Manufacturing the Future Research Priorities Workshop

Hilton Birmingham Metropole

Wednesday 2nd October 2019

Engineering and Physical Sciences Research Council

Introduction

In October 2019 EPSRC's Manufacturing the Future Theme (MtF) held a one-day community workshop as part of the Theme's refresh of its strategy.

The purpose of this workshop was to provide an opportunity for the research community to input into the refresh of the research priorities. The outputs would be considered alongside information from the Manufacturing Futures Retreat as well as the ongoing MtF Strategic Advisory Team discussions.

The aim of the day was for participants to have the opportunity to:

- Discuss future challenges and opportunities in manufacturing-related research
- Meet researchers with similar interests in manufacturing-related research
- Provide input into possible future research priorities for MtF.

Participants

The workshop was open to researchers across all disciplines including engineering, design, materials science, physical sciences, mathematics, computer science, economics and social sciences including business models, sustainability, life sciences and energy systems.

As part of the open call we particularly encouraged applications from early career researchers and researchers with interest in and/or experience of working across disciplinary fields.

On the day

The agenda for the day is in Appendix 1, with the accompanying presentation in Appendix 2. The agenda was designed to give attendees a chance to meet and discuss, through a series of facilitated sessions, focussed questions around manufacturing systems. This resulted in a number of completed proformas, shown in Appendix 3.

Next steps

The proformas are being used as input to the ongoing MtF Strategic Advisory Team discussions on the Theme's research priorities.

It is envisaged that detail from the proformas will end up informing future calls from the Theme.

The Theme would like to thank all participants for their time, enthusiasm and input.

Appendix 1: Workshop Agenda

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Agenda

Manufacturing the Future Research Priorities Workshop
EPSRC, Birmingham, Metropole Hotel
Wednesday 2nd October 2019

09:30 Tea & Coffee

10:00 Introduction to workshop

10:30 Manufacturing Systems World Café

11:30 Break and Marketplace

11:50 Looking at Research Challenges

12:10 Clustering Research Challenges

13:00 Lunch (The Boulevard Restaurant)

14:00 Challenge exploration session

15:30 Break and feedback

15:50 Prioritisation

16:30 Finish

Appendix 2: Workshop Presentation

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Manufacturing the Future Strategy Refresh

Research Priority Workshop October 2019

EPSRC Manufacturing Team

Katie Daniel
Head of Manufacturing

Nick Cooper
Critical Mass, Circular Economy, Plastics

Richard Bailey
Theme Strategy, Impact, Industrial Biotech

Becky Cheesbrough
Additive, Production, Fellowships

Katie Walker
Engineering Design, Digital, Programme Grants

Tracy Hanlon
Materials, Leaders

Vacancy
Operations, Sustainable Manufacturing

Stephanie Williams
Process, Medicines, Standard Research

Stephen Gilligan
Manufacturing & Circular Economy Portfolio Support

Jessica Bonham
Senior Portfolio Manager, ICT Theme

Why the refresh?

- New EPSRC Delivery Plan → refresh MtF strategy
- How do we use our strategy?
  - Show what we consider important and our place in the landscape
  - Highlight the research we want to fund
    - e.g. Fellowship priorities, SI & CL calls
  - Inform & explain what we do

Strategy overview

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Our vision is of a prosperous and productive UK, supported by a thriving, research and knowledge-led manufacturing base

To enable this, our mission is to create and capture the benefits of basic research for UK manufacturing industries

'Research' Priorities	The areas of science and engineering we will focus on in our activities

So far …

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Retreat — MANUFACTURING FUTURES

Strategic Advisory Team, Hub Directors, Early Career Forum, Regional Meetings

Community Workshop

Strategic Advisory Team

What do we want?

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- Exciting, multidisciplinary areas
- Clear opportunity for manufacturing research
- Clear route to impact and benefits for UK

- A lot of scientific detail
- Research proposals
- Funding schemes

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Any questions before we start …

World Café

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- Contribute your thinking, speak your mind
- Listen for insights and deeper connections, linking ideas
- Writing and doodling on tablecloths is encouraged!

World Cafe

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Q1 How might manufacturing systems be different in the future?

- Possibilities, utopia

World Cafe

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Q2 Why aren't we there yet?

- Barriers, knowledge gaps

Ideas capture

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Q3 What research challenges do we still need to address to create potential new manufacturing systems?

- 10min group discussion
- 5min to decide main points – choose a **MAX** of 4
  - **ONE** option per card

Cluster

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- Three minutes to put up and briefly describe your research challenges.
- Can they be clustered with others?

Challenge exploration – open space

- Anything we missed?
- Make your choice(s)!
- Champion a cluster

Vote with your feet

Feedback

Marketplace

- Champions next to proformas
- Post-it note feedback
- Sticky dots

Which research challenge would you invest your research money in?

Appendix 3: Workshop Outputs

Red numbers represent participants' sticky dot voting.

Computational Modelling 11

What is this priority all about?

- Predictive capability in design, manufacture and through-life performance
- Allow for closed-loop manufacturing

Why do we think it is important?

- Efficient manufacturing
- Quality control of products
- Improved structural integrity
- Reduce experimental testing (hence costs)
- Facilitate human-machine partnership

What are the research challenges to be explored?

- Need "new" physics/chem models ???? for rapid/just-in-time predictive computations
- Linking manufacturing processes to as-manufactured product
    - 3D complexity of materials through the manufacturing process
    - Link to structural integrity and performance
    - Fast, efficient inverse problem approaches; materials characterisation
- Standardise data between models and experiments

Precision Synthesis 7

What is this priority all about?

Manufacturing Materials with new or improved properties to give a step change in performance and create disruptive materials and technologies.

Why do we think it is important?

Material function is derived from material structure. Controlling structure at the atomic and nanoscales. Incorporating new material architectures will give new and improved functionality:

- Optical
- Electronic
- Catalytic
- Sensing
- Charge separation and storage

What are the research challenges to be explored?

- Developing self-organisation and chemical patterning
- Controlling growth of layers and architecture (eg micropores) in heterogeneous materials
- Underlying chemistry to achieve the above.

Data driven Manufacturing Process - Product (data linking the two) 15

What is this priority all about?

- Value from data ↔ data has value
- Data → actionable info
- New sensors:
  - Quality analysis online
  - Need industrial input
- Data lifecycle
- Sharing, trust, traceability, ownership, presentation
- Continuous monitoring and process optimisation
- Business case for sensors + data interoperability
- What do you want?
  1. Sensors
  2. Analysis
  3. Actions
  4. Connectivity

Why do we think it is important?

- Evidence based productivity improvement benefits
- Enables many other areas: circular economy
- More informed decision making
- Better, cheaper, faster
- Ethics, ownership

What are the research challenges to be explored?

- New sensors and other hardware:
  - Connecting data to manufacturing system
  - New data visualisation methods
- Need for open source dataset on manufacturing
- Ethics of data collection and use
- Understand what data is required for a specific application – metadata?
- Interoperability and integration.

Interdisciplinary collaboration 4

What is this priority all about?

- Connecting and understanding requirements for collaboration – breadth of understanding of “how to get things done” or “who” can help (Builds/grows from interdisciplinary skills)
- Team dynamic/formation – complex, hard to crack, good team compatibility
- Possibilities:
  - Split PhD between disciplines
  - Sandpits
  - Networking

Why do we think it is important?

- Manufacturing is moving towards interdisciplinary methods: Better solutions, Different thinking
- Complexity – need multiple experts in varied fields
- Need to develop effective collaboration – share best practice
- Silo’d skills, possible resistance to collaboration reduces knowledge share
  - Needs to be integrated/interoperable collaboration
  - Breaking silos to access knowledge

What are the research challenges to be explored?

- Split of research (this process is currently split into segments making the transition from research to real world benefit difficult) → deployment (ie funding breaks, paperwork etc.)
- How to facilitate/initiate or grow collaboration and free discussion across disciplines/areas? – language use, terms semantics etc; willingness, engagement
- How to support cross-disciplinary research eg. funding, doctoral college support, industrially posed problems
- How to expand networks outside of known contacts?
- Support collaboration in practice
  - Communication
  - Knowledge share
  - Check existing solutions
- How to address silo/reluctant collaborators – why? motivations, competitors, ownership of knowledge rather than real sharing (existing reward structure supports)
- Are there any characteristics that determine collaboration ability, ie how collaborative a person/team is going to be?
- What skills are required to facilitate this? (see interdisciplinary skills group)
- How proposals are reviewed – if interdisciplinary it may not fit one or other funding area.

Interdisciplinary Skills 2

What is this priority all about?

- Understanding the lifelong educational requirement for all level of employees in manufacturing
- To respond and take advantage of changing knowledge
- To facilitate the creation of interdisciplinary teams

Why do we think it is important?

- Manufacturing is multidisciplinary and will be improved by having people trained across areas
- Changes to manufacturing process and technology requires new skills; need to provide innovative thinkers
- Create a more diverse manufacturing workforce
    - Recruitment at school
    - Re-training of workforce

What are the research challenges to be explored?

- Ability to have inter-institutional doctoral training
- To understand the future manufacturing skilled workforce requirements in technical and non-technical
- [Joint with ESRC] what are the barriers to interdisciplinary education? How can we effectively engage pupils in manufacturing?
- Training of schoolteachers to integrate manufacturing and industry at early/secondary education
- What should universities focus on – fundamental versus transferable skills?
- Need to explore the issues in cross-council funding process – panels, reviews

Life-cycle perspectives of manufacturing 5

What is this priority all about?

- Immortality
- Understanding and measuring the totality of impact of the manufactured artefact throughout its life
- Using that whole life knowledge/experience to inform future manufacturing design and manufacturing / decision making (learning things to make improvements and predicting)

Why do we think it is important?

A. Pre-requisite for a circular economy
B. Pre-requisite for responsive system change (you can't improve without knowing what has really happened)

What are the research challenges to be explored?

- Complicated meta-data structures to support optimising or life cycle experience (Sensors? Linking from disparate sources? IP? Sharing? Qualitative and ethnographic etc.)
- Loads and loads of reasons!!!!
- (once we've got the data) model / analytics ("a platform") / algorithms ("digital twins") to enable A, B and anything else we want to do.

Sustainable Radical Manufacturing Technologies for Resource Efficiency 13

What is this priority all about?

- Preserving resource security and resilience
- Limiting negative environmental impact
- Preserving quality of life (long term requirement)

Why do we think it is important?

- Managing resource constraints
- Minimising environmental impacts
    - Emissions to air, land, water
    - Deforestation, loss of habitat etc.
- Bring resource efficiency into mainstream – allowing “more sustainable” technologies/approaches to be industrially viable
- Political and social pressures require this approach
- Supporting supply chain resilience

What are the research challenges to be explored?

- Understanding the impacts of products and processes and utilising life cycle (repeating circular approach) management approaches to reduce these impacts
- Developing new materials and associated processes and managing economic, risk, knowledge gap issues etc. to make the technologies more industrially viable
- Recovery of legacy wastes (eg. Plastics, WEEE in landfill)
- Capturing the knowledge of ageing manufacturers (enabling resource efficiency)

Transformative manufacturing systems 12

What is this priority all about?

- Understanding the whole system, beyond organisational boundaries to support value creation within the overall manufacturing ecosystem.
- Understanding manufacturing systems through meta-integration (integration at various levels and across hardware, software, organisation and business processes, models etc.)

Why do we think it is important?

- Improving working life and working conditions
- Reuse of materials etc.
- Enabling, supporting appropriate use of disruptive technology
- Value proposition for organisations (individual within overall ecosystem)

What are the research challenges to be explored?

- Data: standardisation; interoperability; security; ethics
- Human factors: user centred design, effective job design
- How to effectively harness new tech and processes within the lifecycle
- Wider interoperability of tech and processes to support flexibility and adaptability within the operation.

Enabling new technologies for development of long lasting product, integrated processes and machine design: Transformative technologies for process and machine

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What is this priority all about?

- New process invention for machine innovation / material design
- New transformative technologies
- Hybrid technologies based on existing processes with novel elements
- Material design by functionality
- Next generation products
- Bottom-up design of machine tools

Why do we think it is important?

- Sustainability
- Economic
- New products
- Re-imagining machine building
- Make employment
- Spin-off opportunities (IP)

What are the research challenges to be explored?

- Scalability
- Surface Engineering
- Nano-micro-macro approaches to material design
- Hybrid processes development
- Energy and resource efficiency
- Job and task design
- Self-transforming / self-adapting products and processes.