Cranfield University

Aerospace capabilities

The future of aerospace starts with Cranfield

Aerospace capabilities at Cranfield

At the forefront of aerospace technology, we have been providing postgraduate education, training and research for over 70 years. Our world-leading research, in collaboration with strategic partners, directly contributes to the economic growth of the global aerospace sector.

Everything we do is concentrated on technology and management and our insight is rooted in our powerful international industry links, our ability to work with regulatory and Government stakeholders, our world-class research and what really works in practice.

Cranfield is committed to working across the breadth of aerospace activity in our sector-facing Aerospace, Manufacturing, Transport Systems and Defence and Security specialist teams. This includes **aircraft, airline, airspace and airport** (see diagram opposite), and over a broad range of technology readiness levels.

We are excited to have a programme of integrated research and development across these areas which offers significant opportunities that our partners can benefit from.

Whichever route you take in working with Cranfield, you will have access to all capability areas, giving you the opportunity to enhance your research and development across aerospace all in one location.

We can make a real difference to you and your organisation, whether you are a multinational company, a growing SME or a small start-up.

The Cranfield Flying Laboratory and Classroom

Cranfield's interconnected capabilities

Cranfield's global research airport

A national asset for the UK

Multi-User Environment for Autonomous Vehicle Innovation (MUEAVI)

This instrumented transport corridor runs through the middle of the campus and is used for the development of intelligent and autonomous vehicles, including drones and connected vehicles for smart city infrastructure. Sensors include lidar (laser scanners that can measure distance), radar that can detect pedestrians and cyclists at up to 200 metres, and thermal imaging cameras.

Digital air traffic control centre

Housing the UK's first operational remote air traffic control tower, the centre provides air traffic services for the airport.

Boeing 737

Donated by British Airways, the aircraft is used for research and teaching and is an important part of DARTeC.

Holographic radar

State-of-the-art Aveillant drone detection radar for research as part of DARTeC

Digital Aviation Research and Technology Centre (DARTeC)

A unique centre addressing the global challenges of digital systems integration across aviation. It includes future maintenance, repair and overhaul (MRO), passenger experience, air traffic management and communications laboratories.

Gas turbine power and propulsion laboratories

Living laboratory

Sensors around the airport monitor air quality, soil moisture, temperature and noise levels, including sound from wildlife. Other sensors monitor water quality and levels, and runway and ground movements.

Aviation Innovation and Technology Entrepreneurship cluster (AVIATE+)

Hydrogen refuelling point

HyPER Hydrogen Production

'Smart' car park connected to MUEAVI

Aerospace Integration Research Centre (AIRC)

Major research facility with Airbus and Rolls-Royce dedicated to future aerospace integration challenges.

Drone test and development

Regulatory compliance and safety (including Beyond Visual Line of Sight - BVLOS).

National Flying Laboratory Centre (NFLC) including the SAAB 340B Flying Test Bed

The NFLC's 'flying laboratory' provides a viable alternative to flight test and research work using simulators, wind tunnels, or more expensive turbine aircraft, often testing new parts and equipment for industry partners. The NFLC also has other light aircraft used for research.

FAAM Airborne Laboratory

Dedicated to the advancement of atmospheric science, the specially-modified BAe-146 research aircraft is owned and run by the Natural Environment Research Council (NERC). This is used by many UK and overseas universities and by the Met Office.

Intelligent Mobility Engineering Centre (IMEC)

Data from MUEAVI is relayed into the control room. Within IMEC there are vehicle workshops, vehicle electrification and autonomous vehicle research capabilities.

Cranfield Aerospace Solutions Ltd

A partner company specialising in aircraft prototyping, modifications and approvals located at the heart of the Cranfield campus.

Fire station

Cover up to RFF category 6 with prior arrangement with Cranfield Airport.

Solar power farm

Clean, renewable energy for the airport flows from a solar power farm located on the other side of the airfield.

Aero-structure assembly and systems installation laboratory

Aviation and aerospace laboratories

Cranfield is an established leader in aviation research with world-class expertise, relationships and facilities.

Uniquely within Europe, Cranfield is the only university to own and operate its own airport, aircraft and have its own air navigation service provider. This gives us unrivalled access to an at-scale research and development environment that is directly adjacent to leading specialist technology centres and laboratories including:

Centre	Lead	Laboratories
Advanced Vehicle Engineering Centre	**Professor James Brighton** j.l.brighton@cranfield.ac.uk	Unique laboratories comprising of the multi-user environment for autonomous vehicle innovation (MUEAVI), Intelligent Mobility Engineering Centre (IMEC) and Cranfield off-road dynamics facility provide unique experimental and modelling capability for the optimisation of aircraft tyre and landing gear dynamics, terramechanics for aircraft operation on unsealed runways, vehicle electrification, aerodynamic research and aircraft crash investigation.
Aerospace Integration Research Centre	**Dr Tim Mackley** t.c.mackley@cranfield.ac.uk	One of our newest major facilities, co-funded by Airbus, Rolls-Royce, Research England and Cranfield University – see pages 8-11.
Centre for Aeronautics	**Professor Mark Westwood** mark.westwood@cranfield.ac.uk	The Centre provides software and rapid prototyping tools for aerospace vehicle design and applied aerodynamics as well as part of the National Wind Tunnel facility.
Centre for Autonomous and Cyber-Physical Systems	**Professor Antonios Tsourdos** a.tsourdos@cranfield.ac.uk	The Centre includes a wide range of laboratories covering artificial intelligence and machine learning, guidance navigation and control, autonomous systems, structural dynamics, condition monitoring, signal processing, space systems with clean labs, geosynchronous radar, space debris mitigation, astrobiology, space trajectory design, UAV labs and flying test area, beyond visual line of sight drone flying – see pages 20-21.
Centre for Computational Engineering Sciences	**Professor Karl Jenkins** k.w.jenkins@cranfield.ac.uk	Laboratories for computational fluid dynamics and scientific computing including for artificial intelligence and machine learning, software engineering for technical computing, advanced image analysis and a virtual wind tunnel facilitated by the University High Performance Computing facility.
Centre for Engineering Photonics	**Professor Ralph Tatam** r.p.tatam@cranfield.ac.uk	Laboratories for sensor development including for testing at-scale on aircraft structures and in-flight.
Centre for Thermal Power and Propulsion	**Professor Vassilios Pachidis** v.pachidis@cranfield.ac.uk	Major suite of test laboratories for aeroengines, gas turbine technology, turbo-electric, hybrid electric and hydrogen propulsion.
Safety and Accident Investigation Centre	**Professor Graham Braithwaite** g.r.braithwaite@cranfield.ac.uk	Laboratories for aircraft accident investigation work including flight data analysis, Boeing 737-436 ground demonstrator and B737NG flight deck simulator. Linked to the Cranfield Impact Centre which provides dynamic structural testing capability.
Centre for Structures, Assembly and Intelligent Automation	**Professor Phil Webb** p.f.webb@cranfield.ac.uk	Laboratories for aero-structure assembly and systems installation, industrial psychology and human factors, lightweight and composite structures, intelligent automation and robotics.
Enhanced Composites and Structures Centre	**Professor Krzysztof Koziol** k.koziol@cranfield.ac.uk	Laboratories for composites manufacturing for aerospace applications such as airframes, landing gear and structures for built-in detection of structural degradation.
National Flying Laboratory Centre	**Robert Harrison** robert.a.harrison@cranfield.ac.uk	Jetstream 31 and Saab 340B+ flying laboratories and classrooms plus instrumented Scottish Aviation Bulldog light aircraft – see pages 26-27.
Surface Engineering and Precision Institute	**Dr Greg Bizarri** gregory.a.bizarri@cranfield.ac.uk	Laboratories for developing and testing high temperature coatings for turbine blades, aerospace materials, high temperature corrosion and mechanical interactions.
Hydrogen	**Dr Peter Clough** p.t.clough@cranfield.ac.uk	HyPER, H_2 fuel cell vehicle refuelling, internal combustion engine laboratory – see pages 30-33.
Sustainable Manufacturing Systems Centre	**Professor Kostas Salonitis** k.salonitis@cranfield.ac.uk	Laboratories for the development of manufacturing processes, systems modelling and simulation.
Through Life Engineering Services	**Professor Andrew Starr** a.starr@cranfield.ac.uk	Laboratories for the development, simulation and testing of diagnostics and prognostics solutions for mechanical and digital systems including degradation analysis, data analytics, image and signal processing, augmented and virtual reality, fatigue and damage tolerance, maintenance and asset management.
Welding Engineering and Laser Processing	**Professor Stewart Williams** s.williams@cranfield.ac.uk	Laboratories for the development of Wire Arc Additive Manufacturing (WAAM) of large-scale components for applications such as aerospace and robotics.

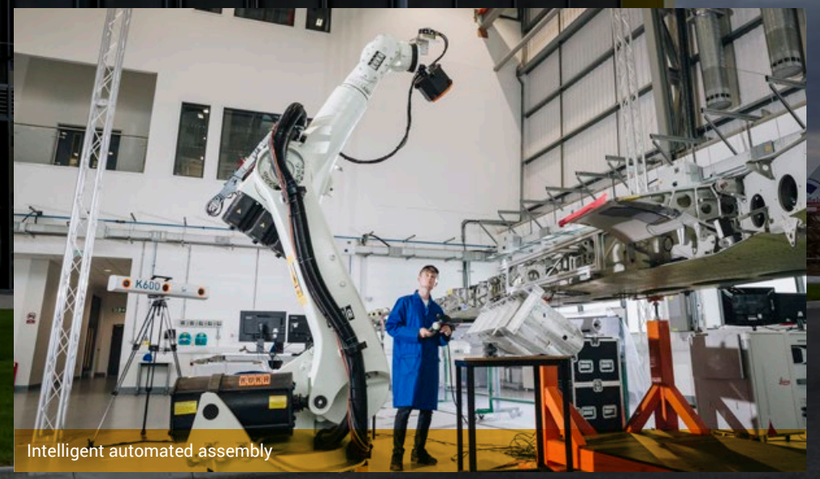
Aerospace Integration Research Centre (AIRC)

The £35 million AIRC is one of Cranfield's newest world-class facilities and has been operational since March 2017. We are using this facility to change the way the world thinks about flight, working with industry to re-imagine aircraft and airspace concepts and shape the future of aerospace globally.

Connecting our land-side, ground-based research with our air-side flight research, the AIRC provides the capability to take aerospace concepts from theory to flight demonstration. It allows us to validate our research to technology readiness levels TRL 6/7 – levels normally addressed only by industry.

By providing a collaborative space, the AIRC offers a unique opportunity for industry and academia to work together seamlessly on cutting-edge research. Working closely with our inaugural co-funders, Airbus and Rolls-Royce, our research focuses on all aspects of integration in aerospace, including integrating power plant with platform, systems with structure and platforms into airspace.

We are able to integrate advanced technologies in areas such as autonomous systems and intelligent automation, as well as reducing the time from innovation to industrial application.



Intelligent automated assembly

For further information about the AIRC please contact:

Dr Tim Mackley,
Head of the Aerospace Integration Research Centre
E: t.c.mackley@cranfield.ac.uk

The AIRC has been co-funded by Airbus, Rolls-Royce, the Higher Education Funding Council for England and Cranfield University.

Air traffic management (ATM) laboratory

AIRC research

Autonomy in aerospace

Research into autonomy involves medium and large aerial platforms, developing sensors, communications, network systems and advanced decision-making using Artificial Intelligence (AI). We are also researching new technologies that can be used on board autonomous flight vehicles, such as thermoelectric generators and novel real-time control, as well as technologies that enable autonomous inspection for maintenance.

Air Traffic Management (ATM)

We investigate new and novel air traffic management strategies using our airport control tower simulator. Fully networked, it links with other flight simulators, enabling pilots and air traffic controllers to understand the impact of different strategies on airspace users.

Intelligent automation and robotics

Industrial robot cells are used to perform research into human-robot collaboration and robots such as the FANUC-CR-35iA robot can be operated in uncaged configurations. Large industrial scale rigs are used to research the introduction of intelligent automated assembly into representative productions lines at TRL 7.

Digital Wind Tunnel

The development of a fully digitised ‘wind tunnel’ using virtual reality goggles to visualise aerodynamic flows from CFD simulation, provides the AIRC with a unique research and development tool for the support of aerodynamic assessment of new designs.

Flight simulation

We operate a suite of flight simulators for research, enabling pilots to gauge the effect of new aircraft designs on performance, handling and safety. Different model fidelities are used for rapid design evolution to shorten development times and also supporting a hardware-in-the-loop capability. Research areas to date include trajectory optimisation and Human Machine Interface (HMI) design that enhances pilot decision making of both current and future aircraft concepts.

Collaborative design

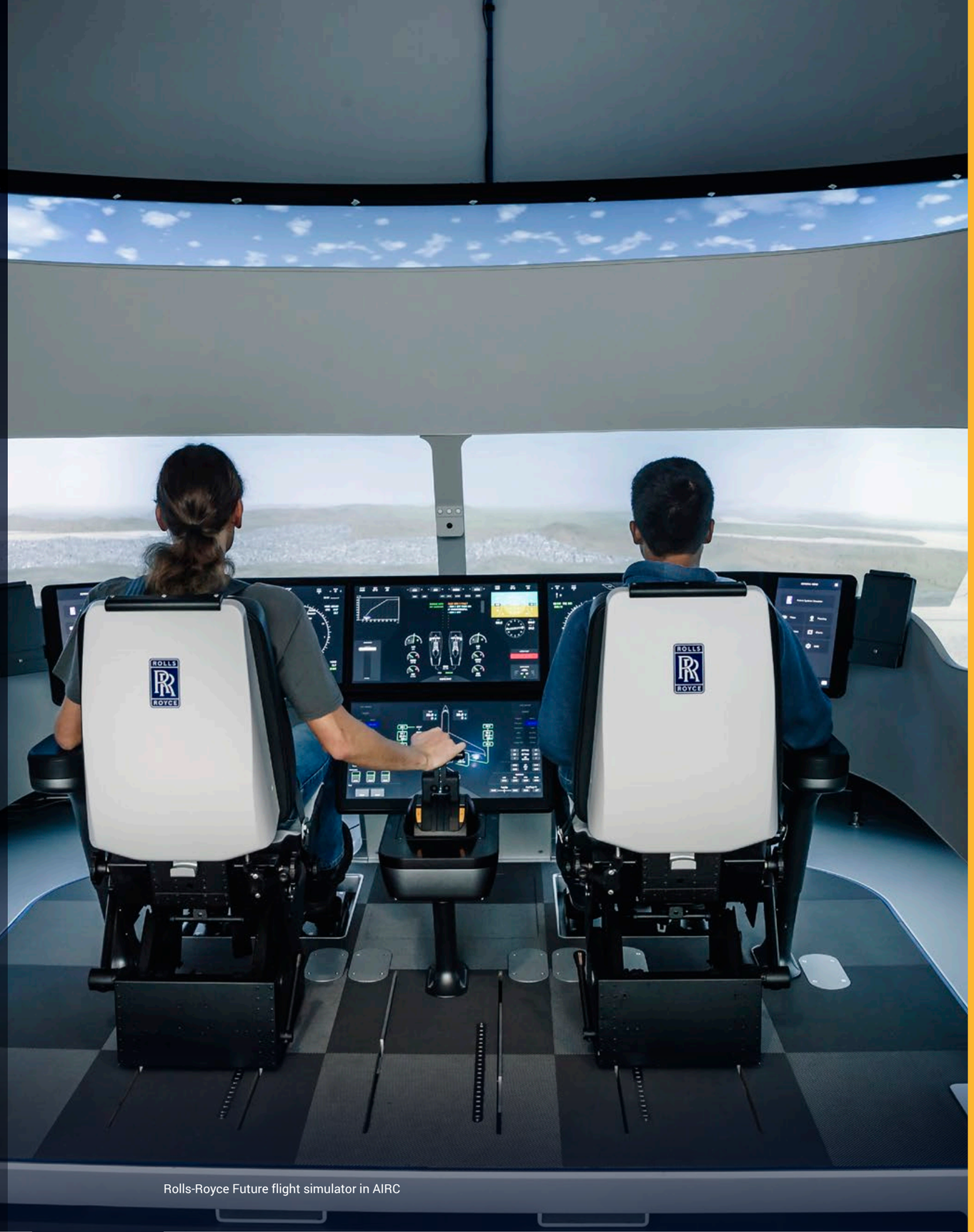
An integration, demonstration, engineering analysis and simulation (IDEAS) collaboration space supports collaborative research activities of the Centre. Widescreen displays with multiple live feeds are used for the visualisation of simulation and design activities involving large teams from both industry and academia.

Thermal management

Cranfield have worked with Rolls-Royce, to design and build a ‘plug-and-play’ thermal management systems facility that supports rapid assembly, test and disassembly of a wide range of low to mid-TRL integrated thermal management systems. It offers potential for representative engine oil and fuel systems to be operated simultaneously alongside new technologies for heat transfer and autonomous control.”

Open laboratory

A lab space of greater than 1,500m^2 has enabled rigs at industrial scale, with large hangar doors allowing access inside for Cranfield’s aircraft to allow flight testing of research from the airfield. One of three A320 wings is part of a structural test rig used to validate research into new engine on wing configurations. A Rolls-Royce sponsored facility, University-designed and built, supports thermal management research at full scale with benefits in fuel efficiency and emissions.



Rolls-Royce Future flight simulator in AIRC

Digital Aviation Research and Technology Centre (DARTeC)

Advances in digital aviation are driving innovation opportunities in all aspects of the aerospace industry. New and challenging ideas are now emerging and being actively researched that are defining the aircraft, airport, airline and airspace industries for the future including:

- Connected systems,
- Seamless passenger experience,
- Unmanned traffic management,
- Conscious aircraft,
- Distributed airport and airspace management.

Independent research programmes in specific applications of digital aviation have the advantage of accelerating technological progress but they tend not to consider the systems integration challenges that often hinder their actual market adoption. Research and technical development is required in this area that has a systems integration approach at its core – whether the system involves technical control and data exchange, operational management or the business environment itself. By adopting a systems integration focus, digital aviation has enormous potential to support the future development of air transport.

The Digital Aviation Research and Technology Centre (DARTeC) was custom built at Cranfield
opened in 2021 to spearhead the UK's research into digital aviation technology.

DARTeC will support the delivery of leading-edge research across five streams that address digital systems integration: connected systems, conscious aircraft, distributed airport and airspace management, seamless journey and unmanned traffic management.

Capability support for DARTeC is being provided from a consortium of aerospace and aviation organisations including; **Aveillant, Blue Bear Systems Research, Boeing, Boxarr, Connected Places Catapult, Cranfield Integrated Vehicle Health Management Centre, Etihad Airways, Heathrow Airport, Inmarsat, International Air Transport Association, Saab, Satellite Applications Catapult, Spirent Communications, Thales UK, as well as Research England and Cranfield University.**

For further information regarding the DARTeC initiative, please contact:

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Director of Transport Systems
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Integrated vehicle health management

Conscious aircraft

The Integrated Vehicle Health Management (IVHM) Centre, with its industrial partners, has a long-term aspiration to deliver a 'conscious aircraft' that is self-monitoring and self-learning.

This self-sensing/aware aircraft will be capable of monitoring its current health, reliably predicting remaining useful life and automatically reconfiguring to optimise and plan future maintenance, repair and overhaul to minimise cost. The conscious aircraft is likely to be hybrid-electric, with smaller new entrant aircraft being all-electric and autonomous.

Our projects in this area include:

- Prognostics Health Management (PHM)-based adaptive power management for hybrid-electric aircraft: a novel approach for adaptive power management considering prognostics health indicators for electrical power generation and distribution systems.
- Reliable power electronics for aircraft systems: with growth in the electrification of aircraft, power electronics will increasingly be placed in harsher environments for weight and cost savings. PHM algorithms have been developed to monitor and predict failures and calculate remaining useful life. This could be used for optimised maintenance planning and to provide high availability of new, more-electric aircraft systems.
- Health monitoring of motors and generators: we have developed health monitoring and prognostics capability for Integrated Drive Generators (IDG) in the European Union-funded RepAIR project. We have also developed 95 kilowatt electrical motors connected back-to-back to test and develop real-time health indicators for electrical motors and generators. These could be used to detect mechanical and electrical faults and evaluate new designs for reliability and performance.
- Autonomous non-destructive testing diagnostics and monitoring: for defect analysis and classification of aerospace structures to increase operational efficiency of aircraft and rotorcraft.

A step towards conscious aircraft – Cranfield's 737-400 ground-based demonstrator aircraft.

For further information, please contact:

Professor Nico Avdelidis,
Head of Integrated Vehicle Health Management Centre
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Digital Air Traffic Control Centre

Cranfield's airport was the first in the UK to have an operational digital air traffic control centre.

Supplied by Saab Digital Air Traffic Solutions, the innovative technology replicates and enhances what can be seen through the windows of a traditional air traffic control tower. It enables smarter approaches to air traffic control by digitising and integrating airport functions and improves a controller's situational awareness, enabling quick and informed decisions.

The new system provides controllers with a 360-degree view of the airport and the ability to zoom-in on aircraft, improving visibility.

Digital aviation has often been cited as being the next significant business transformation in the sector and one which can support the aerospace industry towards delivering greater customer satisfaction, while addressing efficiency, cost and capacity issues.

As exciting new opportunities for alternative fuels, new classes of air vehicle and new air routes are identified, modernising the way air traffic is managed is essential.

The digital air traffic control centre plays a critical role as part the Cranfield Global Research Airport in ensuring operational safety.

For further information on the Centre, or to express an interest in becoming an industry partner, please contact:

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Dr Yan Xu,
Lecturer in Air Traffic Management and Communication Navigation and Surveillance
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Drone testing and development

The key to unlock the future of remotely piloted / uncrewed drone and personal (vertical take-off and landing) air transport will be to move beyond current airspace segregation principles for Beyond Visual Line of Sight (BVLOS) flight, and to move towards airspace integration (or unification).

New technical and regulatory frameworks are needed to ensure fair and equitable use of this new and exciting airspace utilisation opportunity.

Thales has joined with Cranfield to provide industry and academia with a unique development facility at Cranfield University's global research airport in conjunction with the UK Civil Aviation Authority to help solve the challenges that low-altitude, integrated flight present.

Our research airport provides a safe regulated environment for drone and airspace management experimentation which works towards incrementally integrating uncrewed and crewed aircraft within the same airspace.

Future development of a BVLOS airspace management solution is planned to include city and urban airspace environments across the South East, and in alignment with future autonomous road networks.

Incremental airspace development requires close liaison with airspace regulators to safely and meaningfully demonstrate new capability. Cranfield Airport, a licensed Air Navigation Service Provider, with its digital control tower, continues to enhance its technical systems and operational procedures to enables BVLOS flight whilst recognising regulatory frameworks and assurance requirements. Particular focus is given to incorporation of detect and avoid capability and enabling trials airspace, both core foundations for integrated airspace development.

For further information, please contact:

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Dr Yan Xu,
Lecturer in Air Traffic Management and Communication Navigation and Surveillance
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Autonomous systems

Our reputation for being at the forefront of autonomous and space systems, unmanned aircraft systems (UAS) traffic management has been established through more than 30 years of research into this field.

We cover all types of autonomous vehicles including airborne, ground and marine, as well as space.

Our research spans from fundamental research and development to single client contract research and development.

Recent research includes:

- the airborne monitoring of ground traffic behaviour for hidden threats by autonomous sensor platforms,
- the safe integration of Unmanned Air Mobility (UAM) in non-segregated airspaces,
- developing an analytical framework for understanding the behaviours of multiple unmanned aerial aircraft and
- creating strategic and tactical deconflict algorithms for unmanned surface vessels operating out of human eyesight.

We have an outstanding international reputation for the quality of our work and our capability to perform both theoretical and experimental studies. This is supplemented with a close collaboration with regulators including the Civil Aviation Authority (CAA).

Our capability is being enhanced with the establishment of National Beyond Visual Line of Sight Experimentation Corridor (NBEC) and recruitment of two leading academics in the fields of AI, Human Machine Interface (Professor Gokhan Inalhan and Professor Weisi Guo,Turing Fellow).

> "The age of unmanned aircraft is upon us — and this no longer means small purpose-built drones and remotely operated miniature vehicles. Last month, a team of British engineers (BAE Systems and Cranfield Aerospace) announced that an adapted conventional Jetstream passenger plane had flown 500 miles in UK airspace without the aid of a human operator."
>
> *The Engineer*

UAV laboratory in the Aerospace Integration Research Centre.

DEMON – a 90kgs, turbojet-powered UAV.

For further information, please contact:

Professor Antonios Tsourdos,
Director of Research for Aerospace, Transport and Manufacturing
E: a.tsourdos@cranfield.ac.uk

Titanium frame for fast jets application, in the as-WAAMed conditions.

For further information, please contact:

Professor Stewart Williams,
Professor of Welding Science and Engineering
E: s.williams@cranfield.ac.uk

Wire Arc and Additive Manufacturing (WAAM)

The Welding Engineering and Laser Processing Centre has been researching and developing wire-based, directed energy deposition additive manufacturing processes and associated technology for more than 12 years.

This has been focused on providing a full technology solution for industry including:

- Deposition processes – WAAM using plasma as a power source, wire and laser for high resolution and hybrid processes for high build rates.
- Materials – large range of types including titanium (6-4, 5553, 407, CP), aluminium (AlCu, AlMg, AlMgSc and AlLi), steels (low alloy, stainless, duplex, maraging), nickel alloys (IN718, 625, Invar) and special materials (refractory, Cu, Mg).
- Deposition and cold work – cold rolling or pneumatic peening for materials with better than wrought properties (e.g. Ti6-4 IN718).
- Systems – single and multi-robot, CNC, multi-process, processing monitoring and control.
- Software – toolpath planning, control, process data display.
- Part building – highly complex and large parts.
- Supply chain – WAAM3D Ltd has been established to provide software, systems, quality guaranteed wire and part building service and support.

Winner of 3D printing award

Cranfield University (with BAE Systems) won the 2019 3D Printing Industry Award for Automotive/Aerospace Application of the Year for a multi-meter Ti6-4 Eurofighter Typhoon frame.

AVIATE+ - shared maker space

A national hub for aviation and aerospace entrepreneurship.

The UK Government has identified aerospace as an area of strategic importance to the economy. While the sector has evolved, there remains a gap in the pathway from research to market. Support programmes in the sector have largely ignored the UK's vibrant entrepreneurial community, that will form the foundation for the next generation of innovative SMEs.

With recent developments in autonomy and aviation technologies, plus the easing of the E-Conditions regulatory framework for light aircraft, small agile firms are now in an ideal position to bring through the technologies of the future.

Cranfield University Enterprise Zone is the University's business incubation infrastructure, helping small businesses develop the technology of the future. One of 20 University Enterprise Zones (UEZ), Cranfield uses its world-renowned expertise in this area to support start-ups and SMEs with specialist facilities, programmes and collaborations. Our location benefits from good rail and road transport links and we are the only university to own and operate our own airport, our own aircraft and our own air navigation service provider. This gives unrivalled access to an at-scale research and development environment.

This business cluster hosts several business incubators with the space and flexibility to support every stage of a business's growth:

- Pre-start up advice and mentoring in conjunction with our world-leading School of Management, and the **Bettany Centre for Entrepreneurship**
- **AVIATE+**, Cranfield University is a designated University Enterprise Zone and was awarded £1.2 million from Research England to help create a UK Aviation Innovation and Technology Entrepreneurship cluster. Funding has enabled the development of the AVIATE+ facility. Operating alongside Cranfield Eagle lab, this centre provides grow-on space, tailored support and specialist workshops for high-growth businesses.
- **Cranfield Eagle Lab**, is an exciting collaboration between Barclays and Cranfield University, supported by the Royal Aeronautical Society and various key aerospace industry players. It is an innovation laboratory specialising in aviation technology. It offers a co-working space for ambitious entrepreneurs to scale and grow their businesses.

With membership options including workshops, co-working desks and virtual workspace, we welcome enquiries from the local, regional, national and international AvTech businesses to become a part of this vibrant community.

For information please contact:

AVIATE+:
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Business Development Manager
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www.cranfield.ac.uk/aviate

Bettany Centre for Entrepreneurship:
Claire Banwell Spencer,
Head of the Entrepreneurship Growth Portfolio
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Cranfield Eagle Lab:
Christine Lucas
Eagle Lab Manager
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National Flying Laboratory Centre (NFLC)

The National Flying Laboratory Centre (NFLC) is a unique combination of experienced academics, technical specialists (including pilots and engineers) and instrumented aircraft including a Saab 340B+, Jetstream 31 and two light aircraft. Together, they allow the University to undertake in-flight research and deliver experiential learning for aerospace students across the UK.

Our flying classroom provides an immersive flight test engineer experience through the acclaimed flight test course. Around 1,500 students per year from over 20 universities learn about aerodynamics and flight dynamics by collecting data while on board the specially-instrumented aircraft, under the supervision of a fully-qualified flight test engineer. Our current Jetstream will be phased out in 2021 and be replaced by a Saab 340B+, increasing our capabilities.

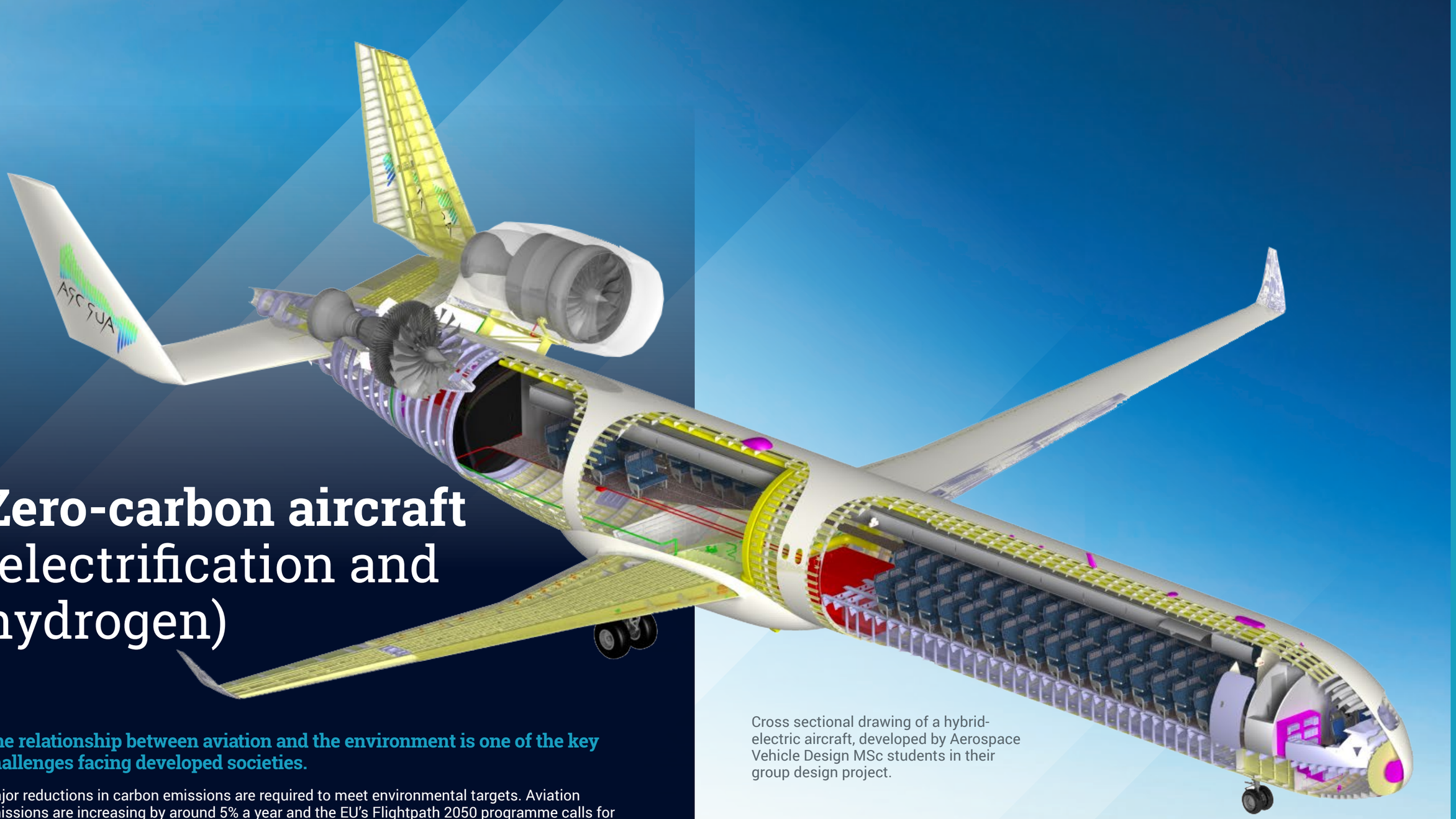
Our aircraft are able to carry a range of sensors and payloads with a design approval service available from our partner company, Cranfield Aerospace Solutions. We have supported major aerospace companies in their development work, including BAE Systems on the Autonomous Systems Technology Related Airborne Evaluation & Assessment (ASTRAEA) project and Meggitt with industrial flight trials.

In 2019, the University received its sixth highly-prestigious Queen's Anniversary Prize – for the work of the NFLC.

For further information, please contact:
Robert Harrison,
Head of the National Flying Laboratory Centre
E: robert.a.harrison@cranfield.ac.uk

Saab 340B+ G-NFLB Flying Classroom and Laboratory

Zero-carbon aircraft (electrification and hydrogen)



Cross sectional drawing of a hybrid-electric aircraft, developed by Aerospace Vehicle Design MSc students in their group design project.

The relationship between aviation and the environment is one of the key challenges facing developed societies.

Major reductions in carbon emissions are required to meet environmental targets. Aviation emissions are increasing by around 5% a year and the EU's Flightpath 2050 programme calls for a 75% reduction in carbon emissions per passenger kilometre by 2050. Aircraft electrification and hydrogen are key enablers towards achieving those goals and tackling climate change.

Challenges in electrification include thermal management, systems design for integration into the airframe, battery management, power-to-weight ratios, testing, reliability and certification of new aircraft technology.

Cranfield is able to draw upon its strengths in aircraft structures, systems, avionics and propulsion systems to design revolutionary aircraft. With the support of specialists in battery management and electric motors, materials technology, integrated vehicle health management, rotorcraft, airworthiness and air transport management, hydrogen production, storage and utilisation we offer a capability that is second to none.

For more information, please contact:

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Professor Howard Smith,
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Jenny Kavanagh,
Associate Director and Head of Airborne Systems Group, Cranfield Aerospace Solutions
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Dr Tim Mackley,
Head of the Aerospace Integration Research Centre
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Dr Tosin Adedipe, Technical Project Manager of the £8 million Department for Business, Energy and Industrial Strategy's Energy Innovation Programme-funded project HyPER was recognised as one of the Top 50 Women in Engineering awards 2022.

For further information, please contact:

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Professor Upul Wijayantha,
Head of Centre for Renewable and Low Carbon Energy
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Professor Vishal Sethi,
Head of Low Emissions Technologies and Combustion Group and Associate Professor in Gas Turbine Combustion and Environmental Impact
v.sethi@cranfield.ac.uk

Hydrogen – revolutionary clean energy for aviation

At Cranfield we believe that hydrogen is a viable clean aviation fuel that will help the world meet its net zero emissions targets and limit the effects of climate breakdown. Our expert engineers are investigating hydrogen in terms of production, storage, utilisation and transport.

Flying is not the problem, carbon's the problem. The aviation industry has come a long way since the Wright brothers. Cranfield University brings all the facilities and capabilities together to test and validate new technologies and provide new ways of looking at the aviation ecosystem. The diagram on the next page shows some of the related facilities at Cranfield.

CASE STUDY

The HyPER project

An international collaboration between Cranfield University, GTI Energy and Doosan Babcock, funded through the Department of Business, Energy and Industrial Strategy's (BEIS) Energy Innovation Programme will examine the potential for low-carbon hydrogen (H_2) to be the clean fuel of the future. The HyPER project (bulk H_2 production by sorbent enhanced steam reforming) will construct a state-of-the-art 1.5-megawatt H_2 production pilot plant at Cranfield University to test an innovative H_2 production technology that substantially reduces greenhouse gas emissions.

www.cranfield.ac.uk/research-projects/hyper

CASE STUDY

The ENABLE H_2 project

The ENABLE H_2 Horizon 2020 project funded by the European Commission aims to revitalise enthusiasm in liquid hydrogen (LH_2) research for civil aviation by maturing key-enabling technologies. This includes hydrogen (H_2) micromix combustion and fuel system heat management to use the formidable heatsink potential of H_2 to facilitate advanced propulsion technologies.

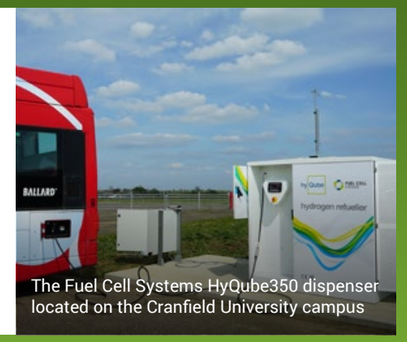
The project is key in the initiative to decarbonise civil aviation through the adoption of LH_2 and contributes to the goals of Flightpath 2050, in that it will demonstrate that LH_2 combined with advanced airframes, propulsion systems and air transport operations can meet sustainability targets for civil aviation.

www.enableh2.eu

CASE STUDY

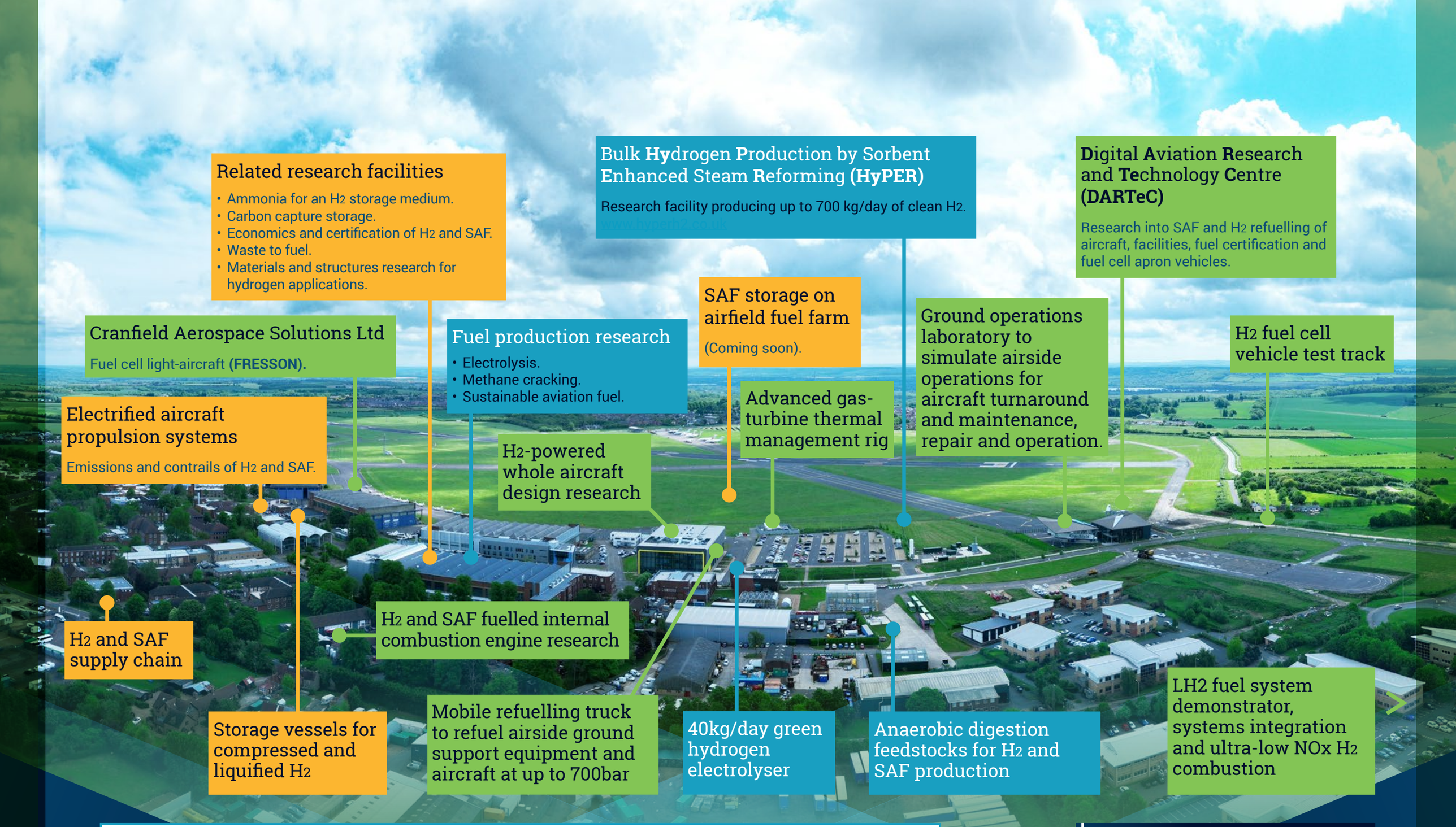
Hydrogen refuelling station

Cranfield has opened a new hydrogen refuelling station on campus to service vehicles with this pioneering fuel. There are only a handful of hydrogen refuelling stations around the UK – with the one at Cranfield ideally placed for researchers working on hydrogen projects. This is the first step towards Cranfield installing its own electrolyser and mobile refuelling facility, supported by Research England's RPIF Net Zero fund, which will enable compressed gaseous hydrogen to be taken airside to refuel fuel-cell aircraft on Cranfield's airport and at our Digital Aviation Research and Technology Centre (DARTeC).



The Fuel Cell Systems HyQube350 dispenser located on the Cranfield University campus

For more information see **www.cranfield.ac.uk/hydrogen**



Key

Feedstocks and fuel production. **Transport, storage, economics, supply chain.** **End users – aerospace and road vehicles.**

• **H2** = Hydrogen • **LH2** = Liquid hydrogen • **SAF** = Sustainable aviation fuels

For more information, please contact:

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Transport Systems Development Manager
E: j.horsley@cranfield.ac.uk

The pebble bed heater. With its 1800K, 15 bar and 4kg/s capability, it is already pushing the boundaries of ultra-low NOx combustion systems within the EU H2020 ENABLEH2 project and is spearheading Cranfield's activities in hydrogen propulsion for civil aircraft.

For further information, please contact:

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Head of the Centre for Propulsion and Thermal Power Engineering
E: v.pachidis@cranfield.ac.uk

Aircraft propulsion

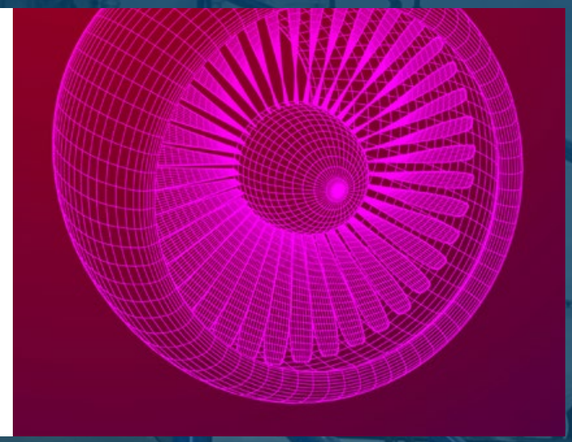
Our capabilities span from gas turbines through hydrogen, hybrid electric and all-electric propulsion. We deliver performance evaluation, design space assessment and optimisation, component and prototype R&D, mission assessment and powerplant integration and diagnostics. This unique set of capabilities has been developed through sustained collaboration with industry including the Cranfield Rolls-Royce University Technology Centre, Siemens, Hitachi, Samsung, easyJet, NASA, DSTL, MoD, EU Clean Sky, EPSRC, ATI, Innovate UK.

Specific capabilities

- Fundamental research on key technologies: hybrid gas turbine design and performance including variable cycles, gas turbine re-sizing and the aerodynamic integration of electric propulsors.
- Bespoke multi-fidelity methods, tools and facilities to analyse and test a wide range of propulsion systems (hydrogen, hybrid, electric, Vertical Take-Off and Landing (VTOL) and Vertical and/or Short Take-Off and Landing (VSTOL) and gas turbine propulsion) including models for propulsion system components, whole powerplant, general arrangement and weight estimation, emissions, lifing, economics and integration. The whole capability can be used in an integrated way for a full Technoeconomic Environmental Risk Analysis (TERA). These capabilities integrated with advanced diagnostic and lifecycle analysis methods can form the basis of digital twins.
- The Centre for Propulsion and Thermal Power Engineering operates a large suite of facilities occupying a 3,000 square metre site that comprises 12 test houses and ancillary facilities including a workshop. The team can conceive, design, build, commission and operate large-scale, one-off prototype rigs for bespoke research and development requirements up to TRL 6. The Centre has 11 gas turbines (of up to 1 MW) at its disposal to support its education and research activities. Facilities comprise, icing, combustion, thermal management, turbomachinery (including SCO2), instrumentation and measurement development, inlet and exhaust ducting etc.
- System architecture: modelling, sizing and analysis of fully integrated systems at system, aircraft and mission levels, including the ability to size and match electrical, energy storage, thermal management and propulsion modules.
- Advanced energy management strategies to minimise fuel, energy and maintenance costs, emissions and environmental impact. Schedules are customised for aircraft size and mission as well as technology level.
- Design concepts for cryogenic cooling systems for all-electric or combustion-based gas turbine propulsion systems.

NASA research grant

In 2013, NASA awarded Cranfield a three-year grant for research into future distributed propulsion systems, including turbo-electric. The award to a non-US institution was a first and provided for wide-ranging research to improve both propulsive efficiency and air frame performance, as well as achieving reductions in noise, emissions and energy consumption.



Cranfield Aerospace Solutions Ltd

Cranfield Aerospace Solutions is at the centre of a number of market-leading electric and hybrid-electric aircraft projects.

A unique UK aerospace SME with the capability to design, build and fly a whole new aircraft concept, it holds CAA/EASA Design Organisation (DOA) and Production Organisation (POA) Approvals.

A partner company, located at the heart of Cranfield University's campus, Cranfield Aerospace Solutions Ltd, aims to accelerate the world's transition to innovative, electric and autonomous air vehicles. It is the aircraft DOA and POA for the Volante Vision eVTOL aircraft concept, launched at Farnborough 2018 with partners Cranfield University, Aston Martin and Rolls-Royce.

Project Fresson – Scottish islands electric aircraft service

Project Fresson is the first phase in a long-term strategy to exploit the sub-regional global aviation market that is now ripe for disruption by means of electric and hybrid-electric propulsion. The project aims to develop the world's first passenger-carrying commercial electric aircraft by modifying an existing aircraft design – the nine-seat, twin-turboprop Britten-Norman Islander – with an electric propulsion system. The project hopes to have the aircraft EASA-approved by 2023/24, ready to launch the world's first commercial electric air transport routes. Routes operated by Scottish regional airline Loganair in the Orkney Islands are targeted for the initial service launch.

The final phase of the strategy will be to design, flight-test and manufacture a new EASA-certified 19-seat aircraft at Cranfield.

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Continuing Professional Development

We are globally recognised for designing and delivering learning programmes that achieve a positive impact within an organisation. To achieve this, we partner with clients and bring a level of challenge and rigour to every aspect of the engagement, to ensure we deliver impact for individuals and the organisation. Our mission is to create leaders in technology and management. Our sharply-defined focus on science, technology, engineering and management means that we have a deep understanding of how technology and management work hand-in-hand.

We have a long-standing history of partnering with organisations across the aviation, aerospace and defence sectors. Our air transport management graduates are found at senior levels across the global aviation industry including airlines, airports, manufacturers, maintainers and government. Our Aerospace engineering graduates are represented in just about all tier-1 and tier-2 aerospace companies including Boeing, Airbus, Rolls-Royce, Embraer, Safran and GE.

Our continuing professional development courses are valued across the aerospace sector. Recent customers include:

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- ANA,
- Australian Defence Force,
- BAE Systems,
- Boeing,
- Bombardier,
- British Airways,
- Canadian Armed Forces,
- Cathay Pacific,
- Civil Aviation Administration of China,
- Civil Aviation Safety Authority (Australia),
- Civil Aviation Authorities of UK, Belgium, Kenya, Poland, Ireland and Hong Kong,
- COMAC,
- easyJet,
- Embraer,
- Emirates,
- Etihad,
- European Aviation Safety Agency,
- GE,
- Lockheed Martin,
- Lufthansa,
- Ministry of Defence,
- Qantas,
- Qatar Airways,
- QinetiQ,
- Raytheon,
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Boeing apprentices with the Cranfield 737-400.

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