MI SPACE

MIDLANDS INNOVATION SPACE

Strengths and Capabilities

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MIDLANDS INNOVATION

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> “We form **one of the largest collections of space expertise in the world**, numbering over **900 academic, research and technical staff**.”

Foreword

The Midlands Innovation Space Group has been formed to foster collaboration across the Midlands, and beyond, in this very important sector of the UK’s research base and the UK economy.

The group represents a critical mass of over 900 academic, research and technical staff in eight institutions that span the full capability of the UK in space, in upstream, downstream, satellite applications and space-enabled businesses.

These institutions also offer a variety of relevant training courses and host a wide range of complementary facilities that can support research and development in both industry and academia.

Its importance has been recognised by the UK Government in its Industrial Strategy and highlighted in the Integrated Review of Security, Defence, Development and Foreign Policy in March 2021, with the aim of developing a £40 billion UK sector, a significant share of global activity, and 100,000 new jobs by 2030. The National Space Strategy was published in September 2021, continuing the theme, and is now being implemented. A major goal is the development of regional clusters, of which one is the Midlands Space Cluster, supported by this group.

To make the expertise and facilities of the Midlands Innovation Space Group as widely accessible as possible, we have assembled this brochure to provide a one-stop guide, summarising the capabilities of each institution. We hope that you find it useful as a source of information and encourage you to contact us if you need support in any area of space.

This document summarises the collective expertise of the Midlands Innovation Space Group by institution. Narrative information on the specialities of each member of the Group is followed by detailed appendices on the areas of expertise and the supporting facilities available from university partners. The data also include a census of activity across the consortium by job type and a list of training opportunities available from the partners.

Professor Martin Barstow
Chair, Midlands Innovation Space Group

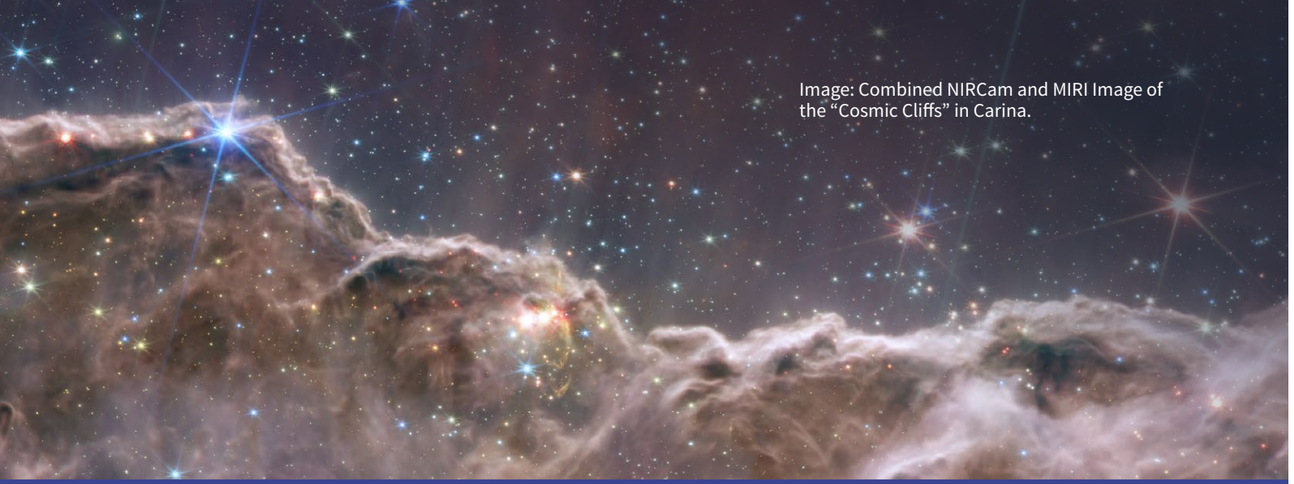

Image: Combined NIRCam and MIRI Image of the “Cosmic Cliffs” in Carina.

Partner expertise

Aston University

The Aston Institute of Photonic Technologies (AIPT), in the School of Engineering and Applied Science (SEAS), is one of the largest photonic groups in UK, an internationally leading research centre in the field of lasers, fibre-optics, high-speed optical communications and nonlinear photonic technologies. The Optoelectronics and Biomedical Photonics Group (OBPG) is part of the AIPT is currently focused on photonics and nanomaterials, with an emphasis on the interface between these research areas and the growing life sciences research at the university. The group conducts cutting-edge experimental research in a wide variety of compact semiconductor and solid-state lasers, non-linear optics, nanostructured materials, ultrafast optics, THz generation and Biophotonics. The Optical Communication Group is focused on increasing the capacity and reach of both fibre optical links and free space optical links. The group has the capability to perform research from O to L bands, and from Gbit/s to Tbit/s per wavelength and to both mitigate or exploit nonlinear optical effets.

The AIPT are fully equipped with state-of-the-art equipment including: Cleanroom, BioLab, optical spectrum analysers, monochromators from 200nm to 10um, 100+ Gs/s arbitrary waveform generators and 200 Gs/s digital oscilloscopes. There is a range of different continuous wave and ultrashort pulse lasers including: tuneable semiconductor lasers, broadly tuneable Ti:sapphire, Cr:forsterite and fibre-based femtosecond and continuous wave lasers. There is equipment for development and full characterisation of semiconductor, fibre and solid state lasers and sensing and communication systems.

Space science at the AIPT is focussed on aspects of optical communication links, including technologies for pointing and tracking, high speed turbulence mitigation, low noise optical amplifier development and enhancement of link capacity towards Tbit/s per wavelength class systems. Additionally, AIPT is strongly involved in the development of compact light sources, detectors, and sensors which can be applied in space sciences.

AIPT was very successful in the past five years securing funding from EPSRC, Leverhulme, and FP7/H2020. For instance, within the context of H2020/Horizon Europe AIPT is currently coordinating the H2020 FET OPEN MESO-BRAIN and NEUROPA projects and participating in H2020 PULSE, AMPLITUDE and RISE VISGEN projects. Within the context of UKRI funding, AiPT coordinates five projects on subjects including from optical frequency combs, optical amplification, free space communications and optical transponders.

University of Birmingham

The University of Birmingham has a long history of research excellence in space. Originally focused on space science in physics, groups across the university have since emerged, working on a range of space research areas. These include manufacturing for, and in, space; radio systems that exploit, or are impaired by the space environment; and quantum devices for advanced spaced based applications (such as timing and navigation).

Our **astrophysics and space research group** interests span a wide swathe of astronomy and fundamental physics, including the study of galaxies and larger cosmological structures, of black holes and neutron stars, using both electromagnetic and gravitational radiation, and of stars and exoplanets. We also study gravity itself, and other ultra-weak forces, using sensitive experiments in the laboratory and in space. The university was involved in the design and build of the Phasemeter for the ESA LISA Pathfinder mission.

The **Space Environment and Radio Engineering (SERENE) group** tackles the challenges faced by space weather on modern society, including impacts on Global Navigation Satellite Systems (GNSS), HF radar, low frequency radio astronomy and the orbit of satellites. The SERENE group developed the Advanced Ensemble electron density (Ne) Assimilation System (AENeAS), which is the operational ionosphere/thermosphere model used by the Met Office Space Weather Operations Centre. The group’s research investigates long-term likelihoods and impacts of extreme space weather events.

The **UK Quantum Technology Hub Sensors and Timing** (led by the University of Birmingham) is one of four Hubs within the UK National Quantum Technologies Programme. The Hub brings together experts from across the university, and other academic and industrial partners. Since 2014, the Hub has over 200 projects, valued at over £170 million, and has 26 patent applications.

Research which involves space-based applications include the International Clock and Oscillator Network (ICON) project which brings together the best international transportable optical clocks and optical link space infrastructure to explore the limits of precision time transfer. Birmingham also has a world leading research programme that is building a new generation of gravity sensors based on quantum technology. Future space-based versions will enable high-definition gravity maps that provide data for earth observation, environmental monitoring and navigation.

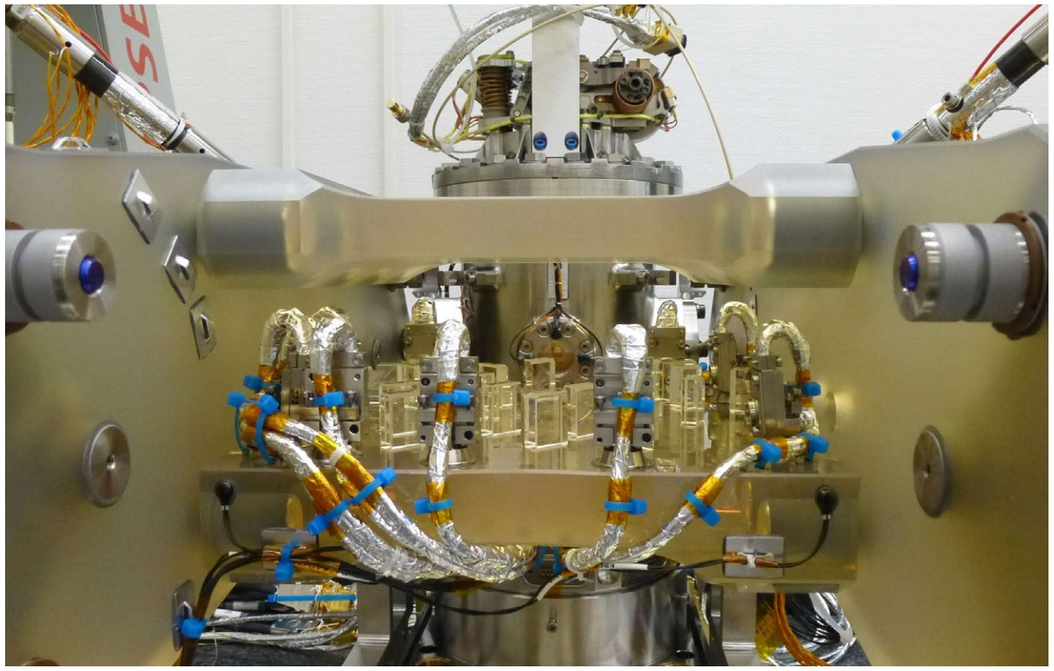

Image: Optical bench developed by University of Birmingham with University of Glasgow for the LISA Pathfinder spacecraft. Courtesy of ESA.

> The University of Birmingham-led **UK Quantum Technology Hub Sensors and Timing** has engaged **over 200 projects,** valued at **over £170 million,** and has **26 patent applications.**

Image: James Webb Space Telescope Mirror.

Additionally, the Birmingham team is involved in the Cold Atoms for Space roadmap and the Space mission proposal AEDGE, aiming at detecting dark matter and gravitational waves in unprecedented parameter spaces.

The **Microwave Integrated Systems Laboratory (MISL)** is the biggest academic research team in the UK working in radar, spanning a range of radar technology for space, maritime, and automotive applications. Specific MISL research on space applications includes: passive ground, airborne and space borne Synthetic Aperture Radar (SAR) and real aperture radars with navigation satellites (GNSS) as the transmitters, ground based passive radars for maritime target detection utilising communications satellite transmitters, microsatellites borne passive radar networks for persistent surface observation, sub-THz ISAR for space domain awareness (SDA), and ground-based RF sensing for space situational awareness (SSA).

Outside of dedicated research groups previously described, the University of Birmingham also has research activity based around **robotics in harsh environments, additive manufacturing of space components,** and **enabling regional growth of the UK space sector.**

Cranfield University

Cranfield University's core expertise is aerospace. Space is a strong and increasingly important axis within the breadth of aerospace expertise, and the interplay between space and the broader aerospace sector within the university is a key part of our strength. Cranfield's main space activities are in space engineering and space system applications, and we are making significant contributions to areas of space science.

Space engineering at Cranfield draws on the breadth of Cranfield's aerospace expertise from hypersonic aerodynamics to manufacturing and includes emerging technologies such as artificial intelligence / machine learning. Specific space engineering expertise includes:

- Space system engineering
- Autonomous systems
- Ultra-precision engineering
- Space debris mitigation technologies.

As a university, Cranfield has a unique breadth and depth in practically all disciplines of aerospace technology and this resource is drawn on as necessary for our space research. An example of this is the de-orbit system technology being developed. We have three of our systems in orbit (with two already deployed). The core technology reflects system engineering principles, and the hardware draws on expertise in satellite dynamics, material science, and mechanical engineering: all applied to enable sustainable use of space and to create business opportunities. Cranfield's ultra-precision engineering was chosen to manufacture the infra-red beam-splitter optical surfaces for the James Webb space telescope – launched in December 2021, and a third example is the use of Cranfield's expertise in additive manufacturing to produce lightweight fuel tanks faster and cheaper than is possible conventionally.

Cranfield's **space system applications** research includes Earth observation (EO), communications, and position / navigation / timing (PNT). In each of these domains it is the application of science and technology to solve real-world problems which is at the core of our research. Agriculture yield estimates using EO have been a long-term strength at Cranfield, developed in the UK, Europe and globally – with commercial, environmental and security applications. For communications and PNT it is the integration of these services in other systems (for example autonomous vehicles) which has been Cranfield's forte, and we have access to world-class test facilities including our airport to support this research.

Cranfield's contributions to space science draw on our engineering expertise. In EO, Cranfield led the Hydroterra proposal for the European Space Agency (ESA) and provided the astrodynamics lead for ESA's Comet Interceptor mission. We are a leading UK centre for the application of biosensors and biotechnology to space missions (building on sensor development for the ExoMars rover).

Postgraduate education and training is another significant contribution of Cranfield to the UK and global space sector. Around 50% of the UK postgraduate students in aerospace are at Cranfield, and Cranfield provides one of the leading European space masters courses with its MSc in Astronautics and Space Engineering.

Image: ESA-NASA image taken during Proxima mission.

Keele University

Space science at the University of Keele focuses on exploitation of space data. Our exploitation activities include primarily astrophysics research but extends also to other topics such as Earth observation. In astrophysics we operate over most of the electromagnetic spectrum, from X-ray through to radio wavelengths. Astrophysics research includes a strong theoretical/computational programme and observational studies of exo-planets, stars, galaxies and active galactic nuclei, with considerable expertise with data from space-based observatories.

Earth observation is used for a wide variety of research projects, such as measuring public space population density in cities, the spread of agricultural pests in Sub-Saharan Africa, the response of Arctic lakes to climate change or assessing natural hazards, such as hazards related to volcanic eruptions. Therefore, our approach to using remotely sensed data sets bridges across the divide between the social and the natural sciences bringing together specialists from a range of disciplines using satellite and aerial data to solve current and very relevant issues.

Data analysis and exploitation are achieved through advanced data science techniques such as Bayesian inference, machine learning and artificial intelligence. We are experienced applying these 'big data' techniques in collaboration with Computer Science and Mathematics to a variety of sectors. This approach is embodied by Keele's recently launched Digital Society Institute, which brings businesses and academics together to solve the problems of the digital economy, fostering collaboration and growth.

Image: James Webb NIRCam captures a cosmic tarantula. Courtesy of ESA.

Image: Space Park Leicester. Photo ©Martine Hamilton Knight.

University of Leicester

Space research at the University of Leicester covers a very broad range of expertise. We have a cradle-to-grave approach for space missions with experience in mission design, construction, test, operation, exploitation, data centres and archives, and growing research in space policy, law and social impact. All these are supported by a strong programme in instrumentation and space engineering, and a comprehensive and innovative skills and training programme which spans pre-university training through to postgraduate degrees and Continuing Professional Development.

Our science and data **exploitation activities** include astrophysics, space plasma physics, planetary exploration and Earth observation. In astrophysics we operate over most of the electromagnetic spectrum, from gamma rays through to infra-red. We are also now working in astro-particle physics, with a key role in the Cerenkov Telescope Array (CTA), and multi-messenger astronomy, leading searches for electromagnetic counterparts to gravitational wave detections. **Astrophysics** research includes a strong theoretical/computational programme and observational studies of gamma ray bursts, active galactic nuclei, white dwarfs, stellar coronae, brown dwarfs and extrasolar planets. Our **planetary science programme** has a long heritage of studies of the ionospheres of the Earth and other planets, principally Jupiter and Saturn, and extends into planetary geology and geochemistry on Mars and Mercury. We are part of plans to develop Mars Sample Return and to explore the "ice giants" Uranus and Neptune. **Earth observation** has a wide-ranging portfolio including, sea surface temperature measurement providing one of the primary datasets for monitoring climate change. There are also strong programmes in atmospheric chemistry, monitoring pollution, and land-use, including forestry and the effect of forest fires and the loss of peat in ecosystems.

In **space engineering**, there is a large focus on detector systems for instruments together with optical system design and X-ray optics. This is supported by a broad electronic and mechanical

engineering programme. The X-ray optics programme, in recent years, has provided telescopes for three major space missions – BepiColombo, SVOM and SMILE. Other major projects supported are the ESA MIRI instrument on the James Webb Space Telescope (launched 2021), and the Raman Laser Spectrometer on the ESA ExoMars rover (2028 TBC). There is related expertise in the Schools of Engineering, Computer Science and Mathematics, and Business that can support the engineering, design and build of space systems, instruments, payloads and missions varying from radiation hard by design embedded systems through to advanced manufacturing techniques, materials modelling, software engineering, use of artificial intelligence techniques and space policy and law. This expertise is being increasingly applied to both space mission design, concepts and joint studies with industry via the **Research England UKRPIF METEOR research programme** as part of **Space Park Leicester** as well as supporting other research.

Space Park Leicester (SPL) was formally opened in March 2022. It contains new state-of-the-art flexible workspaces, including offices, meeting rooms, teaching space, workshops, laboratories and a large ISO-6 cleanroom. A key aim of SPL is to facilitate collaboration between academia and industry by allowing co-location of space businesses alongside the university research community. The facilities are open to anyone, through competitive rental agreements and a range of bespoke solutions to suit collaborator and business requirements. Some 25 companies have already chosen to become part of **Space Park Leicester.**

There is a long track-record of **building and operating data centres** for space missions, including ROSAT, XMM-Newton and Swift. This expertise along with data analysis and exploitation is being enhanced by contributions from Computer Science and Mathematics in big data and Artificial Intelligence applications via the METEOR programme.

Training and outreach activities cover the full range from primary schools through to post graduate (both MSc and PhD) and Continuing Professional Development. In addition to our long established and internationally respected undergraduate courses in astrophysics and space science, we have been involved in the development of new apprenticeship routes into the space sector, leading to the introduction of Level 4 (Space Technician) and Level 6 (Space Engineer Degree) apprenticeship training programmes. A new range of professional training courses is also planned for launch in late 2023, designed to provide targeted learning in space systems engineering, regulations, and applications, providing an essential grounding in space-specific topics for those entering the sector. All of these training activities exploit the unique environment and range of technical capabilities at Space Park Leicester to provide learners with an experience that prepares them for work in the rapidly expanding space sector.

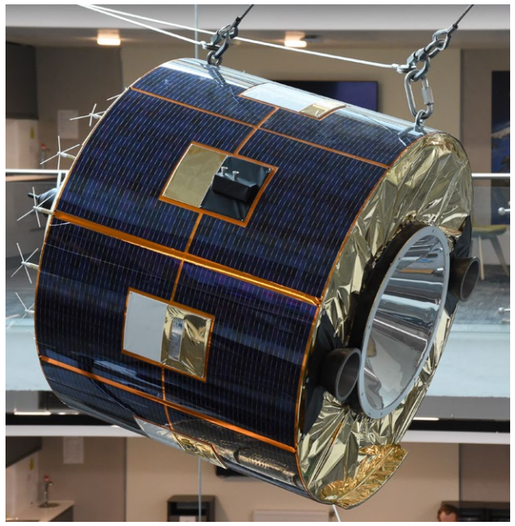

Image: Meteosat Scale Model. Space Park Leicester.

Since it opened in March 2022, the Space Park Leicester is now home to **25 companies**

Loughborough University

There are three research clusters where Loughborough's expertise can contribute to upstream space technologies: Systems design and robotic servicing for modular space craft; Materials and manufacturing processes for extreme environments; Digital design and Hybrid additive manufacturing for space craft structures and RF antennas.

Our world-leading systems design experience is coupled with expertise that can address **in-service monitoring and repair strategies** for extended service life, autonomous inspection and repair robotics for modular space craft, supported by a comprehensive, advanced industrial robotics laboratory. With applications including robot welding, grinding, inspection and metrology, specialising in advanced materials innovation, extensive product design and engineering design, resources support production, inspection and characterisation of functional parts in a variety of materials including ceramics, metals, polymers and composites, Loughborough has a unique capability in **engineering for extreme environments.**

We have extensive expertise in the development of **advanced functional surfaces** for military, aerospace and space applications. This work is supported by large volume metrology and non-destructive testing capabilities to support manufacture and remanufacture of reusable launch vehicles and parts. There is specialist expertise in **digital design and manufacturing**, including design for additive manufacturing (3D printing) and other forms of digital fabrication including joining, composites and advanced coatings; and the use of **virtual and augmented reality** (VR/AR) to support manufacturing, including **digital twins**. We have extensive product design and engineering design resources including a wide variety of computer aided design simulation and analysis software and multiple research laboratories and prototyping facilities capable of designing, manufacturing, inspecting and characterising functional parts in a variety of ceramic, metal, polymer and composite materials including ultra-high temperature ceramics for re–entry.

Space-related activity is supported by facilities that include a suite of surface analytical techniques provided by Loughborough Materials Characterisation Centre (LMCC) and a dedicated Materials Degradation Laboratory which has facilities to undertake electrochemical coatings research as well as corrosion studies in various environments.

The Centre for Autonomous Systems develops attitude and control systems for spacecraft and surface rovers. Additionally, our robotic assembly/disassembly knowledge, coupled with machine vision, can assist assembly of complex space vehicles while also being applied to quality assurance and reducing the cost of vehicle manufacture/remanufacture. We have expertise in **photovoltaics**, solar resource modelling, solar energy materials and tandem solar cell design. Our solar energy and solar resource research include long-term changes and trends, and tandem and multijunction solar cells using improved materials and alternative architectures. We also work with human factors where our physiologists and ergonomists have expertise in environmental extremes and protective clothing.

Loughborough has world-leading expertise in **RF antenna research.** Specialisms include additive manufacturing of microwave components, and the design, test and fabrication of microwave antennas and lenses used in the space sector. This work is supported by a range of facilities, including anechoic chambers for testing of antennas from 1GHz through to 50GHz, a vector network analyser test kit to characterise microwave components' performance, equipment to assess the microwave properties of materials, and a range of 3D printers capable of using a wide variety of materials within the additive manufacturing labs across campus. Additive manufacturing (3D Printing) laboratory facilities are available including selective laser melting (metals and ceramics), selective laser sintering (polymers), stereolithography (polymers and ceramics), material extrusion (polymers and inks) and 5-axis hybrid fibre-reinforced composite 3D Printing.

University of Nottingham

The University of Nottingham has historic strengths in Global Navigation Satellite Systems (GNSS), astronomy, materials and manufacturing for space, Earth Observation (EO) for engineering, environmental and human rights endeavors, and space medicine, shaping national and international policy in these areas.

Satellite navigation and positioning systems: Satellite orbit and clock modelling, GNSS receivers, orbital dynamics, multi-constellation precise point positioning, applications and signal propagation. GNSS and EO applications include uses in precise orbit determination, structural health and integrity monitoring, transport, Uncrewed Air Vehicles and precision agriculture. Recent activity includes work on trans-Lunar navigation and high precision GNSS. **EO work:** multi-spectral imagery, hyperspectral and thermal data, InSAR, and Super-Resolution analysis. **Remote sensing activities:** identification of hydrocarbon and geothermal resources, detection of natural offshore oil seep and monitoring of ground motion to understand the related hazards and the role of groundwater. We have expertise in image classification and enhancement methods to increase data quality, including optimal extraction of information relating to terrestrial and freshwater ecosystems. Including mapping peat conditions in Scotland and Southeast Asia and identification of slavery locations to support efforts to put an end to modern slavery.

Space Medicine: evaluating the **spaceflight effects on human and worm muscle health** to improve our understanding of metabolic changes. This includes molecular muscle experiments on-board the International Space Station to test if specific signals control the reproducible gene expression changes observed in space, and to confirm that worms could be cultured in space for long enough to reach Mars (24 generations). We also assess the evolution of life and molecular evolution in space and the health effects of space tourism. In **Astropharmacy**, we work with the National Aeronautics and Space Administration (NASA) to develop methods for on-demand, on-site manufacture of biopharmaceuticals in extreme environments. This includes research on assessing and redressing the effects of spaceflight on the human body and materials. **Astrofarming** and **space food** work are used to promote physical and mental wellbeing.

Materials and Manufacturing: testing materials for space, in-space manufacturing, assembly and repair operations, autonomous robotic processes, artificial intelligence and smart integration. We complete computational full field 3D electromagnetic simulations that are suitable for application to all areas of the spectrum from static problems through to optical frequencies and SACAMOS, a cross platform set of Open-Source software tools for the development of cable models for satellite applications. We have system dynamics and control expertise, focusing mainly on worst-case analysis of launcher ascent trajectories and robust control theory. Our additive manufacturing processes allow us to reduce the mass and thermal properties of space systems as well as produce novel antenna for spacecraft. We are developing lightweight fluorescent sensors to monitor bioprocesses in space environments in real time.

Space system design: mainly focused on (but not limited to) small satellites, including mission analysis and design, satellite systems analysis, design and implementation, AITV activities, in orbit operations, interplanetary missions, deployment mechanisms, including innovative methods for CubeSats, PocketQubes, TubeSats and advanced manufacturing technologies. We have space debris know-how including observation and mitigation. We have a ground station for satellite communication.

Astrophysics research: cosmology and extragalactic astronomy, from studies of the large-scale structure of the Universe to understanding the formation and evolution of galaxies using the Hubble Space Telescope amongst other space missions. We tackle these fundamental problems using a variety of approaches, from detailed studies of galaxies in the local Universe through to evolving galaxies at intermediate redshifts and finally by observing the most distant galaxies in the process of formation. Complementing our observational effort, theoretical/numerical expertise provides the vital context for our observational programmes, from numerical studies of galaxy and structure formation through to studying the physics of the intergalactic medium and the cosmic web.

Top image: The dynamic test vehicle (train) on top of the Nottingham Geospatial Institute building.
Bottom image: Molecular Muscle Experiment team at launch, including staff from the University of Nottingham.

University of Warwick

The University of Warwick has a range of research and development activities in space:

The university's **Satellite Engineering Programme WUSAT** has 17 years of experience in designing, building, launching and operating small satellites to European Space Agency standards. This includes training engineering students to work to high standards of Space Systems Engineering in their approach to WUSAT missions. We work widely with industry and can trial research and/ or industrial technology on 'proof of concept' missions where possible. We are also keen to pursue the development of technology that can assist conservation/ sustainability activity where possible, including within the Space environment itself, for example, minimising space debris, developing knowledge of testing, evaluation, space compliance of satellite subsystem units/ payloads, for flight readiness. The Centre for Space Domain Awareness (CSDA) draws on cross-university experience and expertise to tackle issues relating to the safety and sustainability of satellite operations in the space domain.

The Physics Department has an extensive track record in space-related areas such as observational techniques, extrasolar planets, space debris and astrophysics. Warwick leads the science preparation for the ESA PLATO mission (launch 2026). We have also developed a separate activity of space debris (detection, characterisation, orbital determination) and in the future, most likely through collaboration, mitigation through spacecraft design. We lead the **Global Network of Sustainable use of space (GNOSIS)** which is an STFC funded network connecting academics with industrial partners. Space-related research include; space weather, plasma physics, nuclear fusion, complexity, nonlinear systems, heliospheric physics, and Earth climate change.

Warwick Engineering and Warwick Manufacturing Group have wide ranging expertise that is of direct application to manufacturing of space systems and subsystems, including multiscale modelling, functional materials and finite-element simulations. Capabilities also include power electronics, radiation hardening of devices, electric propulsion and satellite power supplies. There is related activity in **energy storage technologies for space and extreme environments** and prototyping and testing of energy storage systems.

We have considerable expertise in innovative manufacturing and future materials, including silicon carbide. Major initiatives are underway to direct this resource towards space technology manufacturing requirements **focusing on materials and manufacturing processes for extreme environments as well as low-cost manufacturing**. Capability in materials applications include ceramics, polymers, biomaterials, cryopreservation, diagnostics, infection and glycol-biology. A particular strength is low temperature science working with polymers to control ice formation and growth, which is major problem across all areas of space science (for example ice on fuel tanks), to preserving biological samples for space-based research and storing for long-term space exploration.

Increasing reliance on robotic activities and AI in space requires robust and secure systems. Warwick research covers computational work related to communication, security, protocols, reliability and trust. Work that translates readily into space-based applications in both upstream and downstream activities include security of sensor systems, secure software design, secure systems design, cyber security testing, securing data networks, security of autonomous systems. An important theme is trust-based task offloading from resource constrained devices such as those used in space systems.

> "The university's **Satellite Engineering Programme WUSAT** has 17 years of experience in designing, building, launching and operating small satellites to European Space Agency standards.

Image: WUSAT Team++ at Airbus, Stevenage, November 2022. Airbus visit four, University of Warwick.

Table 1. Summary of Midlands Innovation space and space-related expertise

Area of expertise	Aston	Birmingham	Cranfield	Keele	Leicester	Loughborough	Nottingham	Warwick
Advanced materials	x	x	x		x	x	x	
Aerospace engineering		x	x		x	x	x	x
Agriculture			x	x	x	x	x	
AI/Augmented reality		x	x		x	x	x	
Antenna						x	x	
Astrophysics		x		x	x	x	x	x
Data processing and informatics			x	x	x	x	x	
Defence		x	x		x	x		
Earth observation/ Environment		x	x	x	x	x	x	x
Electronic systems					x	x		x
GNSS		x	x			x	x	
High performance computing				x	x	x		
In-service monitoring and repair			x			x		
Laser physics	x					x		
Machine vision						x		
Management			x		x	x		x
Manufacturing		x	x		x	x	x	
Metrology					x	x	x	
Non-linear physics	x							
Optics	x		x		x			
Orbital mechanics			x		x		x	
Pharmacy				x			x	
Photonics/ Biophotonics	x		x					
Planetary exploration			x		x			

Area of expertise	Aston	Birmingham	Cranfield	Keele	Leicester	Loughborough	Nottingham	Warwick
Robotic assembly			x			x		
Space economics, law and policy					x			
Space instrumentation		x			x		x	x
Space nuclear power					x			
Space plasmas		x			x			x
Space system design			x		x	x	x	x
Telecomms	x	x	x			x	x	
Transport		x	x	x	x	x	x	
Water			x	x	x	x	x	

Table 2. Summary of Midlands Innovation space and space-related equipment/ facilities

Facilty/equipment	Aston	Birmingham	Cranfield	Keele	Leicester	Loughborough	Nottingham	Warwick
3-D scanners				x		x	x	
Additive manufacturing		x	x		x	x	x	
Advanced design tools			x		x	x		
Anechoic chambers		x				x	x	
Antenna test lab					x	x	x	
Autonomous aerobot test environment			x			x		
Autonomous vehicle test ground			x	x				
Cleanroom	x	x	x		x	x		x
Concurrent design facility					x			
Dynamics and control lab						x		
Electronics workshop		x			x	x	x	
ESATAN thermal modelling			x		x			x
Glasshouse			x					

Facilty/equipment	Aston	Birmingham	Cranfield	Keele	Leicester	Loughborough	Nottingham	Warwick
GNSS recorder		x	x				x	
GNSS simulator		x					x	
High-speed communications test equipment	x							
HPC		x		x	x	x		
Laser welding			x					
Lasers	x					x		
Light sources					x			
Long beam line					x			
Mechanical workshop		x	x		x	x	x	x
Mobile positioning test lab							x	
Multi-sensor positioning testbed							x	
Optical characterisation	x				x		x	
Optical spectrum analyser	x							
Photonics lab	x		x					
Physiological sensors						x		
Positioning test track							x	
Propulsion test cells			x		x	x		
Soil simulation			x					
Solar environment test						x		x
Surface analysis tools			x		x	x		
Thermal Vac.		x			x			
Ultraprecision machining/ metrology			x		x	x	x	
Vacuum bakeout		x			x			
Vacuum coating			x		x	x		
Vacuum test					x			x

Facilty/equipment	Aston	Birmingham	Cranfield	Keele	Leicester	Loughborough	Nottingham	Warwick
Vector network analyser		x	x			x		
Vibration table			x		x		x	x
Wind tunnel			x		x	x	x	x

Table 3. Census of staff across the MI partnership engaged in space-related activity

Area of activity	Aston	Birmingham	Cranfield	Keele	Leicester	Loughborough	Nottingham	Warwick	Total
Space programme staff	90	95	41	17	190	40	48	41	**562**
Business Development		3	10		10	4	2	4	**33**
PhD students	40	30	10	18	115	40	48	38	**339**
TOTAL	**130**	**128**	**61**	**35**	**315**	**84**	**98**	**83**	**934**

Staff breakdown:

- Aston University (Aston Institute of Photonic Technologies) : 10 academics, 70 researchers, 5 technicians/ engineers, 5 management/admin.
- University of Birmingham: 45 academics, 30 researchers, 10 technicians/engineers, 10 management/support.
- Cranfield University: 37 academics, 4 technicians/engineers.
- Keele University: 16 academics, 1 researcher.
- University of Leicester: 81 academics, 71 researchers, 19 technicians/engineers, 19 management/support.
- Loughborough University: 20 academics, 15 researchers, 5 technicians/engineers.
- University of Nottingham: 28 academics, 13 researchers, 5 technicians/engineers, 2 management/admin.
- University of Warwick: 12 academics, 3 researchers, 16 technicians/engineers, 10 management/admin.

PhD students:

- Cranfield University: 10 space PhD students within a community of ~150 aerospace doctoral researchers.

Table 4. Training opportunities – space and space-related

Training opportunities	Aston	Birmingham	Cranfield	Keele	Leicester	Loughborough	Nottingham	Warwick
Apprenticeships	x				x			
Undergraduate	x	x		x	x	x	x	x
Masters	x	x	x	x	x	x	x	x
Postgraduate Research	x	x	x	x	x	x	x	x
CPD			x		x		x	

MIDLANDS INNOVATION

Collaborate with us

For more information about the Midlands Innovation Space Group, or if you are interested in working with us, please contact Sue Clayton at: **info@midlandsinnovation.org.uk**

Find out more

midlandsinnovation.org.uk/space

About Midlands Innovation

Midlands Innovation is a world-class research and innovation partnership, combining the collective excellence of leading universities in the heart of the UK. We unite the power of university research with the unique strengths of Midlands industry to drive cutting-edge research, innovation and skills development.

Aston University BIRMINGHAM UK

UNIVERSITY OF BIRMINGHAM

Cranfield University

Keele UNIVERSITY

UNIVERSITY OF LEICESTER

Loughborough University

University of Nottingham UK | CHINA | MALAYSIA

WARWICK THE UNIVERSITY OF WARWICK