February 2020

Opportunities for industry engagement

- Engaging with any existing academic contacts
  - If you don’t identify applicants, details of successful outline proposals will be announced in late January 2020

- Attendance at community building workshops in February and March 2020
  - Opportunities to network with and shape Centre proposals

- Engagement with Centres and Hub when launched (Oct 2020; Jan 2021)

- Future CR&D competitions from Innovate UK, linked to the five Centres
  - Estimated to launch autumn 2020 – up to £2.5m of UKRI funding available

Engineering and Physical Sciences Research Council

@EPSRC

EPSRCvideo

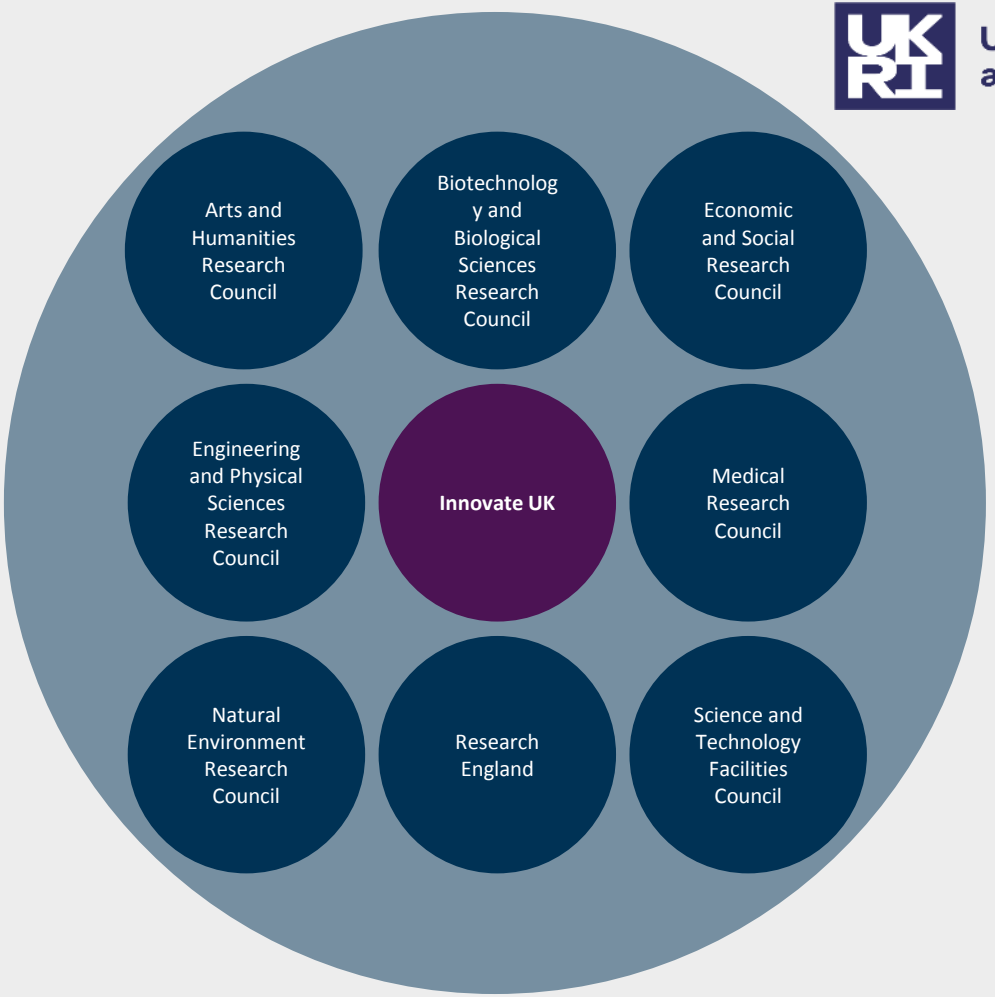
IUK Funding Landscape

Malcolm Hannaby
Innovation Lead Manufacturing &
Materials

Benefiting everyone through knowledge, talent and ideas.

UK Research and Innovation brings together the 7 Research Councils, Innovate UK and Research England.

As part of UK Research and Innovation, Innovate UK drives productivity and economic growth by supporting businesses to develop and realise the potential of new ideas including those from the UK's world-class research base.



Investment of
£2.5bn
since 2007

Industry match funding taking the total value of projects above
£4.3bn

Up to
£18bn
in added value to the economy

Up to
£6-7
for every **£1** we've invested

We've funded around
11,000
projects

8,500
unique organisations involved

9 jobs
for each organisation involved

70,000
jobs created in total

5 foundations of The Industrial Strategy

The Industrial Strategy is driving productivity and earning power across the country by focusing on the 5 foundations of productivity that support a vision for a transformed economy.

Ideas

The world's most innovative economy

People

Good jobs and greater earning power for all

Infrastructure

A major upgrade to UK's infrastructure

Business environment

The best place to start and grow a business

Places

Prosperous communities across the UK

UK Research and Innovation

ISCF Wave 3 challenges

INDUSTRIAL STRATEGY

Ageing society

Accelerating Detection of Disease (up to £79m)

AI and data economy

Manufacturing Made Smarter (up to £147m)

Commercialising Quantum Technologies (up to £153m)

Digital Security by Design (up to £70m)

Clean growth

Transforming Foundation Industries (up to £66m)

Smart Sustainable Plastic Packaging (up to £60m)

Industrial Decarbonisation (up to £170m)

Future of mobility

Driving the Electric Revolution (up to £78m)

Future Flight (up to £125m)

UK Research and Innovation

Examples of additional opportunities for Innovate UK / UKRI funding

SMART Grants

Innovation Loans

APC Programmes

ATI Programmes

e.g. National Aerospace Technology Program (NATEP)

Innovate UK Smart funding

For businesses in any sector

- enables businesses to apply for grant funding regardless of technical or industrial area of focus
- funding for the best proposals in a competitive application process
- 4 open competitions run in 2019/20, offering a total of £100 million funding

Paul Holt, founder, Photocentric

Innovation loans

A pilot programme of competitions to the end of 2020 aiming to ensure that businesses can access funding at all stages of innovation.

Up to **£50 million** available	Competitions for UK SMEs wanting to scale up
Can be used for late-stage R&D projects	Delivered by Innovate UK Loans Ltd.

Managed Programme: Aerospace

UK Aerospace Research & Technology Programme (UKART)
£3.9 billion

Strategic Programme

Key Facts
Total grant funding: up to £1.9bn
Up to £150m grant/year available

Key Dates
Calls for Expressions of Interest open Monthly

Portfolio to date:
ATI Strategic Programme
Total value so far: £2.3bn
Total grant so far: £1.2bn
Projects: 228 on contract
Unique partners: 219
Total SMEs: 115
Average project grant: £5.2m
Average partners per project: 4

Collaborative R&D Competition Calls (CR&D)

Key Facts
Total grant funding: up to £20m
First call now up to £8m grant

Key Dates
Details announced in 2019

Previous waves:
CR&D1 (2013) & CR&D2 (2014)
Total value: ~£77m
Total grant: ~£43m
Projects contracted: 34
Partners: 174
Total SMEs: 80

NATEP (under UKART since 2017)

Key Facts
Total grant funding: up to £10m
Details announced in 2019

Key Dates
Details announced in 2019

Previous waves:
NATEP1 (2013)&NATEP2 (2017)
Total value: £54.4m
Total grant: £31m
Projects contracted: 152
Partners: 368
Most of which are SMEs

UK-Sweden EUREKA Call

Key Facts
Total grant funding: up to £2.25m

Key Dates
Details announced in 2019

First bi-lateral call

Managed Programme: Automotive

Low/Zero Emission Vehicles

Since 2007 Innovate UK and OLEV have supported mid TRL:
325 projects
490 organisations
£603m project value

APC have supported high TRL:
49 projects
176 organisations
£838m project value

Office for Low Emission Vehicles

ADVANCED PROPULSION CENTRE

Vehicle Charging

Investment in UK's capability in vehicle charging:

£30m Vehicle to Grid competition

£40m Street and Wireless competitions

Office for Low Emission Vehicles

Department for Business, Energy & Industrial Strategy

Connected & Autonomous Vehicles

Funding to position the UK at the forefront of CAV research, development testing and use

CCAV £100m R&D funding

£28m ISCF self driving vehicles

£20m funding pre-dating CCAV

CCAV £100m testing infrastructure funding

Centre for Connected & Autonomous Vehicles

ZENZIC SELF-DRIVING REVOLUTION

£255m of support to projects that started in 2018

Innovate UK

Thank you

Malcolm.hannaby
@InnovateUK

https://www.gov.uk/government/organisations/innovate-uk

ReDisCoveR Composites

Workshops – Lucy Eggleston, ReDisCoveR Project Lead, the National Composites Centre

12th November 2019

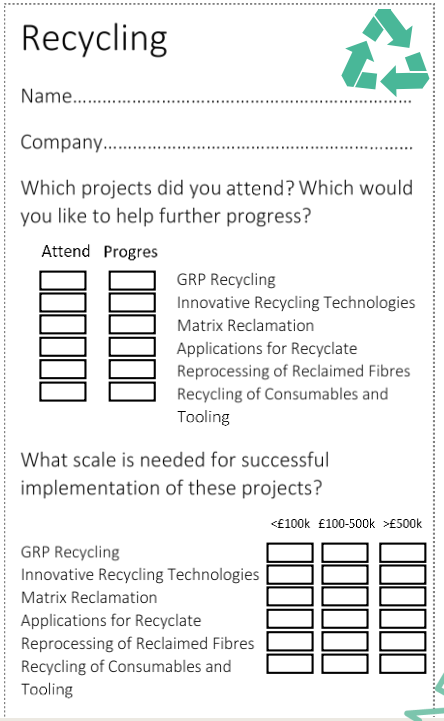
Recycling – the agenda

10:15-10:25 – Introduction to the Recycling stream

10:25-11:05 – Recycling projects engagement and workshopping

11:05-11:15 – Recycling stream feedback

- Engage with as many projects as you would like during the 40 minute session
- Use your sticky notes to have your say and help steer the direction of the projects
- At the end of the session, fill out the Recycling feedback form in your welcome pack and submit this as you leave the session
- Place your three stickers on the projects of highest priority for your organisation



Recycling

Name.....

Company.....

Which projects did you attend? Which would you like to help further progress?

Attend	Progres	
☐	☐	GRP Recycling
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☐	☐	Recycling of Consumables and Tooling

What scale is needed for successful implementation of these projects?

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Recycling of Consumables and Tooling	☐	☐	☐

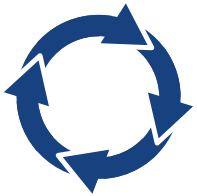
Recycling – the current state

The global composites market is expected to reach $95bn by 2020, yet less than 2% of composites waste is currently recycled

Collection

- Harvesting is difficult due to the wide range of materials used
- There is no centralised or standardised system or strategies

Reclaim



- Reclamation technologies are limited
- Emphasis is on the fibres, and predominantly only on carbon
- Degradation occurs during reclamation

Reprocess

- Reprocessing methods often leave recyclate in sub-optimal formats
- Applications are therefore limited

Use

- The performance of recyclate is not well understood
- There are limited identified end users

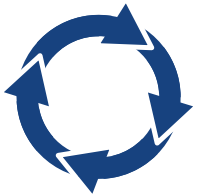
Recycling – the future state

All composites will be reclaimed, without significant degradation, using low energy, high efficiency methods, and reprocessed into high value and in-demand recyclate

Collection

- Harvesting of composites will be commonplace
- Legislation will be in place
- Certification and standardisation will be the norm

Reclaim



- All fibres will be reclaimed without significant degradation
- The matrix will be reclaimed as well as the reinforcement
- Reclamation processes will be low energy and efficient

Reprocess

- Reprocessing techniques will result in recycled fibres and resins in usable, desirable formats
- Methods will be affordable and low impact

Use

- Composites recyclate will be sought after and valuable
- There will be a plethora of possible applications and willing end users

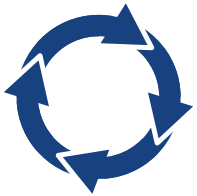
Recycling – the opportunities

Based directly from the industry feedback we've gained over the past four months, we have identified the following opportunities

Collection

- Methods for harvesting and processing composite manufacturing consumables and tooling

Reclaim



- Techniques specific to glass fibre reinforced polymer composites
- Methods that focus on reclaiming the polymeric matrix
- New and innovative processes that maintain performance

Reprocess

- Technologies that reprocess fibres into usable formats

Use

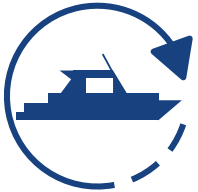
- Applications and end users for recyclate

Recycling – the projects

Recycling of Consumables and Tooling

Matrix Reclamation

Innovative Reclamation Technologies



GRP Recycling

Applications for Recycalte

Reprocessing of Reclaimed Fibres

GRP Recycling

Investigate and develop glass fibre reinforced polymer (GRP) composite recycling technologies that are able to reclaim greater value fibres from GRP waste than is currently commercially available

Background

Currently only approximately 2% of glass is recycled. Commercial routes are limited to grinding or co-processing in cement kilns. These techniques limit potential end applications and drastically reduce the value of the recyclate. Other composite recycling routes, such as pyrolysis, significantly degrade the glass fibre properties to the point where they are no longer of use, and are often thought to be of little or no economic value.

Milestones

Technology or Capability Gaps

Your Involvement

Future state

In the future, there will be economically viable and effective methods for recycling GRP composites that reclaim higher value recyclate than is currently commercially attainable. There will be a robust and cohesive supply chain in place, providing industry with an alternative end of life route to landfill or grinding. Glass recyclate will be high quality, valuable, and have a plethora of potential applications and willing end users.

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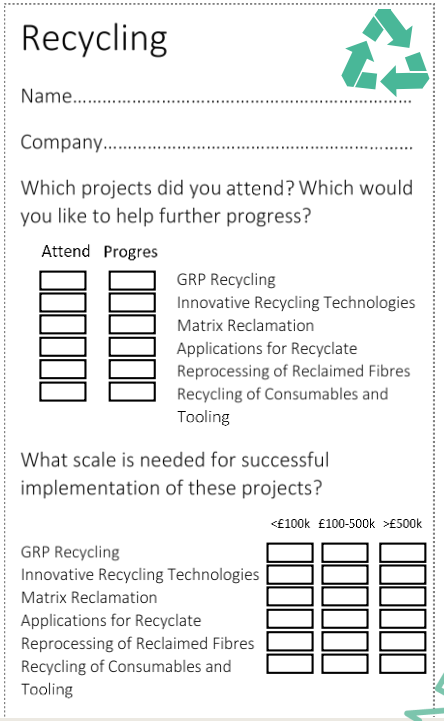

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☐	☐	Recycling of Consumables and Tooling

What scale is needed for successful implementation of these projects?

	<£100k	£100-500k	>£500k
GRP Recycling	☐	☐	☐
Innovative Recycling Technologies	☐	☐	☐
Matrix Reclamation	☐	☐	☐
Applications for Recyclate	☐	☐	☐
Reprocessing of Reclaimed Fibres	☐	☐	☐
Recycling of Consumables and Tooling	☐	☐	☐

Circular Materials – the agenda

11:15-11:25 – Introduction to the Circular Materials stream

11:25-12:05 – Circular Materials projects engagement and workshopping

12:05-12:15 – Circular Materials stream feedback

- Engage with as many projects as you would like during the 40 minute session
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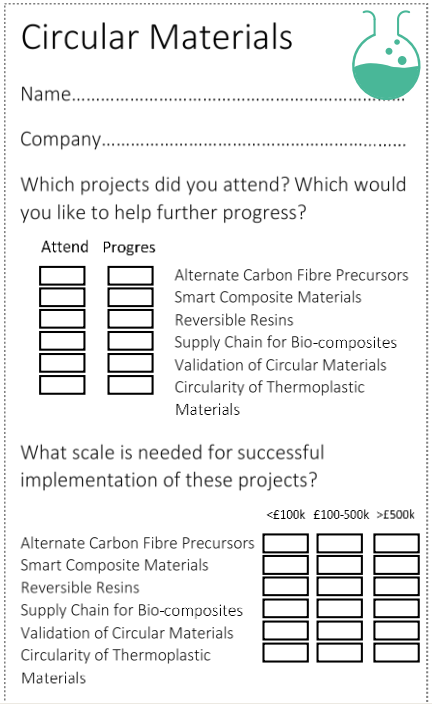


Circular Materials

Name.....

Company.....

Which projects did you attend? Which would you like to help further progress?

Attend	Progres	
☐	☐	Alternate Carbon Fibre Precursors
☐	☐	Smart Composite Materials
☐	☐	Reversible Resins
☐	☐	Supply Chain for Bio-composites
☐	☐	Validation of Circular Materials
☐	☐	Circularity of Thermoplastic Materials

What scale is needed for successful implementation of these projects?

	<£100k	£100-500k	>£500k
Alternate Carbon Fibre Precursors	☐	☐	☐
Smart Composite Materials	☐	☐	☐
Reversible Resins	☐	☐	☐
Supply Chain for Bio-composites	☐	☐	☐
Validation of Circular Materials	☐	☐	☐
Circularity of Thermoplastic Materials	☐	☐	☐

Circular Materials – the current state

The majority of composite materials are petroleum derived, virgin materials that are not currently manufactured to align with the principles of a circular economy

Precursors

- Fibres and resins are mainly manufactured using precursors derived from petroleum
- Bio-based alternatives are considered novel

Manufacture

- Composite materials are not designed with end of life in mind
- Manufacturing processes are high energy
- Some materials used are toxic or harmful

Supply Chain

- The supply chain for circular materials is immature and poorly linked
- Materials are expensive (precursors, intermediates, and products)

Use

- The performance of circular materials is not well understood
- Small amounts of bio or recycled materials are actually used

Circular Materials – the future state

All composite materials will be circular. Non-virgin and non-petroleum-derived, cost competitive alternatives will be used at every opportunity, and manufacture will be low toxicity and low energy

Precursors

- Alternative, lower energy precursors for fibres will be available and desirable
- Bio-based precursors from agricultural waste will be commonplace

Manufacture

- Materials will be designed with end of life in mind and will be smart, biodegradable or reversible where appropriate
- Manufacturing will be low toxicity and low energy

Supply Chain

- The supply chain for bio-materials will be well linked
- Circular materials will be cost competitive and sought after
- Recyclate will be imbedded in the supply chain

Use

- The performance of circular materials will be understood
- A large proportion of composite materials will be non-virgin and non-petroleum derived

Circular Materials – the opportunities

Based directly from the industry feedback we've gained over the past four months, we have identified the following opportunities

Precursors

- Alternative, low energy or non-petroleum-derived precursors for carbon fibre

Manufacture

- Resins that are easier to reverse, reclaim, or recycle
- Composite materials with innate secondary functions that help facilitate end of life

Supply Chain

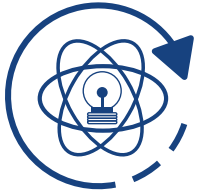
- Circular supply chains for thermoplastics
- A cost effective supply chain for bio-based materials

Use

- Validated performance data for bio-based materials

Circular Materials – the projects

Alternative Carbon Fibre Precursors

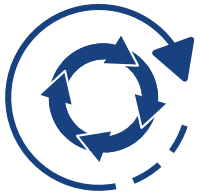


Smart Composite Materials

Reversible Resins

Supply Chain for Bio-based Composites

Validation of Circular Materials



Circularity of Thermoplastic Composites

Reversible Resins

Develop cost effective and scalable manufacturing process for reversible resins that facilitate easier reclamation and recycling at end of life

Background

Although thermoplastic matrix composites can be ground, melted, or reformed, thermosets are not easily reversed once cured. Current commercial composite reclamation methods in the UK are almost entirely focused on the fibres and require an additional, external process. Work to develop alternative reversible resin chemistries with the inherent ability to facilitate both reinforcement and matrix reclamation at end of life is very limited.

Milestones

Technology or Capability Gaps

Your Involvement

Future state

In the future, there will be a range of reversible matrices commercially available that facilitate reclamation at end of life. These will be standardised, verified, and well understood. These chemistries will not only make it possible to gain value from end of life resins, but also enable easier reclamation of fibres without additional and often high energy processes. End of life composites will be fully recyclable into high value and usable recyclate.

Circular Materials – the agenda

11:15-11:25 – Introduction to the Circular Materials stream

11:25-12:05 – Circular Materials projects engagement and workshopping

12:05-12:15 – Circular Materials stream feedback

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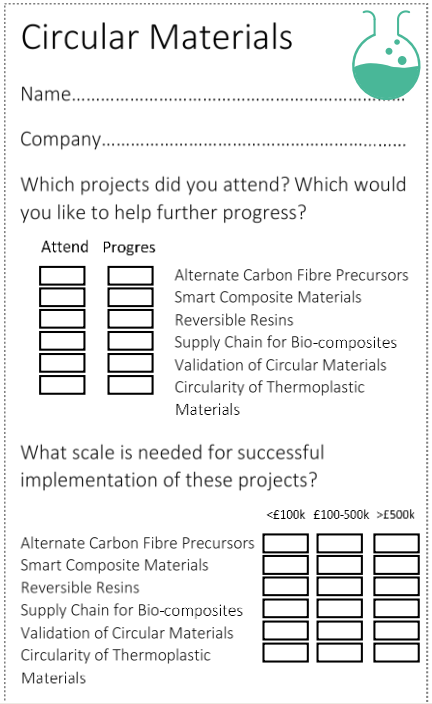

Circular Materials

Name.....

Company.....

Which projects did you attend? Which would you like to help further progress?

Attend	Progres	
☐	☐	Alternate Carbon Fibre Precursors
☐	☐	Smart Composite Materials
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What scale is needed for successful implementation of these projects?

	<£100k	£100-500k	>£500k
Alternate Carbon Fibre Precursors	☐	☐	☐
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Supply Chain for Bio-composites	☐	☐	☐
Validation of Circular Materials	☐	☐	☐
Circularity of Thermoplastic Materials	☐	☐	☐

Reuse – the agenda

13:15-13:25 – Introduction to the Reuse stream

13:25-13:05 – Reuse projects engagement and workshopping

14:05-14:15 – Reuse stream feedback

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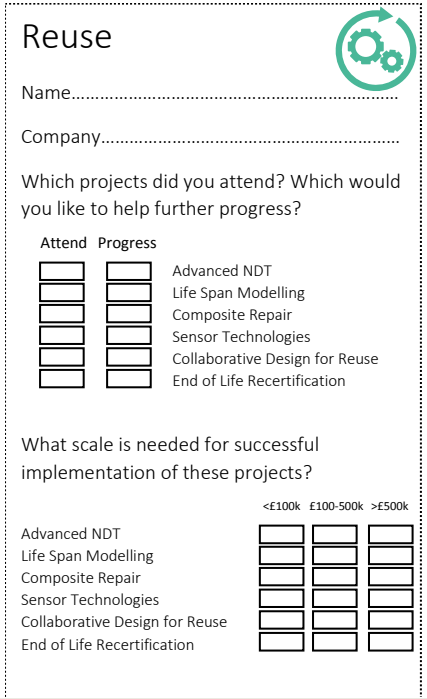

Reuse

Name.....

Company.....

Which projects did you attend? Which would you like to help further progress?

Attend	Progress	
☐	☐	Advanced NDT
☐	☐	Life Span Modelling
☐	☐	Composite Repair
☐	☐	Sensor Technologies
☐	☐	Collaborative Design for Reuse
☐	☐	End of Life Recertification

What scale is needed for successful implementation of these projects?

	<£100k	£100-500k	>£500k
Advanced NDT	☐	☐	☐
Life Span Modelling	☐	☐	☐
Composite Repair	☐	☐	☐
Sensor Technologies	☐	☐	☐
Collaborative Design for Reuse	☐	☐	☐
End of Life Recertification	☐	☐	☐

Reuse – the current state

Composite structures are designed with predetermined life spans, however decommissioning and end of life at this set point often occurs for reasons outside of insufficient structural integrity

Monitor

- Monitoring of structures is expensive and requires additional capability
- Composite structures are designed with predetermined life spans

Repair

- There are techniques with the ability to validate end of life structures, but they're rarely used
- Some composite repair methods exist, however they are limited in number and in variety

Validate

- Recertification is uncommon
- There is very little legislation surrounding recertification
- Lack of understanding renders potential users and insurers hesitant

Reuse

- There is little understanding of potential secondary reuse applications for primary components
- Structural integrity can be a concern

Reuse – the future state

All composite components will be design to facilitate life extensions and secondary functions. Parts will be monitored throughout their lives, and validation for recertification will be commonplace

Monitor

- Environmental stresses will be monitored using embedded sensors
- Real data will be used in conjunction with accurate models and digital twins

Repair

- Validation methods will be automated and operated remotely
- There will be a plethora of composite repair techniques used in a wide range of applications

Validate

- There will be standards for recertification that are recognised world wide
- Recertification will be commonplace in all industries

Reuse

- End of life performance data will be accurate and readily available
- Parts will be designed with a secondary function in mind

Reuse – the opportunities

Based directly from the industry feedback we've gained over the past four months, we have identified the following opportunities

Monitor

- Accurate, low cost sensors for all applications
- Models and digital twins that are used in unison to determine accurate performance data

Repair

- Remote and automated NDT techniques for applications that are not easily accessed
- Effective composite repair techniques in all sectors

Validate

- Techniques and legislation for recertification

Reuse

- Methods for co-designing new products with secondary functions in mind

Circular Materials – the projects

Advanced NDT

Life Span Modelling

Composite Repair

Sensor Technologies

Collaborative Design for Reuse

End of Life Recertification

Advanced NDT

Investigate the application of composite non-destructive testing (NDT) techniques in novel or extreme environments

Background

Composite NDT techniques are well understood, however they are predominantly performed by hand and in controlled environments. NDT is primarily used to detect manufacturing defects, and is rarely used to recertify or extend the lifespan of parts thought to be at their end of life. Remote and automated methods have the potential to enable the ability to monitor structures that are difficult or dangerous to access.

Milestones

Technology or Capability Gaps

Your Involvement

Future state

In the future, pre-existing NDT techniques will be deployed in end of life applications and used to extend life and recertify components. Methods will be automated, leading to faster, more repeatable, and lower cost operation. The application of remote inspection will have eliminated both structure down-time and the negative health and safety implications of in-situ inspection.

Reuse – the agenda

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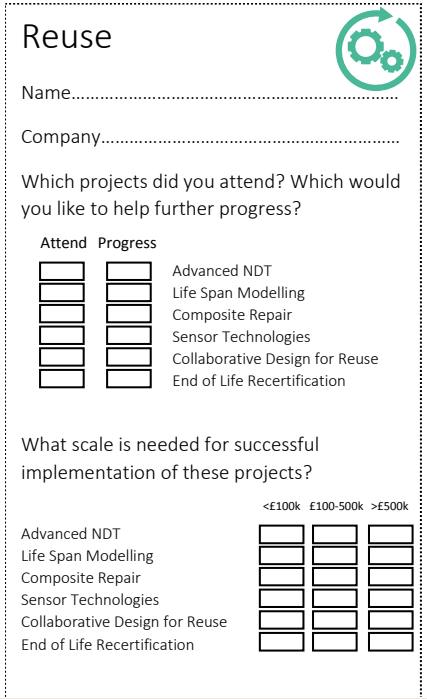

Reuse

Name.....

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Sensor Technologies	☐	☐	☐
Collaborative Design for Reuse	☐	☐	☐
End of Life Recertification	☐	☐	☐

Disassembly – the agenda

14:30-14:40 – Introduction to the Disassembly stream

14:40-15:20 – Disassembly projects engagement and workshopping

15:20-15:30 – Disassembly stream feedback

- Engage with as many projects as you would like during the 40 minute session
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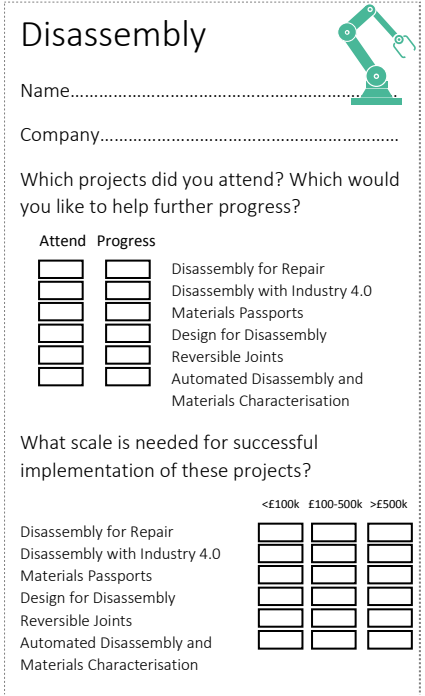

Disassembly

Name.....

Company.....

Which projects did you attend? Which would you like to help further progress?

Attend	Progress	
☐	☐	Disassembly for Repair
☐	☐	Disassembly with Industry 4.0
☐	☐	Materials Passports
☐	☐	Design for Disassembly
☐	☐	Reversible Joints
☐	☐	Automated Disassembly and Materials Characterisation

What scale is needed for successful implementation of these projects?

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Disassembly for Repair	☐	☐	☐
Disassembly with Industry 4.0	☐	☐	☐
Materials Passports	☐	☐	☐
Design for Disassembly	☐	☐	☐
Reversible Joints	☐	☐	☐
Automated Disassembly and Materials Characterisation	☐	☐	☐

Disassembly – the current state

Current disassembly techniques are often either manual and therefore high cost (e.g. aircraft disassembly), or crude and therefore produce low value recyclate (e.g. vehicle shredding)

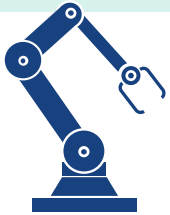
Design

- Products are often designed for function, with little regard given to end of life
- Joining technologies are designed to be lightweight and often permanent

Use

- Once ownership has changed, knowing the material content of parts can be difficult
- Permanent fixtures can result in structures that are difficult to access and therefore repair

End of Life



- Disassembly is often either highly manual or very crude
- Little emphasis is given to automation or digitisation
- Strategy is highly dependent on application and sector

Identification

- Composite materials can be hard to identify and can therefore also be difficult to effectively recycle, particular once shredded

Disassembly – the future state

Disassembly and materials characterisation will be automated, rapid, and accurate. All structures will be designed with disassembly and end of life in mind

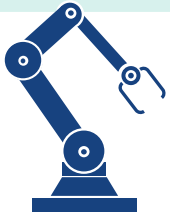
Design

- Composite products and systems will be designed with end of life in mind
- All fixtures will be reversible and lightweight

Use

- Material data will be fully traceable and accessible right across the supply chain
- Components will be designed with disassembly strategies in mind able to facilitate repair

End of Life



- Disassembly will be accurate, automated, fast, and cheap
- All sectors will have effective disassembly techniques to effectively reclaim all components and materials

Identification

- All parts and materials will be identifiable and therefore of higher value
- Subsequent recycling will be effective as the materials will be known

Disassembly – the opportunities

Based directly from the industry feedback we've gained over the past four months, we have identified the following opportunities

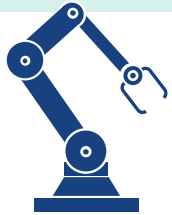
Design

- Products that are designed specifically with end of life, and disassembly, in mind
- Innovative joining methods that are lightweight but reversible

Use

- Records for components and parts, showing material content and environmental stresses faced
- Disassembly techniques that facilitate easier repair of structures

End of Life



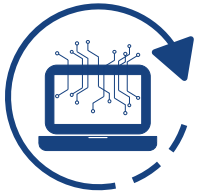
- Integrating end of life with Industry 4.0, looking to use automation and digitisation to increase accuracy and efficiency

Identification

- Rapid and effective methods to identify, characterise, and separate materials

Recycling – the projects

Disassembly for Repair



Disassembly with Industry 4.0

Materials Passport

Design for Disassembly

Reversible Joints

Automated Disassembly and Materials Characterisation

Design for Disassembly

Investigate, develop, and demonstrate design toolsets focused specifically on design for disassembly

Background

At current, performance and function are at the forefront of the majority of requirements for new products. There is rarely any consideration for how the product will behave at end of life. In general, disassembly strategies are devised when they are needed in order to solve an existing problem, and not predetermined to prevent a future problem, this can result in avoidable issues.

Milestones

Technology or Capability Gaps

Your Involvement

Future state

In the future, designing for disassembly will be as common as design for manufacture. There will be widely available toolsets and well understood techniques to aid with this, and designing for disassembly will be a skill that is taught, learnt, and practiced. As a result, disassembly of products and structures will be effective, efficient, and low cost.

Disassembly – the agenda

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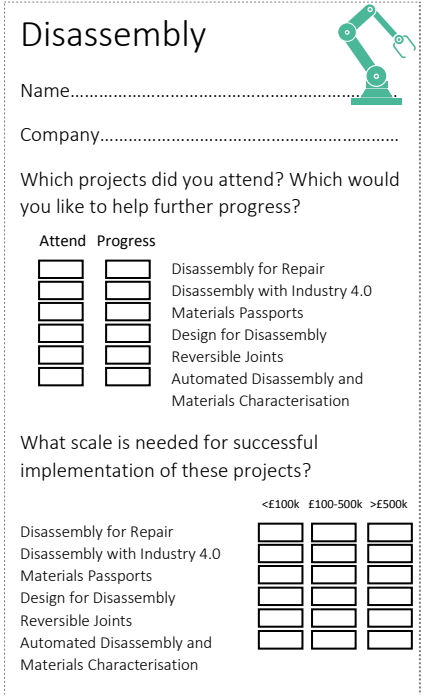

Disassembly

Name.....

Company.....

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Reversible Joints	☐	☐	☐
Automated Disassembly and Materials Characterisation	☐	☐	☐

ReDisCoveR Composites

Closing remarks– Graeme Cruickshank, CTIO , the Centre for Process Innovation

12th November 2019

ReDisCoveR

The aim of ReDisCoveR is to transform the UK's world leading composites end-of-life academic and commercial capabilities into a fully functioning and interconnected supply chain

Research roadmaps and strategies

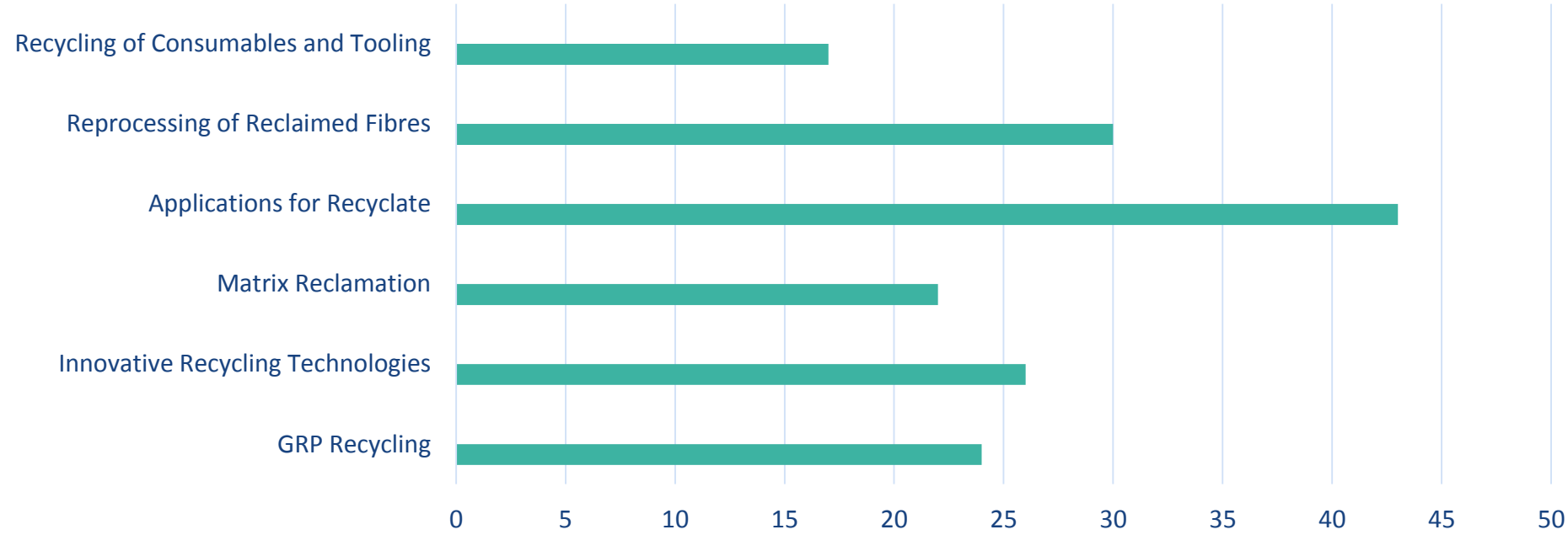
Determine largest perceived value opportunities

Gain feedback from industry and reassess

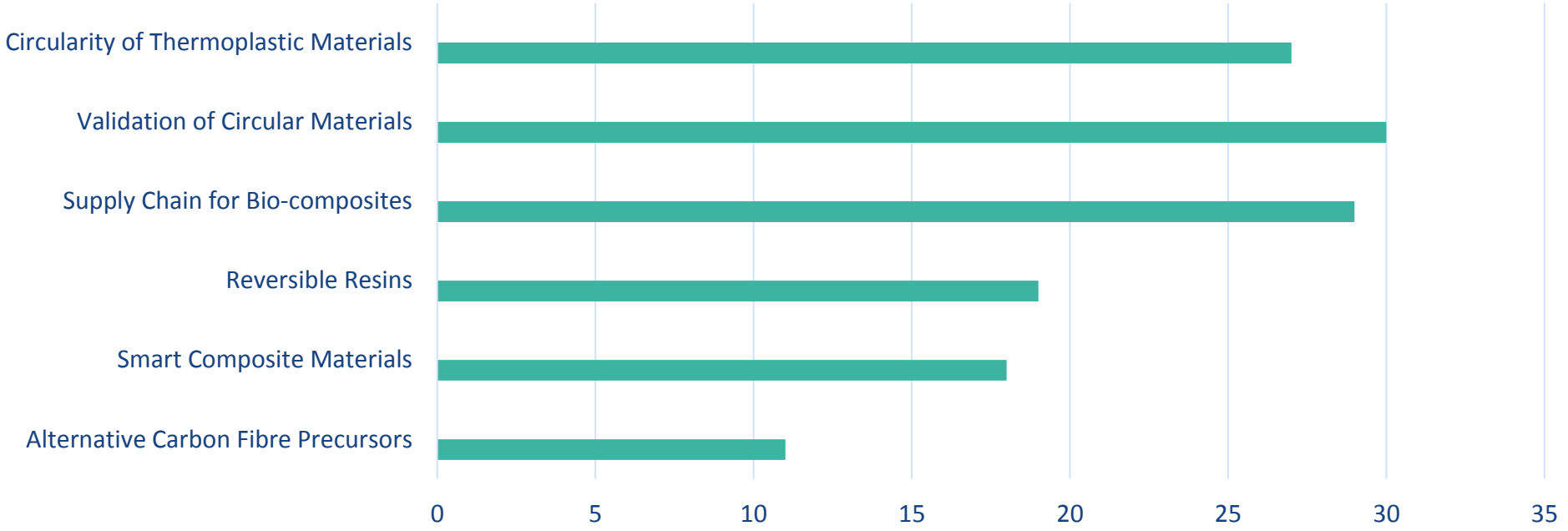
Determine a suite of projects that capitalise on these opportunities

ReDisCoveR Composites event

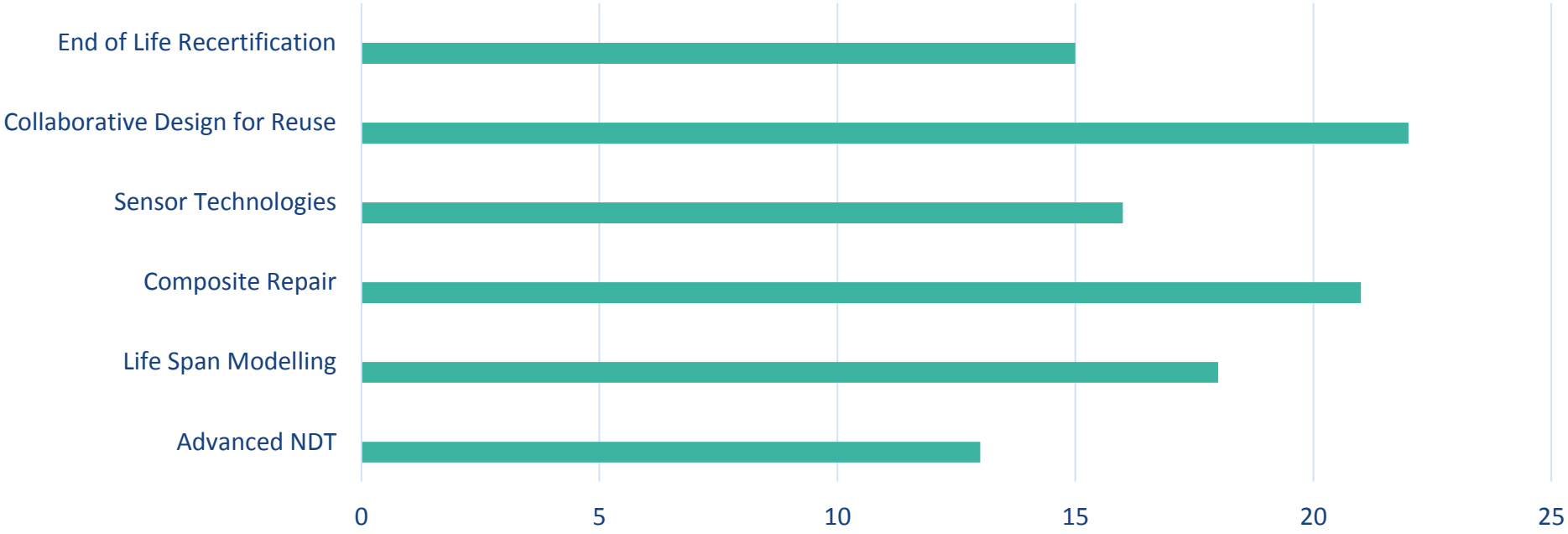
Recycling recap



Circular Materials recap



Reuse recap


End of Life Recertification
Collaborative Design for Reuse
Sensor Technologies
Composite Repair
Life Span Modelling
Advanced NDT
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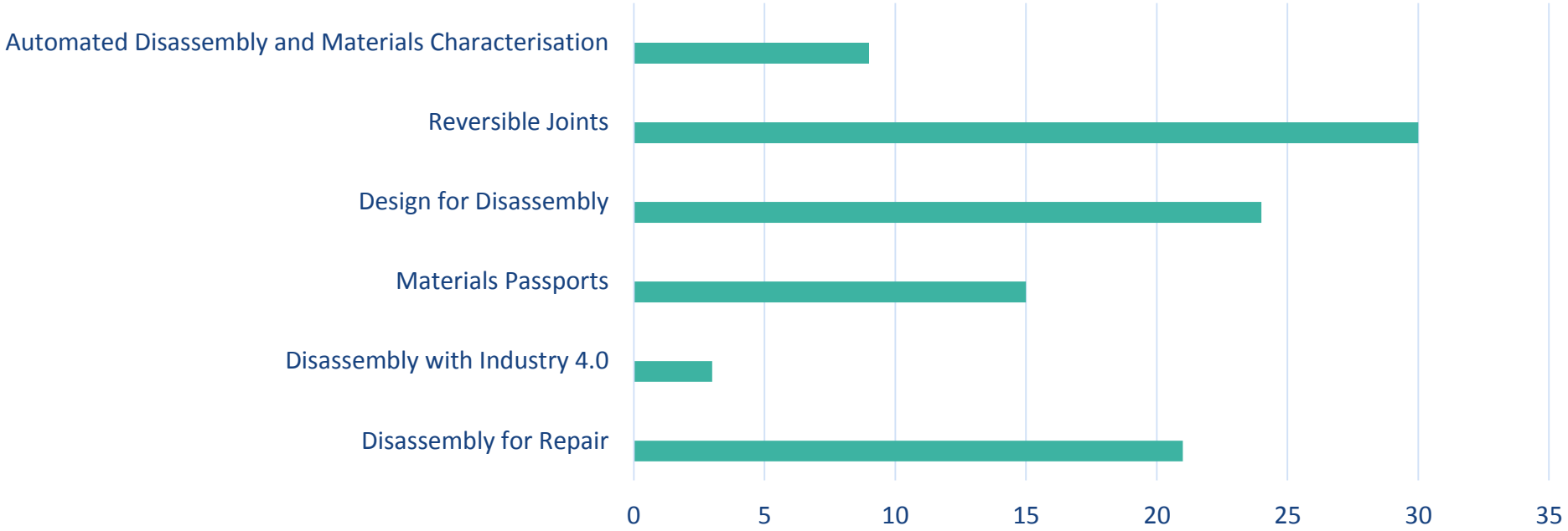
25

Disassembly recap



Next steps

The HVMC will drive all project scoping, planning, and bid writing activities
Look out for invitations to focused workshops based on the feedback you give today

Research roadmaps and strategies

Determine largest perceived value opportunities

Gain feedback from industry and reassess

Determine a suite of projects that capitalise on these opportunities

ReDisCoveR Composites event

Focussed workshops, project scoping, and bid writing