ARC UNIVERSITIES
AND SPACE

The Open University

OXFORD — CAMBRIDGE
ARC
UNIVERSITIES GROUP

“The UK has a thriving space sector and as well as being a science superpower, we want to lead the world in space technology....From artificial intelligence to advanced tracking systems, the UK space industry is leading the way in developing ground-breaking solutions to worldwide problems.”

Rt Hon Amanda Solloway MP, Parliamentary Under Secretary of State (Minister for Science, Research and Innovation)

“By 2030, the space sector could be worth £40bn per year to the UK economy.”

Stuart Martin, CEO and Executive Director, Satellite Applications Catapult

The space sector in the UK has trebled in size since 2000, enjoying a 5.1% share of the total market (equivalent to £14.8bn). It is thriving and growing continually thanks to first-class universities, cutting-edge technology, pioneering companies, and strong government support.

Department of International Trade, 2020

Prosperity from Space (Space Growth Partnership, 2018), has set out a vision to double the value of space to wider industrial activities from £250bn to £500bn over the next decade, generating an extra £5Bn in exports, attracting £3Bn inward investment, and creating up to 15,100 new “green jobs” by 2030.

UK Space, 2020

FOREWORD

"Space is the final frontier. It excites curiosity as we look up at the night sky. But more, it's a domain that will soon become more a part of our daily lives and livelihoods, providing the jobs for our future. The Oxford-Cambridge Arc hosts a number of universities with highly advanced capabilities in space research and education, as well as links to adjacent drone and aerospace technologies. The economic potential of this cluster is enormous.

Working together, we can realise the potential of the space sector to bring growth and employment. Investment in space technology is therefore one of the Arc's key priorities. The Arc Universities, working alongside government, the Satellite Applications Catapult and industry, are using space science to deliver advances in artificial intelligence, machine learning, robotics, and quantum applications. This will create skilled employment in new industries, and opportunities for doctoral and academic research that attract major research funds to the Arc.

For many, the word 'space' evokes images of rockets, astronauts and inter-planetary missions. But space touches our daily lives, from our satellite navigation systems and the technology that drives our mobile phones, to the entertainment that appears on our screens at home.

Space technologies can also achieve much social good, enabling us to monitor food and water security, predict storms and hurricanes, track climate change, and predict extreme weather events. As one of our most distinguished space scientists at The Open University, Professor Monica Grady, puts it... "We explore space to solve problems back on earth."

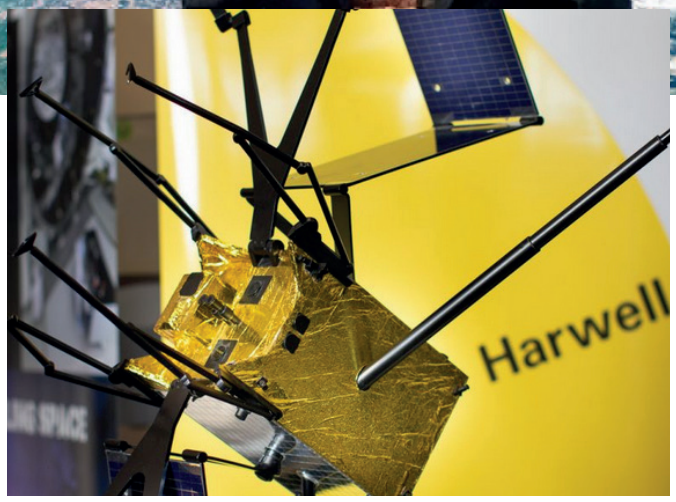
The Open University, widely respected for its capability in this field of science, has led the way in many fields of space research, education, and innovation. We have also brought our discoveries of new planets, findings from our instruments on missions such as the ExoMars mission, and our work on the possibility of humans living and working on the Moon, to millions of people who watch our TV programmes with the BBC or study on our courses. Through initiatives such as the national SPace Research and Innovation Network for Technology (SPRINT) programme, we are able to commercialise our research expertise to the benefit of the Arc economy.

We are therefore delighted, on behalf of all the universities in the Arc, to support this report, which aims to illustrate the significant potential in this area."

Professor Tim Blackman,
Vice-Chancellor, The Open University

With thanks to the Open University for leading on this report; to Prof Kevin Hetherington, Prof Monica Grady and Dr Gemma Maldar at the Open University; to all those who contributed to the study from the universities of the Oxford-Cambridge Arc; to those from the LEPS and other organisations; and to Ceri Evans and Alistair Lomax for editing.

The Oxford-Cambridge Arc is home to the Harwell Campus, with its cluster of space companies including the HQ of the Satellite Applications Catapult, with advanced proposals to develop Westcott Venture Park in Buckinghamshire, as a centre of excellence for research and development in rocket propulsion. The combined result will be the most intensive space cluster in Europe. The UK Space Agency is also supporting small satellite launch facilities in Scotland and Cornwall.



The potential application of the research capability in the Arc is wide-ranging: satellite data and connectivity applications in addressing environmental challenges; med-tech, life sciences, digital health, and digital communications for agri-tech and energy. Geospatial technologies and data are underpinning decision-making processes in both government and business and are increasingly recognised as key in helping to mitigate climate change. Space technology is set to perform a pivotal role in the delivery of a low carbon future.

Space-based technologies, such as remotely sensed data and satellite technology, can effect real change for the region and across the globe – enhancing our understanding of water cycles, air quality, deforestation and other aspects of the natural environment, as well as for agri-tech, satellite communications, and climate change.

RECOMMENDATIONS

1. TO DEVELOP AN ARC-WIDE VISION FOR THE UK SPACE SECTOR

An Arc Space Working Group would foster collaboration between those involved in space: business, the Satelite Applications Catapult, business, LEPs, and the academic community.

2. TO SET UP AN ARC SPACE WORKING GROUP

This will encourage closer collaboration, leading to the development of major funding bids – for example, to the Industrial Strategy Challenge Fund or other national Innovate UK strategic calls. The group will support UK-wide collaborations and knowledge exchange programmes (e.g. SPRINT). Together we will deliver innovative and collective solutions.

3. TO DEVELOP AND DELIVER A SKILLS STRATEGY TO PROVIDE THE FUTURE SKILLS AND TALENT NEEDS OF THE EMERGING SPACE SECTOR AND RETAIN TOP TALENT IN THE ARC

Universities and colleges across the region can raise awareness in the next generations about the many employment opportunities that can support the expansion of the space sector. The universities will also build upon existing links with the space clusters at Harwell and Westcott by launching a joint Doctoral Training Centre in Space Science and Engineering.

4. TO SUPPORT A DEDICATED SPACE PROTOTYPING AND SCALE-UP PROGRAMME

The Arc Space Working Group will work with the Satellite Applications Catapult , and others, on the development of future facilities to support innovation, drawing from emerging technologies across the Arc, such as AI and autonomy, high value manufacturing, and propulsion.

EDUCATION, SKILLS, AND RESEARCH

The Open University (OU) has significant impact on the space sector, with a rich history of involvement in high profile programmes such as the Rosetta Mission, Beagle 2, and Cassini Huygens. The University is world renowned for planetary exploration, electronic imaging, lunar science, and astronomy. The recently formed astrobiology group is leading in planetary protection and governance and is working internationally with developing countries. The University has an excellent track record in the translation of space research into terrestrial applications, is growing its expertise in microgravity, and is driving new initiatives in Earth and Environmental Sciences. Further related areas of research exist in space law, governance, and evaluation of the socio-economic benefits of space exploration.

THE OPEN UNIVERSITY

The OU continues to be involved in many ESA and UKSA initiatives covering a broad range of space research, including the ProSPA mission to the Moon, the Nomad instrument on the ExoMars mission, and Martian atmosphere modelling.

A long standing collaboration with Teledyne-e2v, The Centre for Electronic Imaging and the OU's expertise in research into image sensor technology, has led to involvement in high profile missions answering fundamental questions in universe evolution (ATHENA, EUCLID, THESEUS), galaxy formation (Gaia), and the search for life on other planets (JUICE). Alongside these astronomy missions, the group also plays a leading role in the development of new Earth observation initiatives for plant ecophysiology (TreeView).

The University operates remote telescopes in Tenerife which are made accessible to students and collaborators through the award winning OPENSTEM laboratories. The OU also hosts a wide range of facilities available for planetary and solar system simulation, including a hypervelocity impact facility which allows the simulation of small-scale meteoroid impact. The materials testing and characterisation group (StressMap) enables key partnerships with the aerospace and motorsport industries.

OU astronomers work on everything from gravitational lensing of early Universe galaxies to finding potentially habitable planets orbiting the Sun's nearest neighbour stars.

Just as the University's space research spans the globe, its educational content also reaches millions worldwide through the co-production of programmes with the BBC and provision of free space educational content through award-winning open education platforms.

CASE STUDY
THE OPEN UNIVERSITY AND SPRINT

The Open University is a partner on SPRINT (Space Research and Innovation Network for Technology). SPRINT is a unique partnership of top UK space universities, industry, government agencies, and the investment community. The programme supports the growth of Small to Medium Enterprises (SMEs) in the UK to speed up the commercialisation of their technologies and services.

"SPRINT, funded by Research England and UKSA, provides companies with unprecedented access to expertise and facilities at top UK Space Universities, enabling businesses to accelerate their growth though collaboration.

One of the many benefits of SPRINT is the broad network of specialist know-how and facilities available in one place. The Open University has twelve collaborative projects in the programme, including projects that translate space research into other industry sectors.

The Open University expertise and facilities that have been involved in the programme so far include residual stress and materials characterisation (StressMap), analytical instrumentation, valve technology development, and Earth Observation for tree monitoring. In addition to benefiting SMEs, The Open University benefits from getting access to commercial data, know-how and additional collaborative partnerships in the future.

Space research takes place across a wide range of departments and groups at the University of Oxford, including Physics, Engineering, Computer Science, Earth Sciences, Geography, and the SAID Business School. The University has partnerships with the European Space Agency (ESA) and the Satellite Applications Catapult to translate solutions into economic and societal impact, and collaborates with space agencies and companies globally.

UNIVERSITY OF OXFORD

In terms of space research, the Physics Department has developed infrared radiometry and spectrometry for remote sounding with instruments for the Galileo Jupiter, Cassini Saturn, and Mars and Lunar Reconnaissance Orbiters, together with instrumentation for metrology, seismology and subsurface characterisation of planets. It has testing facility for space instrumentation and satellites and environmental chambers to simulate space and planetary environments, including a Mars wind tunnel. Oxford also has extensive experience of radiative transfer analysis and General Circulation Models for the atmosphere of the Earth and other planets. Astrophysics has groups working on cosmology, galaxies and black holes, stars and planets from theoretical, simulation and observational aspects. It also the hosts the zooniverse.org and Global Jet Watch citizen science platforms.

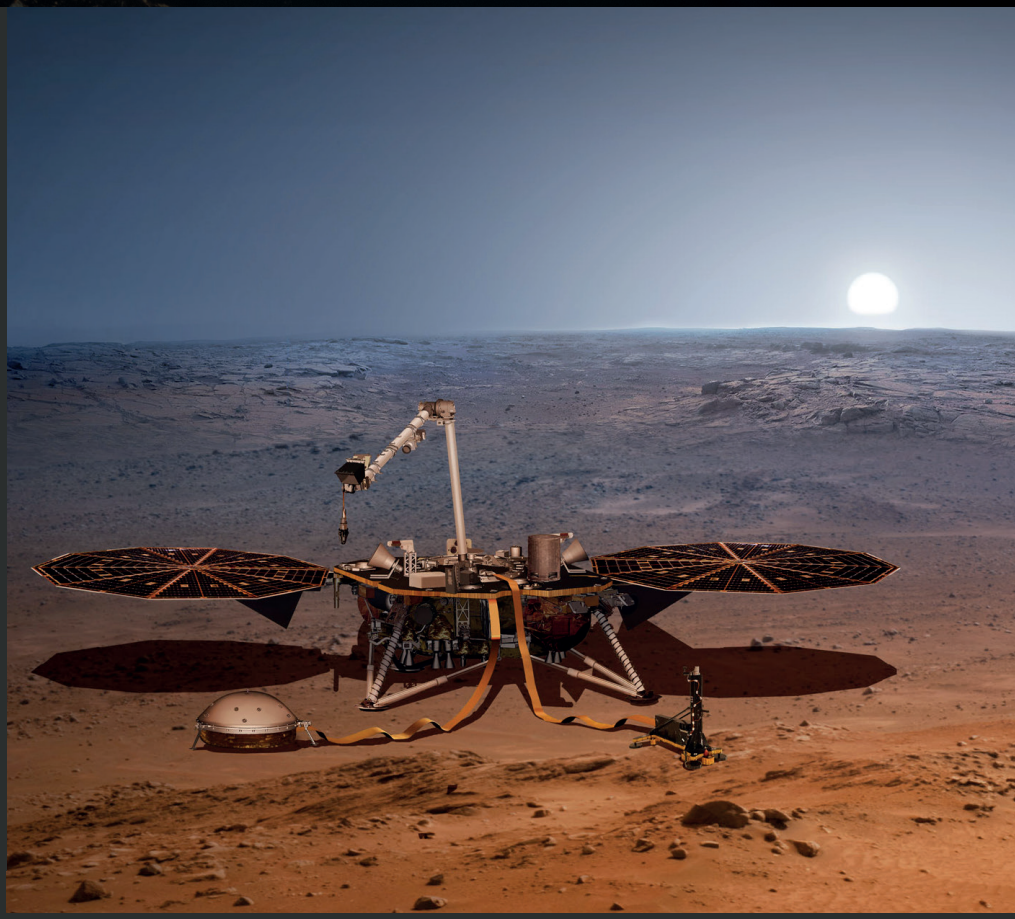
The University hosts unique space-related facilities, including the Infrared Multilayer Laboratory that has provided essential infra-red filter components to many space missions (earth observation, planetary, and astrophysics) as well as the ESA Frontier Development Lab (fdleurope.org), which applies AI technologies to space science to push the frontiers of research and develop new tools to solve challenges. This research accelerator is also in collaboration with NASA and global technology companies.

Oxford has extensive research and translation in AI and autonomy with space data and systems: Novel AI solutions on earth for extreme precipitation forecasting with climate physicists, earthquake fault identification with geologists, elephant tracking with zoologists, drought and flood monitoring with hydrologists and on-board AI processing for flood detection. Other spacecraft projects include modelling of constellation movements for collision avoidance, scheduling of space telescope movements, asteroid shape modelling for the Arecibo observatory, and Mars rover projects, including autonomous software for ExoMars rovers.

Other growing areas of space capability include photonics and optics, drawing on adaptive optics and beam steering capabilities, quantum technologies and computing, business innovation, understanding innovation ecosystems and processes for emerging and transformative technologies.

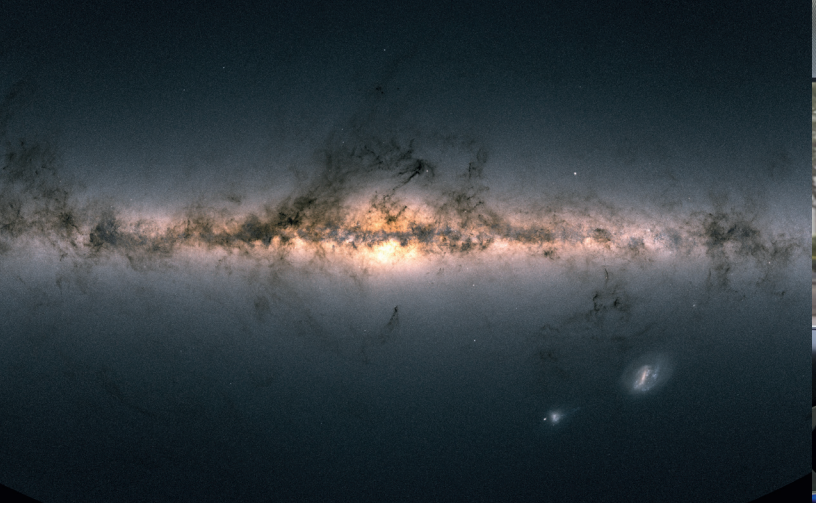
CASE STUDY
UNIVERSITY OF OXFORD AND NASA INSIGHT

The NASA InSight (Interior exploration using Seismic Investigations, Geodesy and Heat Transport) programme studies the deep interior of the Martian planet through a single, multi-instrument lander. The University of Oxford's Physics Department, in collaboration with Imperial College, RAL Space and the UK Space Agency, has been involved in the design and deployment of the NASA InSight mission on Mars.



The aim of the mission is to study how planets, moons, and meteorites with rocky surfaces formed. Oxford's team has primarily been involved in the design of the short period Seismometer (SEIS-SP), a key instrument to detect 'Marsquakes' and meteorite impacts.

Since successfully landing on the Martian surface in 2018, the instrument has detected and recorded more than 400 events, showing for the first time that the planet is still seismically active. The data is crucial to understanding the composition of Mars, as well as helping to trace its geological past.



The colour of the sky from Gaia's Early Data Release 3. Credit: ESA/Gaia/DPAC; CC BY-SA 3.0 IGO. Acknowledgement: A. Moitinho.

Professor Didier Queloz on the phone to the Nobel Prize organisation. Credit: Nick Saffell, University of Cambridge

UNIVERSITY OF CAMBRIDGE

THE UNIVERSITY OF CAMBRIDGE

Cambridge is active in a wide range of research and application areas relating to space. Nobel Prize-winning astrophysicist, Didier Queloz, leads the University's exoplanet research.

Many of the key ideas in modern cosmology and gravitational theory have emerged from the Department of Applied Maths and Theoretical Physics in the Centre established by Stephen Hawking. Nicholas Tosca, Professor of Mineralogy & Petrology is the only UK researcher to be part of NASA's core science team for the Mars Perseverance mission, looking for signs of past microbial life and environmental data within rocks collected on Mars. Meanwhile, Cambridge astronomers are leading an international team at the European Space Agency's Gaia Space Observatory which is busy mapping the Milky Way and has already established the position of nearly two billion stars.

Relevant expertise at Cambridge spans numerous disciplines including astronomy, maths, physics, computer science, engineering, and earth sciences. As well as making a significant contribution to our understanding and exploration of the space environment, Cambridge has deep research interests in the application of space science on earth. At the Centre for Earth Observation, for example, researchers are combining satellite and other sensing technologies with AI to monitor changes to the environment. A multidisciplinary team in the Department of Engineering is working with academic and industry partners, including the Satellite Application Catapult at Harwell, to exploit radar satellite technology to predict signs of failure in infrastructure assets. The UK Space Agency is funding a project using space telescopes to monitor the energy efficiency of buildings.

Cambridge's strengths in AI, robotics, computing, and sensors intersect in a number of areas that support wireless connectivity, particularly the development of space-based IoT networks. These strengths also combine with expertise in advanced manufacturing, industrial sustainability and supply chains to support innovation in space processes, from managing space debris to providing new solutions for satellite development.

THE SQUARE KILOMETRE ARRAY CAMBRIDGE UNIVERSITY

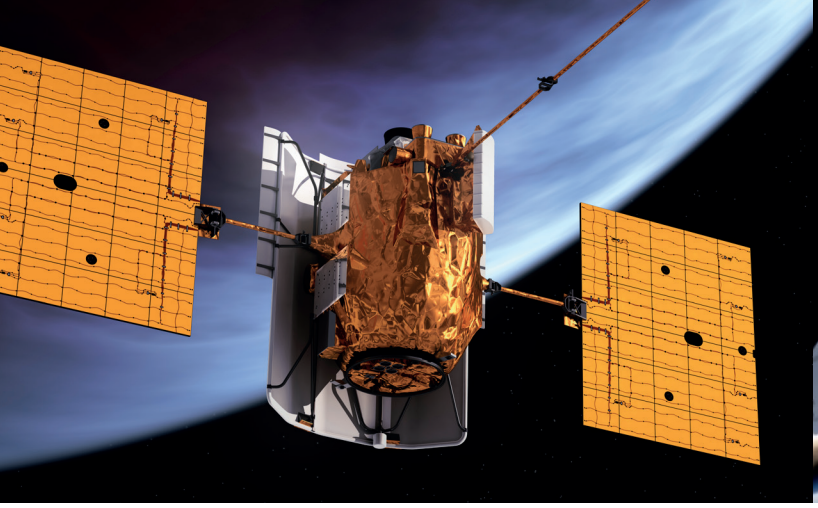
The SKA Science Data Processor: Image of a server rack.
Credit: SKA Organisation

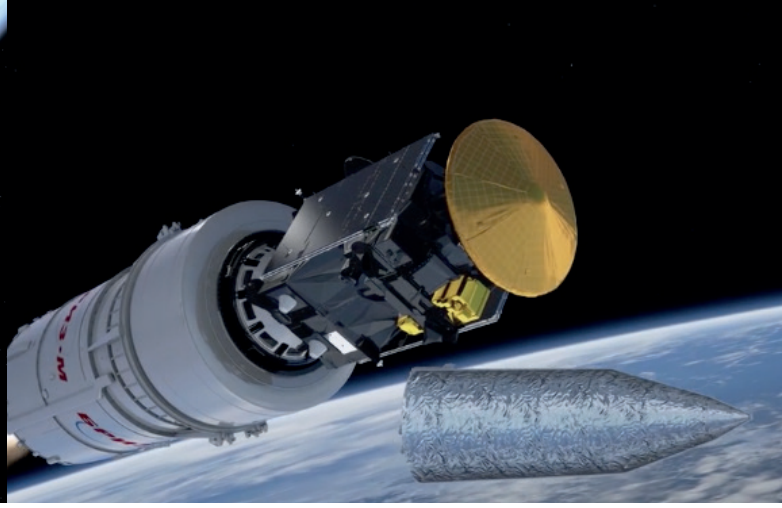
A Cambridge team, with expertise in high-performance computing, led an international group of scientists to design the Science Data Processor for the Square Kilometre Array (SKA), the world's largest radio telescope. The SKA will eventually have over a square kilometre (one million square metres) of collecting area.

The international consortium designed the elements that form the "brain of the SKA". Close to 40 institutions in 11 countries took part in this project including University College London, and the Universities of Oxford and Manchester. A number of the UK's Science Technology Facilities Council laboratories were also involved, including the Rutherford Appleton Laboratory on the Harwell Campus.

Close-up view of the SKA dishes and MeerKAT dishes in South Africa.
Credit: SKA Organisation

SKA will enable astronomers to monitor the sky in unprecedented detail and advance our understanding of fundamental scientific questions such as the nature of gravity and the origins of the universe. A better understanding of solar activity will also help us mitigate electric supply blackouts, satellite damage, and disruption to radio communications.





CRANFIELD UNIVERSITY

Cranfield's space research and teaching builds on its aerospace heritage. Its main activities are in space engineering and space system applications, 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. This includes emerging technologies such as artificial intelligence and machine learning.

Specific space engineering expertise includes:

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

Work spans world-class optical surfaces for space telescopes, designing future space missions for asteroid science or Earth observation, and cleaner agricultural systems using satellite data. Expertise across the University includes sustainability, manufacturing, autonomy, sensors, earth observation, aerospace and mission design, and propulsion.

Cranfield's ultra-precision engineering was chosen to manufacture the infra-red beam-splitter optical surfaces for the James Webb space telescope 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 the 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 (e.g. autonomous vehicles) which has been Cranfield forte, with access to world-class test facilities including the airport to support this research.

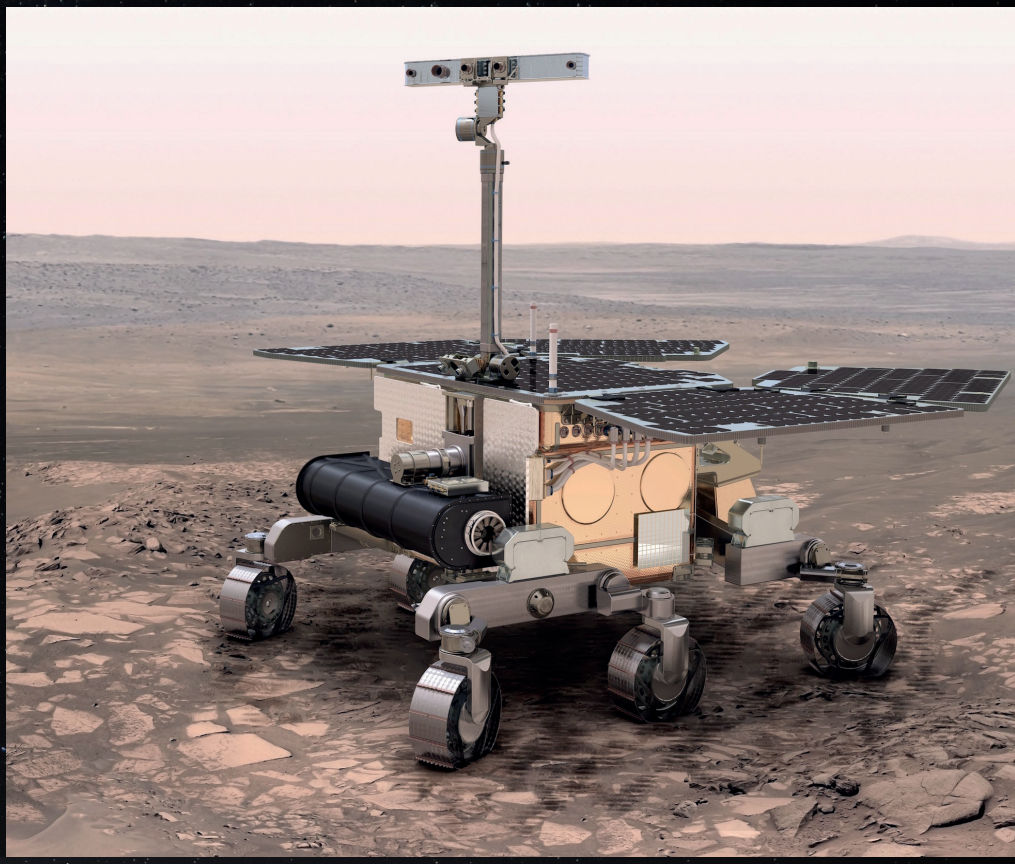
Cranfield leads the Hydroterra proposal for ESA, acting as the astrodynamics lead for ESA's Comet Interceptor mission, and the leading UK centre for the application of biosensors and biotechnology to space missions (building on sensor development for the ExoMars rover).

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

ESA ExoMars: OPEN UNIVERSITY/ UNIVERSITY OF OXFORD/ CRANFIELD UNIVERSITY

The European Space Agency's ExoMars project is a collaborative project involving partners from 16 European countries, four non-European countries and multiple industrial and academic partners. The ExoMars project aims to determine whether life has ever existed on Mars. It comprises of two mission phases - the first launched in 2016 and the second in 2020. The first mission searched for evidence of methane and other traces of atmospheric gasses which could indicate the presence of biological processes.

Academics from The Open University, University of Oxford, and Cranfield University were involved in designing multiple elements for the 2016 mission.



For further information, please visit:
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