Aerospace in the Midlands

The British Midlands is home to one of the world's most significant aerospace clusters. Leading aerospace names such as Rolls-Royce, Goodrich, Meggitt and Smiths are major players in the region.

The Midlands has a long and distinguished association with technology innovation for the aerospace industry and is world-renowned for its core competency technologies:

- systems that power aircraft - gas turbine engines and other propulsion systems
- systems that control the moving parts of aircraft and engines – electrical, mechanical, electronic, hydraulic and pneumatic
- specialist metal and composite materials that enable these systems to perform with precision in exacting environments
- specialist engineering design services, factory equipment and tooling

In the Midlands, aerospace companies access and continually upgrade a regional skills base renowned for its engineering excellence, with more than 45,000 skilled people working in the aerospace cluster directly. In total, over 700 supply chain companies contribute their capabilities to global aerospace in a business environment that fosters the highest levels of innovation. The Midlands universities play an essential role as powerhouses of aerospace knowledge.

The Midlands Aerospace Alliance (MAA) unites the whole aerospace cluster - from Rolls-Royce to the smallest company, from university researchers to private consultants, and from trade unions to local government and skills and training agencies. With strong support from two regional development agencies working in partnership -- Advantage West Midlands and the East Midlands Development Agency -- the MAA's vision is of an internationally recognised, sustainable aerospace industry, creating wealth and opportunity for the entire Midlands region.

Advantage West Midlands

east midlands development agency
the catalyst for change

new technology for aerospace

midlands aerospace alliance

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The Midlands Universities

This brochure was compiled and written by Maike Ockoniewski.
The engine graphic used in the headers of the university pages was kindly supplied by Roll-Royce plc.

Midlands technology genius for global aerospace

The Midlands universities are the lifeblood of our region's world-renowned excellence in engineering technology. Three of the United Kingdom's leading five universities, measured by numbers of engineering graduates, are located in the Midlands – Birmingham, Coventry and Loughborough. Our universities are tightly linked to the success of our automotive, power generation, electronics and other engineering sectors.

The Midlands has a long and distinguished association with technology innovation for the aerospace industry; both the jet engine and radar were first developed here. From global powerhouses such as Rolls-Royce, along the whole aerospace supply chain to small agile firms, technology innovation has translated into leading positions for Midlands aerospace companies on the most advanced aerospace programmes of today — and tomorrow — including the Airbus A380, Boeing 787, Joint Strike Fighter and Eurofighter Typhoon.

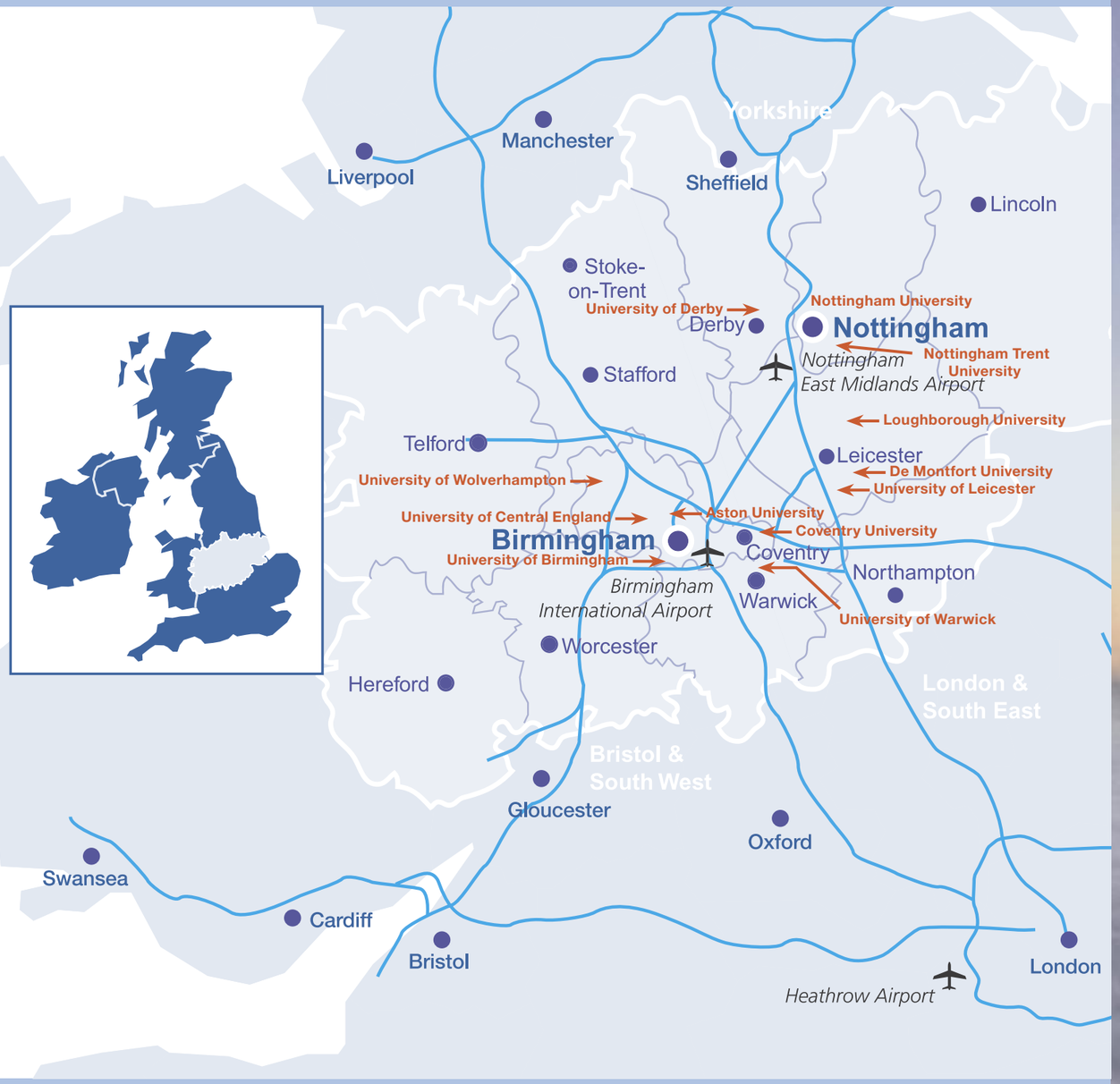
Our universities host national and global centres of research excellence that play leading roles in the continuing success of the Midlands aerospace cluster. They have developed specialist expertise along with Midlands companies in such areas as: clean gas turbine technologies, more-electric control systems, specialist fuel cells, high-temperature and lightweight materials, and innovative development, tooling and manufacturing techniques. Midlands university technology expertise is also sought after by the wider national and global aerospace industry. Our research centres in areas such as helicopter and UAV controls, systems engineering, and photonics increasingly attract the interest of global aerospace companies.

All this expertise is set out for the first time in the Midlands Aerospace Alliance guide to new technologies for aerospace at Midlands universities. The guide illustrates the full potential of close collaboration and technology transfer between the university sector and industry. As chairmen of the West Midlands Innovation and Technology Council and Innovation East Midlands, we are proud of the contribution our knowledge base makes to the Midlands' continuing success in global aerospace markets. We share the goal of building on this guide to further enhance these links between the university research and teaching community and industry in the Midlands and globally.

Clive Hickman
Chairman
West Midlands Innovation and Technology Council

Barry Stickings CBE
Chairman
Innovation East Midlands

Midlands map



How to use this guide

This guide has been produced to introduce the many different aerospace technology activities at universities in the British Midlands.

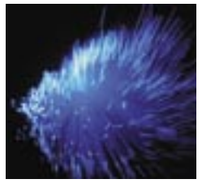
For quick reference consult the capability matrix in the back of the brochure. It gives an overview of a wide range of aerospace research, from engineering to manufacturing and management. In addition, there is a separate matrix that lists relevant courses and modules that are taught at the universities. Bespoke training courses can usually be arranged utilising these modules.

For more detailed information about each university's activities please consult the university profiles. Each profile includes a case study presenting one of the major aerospace projects carried out at the university and a summary of other ways the university supports aerospace technology development.

To find out even more, simply get in touch with the listed contact person. Details are included at the end of each university profile.

ASTON UNIVERSITY

IN THE HEART OF BIRMINGHAM



Aston is known for world-class research and teaching, and its graduate employment record is second to none – due in part to the fact that many students spend a year working in industry as part of their studies. The university's cutting-edge research provides the platform for a range of services relevant to aerospace companies throughout the Midlands, the UK and globally.

CASE STUDY: Photonics for smart structures

The Photonics Research Group at Aston includes over 50 people working at a number of well-equipped laboratories. Research areas include high-speed telecommunications, fibre Bragg gratings, femtosecond laser inscription, polymeric fibre design and fabrication, microwave photonics, biophotonics and optical sensing.

Fibre Bragg grating sensing is one of the most exciting fibre technology areas of recent years with widespread applications. It is particularly relevant to the aerospace industry since it allows easy monitoring of composite structures.

At Aston the technology has been developed via a number of DTI and MoD funded research programmes in partnership with companies such as BAE Systems, Deutsch, Marconi and QinetiQ. The recently completed EMPIRE programme developed connectors for smart composite structures – making the technology suitable for volume manufacturing.

Optical fibres can be used to monitor vibration, strain and temperature throughout a composite structure. Their small size enables them to be embedded within, or bonded to, structures making the system very robust. This technology can be applied to monitoring the in-service stresses of aircraft wings which allows operators to optimize servicing schedules according to work done rather than miles flown.

Optical fibre sensors have a number of further advantages over conventional electrical strain gauges. They are immune to electromagnetic fields and it is possible to interrogate many measurement points using a single fibre – greatly reducing the complexity of installation.

Polymer Processing & Performance Research Unit

The research of the PPP Research Unit covers different stages of the polymer lifecycle, from synthesis to processing. The group also has expertise in the performance of specialty additives and polymers in service during first and subsequent lives. Another research field is polymer oxidation and ageing, where the effects of light and heat are investigated to improve the reliability and performance of polymers.

In the aerospace industry exact knowledge of material lifetime issues is required. Services offered by PPP to the aerospace industry include:

- the application of fundamental understanding to areas of polymer processing & performance;
- the analysis & testing of properties, processability, stability, recyclability, and degradability, including the effects of additives.

The PPP laboratories are equipped with a full suite of polymer processing facilities and state-of-the art tools including spectroscopic (e.g. FTIR-microscopy, FTIR-ATR, Raman, UV-Vis-NIR, fluorescence and NMR), thermal and rheological (e.g. DMA, Hyper DSC, TGA and capillary rheometry), chromatographical characterization and testing techniques (e.g. HPLC and GC) as well as accelerated ageing and weathering devices.

The Information Processing and Pattern Analysis Research Group

The Information Processing and Pattern Analysis Research Group is an internationally recognized centre of excellence in artificial neural networks and advanced pattern processing methods for engineering applications.

The Group's expertise in the non-linear, dynamic and statistical processing of a wide range of data and applications problems has been applied to a number of areas relevant to the aerospace industry including: corrosion detection; condition monitoring, and fault prediction.

Past and current aerospace-related projects include:

- vigilance monitoring in pilots (BAE Systems); novel signal processing and analysis methods were used to determine alertness from an EEG signal;
- fault modelling in gas turbine engines; Bayesian belief networks are used to model dependencies between engine components, thus improving diagnosis of faults.

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Information Engineering: www.ncrg.aston.ac.uk

Polymer Processing and Performance Research Group: www.ceac.aston.ac.uk/research/groups/polymer/ppp

UNIVERSITY OF BIRMINGHAM

The University of Birmingham is well established as a world-class university. The university was founded on Birmingham's science and engineering base and now boasts an annual income of more than £270 million and over 20,000 students. The Department of Metallurgy and Materials Science in particular is a leading centre in materials and manufacturing processes for aerospace applications.

CASE STUDY: Manufacture of net shape components
The university has developed two manufacturing technologies for the production of net shape components. These technologies have been specially developed to be transferred into industry.

Direct laser fabrication
This is a technology which can manufacture net shape components from their CAD files and metal powders using a laser in a single step. The laser is used as heat source to melt the metal powder which is injected into the laser focal point. At the same time the laser moves following the paths defined by the CAD file of the component so that a 3-D fully dense metal component is built layer by layer. No mould and little machining are required in this process.

The turn-over time for manufacturing a component is between one and a few days, dependent on the component size. This technology has a great advantage in manufacturing a small batch of bespoke components and in precision-repair of worn out components. The repair of an aero-engine component for Rolls-Royce using this process has been estimated to save annual maintenance costs of more than £10m.

Hot isostatic pressing (HIPping)
Net shape HIPping is a technology which can produce fully dense net shape large components from metal powder (e.g Ti, Ni) in one step with little machining of the components involved. The mechanical properties obtained are similar to wrought (with suitable alloys) and surface finish and accuracy are as good as investment casting. No material is wasted except the mild steel which is used as the mould material.

Rolls-Royce University Technology Centre for Materials
The Department of Metallurgy and Materials incorporates the Rolls-Royce UTC for titanium based materials. The UTC runs several research projects with topics such as the development of a burn resistant alloy for aeroengines and the exploitation of intermetallic TiAl alloys' high strength and low density properties. The alloys can be used for wrought and cast parts for the Joint Strike Fighter.

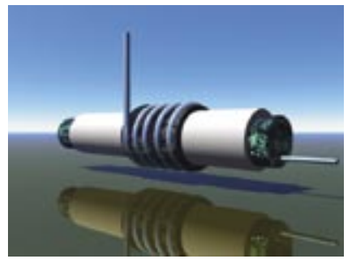
Cold hearth refining
The usage of this production method bears several advantages for the production of moving aircraft components. Weight can be saved and fatigue failures can be reduced. Metallic items normally ultimately fail by cracking, and inclusions can act as the starting points for cracks. An inclusion of about 20 millionths of a gram can lead to failure in a component a metre long.

Cold hearth refining is successful at preventing inclusions from reaching the final product. During the melting process, high density inclusions sink and become trapped in the solid 'skull' of material at the bottom of the hearth. Low density inclusions float and can be removed by interaction with the heat source. Neutral density inclusions dissolve in the molten material, given appropriate conditions.

Corrosion of high strength aluminium airframe alloys
The group investigates the corrosion of welds under consideration for the next generation of aircraft structures. This includes the mechanisms of corrosion, relating microstructure to corrosion susceptibility and examining methods to prevent corrosion, e.g. laser surface treatment and post-weld heat treatment.

Fuel cells research at the Department of Chemical Engineering
Aircraft demand more and more energy for cabin services like air, water, heat and power. In future electric aircraft this power will be supplied from an auxiliary power unit (APU) which will probably be a pressurized gas turbine-fuel cell hybrid. Fuel cells can provide a more efficient energy supply, which saves fuel and weight on board. Fuel cell systems can also be operated independently from the propulsion engines, raising fuel efficiency.

Researchers in the Department of Chemical Engineering have been working with Airbus to demonstrate fuel cell technology for APUs using kerosene JETA1.



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IRC in Materials Processing
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COVENTRY
UNIVERSITY

At Coventry University aerospace activity is especially focused on teaching. The university is one of the top five UK universities in terms of students taking engineering courses. Aerospace research at the university focuses on applied research with industrial partners.

CASE STUDY: Aircraft tyre modelling

A major factor affecting aircraft and landing gear strength requirements is the ground load generated at the tyre/ground interface. This, in turn, depends on tyre properties. System and aircraft level simulation models, which contain tyre models, are used through the whole life of an aircraft project from design to in-service support.

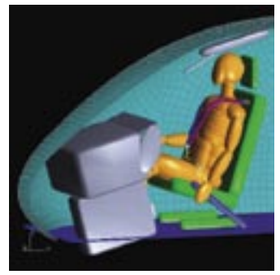
Coventry University runs a project that aims to develop a mathematical model of the forces and moments generated in the tyre contact patch. The current method of defining aircraft tyre characteristics is through extrapolated manufacturer's data and data extracted from flight testing. This means that the validity of data used in load calculations is at risk until flight test results are achieved.

Compared to tyre modelling in automotive industries where most available tyre models have been developed, aircraft tyre modelling is much more technically challenging. The project aim is to develop aircraft tyre models for tyre, system and aircraft level simulations. This work will lead to more accurate predictions of landing gear loads and aircraft manoeuvrability and better steering and braking systems.

The project is funded by Airbus and the EPSRC.

Research and technology

- **Helicopter crash protection:** To improve passenger safety, the European HeliSafe project used information from historical flying accident investigations and developed an overall safety analysis and simulation tool using a generic computer mock-up and an aviation related crash dummy. The research group at Coventry University undertook computer simulations making extensive use of existing automotive technology.
- **Advanced actuation systems for electric aircraft:** Research in this area has looked at electromechanical actuation systems for aircraft primary flying controls, focusing on potential solutions for hard jams.
- **Centre for Advanced Joining:** The focus of the research at the Centre is in the area of high-energy beam processing, specifically plasma arc welding and industrial laser processing. Among the major clients of the Centre have been Rolls-Royce and AugustaWestland Helicopters. The Centre also houses the **Laser Aided Material Processing (LAMP)** project, which provides services and assistance to small companies.
- The **Design Institute** has collaborated with a number of aerospace companies including BAE Systems and Rolls-Royce.



Courses and teaching

The **School of Engineering** offers a number of undergraduate courses in aerospace, designed in close consultation with the aerospace industry and adopting an applied approach using current aerospace designs to explain theories and concepts. The course in Aerospace Systems Engineering includes modules in engineering design, avionic systems, thermofluids, aerodynamics, propulsion systems and aerospace industry studies, to name only a few.

The two other aerospace degrees are Aerospace Technology and Avionics Technology. Technical resources include a specialised aerospace laboratory complete with a Merlin Flight Simulator.

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www.dmu.ac.uk
DE MONTFORT UNIVERSITY
LEICESTER • BEDFORD

The De Montfort University has experience in the aerospace sector providing research, education, training and consultancy support to help companies become more cost effective and responsive to customer demands.

CASE STUDY: Encompassing Lean
The Lean Engineering Research Group has been involved in a range of **projects** including the EPSRC-funded CostMod and SimFMcL research programmes. CostMod delivers software tools for developing improved cost models for aerospace business processes in which cost information is essential to effective decision-making. The SimFMcL project delivered software tools for the design and operation of multi-component versions of single-component flexible machining lines. These more versatile multi-component flexible machining lines permit 'one piece flow' lean manufacturing in the aerospace sector with its high levels of product complexity and low piece volumes.

Recently, the first **students** from the university's BSc (Hons) Lean Engineering degree graduated, a programme initially developed in collaboration with Rolls-Royce. Leading lean practitioners, Toyota and Unipart, sponsored Best Student and Best Project prizes. The range of areas involved in student projects included business improvement, supplier development, shop floor planning and control, cost model development and flow processing. Current PhD research, MSc by independent study projects and in-company training programmes are developing knowledge, expertise and tools in the same areas.

In terms of **consultancy**, the group recently assisted a manufacturing organisation to improve the internal logistics involved in moving materials around their factory site by developing a computer simulation model of on-site vehicle movements and using this model to identify and resolve potential conflicts at traffic junctions. This enabled individual items to be moved over considerable distances from the end of one assembly line to the beginning of the next without line stoppages.

Centre for Manufacturing
The Lean Engineering and Rapid Manufacturing research groups are now part of the Centre for Manufacturing, which focuses on delivering support to regional aerospace companies through projects such as the **Aerospace New Technology Institute Network (ANTIN**). This project is providing capital equipment grants and training to small East Midlands aerospace companies to procure and use advanced manufacturing technology such as CNC milling equipment.

MSc Rapid Product Development
This course has been designed to enable its students to apply the new range of rapid product development tools in a creative and competent way. The course addresses rapid prototyping and its associated technologies.

More about De Montfort University:

- **Rapid Prototyping and Manufacturing Group (RPMG):** The focus of research lies in the reduction of product development lead-times and costs through the use of rapid prototyping and on the rapid manufacturing of high volume components using a combination of layer manufacturing and high speed printing technology. The group collaborates with Alstom, QinetiQ and Rolls-Royce.
- **Mechanical Engineering / Combustion and Computational Fluid Dynamics Research Group:** The group investigates the internal aerodynamics of turbomachinery and develops mathematical models and computational fluid dynamic (CFD) codes as effective design tools to help designers to achieve improvements in various components such as blades.
- **Manufacturing support:** The university offers support in the fields of computer aided design, rapid prototyping, prototype tool manufacture and others.
- **High temperature materials:** The Faculty of Health and Life Sciences is undertaking work in high temperature materials and polymer safety for aerospace use.
- **Technical textiles:** the university houses one of the UK's leading research groups in textile technologies, supporting product innovation in the sector.

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University of Leicester

The University has significant expertise in the aerospace sector, and is a preferred Academic Capability Partner (ACP) of BAE Systems. The partnership focuses on control systems, especially for uninhabited air vehicles (UAVs). The university also houses Europe's largest academic centre for space research.

CASE STUDY: UAV control systems

Uninhabited air vehicles are becoming increasingly important, as they offer a variety of advantages over piloted vehicles - higher manoeuvrability, lower human risk, lower cost and less weight. They can be used for weather and atmospheric monitoring, emergency communications, telecommunications, border patrol, battlefield deployment and other applications.

As demands on UAVs increase they require higher levels of autonomy. To improve performance the Control and Instrumentation Group at the University of Leicester develops algorithms for flight path planning. These algorithms take several aspects into account. The probability of a hit has to be calculated and collisions with other vehicles have to be modelled. When flying at very low altitudes there is a possibility of crashing into ground objects such as trees or hills.

Algorithms find waypoints that lead the UAV to the target avoiding such possible threats. The selected flight path reduces risk to the vehicle, and takes total distance and fuel costs into consideration to achieve optimum results.

A number of technical requirements also have to be fulfilled. The systems have to be fast enough for real time use on airborne processors in uncertain environments, and they have to be efficient in terms of computer memory and computational demand.

The research group at the University of Leicester has developed several models for flight path planning. Each takes different aspects into account to achieve high performance in different scenarios.

Expertise at the Mechanics of Materials Research Group

- Alloy developments for casting applications
- Materials characterisation: Electron Microscopy (ESEM, FEGSEM, TEM); conventional and novel thermal analysis; mechanical testing;
- Simulation of engineering materials - (i) the effects of processing on material properties and (ii) the expected performance of engineering components under their designed operating conditions;
- Tribological behaviour and surface coatings to optimise surface behaviour;
- Semisolid processing (i.e. processing metallic alloys in the semisolid state) of aerospace grade aluminium alloys (e.g. 7075) to reduce manufacturing cost; the feasibility of semisolid processing of titanium alloys is under investigation;
- Modelling surface roughness and contact phenomena that depend on this.

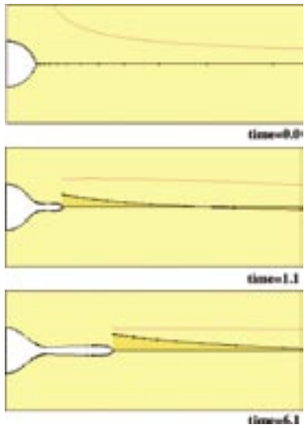
Thermofluids and Environmental Engineering Research Group

Some of the group's research topics include:

- Turbomachinery aerodynamics, with special emphasis on the modelling of unsteady shear layers; experimental work has focused on boundary layer transition.
- The dynamics of separated, reattaching and recirculating flows; vortex dynamics of micro air vehicles; coherent structuring in turbulent flow and aerodynamic and acoustic influences on practical combustion and heat transfer processes.
- The aerodynamic instability of transonic cavities, jets, and turbomachinery blading flows; a specific interest in jet screech and trailing edge wake flows is leading to the further development of time-accurate numerical models that jointly address unsteady aerodynamics and noise.

The Space Research Centre

The Centre houses the Space Research Group of the Department of Physics and Astronomy at the University of Leicester. It carries out the space research programme of the University in collaboration with members of the Department. The main activities of the Space Research Centre are in the areas of instrumentation and missions for space astrophysics, planetary science, earth observation science, technology transfer and exploitation, undergraduate and postgraduate education, and public outreach.



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Mechanics of Materials Research Group
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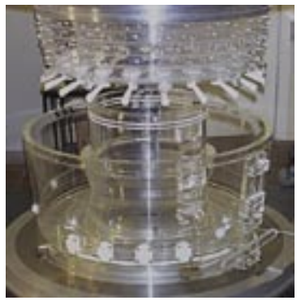
Thermofluids and Environmental Engineering Research Group
www.le.ac.uk/eg/research/groups/thermofluids

Space Centre
www.le.ac.uk/slcem/leicester-space-centre.html

Loughborough University



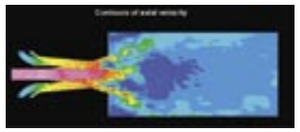
Housing one of Rolls-Royce's flagship University Technology Centres (UTCs) and the Systems Engineering Innovation Centre (SEIC – a partnership with BAE Systems and the East Midlands Development Agency), Loughborough University undertakes a wide range of aerospace research and technology development.

CASE STUDY: University Technology Centre in Combustion Aerodynamics

The Loughborough Rolls-Royce UTC conducts a range of experimental and computational research to improve our understanding of the complex aerodynamic processes that govern the behaviour of gas-turbine combustion systems and associated components. The UTC possesses unique test facilities, which allow fully-annular, engine-representative combustion systems to be studied. Smaller scale rigs are employed to explore the spatially- and temporally-resolved flow fields of system components. A range of instrumentation is used, from multi-hole pneumatic pressure probes to advanced non-intrusive optical techniques.

Recently, increased emphasis has been placed on understanding the detailed unsteady fluid mechanics of combustion systems. Unsteady processes are critical to the occurrence of instabilities, and to the achievement of low emissions performance. This has increased the need for laser doppler anemometry (LDA) and particle image velocimetry (PIV) data, and 3D mapping of the turbulence field.

To complement these experimental studies, computational fluid dynamics (CFD) is used to provide predictions of combustion system aerodynamics. Several recent projects have explored the potential of the large eddy simulation (LES) approach to provide insight into unsteady features of the flow, with notable improvements achieved compared to the more conventional statistical turbulence model CFD approach.



The UTC receives research funding from Rolls-Royce, EPSRC, DTI, and the EU. The Centre has carried out studies on the combustion aerodynamics of the whole range of the Trent series of Rolls-Royce engines, including the latest Trent 900 for the Airbus A380. Work is just beginning at Loughborough on the Trent 1000 design selected for the Boeing 787 Dreamliner aircraft.

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Research in the Department of **Aeronautical and Automotive Engineering** is organized into 6 groups:

Dynamics and control: The group develops advanced dynamics and control techniques and new methods for simulation, dynamic analysis and advanced control.

Acoustics and vibration: The focus of this group is on the development of low-noise and low-vibration aircraft and automotive vehicles.

Structures: The group's research is aimed at improved methods to realise safe structural design, with a special emphasis on composite materials.

Risk and reliability: This group works on the development of mathematical models to assess the reliability of engineering systems.

Energy and combustion: Covering a range of activities, state of the art techniques are developed and applied to engineering applications such as fuel cells and novel fuel injectors for ic-engines.

Applied aerodynamics: as well as hosting the Rolls-Royce UTC in Gas Turbine Combustion Aerodynamics this group undertakes experimental research (low speed wind-tunnel, high pressure nozzle testing) on vehicle, supersonic jet plume and damaged wing aerodynamics, and computational research into jet noise and Short Take Off Vertical Landing (STOVL) aircraft.

Training: The department offers a number of relevant training courses and modules ranging from management to systems engineering and design. Modules can be transformed into special training for companies.

The **Systems Engineering Innovation Centre (SEIC)** was set up in 2003 as a partnership between Loughborough University, BAE Systems and the East Midlands Development Agency. The Centre offers research, training and consulting in all aspects of systems engineering, including requirements capture, risk analysis, systems architecture, rapid prototyping and lifecycle management amongst other product and service development activities. The SEIC is also leading the UK Aerospace Innovation Network (AIN) in Systems Engineering.

Loughborough University also runs the **Innovative Manufacturing and Construction Research Centre (IMCRC)**. Together with industry partners such as Alstom, BAE Systems, Goodrich and Rolls-Royce, the group undertakes research covering new technology, business, organisational performance and human factors.

SEIC

Links:
Department of Aeronautical and Automotive Engineering
www.lboro.ac.uk/departments/tt
SEIC
www.seic-loughborough.com
IMCRC
www.lboro.ac.uk/departments/eng/research/imcrc

Aerospace is a major research theme at Nottingham, where several departments deliver innovative solutions in collaboration with industry leaders such as Rolls-Royce, BAE Systems, and Smiths Aerospace.

CASE STUDY: Electrically Driven Advanced Actuator Systems

The EDAAS project is financed under the Department of Trade and Industry (DTI) CARAD program and involves engineers from Smiths Aerospace Mechanical Systems (Wolverhampton), Semelab and Nottingham University. The team comprises engineers from power electronic, thermal, mechanical, semiconductor packaging and electromechanical disciplines. The program is producing a demonstrator test rig for technology incorporating the first integrated electromechanical actuator with matrix converter power electronics and electric motor drive. The target is to develop the technology for a compact, self-contained actuator system with minimum EMC problems and with only electrical and mechanical connections.

The matrix converter is a new form of power electronic converter which eliminates the need for bulky, unreliable, temperature-sensitive energy storage capacitors required by existing converters. To obtain the best performance from the converter and to minimise the introduction of unwanted harmonics into the electrical supply the permanent magnet actuator motor has to be developed specifically to match the converter.

The application chosen as a basis for the demonstrator is a 30kW rudder actuation system for a large civil aircraft. In normal service, the actuator is only subject to intermittent, transient loading of one or two seconds per operation as trim corrections are made. The particular challenge for this application is the case of one engine of a twin-engined aircraft failing mid-flight. Under this condition, the rudder, and thus actuator, needs to provide a compensating moment to keep the aircraft flying straight. This amounts to a half-load condition at zero motor speed which must be sustained for at least two hours until the nearest airport is reached. The sustained load imposes a substantial thermal challenge for an integrated converter which has been solved by specially engineered heat sinks which form part of the actuator.

More activities at the university:

- **Innovative Manufacturing Research Centre (IMRC):** provides a knowledge driven approach to advanced manufacturing technology, including lightweight structures manufacturing and responsive manufacturing. The IMRC hosts the Rolls-Royce University Technology Centre in Manufacturing Technology.
- **The Structural Integrity and Dynamics Research Group** is developing transmission systems using advanced computational methods and incorporates a second Rolls-Royce University Technology Centre in Gas Turbine Transmission Systems.
- **The Thermofluids Research Group** investigates complex air/oil flows typical of bearing chambers and air/oil separators and the development of advanced in-situ optical flow and particle monitoring.
- **The Composite Materials Group** has an international reputation in polymer composites and processes required to form structures for advanced aerospace and automotive applications.
- **The Advanced Materials Group** focuses on processing techniques such as light alloys, powder processing and surface engineering.
- **The Power Electronics Machines and Control Group** is internationally renowned for an integrated approach to the design of motor, power electronic drive, mechanical actuator and thermal systems.
- **The Ultrasonics and Non-destructive Evaluation Group** is a leader for industrial plant applications and advanced electronic platforms to support rapid application of new measurement and monitoring techniques.
- **The Institute of Engineering Surveying and Space Geodesy:** key themes are GPS, Galileo, optimised position-orientation integration, radar, photogrammetry, hyperspectral scanners, LIDAR, and simulation of navigation and communication systems for the European and British Space Agencies.
- **The University of Nottingham Business School** has strong relationships with Rolls-Royce through the MBA programme and the Operational Management Group which researches multi-disciplinary developments in technology and rapid product development.

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Regional Business Development
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www.nottingham.ac.uk/business-community

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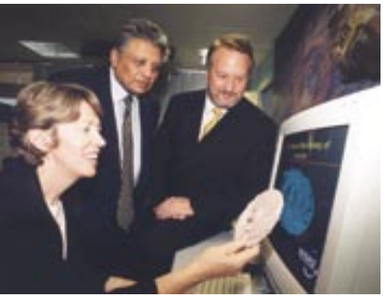
Links:

The University
www.nottingham.ac.uk

Nottingham Innovative Manufacturing Research Centre
www.nimrc.nottingham.ac.uk

THE UNIVERSITY OF
WARWICK



A division of the School of Engineering, Warwick Manufacturing Group (WMG) offers a variety of research and consultancy services and is actively involved in support for aerospace technology development at the national and European levels. The WMG mission is to improve competitiveness through the application of value added skills, innovation and new technologies, and the group benefits from the expertise of over 300 members of staff.

WMG plays a key role in the UK Lean Aerospace Initiative (UKLAI), and is a partner in the National Advisory Committee for Aerospace Manufacturing (NACAM). WMG has a tradition of close collaboration with aerospace companies including Airbus, BAE Systems, GKN, Meggitt/Dunlop, Rolls-Royce and Smiths.

CASE STUDY: Rapid Manufacture of High Integrity Aerospace Components (RAMAC)

WMG partnered with BAE Systems and GKN in the RAMAC project. Different rapid prototyping technologies were tested for their accuracy, processing lead-time and volume and cost limitations. The aim was to identify different techniques that would allow companies to produce high integrity aerospace components in low volumes at minimal cost.

During the research eight major processes were tested, among them laminating, laser sintering castform and MJM thermojet. To test the different processes the industrial partners presented a variety of components incorporating critical design features to be found across many aerospace components. The pieces varied in wall thickness, size and shape, posing different requirements for reproduction. Qualities investigated included accuracy, surface finish, maximum part size and cost. The outcome of the project was a matrix showing engineers the individual qualities of the processes evaluated, including the advantages and disadvantages of each, and where the process' ideal applications lie.

Previous **WMG aerospace research** includes:

- **Quality and reliability:** WMG was a partner in the Ultra Reliable Aircraft Project and subsequently the Reliability Enhancement Methodology and Modelling projects. Partners included Goodrich, Smiths, BAE Systems and Rolls-Royce
- **Concurrent engineering:** WMG is participating in the EU funded VIVACE I Concurrent Engineering Project. The aim is to define a common way of working for joint European aeronautics product development projects.
- **Rapid Manufacturing:** WMG is participating in the BAE Systems-EPSRC Integrated Programme of Research in Aeronautical Engineering which is addressing the grand challenge of a maintenance-free Unmanned Combat Air Vehicle (UCAV) without conventional control surfaces and no cost or performance penalties.
- Research is undertaken in business areas related to technology, including legal and commercial issues involved in product introduction such as contracting, intellectual property and other legal obligations. The aim is to reduce time delays and lower commercial and legal barriers.

Services to business

- The Group's knowledge transfer services focus on best practice, business management, manufacturing strategy, business processes, facilities improvement and rapid manufacturing.
- Tailored courses and training for companies are also available.
- The Innovation-Direct Programme delivers help in identifying new markets, developing new products, improving existing products and using new business processes.

Innovative Manufacturing Research Centre (IMRC): Pursuing a broad cross-sectoral approach, the IMRC achieves significant benefits by tailoring learning, technologies and systems from one sector to a new one and by developing entirely new technologies and systems. Research projects focus on one of the three overarching themes of technology, design or management. Companies, academics, individuals or organisations are welcome to participate actively in the IMRC. Research partners included Rolls-Royce, BAE Systems, QinetiQ and the Society of British Aerospace Companies.

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Links:

Innovative Manufacturing Research Centre (IMRC)
www.warwickimrc.ac.uk

Innovation-Direct Programme
www.innovation-direct.com

Warwick Manufacturing Group
www.warwick.ac.uk

UNIVERSITY OF WOLVERHAMPTON

RIATec

The University of Wolverhampton combines the abilities of several of its schools in the Research Institute in Advanced Technologies (RIATec). The Institute was founded in 2003. Based in the School of Engineering and the Built Environment, it involves staff from a range of schools and draws on the expertise of 50 active researchers and over 100 research students.

RIATec people have strong links with industry and most of their research topics come straight from the real business world and address real problems and opportunities. About 30% of RIATec's research work is relevant to the aerospace industry. The institute has worked in partnership with aerospace organisations such as Goodrich, BAE Systems and RAF Cosford.

CASE STUDY: High temperature dies

High temperature dies are used for hot blow forming (900 C°) of high-performance, light-weight and complex form structures that are required by the aerospace industry. With the help of an advanced finite element computer simulation, dies for the superplastic forming process have been modeled. The original dies that were investigated were axisymmetric and had high principal stresses, which induced failure near the base of the forming cavity.

Large dies require a lot of heat energy and time to attain the correct temperature. Heating time increases with the square of the die size and it would be advantageous to reduce this time. However, there is a risk that increasing the speed of heating of the tooling will tear the die apart as the outside of the die expands too rapidly away from the colder interior.

The computer simulation showed that it is possible to increase the speed of heating without breaking the die by using induction heating. This method is much more effective at getting the heat into the depth of the metal than surface heating. The depth of induction heating was modeled by including volume heating elements. This causes some spurious stresses in the heating region. To increase the possible heating rate even more the peak stresses near the die cavity are eliminated by putting holes around the cavity in a radial direction, so that they do not interrupt the heat flow. This method has been tested by constructing a 3D model.

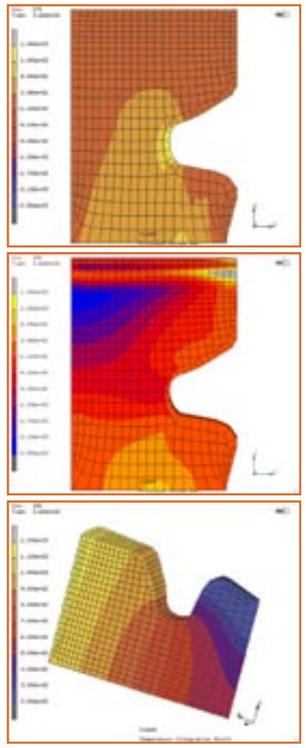
Research and activities

- **Advanced computer modelling and simulation** is a core strength, including engineering computer simulation and metal forging simulation. Facilities include a virtual reality suite.
- **Materials research** is undertaken in the areas of materials engineering and processing
- **Materials testing** is carried out in the Zwick-Roell Materials & Product Testing Centre. The Centre was set up in partnership with Zwick-Roell and offers an extensive range of the company's latest testing products, permitting testing in fracture, fatigue, high temperature and bespoke hydraulics.
- **Powder metallurgy**: powder coatings are developed to improve the characteristics of materials (e.g. harden them) in the Nano-Powders Laboratory.
- **Superplastic forming** is a process in which metal can be made to flow in a nearly Newtonian creep manner. This is seen in blow forming of plastic and glass and allows very large strains to be achieved and complex shapes formed, such as fan-blades and large heat-exchangers.
- **New product development**: The Innovation Product Development Centre (IPDC) is a consultancy service tailored for small manufacturing firms. With £4m of equipment the Centre is able to assist in product design, manufacturing and materials as well as business processes and marketing. Services include 3D CAD modeling and simulation, planning for manufacture, selective laser sintering (SLS) rapid prototyping – metal and nylon parts, 5-axis and 4-axis CNC machining, 5-axis and 3-axis CNC EDM, reverse engineering and co-ordinate measurement.

Courses and degrees

The School of Engineering and the Built Environment offers a variety of engineering degrees and modules. Topics include materials, engineering systems, CAD, innovation & enterprise and others.

A highlight of the School's cooperation with industry is the special part time degree which focuses on supply chain management, with students from automotive and aerospace companies.



Contact:

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Links:
University of Wolverhampton
www.wlv.ac.uk

RIATec
www.riatec.org.uk

University of Derby

In cooperation with Derby College and Rolls-Royce the university delivers a Foundation Degree in Mechanical and Manufacturing Engineering. This is offered as a part-time course, with contents that fit especially Rolls-Royce employees, and will be extended to full-time mode in the future. Other courses have also been developed in cooperation with Rolls-Royce.

Courses in Quality Assurance are offered leading to City and Guilds and Institute of Quality Assurance Awards. The University can tailor short courses in a variety of subject areas (e.g. materials selection, CAD Modelling) many of which can lead to qualifications via Learn Through Work.

The University of Derby is also a member of the East Midlands Aerospace New Technology Initiative Network (ANTIN), offering advanced technology development support including solidification modelling to small aerospace companies.

Other areas of expertise are in manufacturing systems, robotics and expert systems.

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Nottingham Trent University

The University's Business School has carried out several aerospace research projects in the past. Two current research themes are:

- Strategic suppliers: re-structuring in the equipment sector of the UK aerospace industry
- High technology cluster? The aerospace cluster in the East Midlands region

Consulting and training is also offered at the university, focusing mainly on management and management development.

For more details contact:
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University of Central England (UCE)

UCE's Technology Innovation Centre (tic) provides a highly accessible environment where academia and the commercial sector communicate, interact and benefit from each other's respective strengths.

The Centre offers a comprehensive range of services and resources to make businesses more innovative and competitive. Support is offered through:

- **Innovation and technology management consultancy:**
  providing tailor-made solutions to assist organisational development, including access to developmental technology grants.
- **Identification of new business opportunities:**
  encouraging entrepreneurship and support of business initiatives though consultancy which will guide companies in seeking growth.
- **Developing technology solutions:**
  tic's applied research helps companies solve identified problems; key learning benefits are achieved on both sides.
- **Skills development programmes;**
  enabling personnel to keep up with technological change and develop skills to improve their company's performance.

The tic is a major partner of the West Midlands Manufacturing Advisory Service (MAS), delivering consultancy and research to regional manufacturing companies, many of which supply aerospace customers.

For more information contact:
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0121 331 5400
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www.tic-online.com

Organisations and links

Regional Development Agencies

RDAs were set up by Government to promote sustainable economic development in England. Their main tasks are to help the English regions improve their relative economic performance and reduce social and economic disparities within and between regions.

East Midlands Development Agency: **www.emda.org.uk**

Advantage West Midlands: **www.advantagewm.co.uk**

Manufacturing Advisory Service (MAS)

The regional manufacturing advisory services provide subsidised support and hands-on advice for manufacturers to assist in productivity and efficiency improvements.

MAS East Midlands: **www.mas-em.org.uk**

MAS West Midlands: **www.mas-wm.org.uk**

Contact

www.contactke.co.uk

In order to provide businesses with quick and easy access to their combined expertise, the eleven universities of the West Midlands have established Contact – The Knowledge Exchange, a regional brokerage working to match businesses' needs with the university expertise they require. Contact can help aerospace businesses to access this wealth of knowledge, expertise and resources, which includes education and training, consultancy and research, student recruitment and placements together with specialist facilities and equipment.

East Midlands New Technology Initiative

www.eastmidlandsnti.co.uk

The East Midlands NTI is a consortium of universities and colleges and serves to strengthen the linkages between education and the local economy by offering businesses the support of the region's educational institutions in developing and applying advanced technology skills.

Prime Faraday Partnership

www.primefaraday.org.uk

The Prime Faraday Partnership is funded by the government and draws on the academic expertise of the Universities of Loughborough and Nottingham, and Pera. **PRIME** supports companies that are involved in the development of **PR**oducts with **I**nterdependent **M**echanical and **E**lectronic parts, with the overriding aim of fostering greater links between academia and industry.

The programme provides assistance for developing cutting-edge technology through securing UK and European funding for the research and development of such technology.

Year in Industry

www.yini.org.uk

The Year in Industry is the largest provider of gap year student placements. They are a not-for-profit organisation working nation-wide to provide companies with access to the brightest young talent available.

EMUA

www.emua.ac.uk

The East Midlands Universities Association.

WMHEA

www.wmhea.ac.uk

The West Midlands Higher Education Association.

EPSRC

www.epsrc.co.uk

The Engineering and Physical Sciences Research Council is the main UK government agency for funding research and training in engineering and the physical sciences.

About funding

Funding for cooperation with universities is available from various sources. Funding and other support for research and the development of new products and innovative ideas is available especially for small and medium sized companies. Companies normally apply for funding for a certain project and funding is awarded to cover a percentage of the project costs (e.g. 50%). There are regional support initiatives, national schemes and Europe-wide programmes.

Below is a selection of funding schemes that illustrates what kind of support is available for cooperation with universities:

- **Knowledge Transfer Partnerships (KTPs)**: In a KTP, a graduate will work on a special project within the company for a year or longer. The project is jointly supervised by the company and the university.

- **Grant for Research & Development (formerly SMART)**: This grant is dedicated to the development of technologically innovative products. It can also be used to pay for consultancy services to improve exploitation of technology.

- **Shell Technology Enterprise Programme (STEP**): This scheme encourages summer placements of students to work on science, engineering or technology based projects at small and medium companies. It is considered to be a useful path to recruiting new employees.

- **Collaborative Research & Development**: This DTI grant aims at helping companies to take advantage of new technological developments. It funds research cooperation with a partner such as a university and covers between 25% and 75% of the R&D costs of the project.

To find out more about these and other types of support please visit the following websites:

www.businesslink.gov.uk

Under “Finance and Grants” advice on how and where to apply is available, as are links and a business support directory.

www.dti.gov.uk/bss

This link leads to an overview of DTI support schemes for small businesses.

www.primetechnologywatch.org.uk

This information website is run by Loughborough University, the University of Nottingham and Pera and provides links and information about technology funding.

Advice and information is also available at Midlands universities.

Teaching and courses matrix

This matrix lists relevant courses and modules that are taught at the Midlands universities. Bespoke training courses can usually be arranged.

	Aston	Birmingham	Coventry	De Montfort	Leicester	Loughborough	Nottingham	Warwick	Wolverhampton
Aerodynamics			●		○	●			
Aerospace Engineering			●			●	○		
Avionics & Flight Systems			●						
Control Systems		●	●	●	○	●	●		○
Design	●			●		● ○	●	●	
Electronic Systems		○				●			
Engineering Mechanics		●		●					
Environmental Engineering	○	○	○	●	○		○		
Flight Dynamics			●		●	●			
Fluid Systems		●							●
Industrial Design		●	● ○	●			●	●	●
Materials	○	○			●	● ○		● ○	● ○
Materials (Composites)		●	●	●			●		
Materials (Metals)		●		●			●		
Propulsion / Engines		●	●			● ○	●		
Risk & Reliability						●		●	
Structures			●	●		●	●		●
Systems Engineering			○		●	○			
Thermodynamics		●			●				●
Lean Manufacturing	●	●	○	●			●		
Manufacturing Engineering	●	○				●	○		○
Manufacturing Management	●	○	○			○	○	●	
Operations Management	○	●	○	●			○		
Process Modelling				●	●	●	●		
Quality Management	●				○			●	
Rapid Prototyping				○		●			○
Supply Chain Management	●	●	●	●		●	●	● ○	○
Business Strategy	●		○	●			●		
Computer-Aided Design (CAD)	●	●		●	●	●		●	●
Human Factors				●		●	● ○	●	
Innovation Management	●		○	●				●	●
Systems / Computer Systems	○	○		●	○	●			●

● modules ○ courses

Technology capabilities matrix

This matrix gives an overview of the wide range of aerospace research and technology capabilities at the Midlands universities. Topics are arranged in three categories: aerospace technology, manufacturing technology and communication & computer technology.

		Aston	Birmingham	Coventry	De Montfort	Leicester	Loughborough	Nottingham	Warwick	Wolverhampton
Aerospace Technology	Acoustics & Vibration						●			
	Aerodynamics				●	●	●			
	Aircraft Power Systems		●		●	●		●		
	Avionic Mission Systems						●			
	Coatings & Surface Treatments	●	●	●		●		●	●	●
	Control Systems		●	●		●	●	●	●	
	Corrosion & Protection		●							
	Design								●	●
	Environmental Engineering / Technology		●	●					●	●
	Flight Dynamics					●	●			
	Flight Simulation			●		●	●			
	Materials (Composite)		●			●		●	●	●
	Materials (Metals)		●	●					●	●
	Noise					●	●			
	Propulsion				●	●	●			
	Risk & Reliability						●		●	
	Safety	●				●			●	
	Structural Dynamics		●					●		
	Structural Integrity	●	●				●	●		●
	Thermofluids		●	●		●		●		●
Manufacturing Technology	Advanced Machining	●	●					●	●	●
	Chemical Processing		●			●				
	Composites Fabrication		●			●		●	●	
	Lean / Agile Manufacturing		●		●			●	●	●
	Manufacturing Strategy		●					●	●	
	Metal Forming + Joining		●	●				●	●	●
	Operations Management	●	●			●		●	●	
	Precision Assembly		●					●		
	Project Management	●							●	
	Rapid Prototyping	●		●	●		●	●	●	●
Communication & Computer Technology	Business Information Systems	●	●						●	
	High Performance Engineering					●		●	●	●
	Innovation Management	●	●						●	●
	Knowledge Management	●					●	●	●	
	Process Modelling					●	●	●	●	●
	Simulation	●	●	●			●	●	●	●
	Software Engineering	●	●			●				
	Virtual Realization	●	●				●	●	●	●