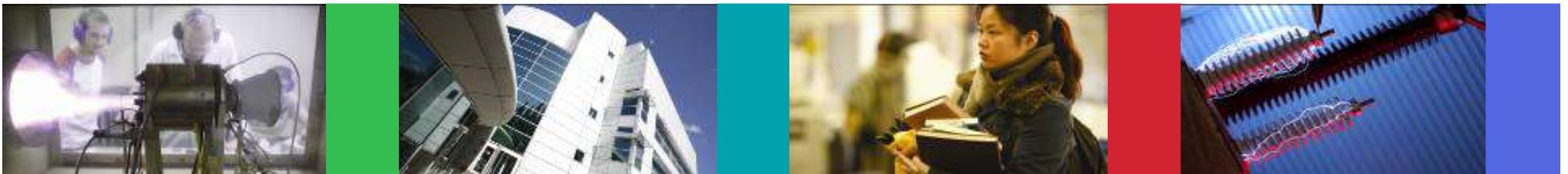


MANCHESTER
1824

The University of Manchester
Aerospace Research Institute



Prof M Moatamedi
The University of Manchester



Who are we?

*“The largest single-site university in the UK,
with a history dating back to 1824”*



History and Achievements

- Associated with 25 Nobel prize winners
- In 1824 Manchester pioneered courses in Mechanical Engineering
- Birth place of the Reynolds Number
- Where Rutherford split the atom
- First programmable computer was built
- 3rd largest steerable radio telescope and home to the Square Kilometre Array control centre
- Arthur Lewis became Britain's first black professor
- Geim and Novoselov isolated graphene for the first time



Ernest Rutherford

Strategic vision 2020

- ❑ To be one of the top 25 research universities in the world
- ❑ Three core goals
 - ❖ World-class research
 - ❖ Outstanding learning and student experience
 - ❖ Social responsibility
- ❑ Excellence—with accessibility and impact



Committed
to
excellence

The University in numbers

39,000

Largest
student
community
in the UK

10,000

Most
international
students of any
UK university

£1.01bn

Annual
income

1,000

More than
1,000 degree
programmes

£345m

More than
£345m in
research income

100

More than
100 spin-out
companies

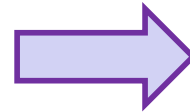
£300m

£300m bond issue
to support Campus
Masterplan



Academic Structure

➤ Faculty of Science
and Engineering (FSE)



➤ Faculty of Biology,
Medicine and Health

➤ Faculty of Humanities

~10,000 students

~3,500 international students

7,200 undergraduates
(24% international)

1,800 taught postgraduates
(67% international)

1,400 research postgraduates
(40% international)

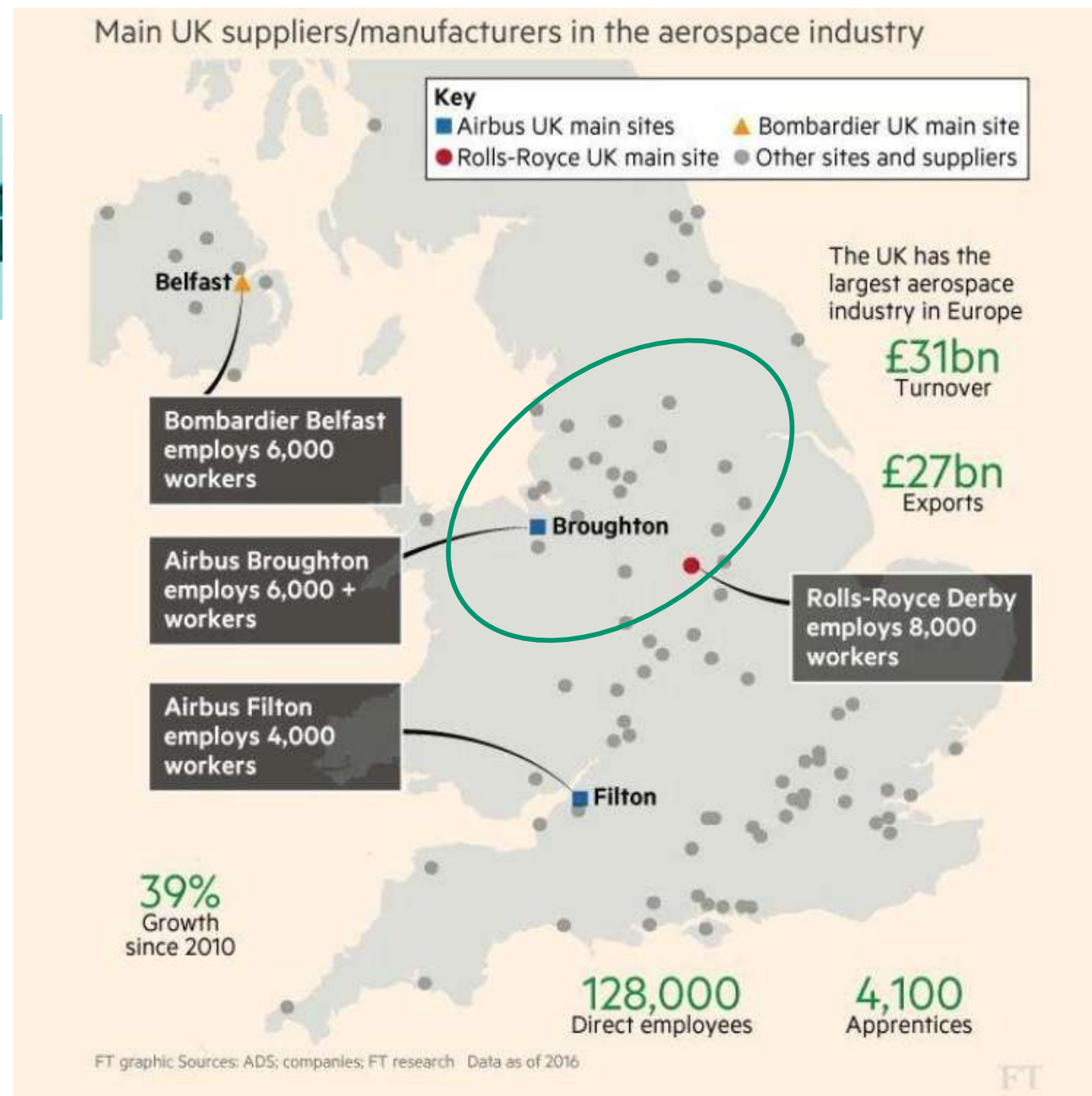
- Aerospace Research Institute
- BP International Centre for Advanced Materials (BPICAM)
- Dalton Nuclear Centre
- Graphene Engineering Innovation Centre
- Jodrell Bank
- Manchester Institute of Biotechnology (MIB)
- National Graphene Institute
- Northwest Composites Centre
- Photon Science Institute (PSI)
- Sir Henry Royce Institute for Advanced Materials
- Tyndall Centre

- Major Companies operating in the area are
 - ❑ Airbus
 - ❑ BAE Systems
 - ❑ Rolls Royce
 - ❑ Safran
- Aerospace Revenue for the region is approximately \$10Bn
- The Aerospace supply chain in the region employs over 20,000 people – 25% of UK total





Aerospace in the Northwest



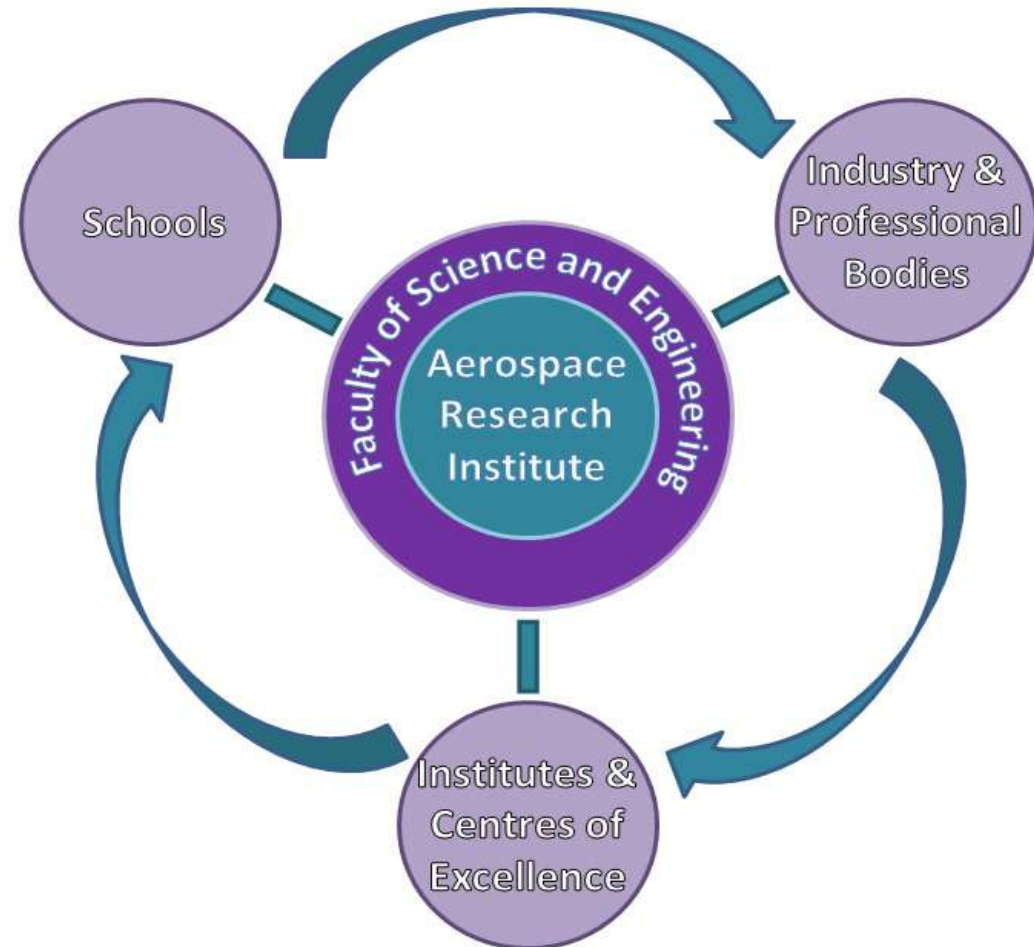
Mission:

- To gain full benefit from the University's diverse research capability, to be internationally recognised as a centre of excellence in aerospace research and innovation and become a collaborator of choice within Europe and for the major aerospace companies.



Function:

An academic network which operates across the Faculty of Science and Engineering, working closely with Schools, Institutes & Centres of Excellence, and Industry.



Academic Members:

The Aerospace Research Institute is truly cross and multi-disciplinary in nature. There are currently more than 100 academics who make up the membership of the Institute. All academic Members and Associates are affiliated with a home School within The University.





Aerodynamics, fluid dynamics and flow control



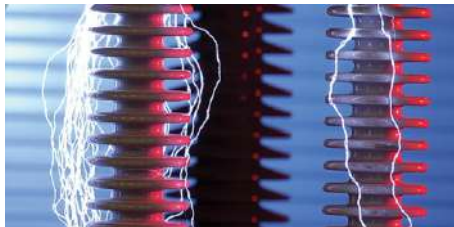
Aerospace light alloys



Aerospace structures



Autonomous systems



Advanced electrical power systems

Aerospace Research Themes



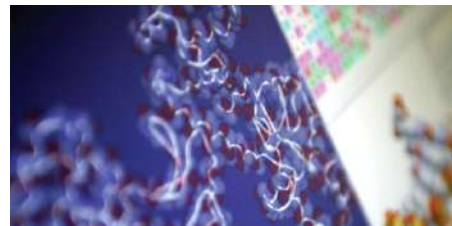
Advanced manufacturing



Aviation security, imaging and non-destructive testing



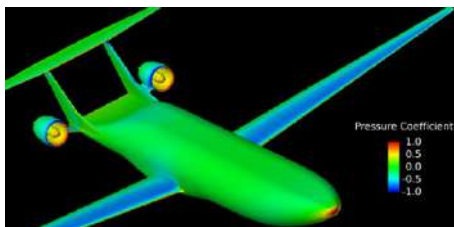
Composites



Enterprise



Environmental sciences



Modelling and simulation



Synthetic environments and systems simulation



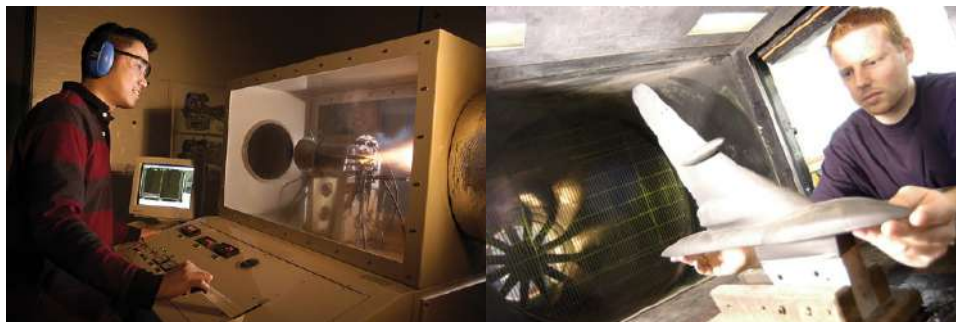
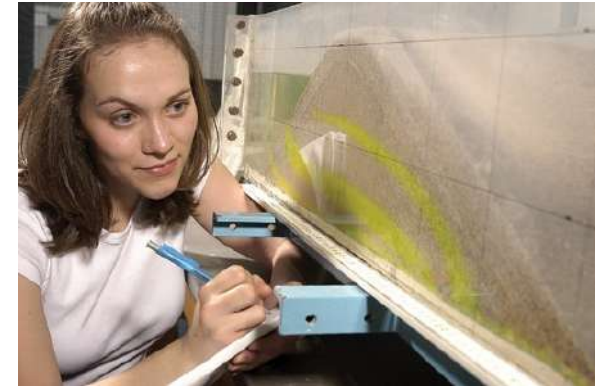
Space

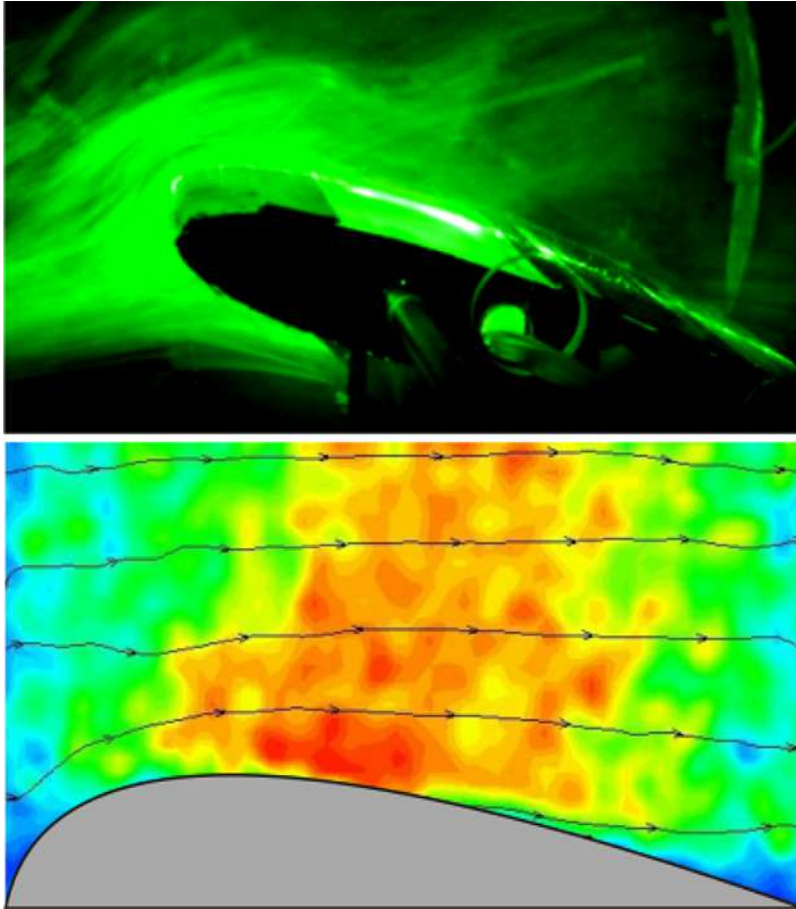
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Mechanical, Aerospace & Civil Engineering

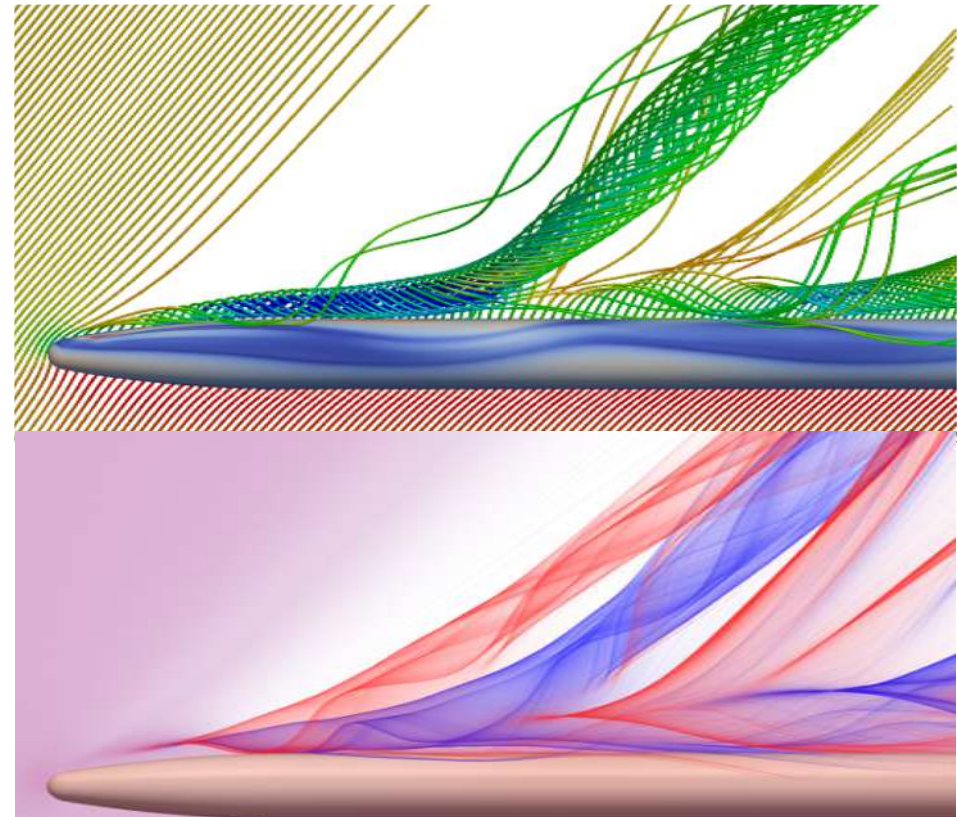
Key points:

- One of the largest engineering schools in Europe
- Strong links with industry
- Professor Levermore contributed to the 2007 Nobel Peace Prize on Environmental Change; Professor Brian Launder is considered the leader in turbulent flow modelling
- Exceptional research facilities; including subsonic, supersonic wind tunnels and the largest tilting flume in the World





Flow over NACA0015, $Re=1.5 \times 10^5$



Blunt ogive at high incidence

Electrical & Electronic Engineering

Key points:

- First to teach Electrical Engineering (1905)
- One of the largest in the UK
- Strategic partnerships with, National Grid, Rolls Royce, Syngenta, Oxford Instruments, EDF

Research groups are as follows:

- Communication & **Microwave Engineering**
- Control Systems
- **Sensing, Imaging and Signal Processing**
- Electrical Energy and Power Systems
- Power Conversion
- Microelectronics and Nanostructures



Advanced Electrical Power Systems

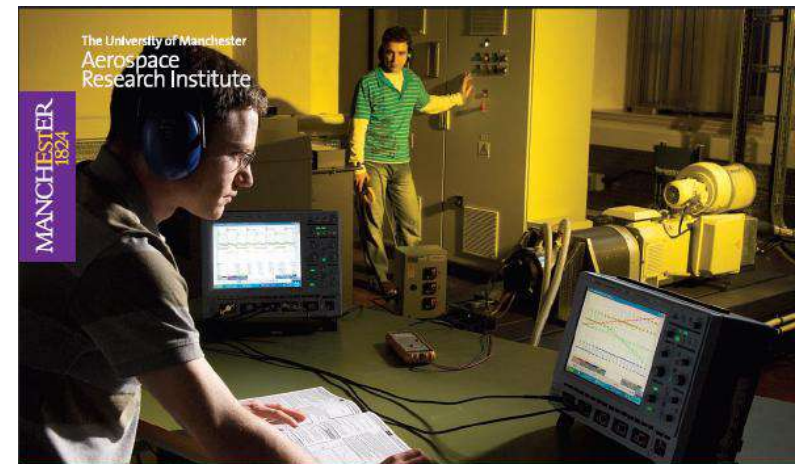
Research electrical technologies and systems that enable more efficient aircraft with reduced emissions through electrification of auxiliaries and hybridisation of propulsion systems.

Grant success:

Rolls-Royce UTC in Power Conversion.
EPSRC Power Electronics Centre -
Converters Theme



Theme Leader – Prof. Andrew Forsyth
Andrew.Forsyth@Manchester.ac.uk



Advanced Electrical Power Systems

To reduce weight and maintenance costs, whilst increasing efficiency and flexibility, mechanical, hydraulic and pneumatic equipment onboard aircraft are being replaced by electrical systems. Furthermore, the integrated electrical systems that are starting to emerge offer new opportunities for further operational flexibility and system optimisation.

The School of Electrical and Electronic Engineering is working on solutions to many of the challenges created by the more-electric revolution in aerospace systems:

- High-performance, engine-embedded, fault-tolerant generation systems
- High integrity power electronics and motor drive systems
- Torque-dense electrical actuation systems
- High-power, high-voltage power system architectures
- Prediction and prevention of partial discharge phenomena
- Power system management techniques including power quality, stability, energy storage, protection and condition monitoring
- Analysis, modelling and simulation techniques for complex

- Rolls-Royce University Technology Centre (UTC) in Electrical Systems
- Hosting the SEAS DTC integrated electrical power networks evaluation facility, a 100 kVA experimental platform for UAV electrical systems

Autonomous Systems


Research in the areas of Vehicles and Platforms, Autonomy and Control Algorithms, Power Optimisation, Sensing Technologies and Application Domains.

Grant success:

Involvement in £4.4m Regional Growth Fund project in Growing Autonomous Systems Mission Management Applications (GAMMA).



Theme Leader – Prof. Alexander Lanzon
Alexander.Lanzon@Manchester.ac.uk



The University of Manchester
Aerospace Research Institute

MANCHESTER 1824

Autonomous Systems

Traditional methods of remotely controlling systems via manual operation become inadequate as the complexity of systems and the required tasks increase, particularly in changing and challenging environments. In recent times, we have seen an exponential increase in the demand for technologies that operate with minimal human intervention.

These emerging technologies, with varying degrees of autonomy, leverage on the ability to accurately and swiftly capture detailed information about their environment and act upon this information. These systems are also designed to perform well under considerable uncertainty in the environment for extended periods of time and to handle safely system failures without external intervention. Autonomy is underpinned by several supporting technologies and the development of autonomous systems requires highly interdisciplinary research carried out in collaboration with industry

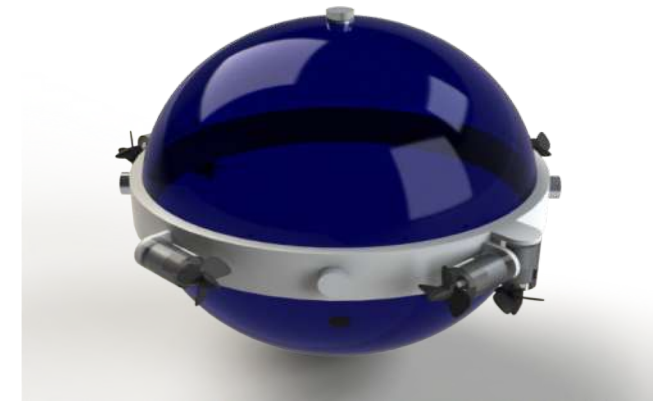
- Rolls-Royce University Technology Centre (UTC) in Electrical Systems hosting the Systems Engineering for Autonomous Systems Defence Technology Centre (SEAS DTC)'s Integrated Electrical Power Networks Evaluation Facility (IEPNEF), a 100kVA experimental platform for UAV electrical systems tests.
- Centre for Interdisciplinary Computational and Dynamical Analysis (CICADA), a £2m EPSRC funded centre of excellence to explore new mathematical and computational methods for analysing hybrid and asynchronous systems and for developing associated adaptive control methods.

www.manchester.ac.uk/umari

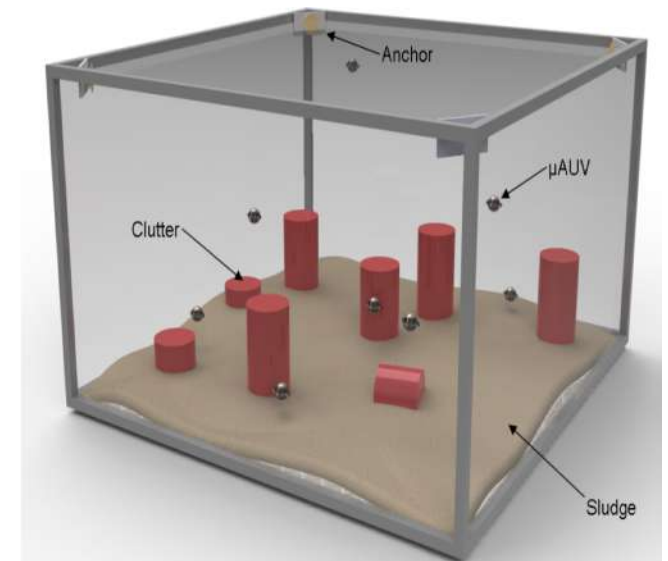
Autonomous Underwater Vehicles

- Generic objective
 - Monitoring liquid-based industrial processes
- Demonstrator system
 - Mapping nuclear storage ponds
 - *In collaboration with National Nuclear Laboratory*
- AUV design
 - Buoyancy, propulsion, hull, control
 - Communications and positioning
 - *Using acoustics*
 - Sensing

(Alexandru Stancu, Zhengtao Ding)



Micro-AUV (μ AUV) design



Nuclear storage pond

Sino-UK Advanced Control System Technology Laboratory

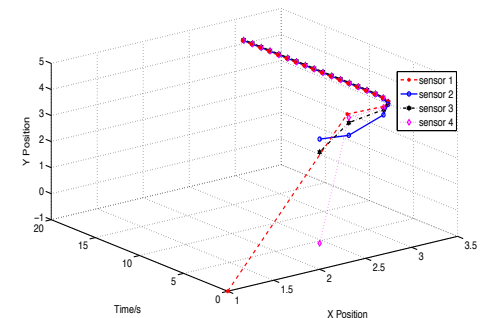
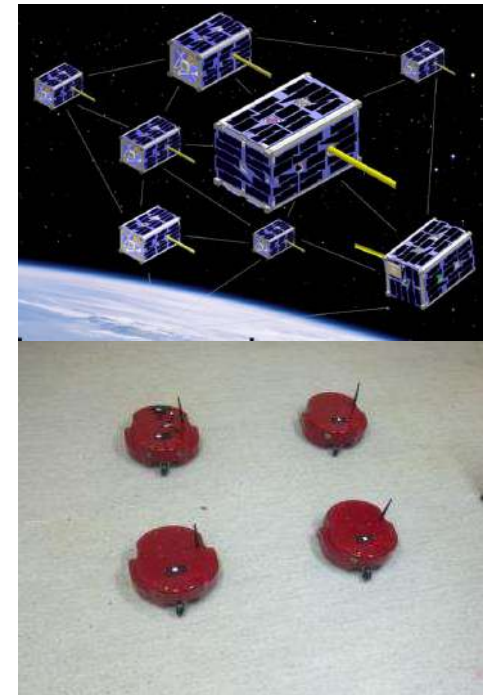
Fundamental control research, in collaboration with China Aerospace Science and Technology Corporation (CASC)

China Academy of Launch Vehicle Technology (CALT) of CASC provides £200k a year from 2016

- 5 academic staff from 3 schools
- 12 project researchers (Academic Visitors, PDRA, PhD and MSc Students)
- 3 current projects, involving nonlinear filtering, cooperative control and optimal coverage of robots



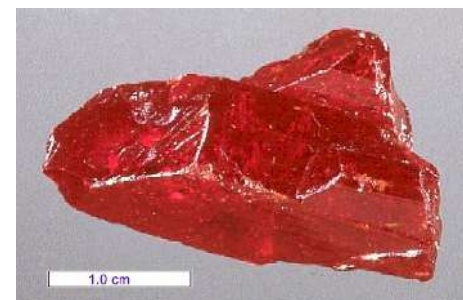
Theme Leader – Dr. Zhengtao Ding (EEE)
Zhengtao.Ding@Manchester.ac.uk



Earth & Environmental Sciences

Key points:

- Geology and related Earth Sciences have been studied at Manchester since 1851
- Highly interdisciplinary
- Practical and field-based study
- Facilities include Aerosol Chamber, Cloud Chamber and **airplanes for atmospheric research**
- Large number of papers in Science & Nature



Physics & Astronomy

Key points:

- One of the largest and most active school of Physics
- **Discovered Graphene**, the first 2-D material
- Many 'firsts' in astronomy (double pulsars etc.)
- Strong involvement in ATLAS
- The University where Rutherford split the atom
- Square Kilometre Array



Lightning strike protection?

Carbon fibre composite aircraft are currently covered with a copper mesh for protection against lightning strike



Could a conductive graphene-modified epoxy matrix provide protection?

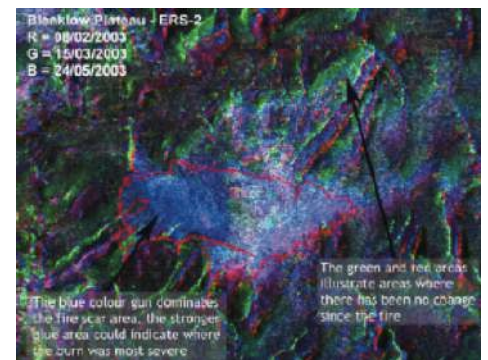
Space

A strong heritage of space research encompassing the pioneering radio astronomy work at Jodrell Bank, astrophysics, planetary science and cosmochemistry, space instrumentation and space technology development.

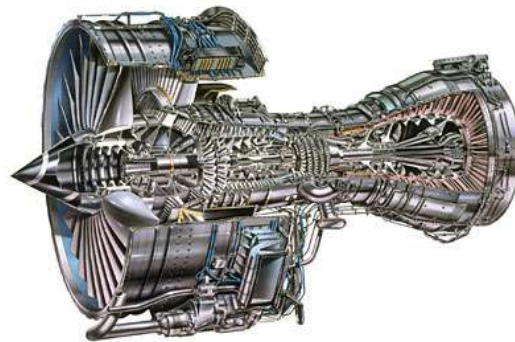
- Home to Jodrell Bank and the HQ for the new Square Kilometer Array radio telescope
- Coordinators for DISCOVERER – 5.7M€ Horizon 2020 funded program to radically redesign Earth observation satellites for operation at significantly lower altitudes
- Winners of the Copernicus Masters Sustainability Living Challenge, with EnviroSAR, a UK wildfire monitoring service that uses satellite Earth Observation data
- 50 academics and research staff from 8 schools



Theme Leader – Dr. Peter Roberts
peter.c.e.roberts@manchester.ac.uk

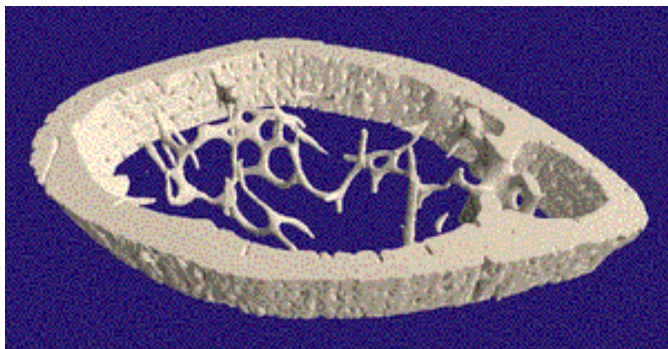


From lightweight alloys and **composites** for planes, trains, ships and cars...



...to high temperature materials for jet engines and power generation

...to electronic ceramics and polymers



...to biomedical materials for implants and tissue engineering

...to engineered 'smart' textiles and composites

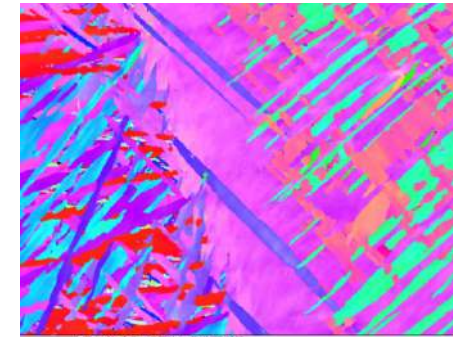
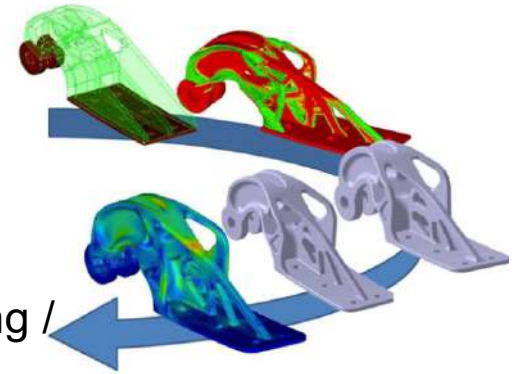
Light Alloys Group

Expertise in Alloy Design, Modelling, Micromechanics, Forming, Joining / AM, Processing, Surface Engineering, Corrosion Control

- 6 core academic staff, ~60 PhD students in Metallurgy
- **LightForm** – Embedding Materials Engineering in Manufacturing with Light Metals – A new £6M programme grant with ~ 20 companies, starting in October 2017.
- **CLARI** – Centre for Light Alloys Research and Innovation. Projects across broad themes.
- **RAEng, Airbus Chair** – The University of Manchester has been selected as Airbus lead partner for metals research, with Prof. Phil Prangnell awarded the first Airbus Chair in Metallic Materials.



Theme Leader – Prof. Philip Prangnell
philip.prangnell@manchester.ac.uk



Protective Organic Coatings

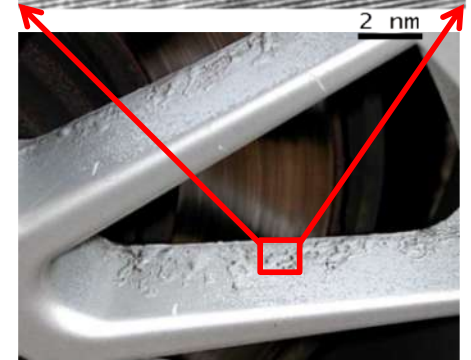
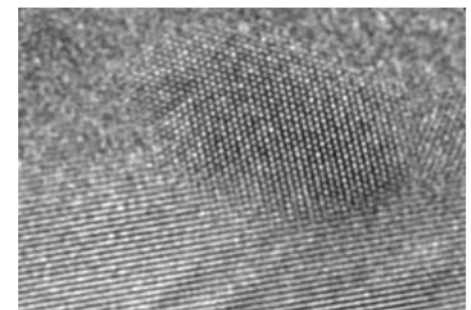
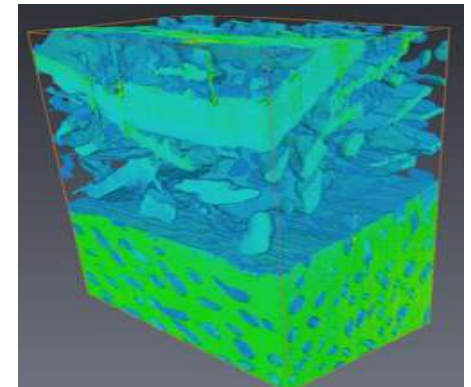
Aim to improve coatings service performance (i.e. lifetime) and shorten the product development cycle by developing a deep mechanistic understanding of the technical systems relevant to businesses and application areas.

AkzoNobel Corrosion Protection Partnership, since 2012/13, ~£600k pa

- 8 academic staff from 3 schools
- 20 project researchers (PDRA, PhD and MSc)
- 19 project leads in 6 business units from 4 countries
- Aerospace, automotive, marine, infrastructure, decorative, packaging, coil coatings
- Use advanced multi-analytical tools



Theme Leader – Prof. Stuart Lyon
stuart.lyon@manchester.ac.uk



Composites

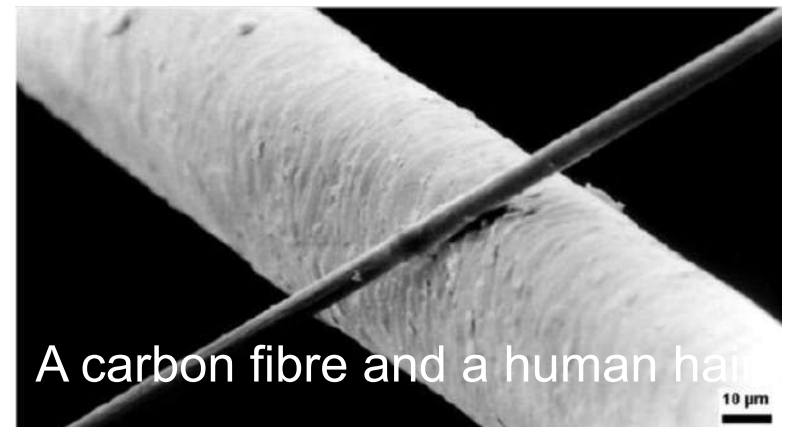
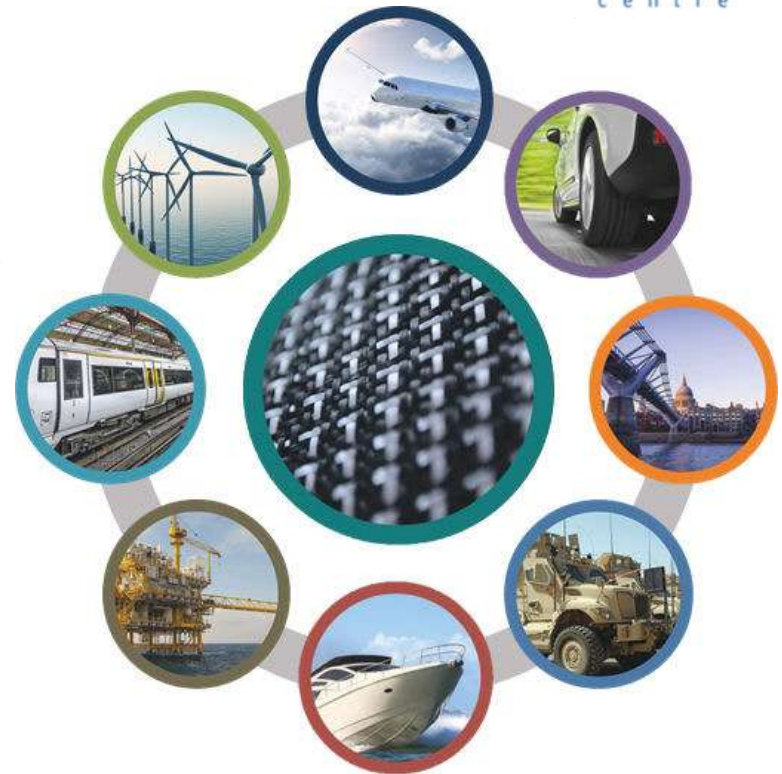
Focus of the **Northwest Composites Centre** includes low cost, low energy, low cycle time manufacture of composites, Non Destructive Testing of materials, SHM, composite matrix chemistry and damage, design and failure analysis in polymer composites.

National Composites Certification & Evaluation Facility

- UKAS Accredited testing laboratory
- Full range of mechanical and physical testing equipment and non-destructive evaluation facilities



Director – Prof. Costas Soutis
costas.soutis@manchester.ac.uk



Opened January 2010

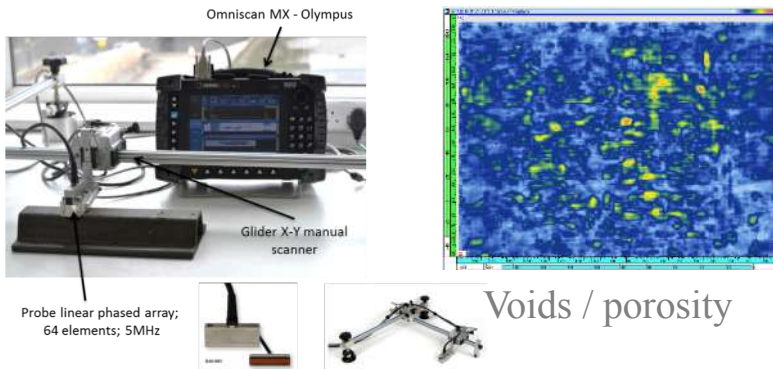
- UKAS Accredited testing laboratory
- Full range of mechanical and physical testing equipment and non-destructive evaluation facilities

Remit: to work with companies in the supply chain to help them:

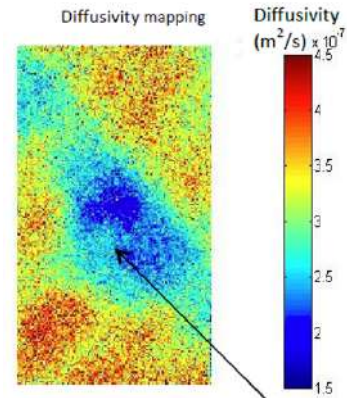
- Make the transition from metals to composites
- Understand composites behaviour
- Understand and evaluate 3D composite structures
- Understand in service performance, including failures
- Assess new composite materials and processes
- Qualify parts for aerospace and other sectors



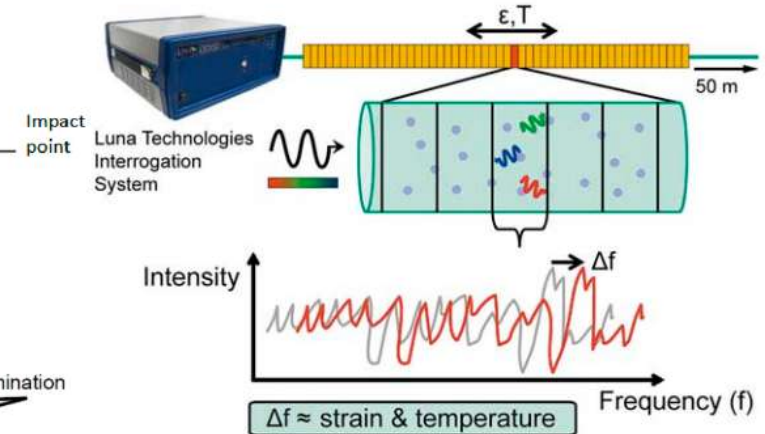
Ultrasound-phased array



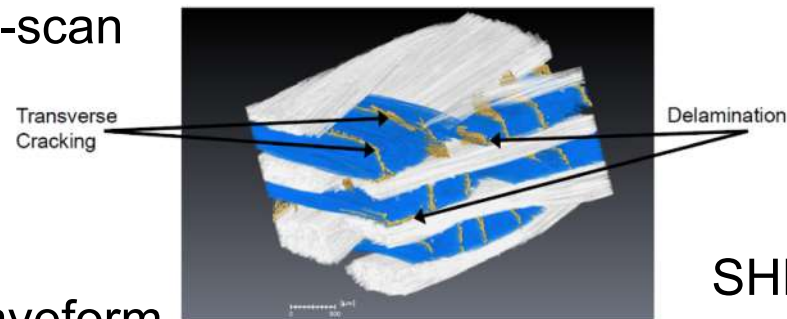
Infra-red thermography



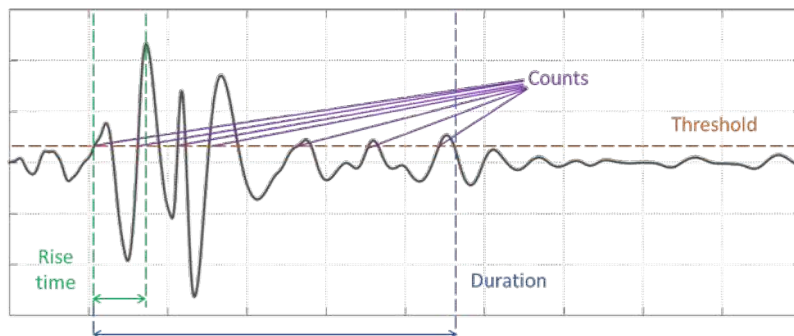
Distributed optical fibre



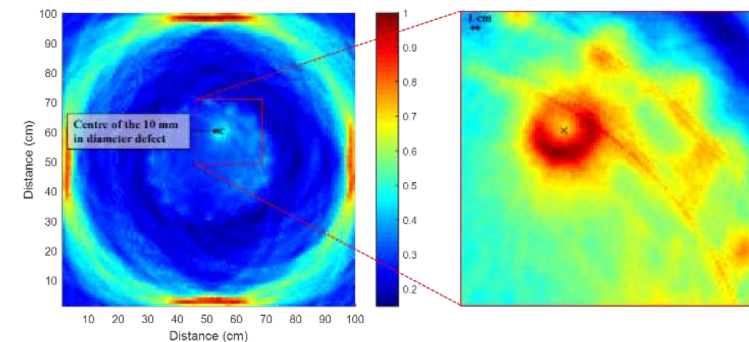
Ultrasonic A, B, S, C-scan



Typical AE signal waveform



SHM Lamb waves tomography



[Yu, B. et al., 2015]



Granta Design Ltd

Automation & data exchange in manufacturing. It includes cyber-physical systems, the internet of things and cloud computing.

Automation & data exchange in manufacturing



MAGMA: Future flight technologies

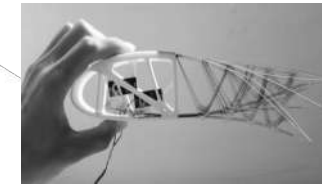
BAE SYSTEMS



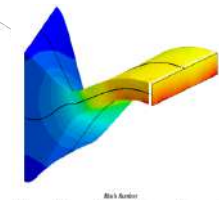
Micro jet
engines
(*MACE*)



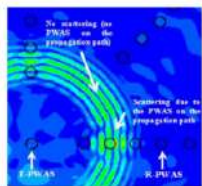
Fault tolerant
flight control
(*EEE*)



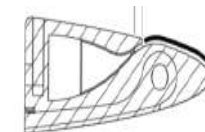
Structural morphing for
optimum efficiency
(*Materials*)



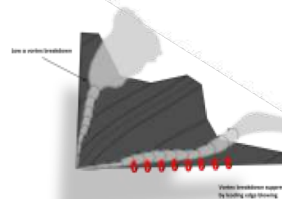
3D Fluidic Thrust
Vectoring (*MACE*)



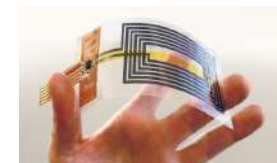
In situ SHM of
composites
(*Materials*)



Supersonic
Circulation Control
for flapless flight
(*MACE*)



Leading edge flow
control (*MACE*)



Printed Graphene
Antenna (*EEE*)

MAGMA is to develop a large model scale flying demonstrator for novel aerospace technologies relevant to next generation low observable aircraft. Funded by BAE SYSTEMS, involving participants from the Aerospace Research Institute, Schools of Mechanical, Aerospace and Civil Engineering (*MACE*), Electrical and Electronic Engineering (*EEE*) and Materials at the University of Manchester.

Manufacturers



BAE SYSTEMS



BOMBARDIER
the evolution of mobility



Supply Chain



Magnesium Elektron
SERVICE & INNOVATION IN MAGNESIUM



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Thank you

