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Science & Technology Facilities Council | UK Research and Innovation

RAL Space

Highlights 2018 – 2019

Science driven,
technology enabled

Science & Technology Facilities Council | UK Research and Innovation

RAL Space R100 building. Credit: STFC RAL Space

Welcome

As a science driven organisation with a long heritage in space technology development, it may come as a surprise that so many of our highlights over the last year have had such an impact directly here on Earth.

Space projects can take years to come to fruition, which means there is plenty of opportunity along the way to explore the benefits that technology developed for space can have as novel applications in other sectors.

For some of our projects here at RAL Space, this technology is already being used in industries from healthcare to geothermal energy. Whilst for some of our newest technologies, like the innovative research taking place in our Quantum Space Laboratory, this work is only just beginning.

Our robotics team have been working with landmine clearance organisations in Cambodia to explore how Mars rover technology can improve the safety and efficiency of their work.

While today's buzzwords are for "Big" data, here we are focusing on "good quality" data. The Centre for Environmental Data Analysis have been rolling out new interfaces to make it easier for researchers to access and use data.

Meanwhile, our test facilities have been busy and we're looking forward to opening the doors to the new National Satellite Test Facility and welcoming even more exciting missions on their way into space.

However, as always, our focus remains firmly on pushing the frontiers of space science and Earth observation research. Our Chief Technologist, Engineer and Scientist outline the projects and missions we're most excited about for the future, from solar weather monitoring to exoplanet exploration.

We couldn't achieve any of this without the extraordinary and committed people who make up RAL Space, some of whom have lent their voices to talk about their personal highlights. I hope you find them as inspiring as I do on a daily basis.

In the pages ahead, I invite you to think about the people behind the projects, because it is their bright ideas and innovative thinking that drive our ambitions in space and benefits us here on Earth.

Professor Chris Mutlow,
Director STFC RAL Space

Disrupting sectors beyond space with innovative technologies

Technologies developed for space can have unforeseen uses closer to home. At RAL Space, analysers developed for detecting trace gases in Earth's atmosphere are now bringing benefits in healthcare, the food industry and environmental monitoring.

Every molecule has a characteristic radiation absorption spectrum. By measuring this unique pattern of frequencies, the presence and the concentration of gas molecules can be determined. The laser analysers developed by RAL Space, operating in the mid-infrared, targets fingerprint patterns to allow remote or local analysis of chemical concentrations. The methods are highly sensitive to tiny traces of gases, offers high spatial resolution, and real time analysis.

Together with optical integration and miniaturisation technologies, RAL Space has developed high performance spectrometers for remote sensing such as the miniaturised Laser Heterodyne Spectro-Radiometer (LHR). Measuring just 6cm x 9cm x 5cm, these LHR can fit on the smallest of satellites and maintain performance in difficult conditions. This makes it ideal for adoption for terrestrial applications.

Breath tests are a cheap, quick and non-invasive diagnostic tool for some diseases and allergies. Mid-infrared spectroscopic laser analysers can detect minute differences in breath gas concentrations, which indicate certain medical conditions. The detail provided by these systems can provide vital information on specific organ functions not possible with other breath tests. One such analyser, developed at RAL Space, is currently being used in clinical trials in partnership with King's College Hospital in London to help diagnose sepsis up to two days earlier than traditional methods. As well as healthcare, this technology has been evolved and demonstrated for many other potential applications: remote detection of explosive devices from drones; measurement of gases at geothermal field sites to help with new clean energy initiatives; mapping and quantification of gas leaks from industrial plants to help reduce emissions; characterisation of volcanic systems; and the easy verification of country of origin for protected foodstuffs.

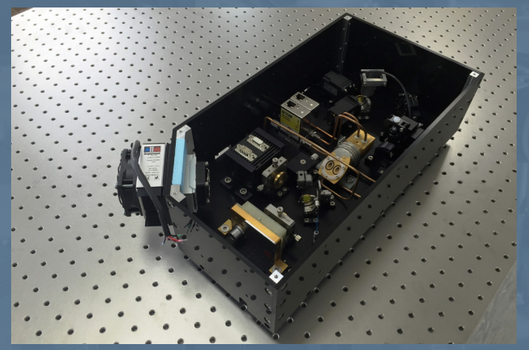
This technology is currently proposed for in-orbit demonstration. With tighter regulation on air quality and global climate change there is a growing demand for more accurate, reliable and versatile technology to monitor the atmosphere from space. The unique capabilities of the technology developed by RAL Space could provide data accurate enough to help attribute the source of gas emissions.

An STFC spin-out company, MIRICO, is exploring the commercialisation opportunities for this technology. The expert team of scientists at RAL Space continue to finesse this technology and apply scientific solutions to real world issues.

Laser spectroscopy facilities at RAL Space. Credit: STFC RAL Space

"Working with RAL Space has been a fantastic opportunity to use their expertise to benefit some of the sickest patients in hospitals. When patients have difficult to treat infections and need to come to intensive care units, they have a high risk of death. Earlier detection can save lives and a breath test that can be performed simply and cheaply at the bedside could greatly improve our ability to detect sepsis."
– Dr Mark McPhail, Senior Lecturer & Consultant in Liver Critical Care & Hepatology, Kings College London & Kings College Hospital

Spectroscopy research and development



RAL Space develops novel concepts and instruments for high-precision laser-based hyperspectral sensing, aiming to pioneer the development of the next generation of sensing systems. This encompasses blue-sky research, concept demonstration, technology maturation, application and prototype development, and instrument field deployment relevant to high precision in-situ sensing and remote sounding. A team of 10 scientists operate a fully equipped facility for high-resolution spectroscopy and collaborate with industry and academia within the UK and internationally.

Prototype demonstrator spectroscopic laser analyser. Credit: STFC RAL Space

Looking to the future: Professor Nick Waltham, Chief Technologist

"We are fortunate to be researching in an exciting time and environment of new technology ambitions. We have long-established and successful centres of expertise in **CCD image sensors** and **mm-wave technology** and are now enjoying new project opportunities. Excitingly, we have new prospects in emerging and novel themes. **Quantum technologies** are the talk of the town with applications in ultra-high precision gravity measurements, quantum communications and inertial measurement; all sponsored through significant UK Government funded programmes. We also have new initiatives in atmospheric chemical composition monitoring using the latest techniques in **laser heterodyne spectroscopic measurements**. Similarly, we are developing the next generation of **black body Earth observation calibration** systems using today's state of the art technology. We have exciting and significant opportunities ahead of us."

Credit: contains modified Copernicus Sentinel data (2017), processed by Sinergise/ESA

Building on our heritage in instrument development to advance understanding of climate change

The Earth Cloud Aerosol and Radiation Explorer (EarthCARE) is the European Space Agency's (ESA) largest and most complex Earth Explorer mission. It will investigate the relationship between clouds and aerosols and their combined effects on the Earth's climate system.

RAL Space has been a key player in the consortium to develop the Broad Band Radiometer (BBR), one of four instruments mounted on the spacecraft. It will look at both solar flux and thermal flux - measuring the temperature of the surface of the Earth, the cloud tops and the brightness of the reflected sunlight. These factors and their role in the Earth's climate system are some of the least understood when it comes to climate modelling.

The mission will provide scientists with the environmental data needed to more accurately monitor climate change and understand more about the processes involved.

BBR is comprised of three telescopes, calibration systems and detectors that cover the electromagnetic spectrum from ultraviolet to the far infrared. RAL Space is responsible for the optical, thermal, mechanical and electronics design for the telescope assembly.

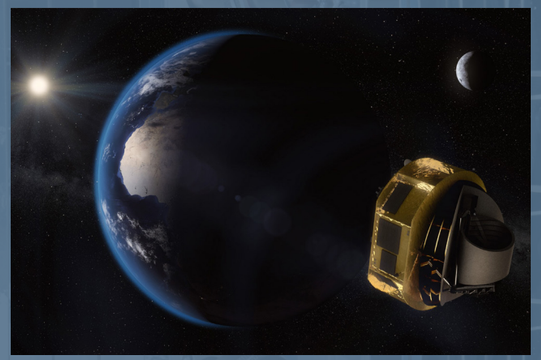
The project presented a number of technical and engineering challenges throughout its 10 year development. RAL Space's engineers were able to apply their extensive knowledge from more than 20 years of experience working on instruments for weather forecasting and climate science. In particular, the engineering expertise established through developing and building the Geostationary Earth Radiation Budget (GERB) instruments on each of the four Meteosat Second Generation weather-monitoring satellites, proved essential when it came to solving the engineering challenges of BBR.

Thales Alenia Space (TAS) in the UK led the design, construction and testing of the BBR. RAL Space were able to provide TAS UK with a wide-range of support on the project. The majority of the environmental testing, functional testing and instrument calibration for BBR were completed at RAL Space facilities. RAL Space collaborated closely with TAS UK to successfully deliver it for integration onto the spacecraft in 2018.

Broadband Radiometer telescope assembly at RAL Space. Credit: STFC RAL Space

"BBR was my first project after graduation. It gave me the opportunity to develop my skills as an engineer whilst working on a global spaceflight project collaborating with international organisations such as TAS, Airbus and ESA. This was the starting point to my career as a mechanical engineer specialising in spaceflight scientific instruments." *– Joe Hampton, Mechanical Engineer at RAL Space*

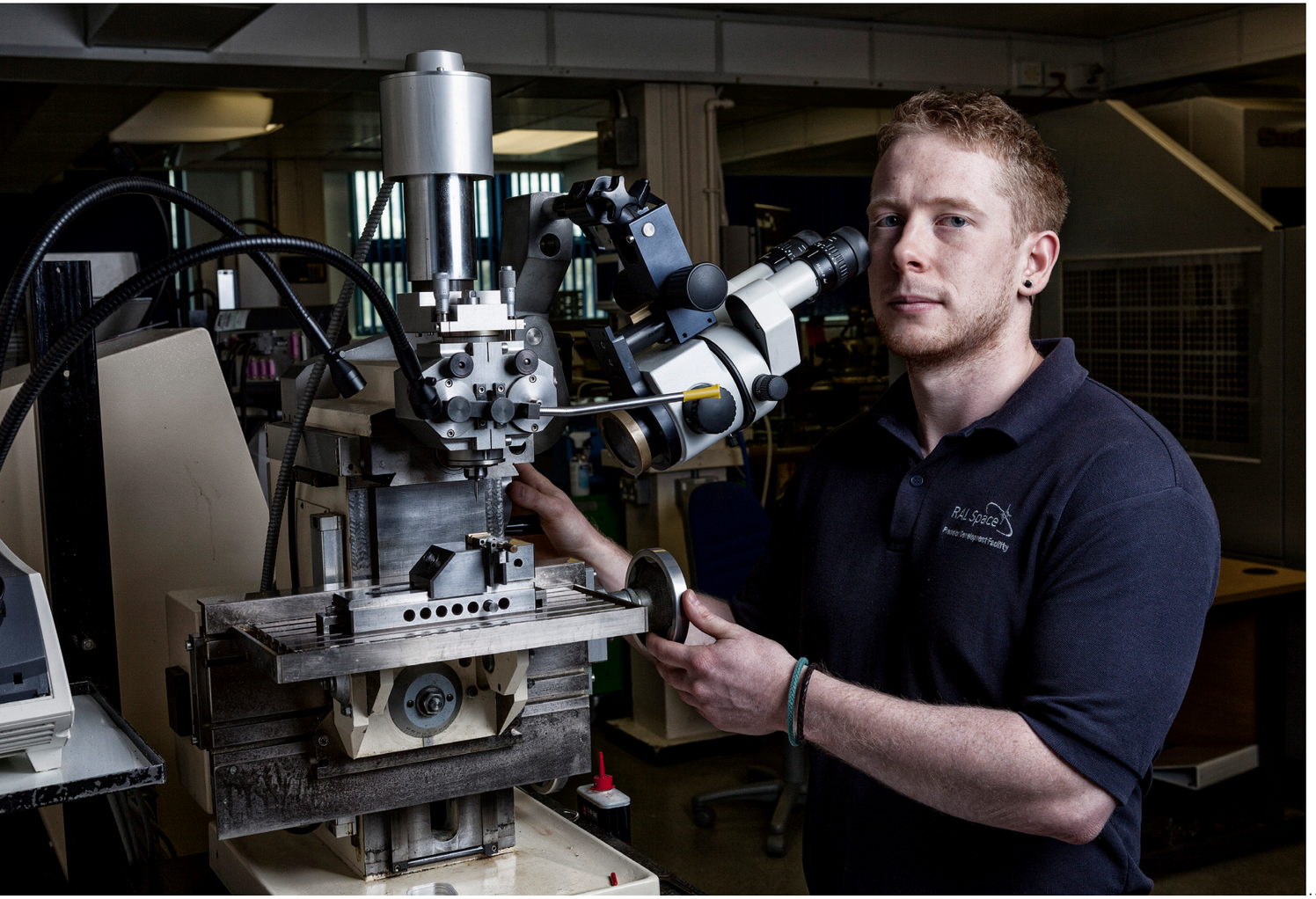
Scientific and technological expertise



With significant involvement in more than 200 space-borne instruments in the past 50 years, RAL Space has an extensive heritage in the development of scientific instrumentation for space. An expert team of research scientists lead concept studies for future missions, which are then brought to life by in-house skilled engineers. RAL Space provides the full life cycle of a space project ranging from pre-feasibility study through design, manufacture, assembly, integration, test, calibration and operations support.

Artist's impression of exoplanet mission ARIEL. RAL Space is providing consortium project management.
Credit: ESA/STFC RAL Space/UCL/Europlanet-Science Office

Luke Bushnell, at work in the Precision Development Facility. Credit: Gatsby - Technicians make it happen



Route to RAL Space – Luke Bushnell, Assembly Integration and Test Technician

Apprenticeship: STFC Rutherford Appleton Laboratory Apprenticeship 2009-2012
Higher National Diploma: Best Project Award from Newbury College
Experience: 9 years working in the space sector

I started at RAL on the apprenticeship scheme when I was 16 and worked my way through different departments and built up my profile to become a mechanical engineer. I then worked full time in the Precision Development Facility of RAL Space as a CNC machinist for 4 years before applying for a job in the Assembly Integration and Verification group. My main role is to work in the cleanrooms, assembling instruments and pieces of equipment that we'll eventually bolt onto satellites.

My work is extremely important because it helps the Earth and mankind. One job I'm working on at the moment is the Sea and Land Surface Temperature Radiometer project which is an instrument used for weather and forest fire monitoring. Knowing that instruments and pieces of equipment that I put together with my own hands are actually flying above us with the purpose of helping humanity is amazing.

The best piece of advice I can give to get a job like mine, is never turn down any opportunity. Every opportunity, whether it be at school or visiting different places around the world, or even seeing different companies, is always an opportunity for you to find an area that you might enjoy or a way of actually entering that industry. Hard work and determination tends to prevail if you haven't always got the grades.

Testing satellites to help get the latest ideas off the ground

The UK's environmental test facilities are meeting the growing demand for high quality testing services to get new ideas into space.

Space is a harsh environment. Satellites endure the violence of a launch, unfiltered sunlight in the vacuum of orbit and extreme temperature differences in passes between light and shadow. Therefore, rigorous testing procedures and facilities that can simulate these conditions are a necessity to ensure mission success.

RAL Space's test facilities support space qualification of hardware, instrumentation and spacecraft for UK and overseas customers.

In 2018 RAL Space managed seven major campaigns in its thermal vacuum facilities. These included completing calibration for the Broadband Radiometer for ESA's EarthCARE satellite and thermal testing on a structural model for the Sentinel-5 air pollution-monitoring mission. These essential tests have enabled projects to progress to the next stages in preparation for the instruments to go into orbit.

The vibration test facility saw a 66% increase in use compared to that of 2017. This has included the testing of mechanisms, imaging systems and deployable and static components for large and small space companies and universities.

In addition to the facilities in Harwell, RAL Space is hosting a website repository signposting all UK space testing sites and other space facilities. It has been established to help companies across the UK find the facilities they need. There is a growing demand for this kind of support and for the facilities run by RAL Space. The Harwell Space Cluster has witnessed a significant growth, with 800 staff working across 80 companies and the wider UK space sector is growing at 6.5% each year. This means an increased need for testing facilities, reflected in the repertoire of space test campaigns RAL Space have managed on behalf of customers over the last year.

The UK Space Agency's Facilities Review 2017 identified the need for expanded and enhanced test facilities to enable further growth in space manufacturing. As a result, RAL Space is building the National Satellite Test Facility, a world-class set of co-located environmental test facilities at the heart of the Harwell Space Cluster.

The £99 million facility, funded from the first wave of UKRI's Industrial Strategy Challenge Fund (ISCF), will allow the space sector to build and test larger (up to 7 tonnes) and more technologically advanced satellites within the UK, thereby helping UK space companies to be more competitive in the rapidly expanding global market for space technology.

Sentinel 5 Structural Thermal Model in the thermal vacuum chamber at RAL Space. Credit: Airbus DS

"I came to RAL Space during the final year of my RAL apprentice scheme. During my time here I have been involved in a variety of exciting opportunities. I have had the chance to work with the space team in completing the installation of two new vacuum vessels. I have also worked closely with the vibration team simulating various rocket launch tests to make sure components will survive these conditions. I was really made to feel part of the team here and am proud to say I was offered a full time role here at the end of my time as an apprentice." *– Connor Sandiford, Facilities Technician at RAL Space*

"Upon finishing my electrical engineering apprenticeship through the STFC scheme I have recently started a technician role at RAL Space. This is a fantastic opportunity for me, learning all about the world of space hardware testing and getting involved with the build of the two new 5 metre vacuum chambers we have on site. With the build of NSTF underway I cannot wait to see what the future brings." *– Max Rippington, Facilities Technician at RAL Space*

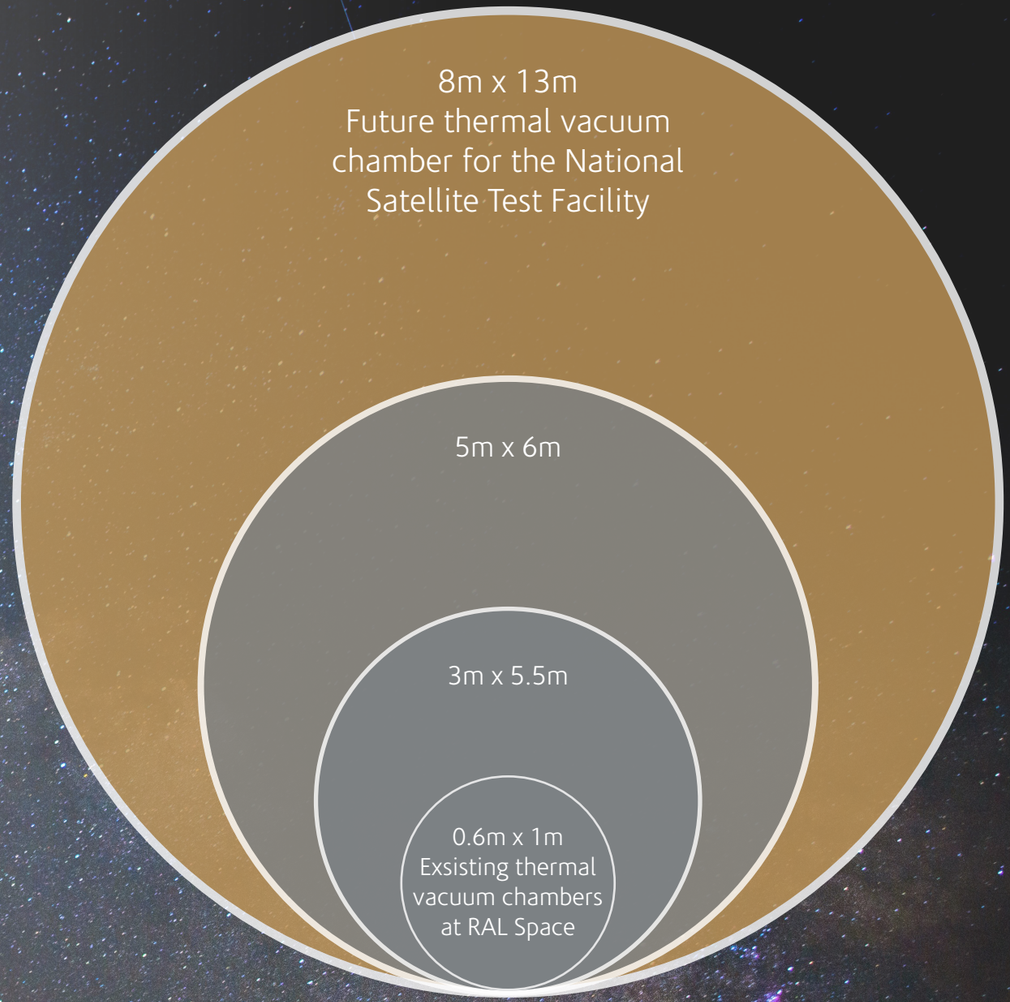
National Satellite Test Facility (NSTF)

Artist's impression of the National Satellite Test Facility. Credit: STFC RAL Space/ Mace/ IBI

The NSTF will be a vital part of the innovative UK space ecosystem, providing the right facilities, run by the experts, to all space organisations on a commercial basis. The NSTF will comprise a full suite of co-located environmental test facilities including, separate horizontal and vertical vibration shakers, direct field acoustic testing, EMC chamber, centre of gravity and moments of inertia, clean rooms for satellite preparation and the UK's largest space test chamber. The NSTF is being built with future phases in mind and can be extended to house additional bespoke test facilities to meet the ever-evolving demands of the UK space industry.

Looking to the future: Paul Eccleston, Chief Engineer

"We are developing and delivering exciting instruments and systems to support measurements and research across a wide range of areas. Our teams are taking the ideas of our scientists and turning them into a reality. They are developing designs for the **next generation of instruments** for monitoring such diverse things as space weather, the changes in the chemistry of the Earth's atmosphere, the temperatures of the land and ocean surfaces, and for studying planets around other stars. We continue to prototype, produce and test model hardware for the **detector systems** on the next generation of meteorological satellites; we have been **building and testing systems** for missions to the Moon and Mars and we provide test facilities and calibration support for instruments for the Sentinel programme. The detailed design and procurements of key test systems for the **National Satellite Test Facility** has continued apace in preparation for the building to start to take shape next year. It is a very busy but rewarding period for the team with many new projects in the pipeline."



Credit: Pixabay

Developing partnerships to address global challenges

RAL Space has led a collaborative effort to investigate how technology developed for Mars exploration could be used by landmine clearance organisations to help save thousands of lives on Earth.

An estimated 110 million active land mines still exist globally. Landmines and unexploded ordnance are a legacy of war and conflict in developing countries. In many areas, contamination prevents children from going to school, blocks aid deliveries and deprives citizens of their livelihoods.

RAL Space worked with Cranfield University and Fardoulis Robotics to explore how to adapt existing space technology to carry out safer surveys of landmine contaminated areas. It is estimated that one mine clearer is killed and two are injured for every 5000 successfully removed mines[2]. More efficient remote surveys could reduce the risks to people when clearing mines and unexploded ordnance.

The project, funded by the Global Challenges Research Fund, looked at how to adapt existing drones, robotic systems and sensors into tools for safer landmine surveying. Space technology is built for hazardous environments. It has to be resilient, autonomous, simple to repair and, crucially, operated remotely. Existing lightweight, versatile robotic systems designed to move over uneven terrains for space exploration could be easily adapted for the unpredictable landscape of landmine contaminated areas.

Cambodia currently has an estimated 1638km^2 area of land that is contaminated by landmines[3] and unexploded ordnance. The team established partnerships with leading mine action organisations in Cambodia including the Cambodian Mine Action Centre, the UN's Development Programme, the Cambodian Mine Action and Victims Assistance Authority and other international non-governmental organisations.

This study has resulted in a better understanding of these organisation's operating environment, priorities and challenges. Expertise gained locally has been used to identify priorities for collaboration on future projects and to ensure that any technologies developed would be usable by the local Cambodian community.

Space technology alone is not the answer to the world's development goals. But with strong local partnerships, robust rover technology and knowledge sharing, there could be major improvement in the safety, speed, efficiency, and quality of the land-release process from mines.

1. United Nations, Assistance in mine clearance: Report of the Secretary-General, document A/49/357, United Nations, 6 September 1994, p. 7.

2. Webpage. Source: http://www.landminefree.org/2017/index.php/support/facts-about-landmines

3. CMAA, "Concept Paper: Cambodian Mine Action Resources Mobilisation," 2016

Teams using manual detection techniques for mine detection and clearance in Laos. Credit: John Fardoulis

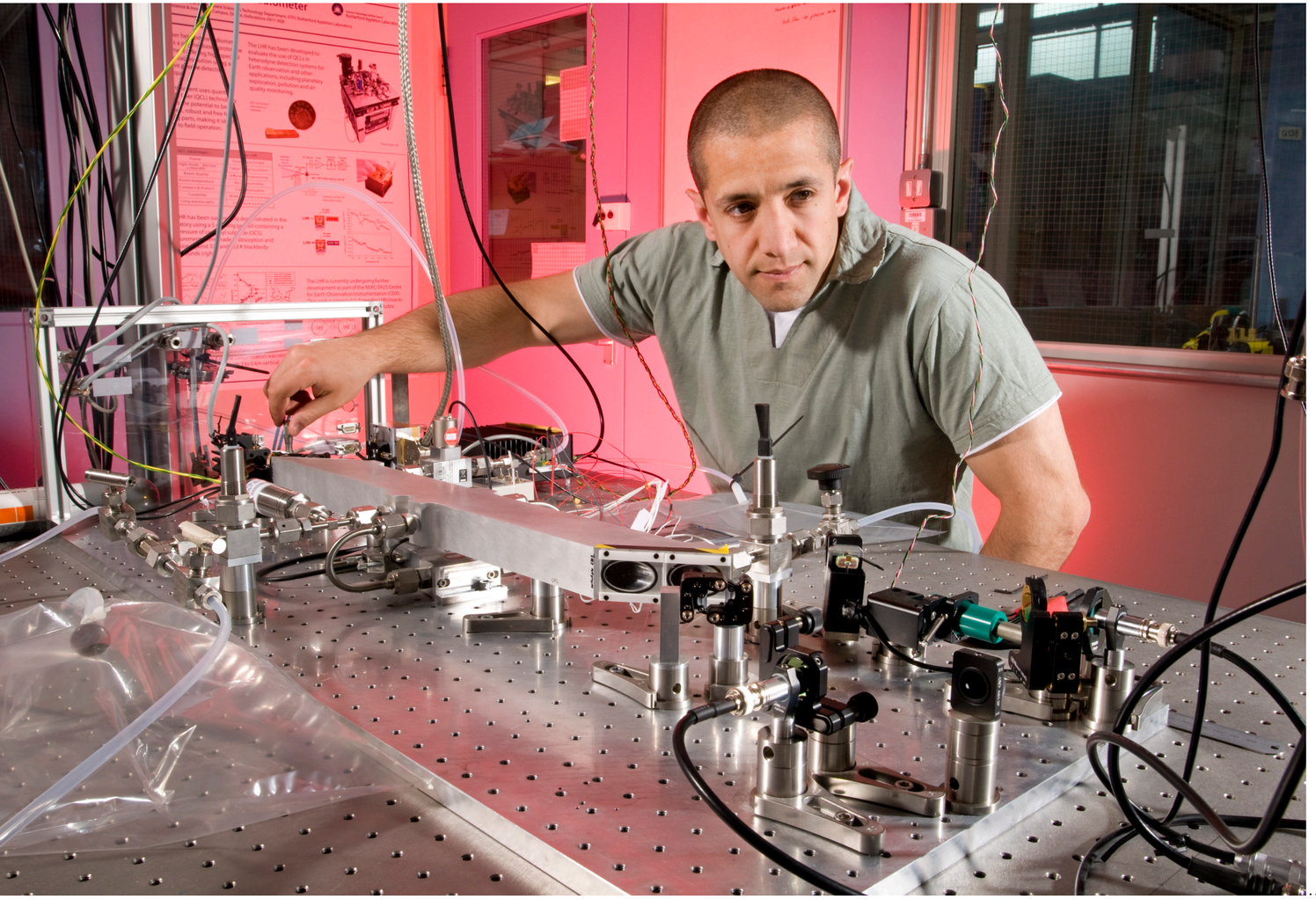
"We welcome expertise from the United Kingdom to help improve processes in the humanitarian demining sector through the development of ground robotics, unmanned aerial vehicles (drones) and improved remote-sensing techniques."
– Prum Sophakmonkol, Secretary General of the Royal Government of Cambodia.

Research for international development

RAL Space's medium size, low cost rugged instrumentation platform. Credit: STFC RAL Space/ Steven Kay

The Global Challenges Research Fund is a £1.5 billion UK government fund aimed at ensuring that UK research takes a proactive role in addressing challenges faced by developing countries. It is one of several initiatives that RAL Space is a part of which strengthen technology and science partnerships between the UK and developing nations. RAL Space have been working on projects to give farmers in sub-Saharan Africa the data to better manage their land and to develop instruments which could help monitor biodiversity in the Amazon rainforest. For each of these, building strong local and interdisciplinary partnerships have been vital for forming appropriate solutions together.

Dr Ali Hussain in the laser spectroscopy laboratory at RAL Space. Credit: STFC RAL Space



Route to RAL Space – Dr Ali Hussain, Optical Instrumentation Physicist

Undergraduate and Masters: Physics, University of Southampton
Doctorate: Physics, University of Bath
Experience: 9 years working in the space sector

I am an optical instrumentation physicist. I design and develop new prototype instruments, using light from the deep ultraviolet to far infrared to derive properties of matter.

There is a growing human impact on the world and I am developing instruments to acquire results that help decision makers manage and reduce this impact. My work is to explore the feasibility of hyperspectral imaging for plant species discrimination. Last year I took a prototype spectrometer to the Amazon as part of a Global Challenge Research Fund pilot study. The main research site was a remote geoglyph, an ancient earthwork created by the indigenous people of Brazil. Insect repellent wasn't effective, flies were landing in my eyes and ants were crawling on the spectrometer but it was a fantastic experience. This project is important because it could help address biodiversity change in a region that is of considerable concern to Brazil and internationally because of its high biodiversity and significance to global climate.

In my job at RAL Space, I am turning ideas into a reality to make a positive impact on global challenges. I get to work on something new that no one else has worked on before, solving challenges along the way, and applying my knowledge and skills where it matters. For example, for the CO_2 instrument I developed when I first started here, I intentionally misaligned my optical system, to achieve perfect beam balance. It's like making a 3-point shot in basketball in windy conditions. You intentionally shoot the ball away from the hoop but the wind moves it in.

Curating quality environmental data for our science community

RAL Space's Centre for Environmental Data Analysis (CEDA) is revolutionising access to large datasets for scientists studying our planet.

JASMIN, a supercomputer and data store for the environmental science community can now store 44 Petabytes of data - equivalent to over 10 billion photos. Since it was established, JASMIN has been at the leading edge of the big data phenomenon. The volume of information, coupled with JASMIN's infrastructure, opens new scientific horizons into exploring our interaction with the Earth and its atmosphere.

Keeping UK researchers at the forefront of the data revolution requires not just big data but good data. This means storing bigger and more complex datasets in a smart way so that it is easy for researchers, organisations and individuals to use and understand. CEDA is a champion for best practice in data formatting, standardisation and consistency, carefully curating the data it stores in order to maximise the use and re-use of these valuable datasets.

Searching for data collected on moving platforms, such as research aircraft, can be difficult. Researchers often do not know exactly where or when a flight took place, or what instruments were operated. CEDA developed a Flight Finder tool for the EUropean Facility for Airborne Research in Environmental and Geo-sciences (EUFAR). The tool helps maximise discovery, access and re-use of data collected by the many European environmental research aircraft.

Users can refine their search geographically, temporally or using keywords to identify particular flights or scenes of interest. The results are displayed on a user-friendly map interface, linking directly to data within the CEDA archive. The flight-finding tool currently includes data from more than 2000 flights.

Once proven, the concept was adapted and reconfigured to also facilitate the discovery of satellite data in the CEDA archives via a new CEDA Satellite Finder. This enables geographic and temporal search capability for over 4.9 million scenes from Sentinel 1, 2, 3 and Landsat 5, 7, 8.

CEDA ensure that the community can tackle today's big data challenges: huge data volumes of highly variable data, arriving at and needing processing at increasing velocities, all the while ensuring their veracity for the long-term. This work ensures scientists looking at some of the planet's biggest environmental challenges have all the information they need, right at their fingertips.

Sentinel-3 Credit: ESA-Pierre Carril

"The Flight Finder and Satellite Finder tools developed at CEDA have widened access to these valuable datasets. This ability to easily identify, locate and co-locate flights or scenes in specific geographic areas or timeframes has really expanded the reuse potential of this unique flight data beyond the original project teams to support research into our weather and climate." – *Wendy Garland, Senior Data Scientist at RAL Space*

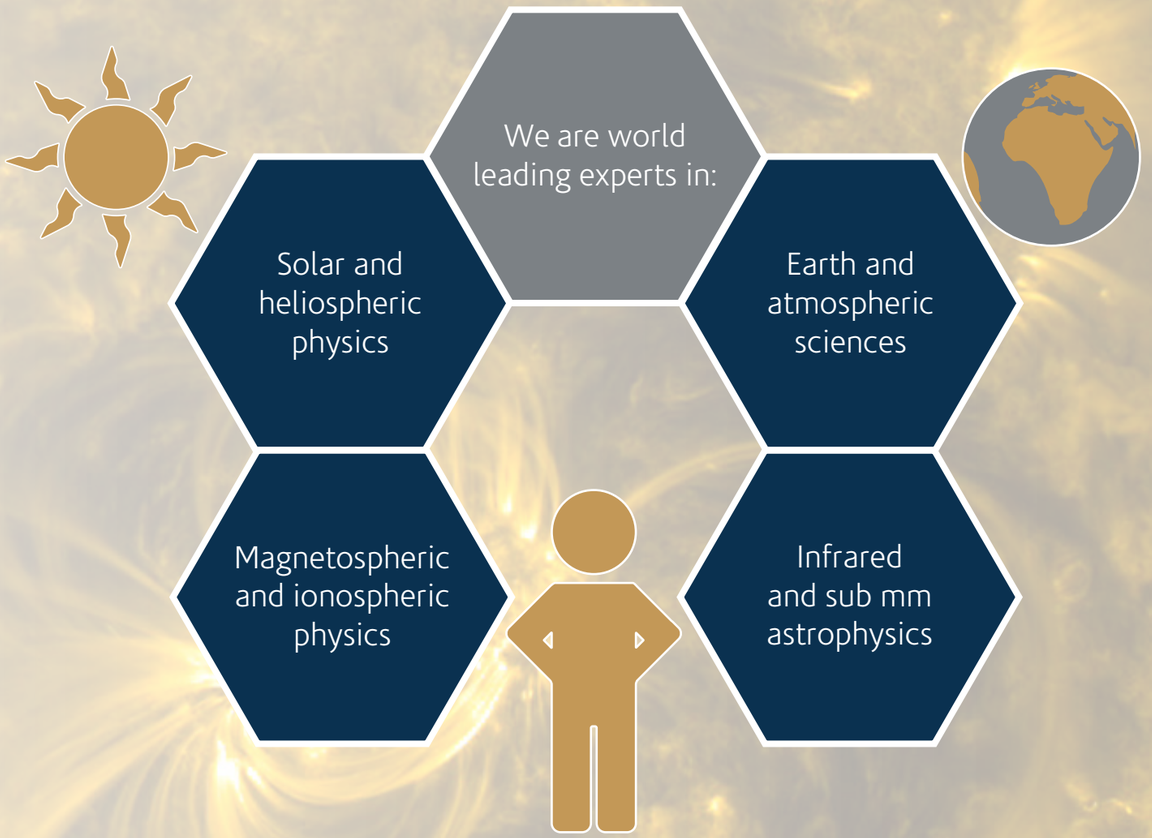
Centre for Environmental Data Analysis archive

The JASMIN supercomputer and data store jointly managed by STFC's RAL Space and Scientific Computing Department. Credit: STFC

As part of RAL Space, CEDA serves the data needs of the Earth observation and atmospheric science research communities on behalf of the Natural Environment Research Council. CEDA hosts an archive holding vast heterogeneous data from sources including, but not limited to: aircraft campaigns, satellites, automatic weather stations and climate models. The CEDA archive currently holds 9 Petabytes of data, in over 185 million files and is used by researchers, businesses and the general public.

Looking to the future: Professor Richard Harrison, Chief Scientist

"Our scientific strengths continue to provide unique opportunities for future space projects, enabling an innovative programme of space science and Earth observation projects for the UK. In 2020 ESA's **Solar Orbiter** will start its journey to study our star and its environment. We're eagerly anticipating the launch in 2021 of the NASA/ESA **James Webb Space Telescope** – a huge infrared astronomical telescope to follow on from the Hubble telescope. We're currently developing the ESA **ARIEL** mission alongside University College London which will study exoplanets. In the field of Earth observation and atmospheric sciences, we are continuing to support the science community as we expand and enhance **JASMIN**, the NERC supercomputer and data store alongside our colleagues at the Scientific Computing Department. We are in the early stages of bringing the **Lagrange** mission to life. This mission will monitor the near-Earth space environment, exploiting lessons learnt from past solar missions, as part of ESA's programme to mitigate the impacts of space weather on Earth. We are working closely with the national and international scientific community to look ahead to the science missions which will answer the big questions of the coming decades."



Dynamic magnetic connections on the surface of the Sun. Credit: Solar Dynamic Observatory/ NASA

Advancing novel quantum technology for space

Strategic support from RAL Space is helping to translate the outputs of the world leading UK National Quantum Technologies Programme for use in space and accelerate the application of these game changing devices.

New quantum technologies have the potential to make orders of magnitude improvements in sensing, computing and communications. The UK is at the forefront of efforts to develop quantum technology staking a claim in the emerging market, said to be worth up to £1 billion[4] to the economy, which will transform a range of sectors including defence, finance, energy and telecommunications.

RAL Space has responded to the growing need to translate quantum technology for use in space by establishing a Quantum Space Laboratory. These state-of-the-art facilities are available for partners across the UK to test their technologies. The laboratory is already collaborating with 11 organisations including universities, research centres and SMEs in the development and qualification of quantum technologies.

As the UKs national space laboratory, RAL Space experts have supported PhD students in the Quantum Space Laboratory to develop the skills and experience needed to grow the quantum research field.

Besides providing a vital new facility and support to the community, RAL Space scientists are researching and developing the next generation of sensors based on the quantum properties of ultra-cold atomic gases. This includes sensors to precisely measure variations in the Earth's gravity from space, which will be used to build 3D maps of the density of material around them.

This new technology is vastly more accurate than existing technologies like sonar or ground penetrating radar. However, cold atom gravimeters are currently too large, too heavy and too fragile for satellites or even for use beyond the laboratory. RAL Space are working to miniaturise the technology, making it robust and compact enough for space.

By taking measurements of mass from space, quantum gravimeters could provide climate scientists and policy makers with an accurate map of global sea level change; enable environmental managers to precisely measure water volume in rivers to assess and avoid flooding; and even help archaeologists uncover the secrets of human history.

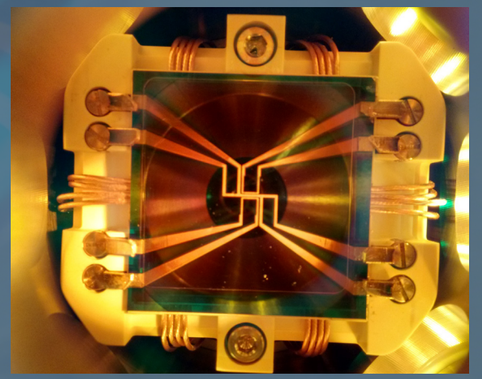
As well as sensor development, the Quantum Space Laboratory is playing an integral role in the development of QKD Qubesat, a small quantum communications satellite. This innovative mission is a collaboration between RAL Space and the Centre for Quantum Technology (CQT) in Singapore to test the next generation of ultra-secure electronic information transfer using quantum key distribution from space. Once proven, it will provide secure communications and have a significant impact on everyday life, from mobile banking to smart home devices.

4. A Roadmap for Quantum Technologies in the UK – UK Quantum Technologies Programme. EPSRC UKRI

Atom Chip for Atom Interferometer. Credit: STFC RAL Space/IQO Hannover

"Having access to quantum-secured communication is a smart step for cybersecurity. We already have trials over fibre for secure communication within Singapore, building on CQT's decade of development of this quantum technology. Reaching into space with our UK partner is a strategic move towards global data security." *– Dr Artur Ekert, Director of Centre for Quantum Technologies*

The RAL Quantum Space Laboratory



Atom Chip for Atom Interferometer. Credit: STFC RAL Space/ IQO Hannover

RAL Space has established a laboratory to help reduce the barriers to space qualifying quantum technologies. The laboratory aims to reduce the risk, time and cost of making existing technologies ready for space by providing a place for industry, SME's, research institutes and academia to collaborate on next generation technologies. The Quantum Space Laboratory houses the accurate lasers, cooling systems, photon-counting detectors common to the development of all quantum systems. It also provides users with access to RAL Space engineering teams and support, access to business support and incubation facilities as well as opportunities for ground, airborne and on orbit demonstrators.

Roisin Speight at work in RAL Space. Credit: STFC RAL Space

Route to RAL Space – Roisin Speight, Systems Engineer for Spacecraft Instrumentation

Undergraduate and Masters: Aerospace Engineering, University of Southampton
Graduate programme: Airbus Defence and Space
Experience: 10 years working in the space sector

I like to describe being a systems engineer as being the hub of a bicycle wheel. You're surrounded by your team who are working on detailed disciplines - Mechanical Engineer, Thermal Engineer, etc. These are people doing very specific work and specific tasks. The Systems Engineer brings all these people together and helps to trade off different elements and to build a connection between the different roles.

For me I think the space industry has so many important and inspiring aspects. There's the functional aspect, helping us to communicate more efficiently. Then there's the science aspect, trying to answer some of the big questions that inspired and excited you from a young age. I think it's great that it's an industry that inspires people, but also helps society function as well.

If you want to work in the space industry, you can, no matter what your background. The "traditional route" would be to finish school and then study science or engineering at university or through an apprenticeship if you don't think university is right for you. There are so many different areas of space that people can get involved in - if you're passionate about it there will be a place for you!

Students from the Science Summer School taking part in a RAL Space workshop. Credit: elizabethnorden.com

Tackling the skills gap to encourage the workforce of tomorrow

RAL Space is dedicated to inspiring the future space community through an extensive outreach programme that maximises the impact of our knowledge, skills and facilities.

The UK space sector faces a skills shortage, making it increasingly important to enthuse students from all backgrounds with STEM subjects. In 2018, only 12% of engineers and technicians in the UK were women and only 8% were from black and minority ethnicities[5].

In 2018, RAL Space worked with the St Paul's Way Trust (SPWT) Science Summer School, an annual two day event to inspire the next generation of engineers and scientists. Over 400 students from schools in the SPWT Partnership in Tower Hamlets took part. Two thirds of the population of the borough are from minority ethnic groups and the Summer School dedicated a day exclusively to female students, providing them with exciting scientific experiences and opportunities.

RAL Space worked with the Alexander Whitley Dance Company to run student choreography workshops which explored solar physics and Earth observation through movement. Incorporating the Arts is an important way of engaging students with STEM subjects who might not otherwise be interested.

Outreach projects like this help make a positive difference, with 67% of students at SPWT going on to study STEM subjects at university.

Through events like these, RAL Space inspires the next generation of scientists, engineers and technologists who provide world-class skills vital for the continued growth of the space sector.

"The arts and sciences have more in common than first meets the eye. The processes that scientists and artists use to evaluate, assess and understand the world around them are almost identical. It is the interpretation of these findings that differs, and art can provide an interpretation that brings science to life. This dance collaboration adds another dimension to our relationship with the sciences." *– Dr Hugh Mortimer, Research Scientist at RAL Space and scientific advisor to the Alexander Whitley Dance Company's production of "8 Minutes".*

5. Engineering UK: The state of engineering, Engineering UK, 2018

Aerial view of RAL Space and the Harwell Campus. Credit: STFC