UK AEROSPACE RESEARCH CONSORTIUM

# Advancing UK Aerospace Research through University Collaboration

## CHYLA Workshop 15 February 2023


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UK-Aerospace Research Consortium


**The 11 founding member universities:**

University of Bristol
University of Cambridge
Cranfield University
Imperial College London
The University of Manchester
University of Nottingham UK | CHINA | MALAYSIA
Queen's University Belfast
The University Of Sheffield.
University of Southampton
University of Strathclyde Glasgow
Prifysgol Abertawe Swansea University

Many others have been contributing

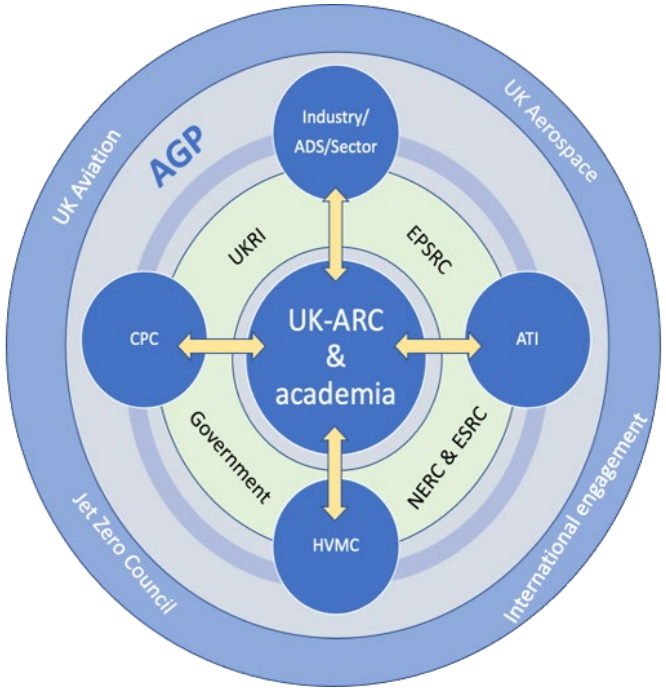
# UK-ARC Aims

Engineering and Physical Sciences Research Council

Supported by the UK's Engineering and Physical Sciences Research Council (EPSRC) with the aim to provide:

1. A single **point of contact** into aerospace and aviation research.
2. Development and **delivery of excellent research**, aligned with the sector.
3. Strengthende **international collaborative research** relationships.
4. Coordination for development of **world-class university strategic facilities**.
5. Nurture the **future aerospace technology skills**.

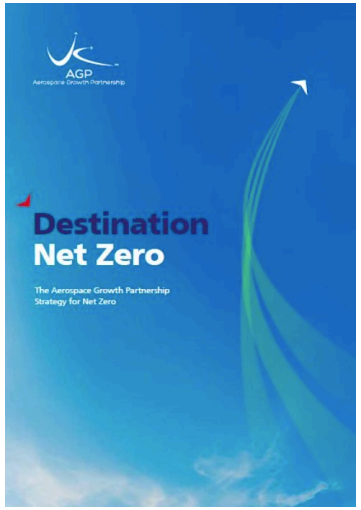
A growing network of experts working across aviation and aerospace



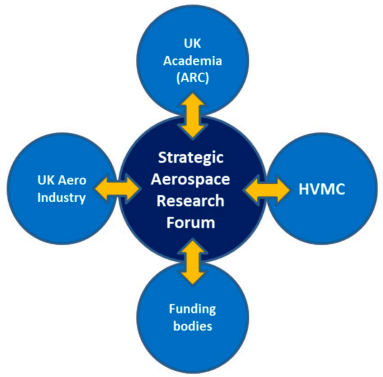
# Rationale

- Responding to urgent climate change stimulus for research
- Getting better alignment with industry on priorities and impact route
- Comparing notes with like-minded researchers internationally
- Leveraging multi-institute and multi-discipline views
- Taking a system view
- Undertake excellent research

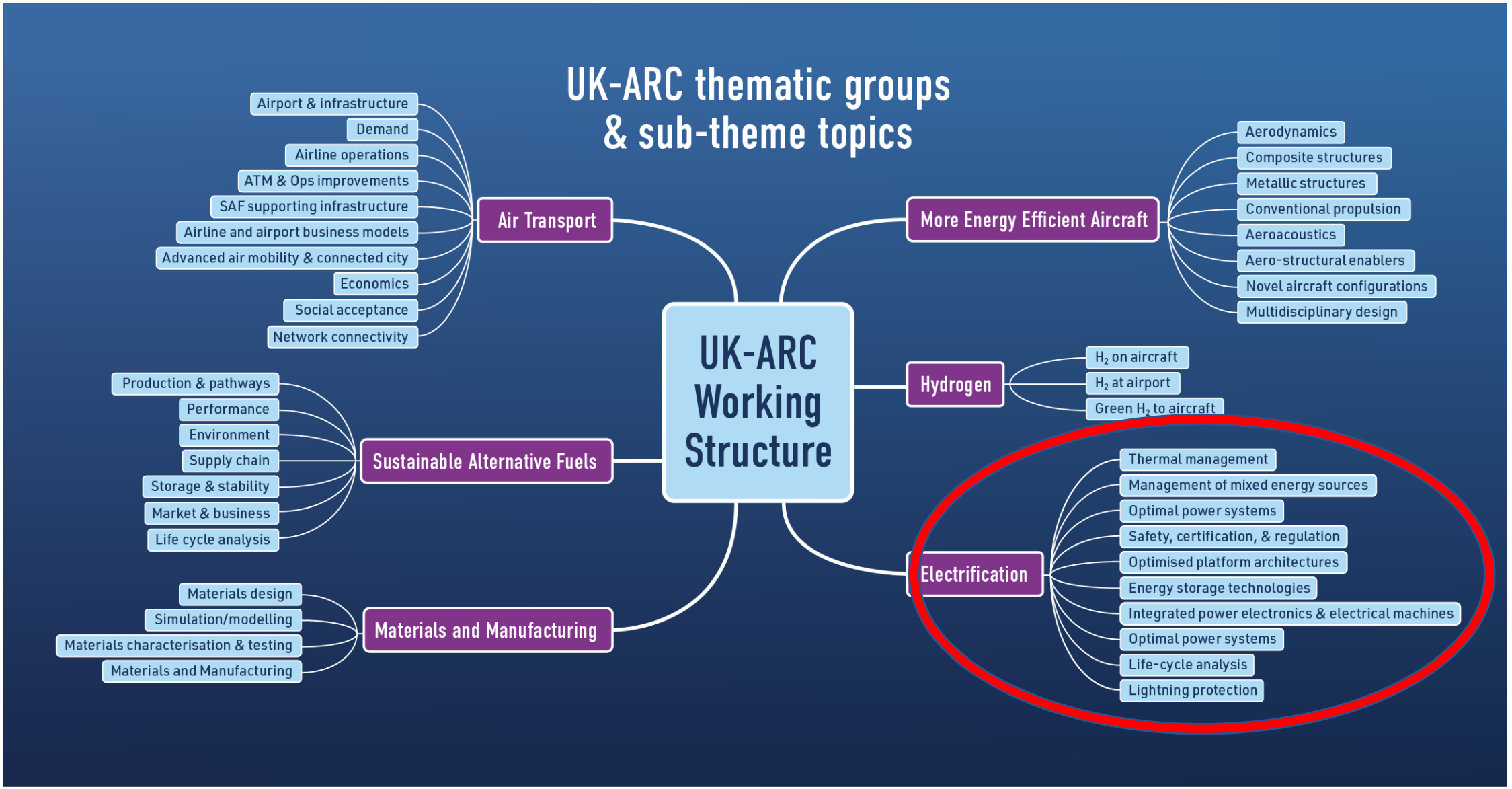






# A strong net zero focus, linking with industry

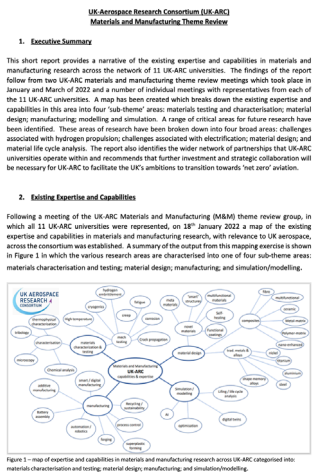


# Outputs – e.g. Material and Manufacturing

## Theme narratives on needs & priorities being tested with ATI, HVMC and industry

Considering the challenges, e.g. :

- Hydrogen – cryogenics/embrittlement
- Composite/multi-materials
- Electrification – thermal management
- Structures – weight saving – bio-based materials
- AM implementation



**UK Aerospace Research Consortium (UK-ARC)**
**Materials and Manufacturing Theme Review**

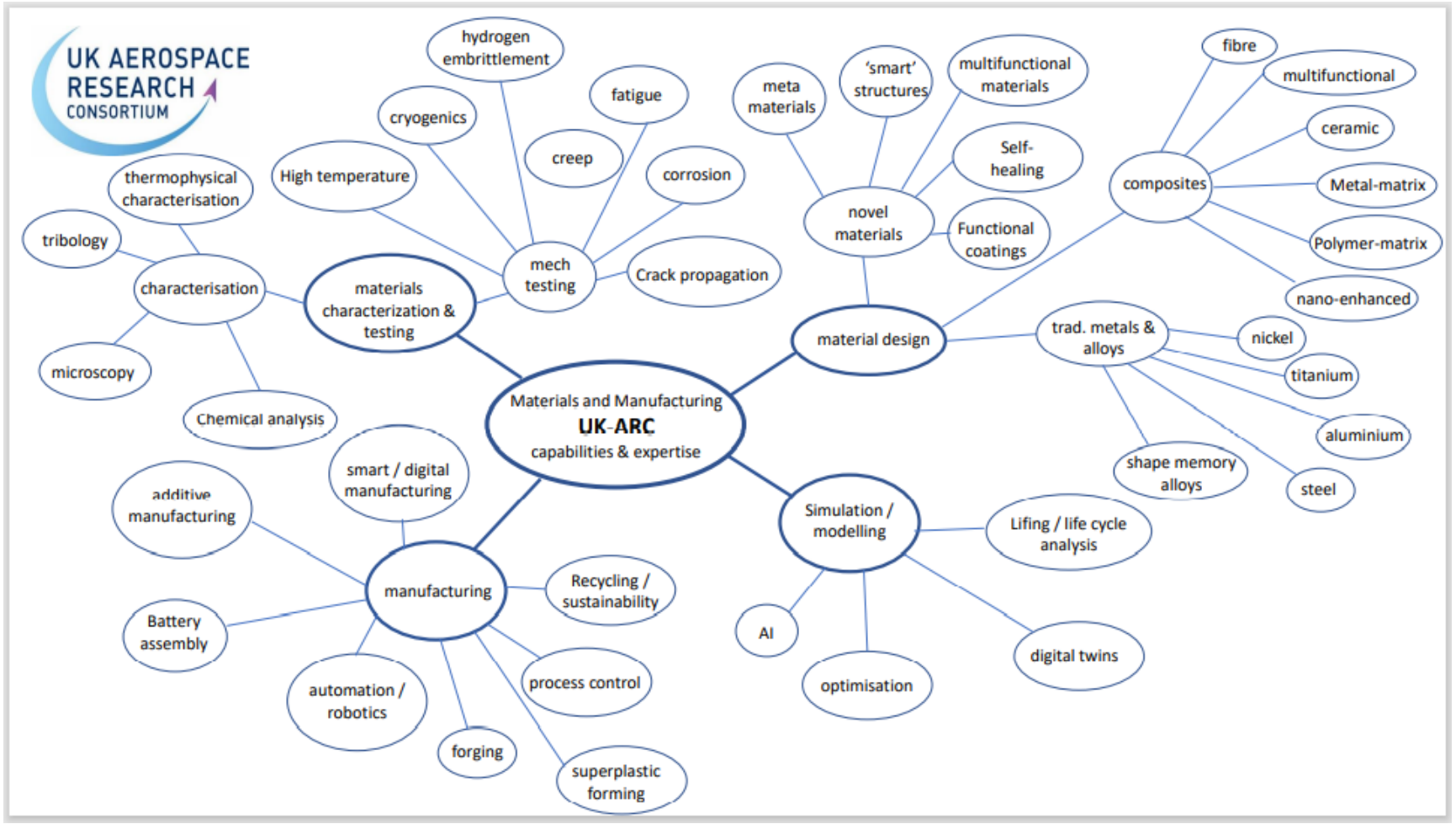
**1. Executive Summary**

This short report provides a narrative of the existing expertise and capabilities in materials and manufacturing research across the network of 11 UK-ARC universities. The findings of the report follow from two UK-ARC materials and manufacturing theme review meetings which took place in January and March of 2022 and a number of individual meetings with representatives from each of the 11 UK-ARC universities. A map has been created which breaks down the existing expertise and capabilities in this area into four 'sub-theme' areas: materials testing and characterisation; material design; manufacturing; modelling and simulation. A range of critical areas for future research have been identified. These areas of research have been broken down into four broad areas: challenges associated with hydrogen propulsion; challenges associated with electrification; material design; and material life cycle analysis. The report also identifies the wider network of partnerships that UK-ARC universities operate within and recommends that further investment and strategic collaboration will be necessary for UK-ARC to facilitate the UK's ambitions to transition towards 'net zero' aviation.

**2. Existing Expertise and Capabilities**

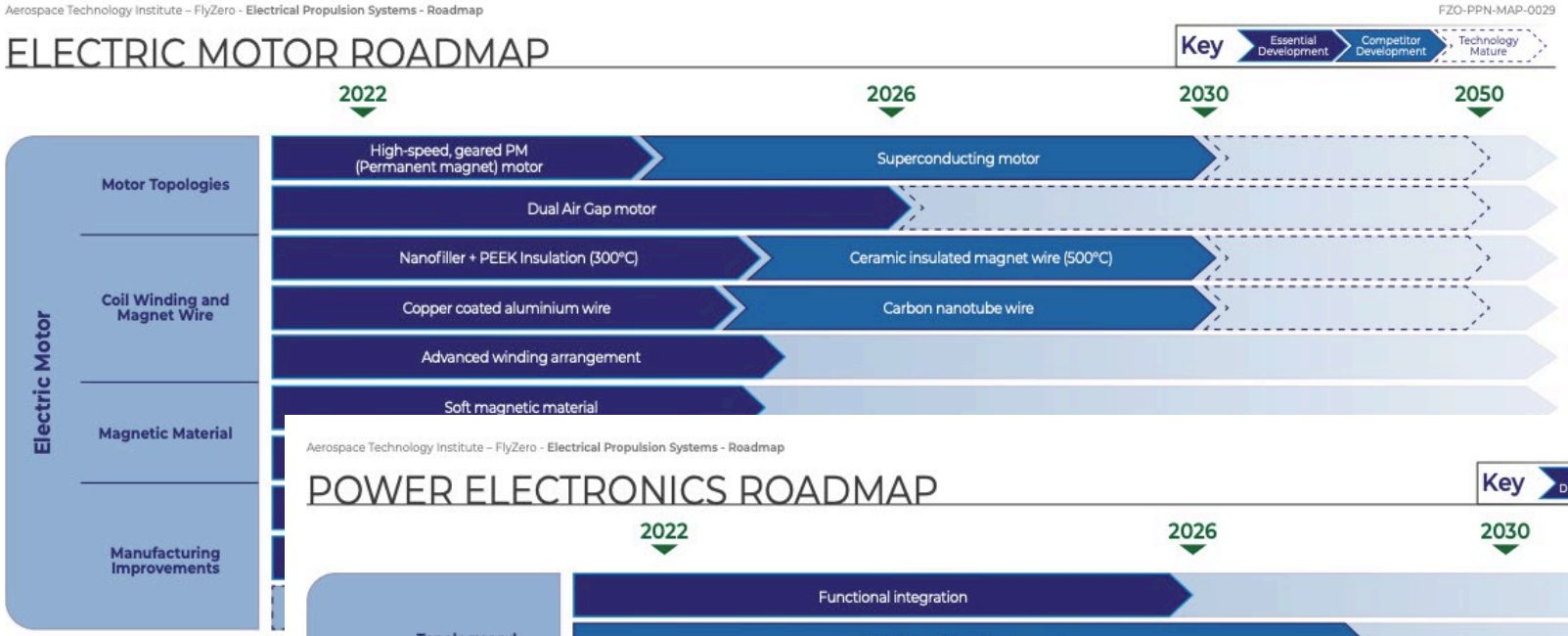
Following a meeting of the UK-ARC Materials and Manufacturing (M&M) theme review group, in which all 11 UK-ARC universities were represented, on 18th January 2022 a map of the existing expertise and capabilities in materials and manufacturing research, with relevance to UK aerospace, across the consortium was established. A summary of the output from this mapping exercise is shown in Figure 1 in which the various research areas are characterised into one of four sub-theme areas: materials characterisation and testing; material design; manufacturing; and simulation/modelling.

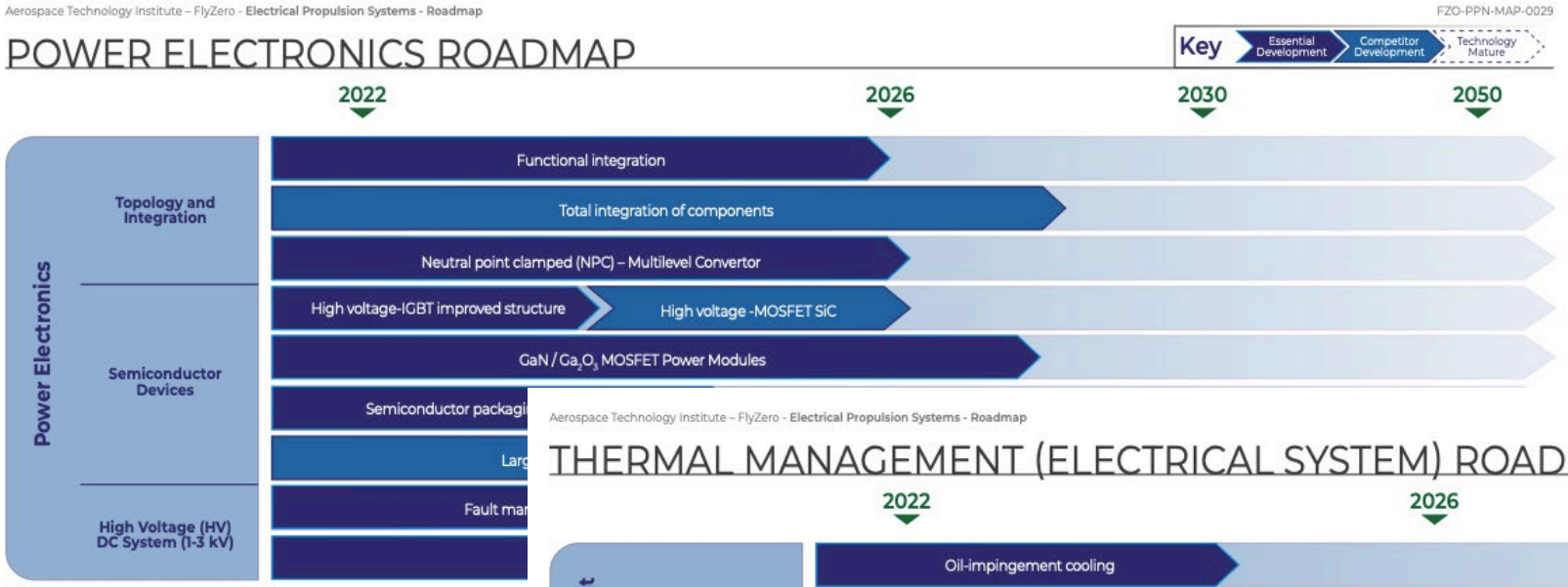
Figure 1 – map of expertise and capabilities in materials and manufacturing research across UK-ARC categorised into: materials characterisation and testing; material design; manufacturing; and simulation/modelling.

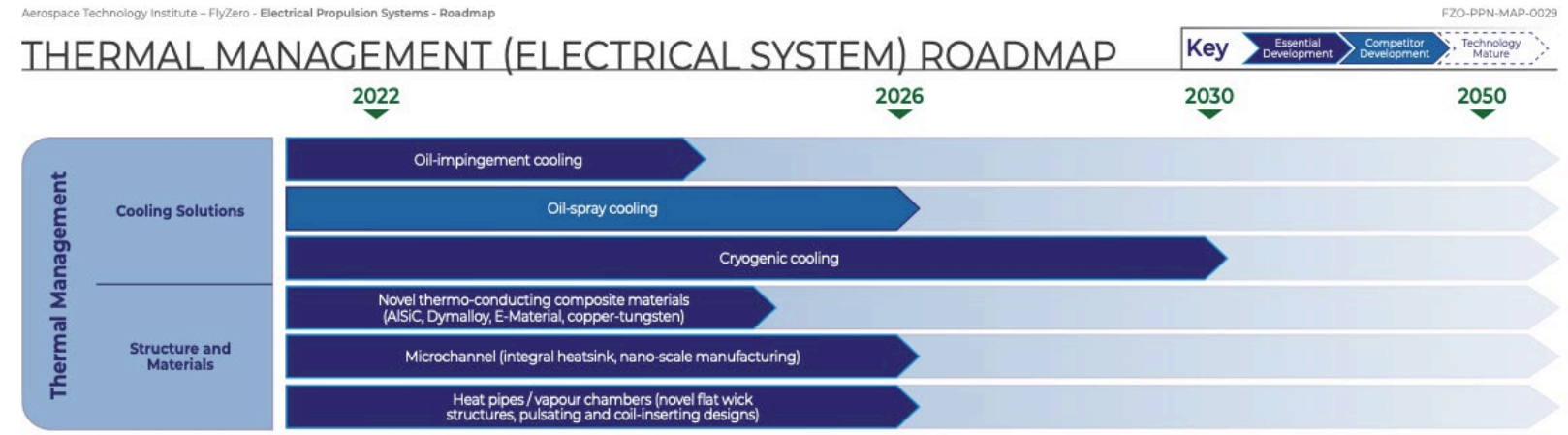


# ATI Electrical systems Roadmaps

(Published March 2022)



# Research facilities

- Access to labs and facilities
- A national resource
- Joint working with industry and academic partners
- Responding to the challenges of tomorrow
- Drawing though future engineering talent

# International reach

- Linking internationally to leverage relationships and boost activity on common goals
- Supporting secondments to build capability and support career development

## UK-Aerospace Research Consortium International

The UK-ARC is committed under its Network Grant from the EPSRC to establish a new international exchange programme between the UK-ARC early career researchers (ECRs) and international research organisations, to create an international network of researchers and foster new collaborations. This closer engagement, cross-fertilization of expertise and the project development helps to strengthen UK university capabilities, enhances academic careers and delivers value to industry.

We want to know about your research needs and to help determine how UK-ARC universities can help you. Examples of secondments being supported by the UK-ARC

**Understanding the wider aerospace requirements of Ceramic matrix Composites** - A secondment at the Rolls-Royce University Technology Centre (RRUTC) based at the University of Virginia (UVa). UVa focuses on ceramic matrix composites (CMCs). The secondment will merge Swansea expertise in advanced mechanical testing and behaviour with UVa advanced characterisation techniques and experience in CMC environmental degradation.

**Investigation of novel acoustic liners for propulsive noise mitigation** - The secondment will investigate and better understand, design and development of novel liner configurations as an effective means for propulsive noise control. The secondment combines Bristol knowledge of design and manufacturing of liner materials and quantification of the material porosity and ONERA detailed acoustic and flow testing to support designs for lower engine noise.

**Integration of novel aircraft and propulsion systems** - The secondment builds on novel multi-fidelity modelling and design research at QUB linking with Technical University of Dresden (TUD) integration expertise for novel aircraft propulsion. The aim is to enable more informed performance evaluation and deeper understanding of the interaction between novel aircraft and propulsion systems.

FARNBOROUGH INTERNATIONAL AIRSHOW 18-22 JULY 2022

www.ukarc.ac.uk

Scan to visit the website:

# Thinking about the future

Considering what the next phase of UK-ARC should look like?

- Community, relationship and narrative building → project building aligned with industry
- Mainly internal UK focus → strengthening research connectivity internationally. Sharing knowledge to build alliances of common interest
- Aerospace research → broader dependencies, e.g. non-CO2 science, ATM,energy, cross-sector knowledge transfer, economics and social aspects
- Research on future tech & ops → supporting skills development and future leaders needed to drive aviation sustainability


# Thank you for your attention

- Interest to discuss common research interests and collaboration opportunites
- UK still seeking association to HE but trusting for UK Government continued guarantees

# UK-ARC electrification theme

- Led by University of Nottingham
- Survey of UK-ARC universities on status of research development, gaps and needs
- Initial workshop to refine work areas to spur project definition
- February ’23 workshop to refine the narrative to ensure logical TRL and interface and strategy alignment with ATI and companies.

Sub-divisions:

- PROPULSION
- ON BOARD SYSTEMS
- ENERGY MANAGEMENT AND ENERGY STORAGE

# PROPULSION RESEARCH PRIORITES

| Electrification of research priorities - from workshop |
| --- |
| **Propulsion Research Priorities** |
| Optimal power system hybridation that minimises CO2 emissions |
| Integration of machines, power electronics in the engine |
| Research to determine the best architecture for each platform - distributed, parallel or series |
| Certification and early flight tests |
| Rapid demonstrator platforms |
| HIL/SIL testing of components |
| Integrated power electronics/electrical machines - design, optimisation, topologies |
| Heat management technologies |
| Integration of electric and thermal systems |
| Gas turbine embedded mega watt and elecrical machines |
| Faults |
| Novel materials and manufacturing processes for light-weighting |
| Hydrogen |
| Safety and reliability |
| Hydrogen - fuel cells, storage, cryogenics, tanks |
| High voltage power systems |
| Electrical insulation systems and management (HV, environment) |
| Battery technology - increasing energy density |
| SSPCs as an enabler for HVDC systems for electric propulsion |
| Recyclability - through life design |

# ENERGY STORAGE AND MANAGEMENT RESEARCH PRIORITES

| Electrification of research priorities - from workshop |
| --- |
| **Energy Storage and Management Research Priorities** |
| Early fault detection/prognostics |
| Battery certification |
| Determine the best energy storage devices for propulsion systems - batteries, fuel cells? |
| Safety and reliability of energy storage and management systems |
| Life cycle - are batteries really sustainable |
| Fast charging |
| System integration |
| Integration of mixed energy sources and management of such (electrical, thermal, chemical, nuclear, liquid etc.) |
| Allowing for different battery types |
| Thermal management (heat) within the overall energy management system of aircraft |
| Flight critical energy/thermal management within integrated systems |

# ONBOARD SYSTEMS
# RESEARCH PRIORITES

| Electrification of research priorities - from workshop |
| --- |
| **On Board Systems** |
| Communications - similar to 5G |
| EMC/EMI cyber security |
| Cabling - lightweight, high current/voltage, thermal |
| Safety and back-up systems - non-electrical fail-safes and implication for design of electrical systems |
| Lightning protection |
| Secondary systems - advanced control and optimisation of individual systems |
| Secondary systems - low/no power ice protection |
| Secondary systems - thermal management, reuse of thermal and recovery |
| Maximum electrification and automation for power energy management |
| Voltage and power levels for safe, efficient systems |
| Infrastructure integration - charging mechanisms and onboard power storage |
| Thermal integration |
| Trade-off tools |
| Actuators |

# RESEARCH PRIORITIES - HEADINGS

# PROPOSED RESEARCH HEADINGS

- Thermal management
- Management of mixed energy sources
- Optimal power systems
- Safety, certification and regulation
- Optimised platform architectures
- Energy storage technologies
- Integrated power electronics and electrical machines
- Optimal power systems
- Life-cycle analysis
- Lightning protection

# GAPS IN FACILITIES/CAPABILITIES

# GAPS IN FACILITIES AND ENABLING TECHNOLOGIES

Are there any additional facilities/enabling technologies gaps to add

## CURRENT GAPS IN FACILITIES

- Hydrogen and helium test facilities
- Large scale aerospace system test facilities;
- Material characterisation facilities
- Rapid prototyping facilities
- Representative flying demonstrators
- Ground Test Facilities at system level
- There is a good coverage of PEMD facilities in the UK, the issue is more around access and capacity

## CURRENT GAPS IN ENABLING TECHNOLOGIES

- Core technologies and their integration
- Understanding of dynamic behavior
- Transient and integrated control of hybrid systems
- Linking material innovation to electrical technologies

# KEY MESSAGES:
# UK AND INTERNATIONAL

## KEY MESSAGES FOR UK GOVERNMENT AND UK FUNDERS AND INTERNATIONAL SECTOR STAKEHOLDERS

Are there additional messages to add?

- Lack of fundamental research and facilities for hydrogen in aerospace
- Highlighting technology roadmaps prioritising funding needs for different air vehicle classes decarbonisation
- The importance of integrated aircraft thermal management.
- More funding at low TRL but for integrated and multidisciplinary systems (High Risk and High Reward technologies)
- A joint initiative between EPSRC and ATI to bridge the gap between TRL 1 (EPSRC) and TRL 4-6 (ATI).
- Invest in research infrastructure and facilities
- Need for international collaboration to access full capabilities of some energy storage technology
- Funding landscape is complex with synergies between ATI, APC, DER….. Danger of overlap and inefficiencies as different schemes compete for government funding.
- Encourage the EPSRC to invest more in Engineering, for example centres for doctoral training priorities seem heavily biased to sciences rather than engineering practice
- Commuter category, short haul electric Part 23 transports are a perfect fit for the scale of the UK;
- Battery electric domestic air transport network might be economically very compelling into the 2030s;
- New energy storage and convergence needs to be coupled with new airframe technologies as well as new aircraft configurations to enable longer range zero emission flight
- There should be greater opportunities for IUK/ATI funding for academic-led, mixed academic-industrial consortia