Summer 2011 Issue 32

space:uk

Building a new Hubble: massive new space telescope takes shape

Big plans for small satellites

UK spaceplane: inside the research labs

Plus: News from the UK Space Conference, broadband from space, Arctic adventure for ice mission scientists and UK in space pull-out poster

UK SPACE AGENCY

Contents

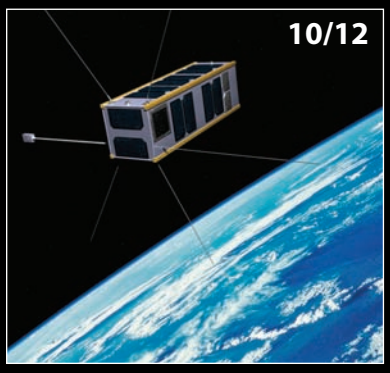
From the editor

For a journalist, space is one of the most exciting areas of science to report on. From stars being devoured by black holes or the latest images sent back from Mars, to a complex new spacecraft taking shape or the exploits of astronauts on the International Space Station. But the things I find most exciting at the moment are nothing much to look at: satellites the size of a shoebox. And these nondescript 'CubeSats' could be the future of space exploration.

Just like the TARDIS, it's not what's on the outside that matters but what you can cram inside. UKube-1, for instance, is packed with five substantial experiments including an entire satellite within a satellite. You can read more about this fascinating project on page 10. Some people are likening these tiny spacecraft to the development of the computer – not so long ago computers filled entire rooms, now we all have our own. Could we be entering the age of the personal satellite?

Told you it was exciting.

Richard Hollingham
Editor



Credit: Astrium UK

Credit: NASA, Chris Gunn

Credit: Reaction Engines

Front cover image: Hubble image of a pair of interacting galaxies called Arp 273
Credit: ESA, NASA

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Testing MIRI

Credit: ESA, NASA

Hubble, seen here attached to the Space Shuttle's robotic arm during its servicing mission in 2008, will be a tough act to follow

A key instrument for the next generation space telescope, the UK-led MIRI, has successfully reached the halfway stage of its three-month test campaign at the Science and Technology Facilities Council's Rutherford Appleton Laboratory (RAL) in Oxfordshire.

Destined for Hubble's replacement, the James Webb Space Telescope, MIRI (Mid-InfraRed Instrument) is a pioneering camera and spectrometer. It will be able to observe star formation and search for planets in the coldness of space after the telescope launches in 2014.

Forty scientists from the 11 participating countries are involved in the rigorous tests at the RAL space test chamber, including MIRI European Principal Investigator Gillian Wright. She told *space:uk* she was "delighted" at the progress so far, especially since the instrument operates at extremely low temperatures (7 Kelvin or minus 266°C).

"We need to check that all the parts of MIRI work at this very cold temperature," said Wright, who works at the UK Astronomy Technology Centre in Edinburgh. "For example, that the mechanisms can still move properly and that all the detector signals are correct. So far so good."

After switching on its internal calibration source for the first time in May, MIRI opened its eyes and produced accurate test images. Once the tests are complete, MIRI will be delivered to NASA's Goddard Space Flight Center later this year.

For more on MIRI see our feature on page 13

Sat Nav win for UK

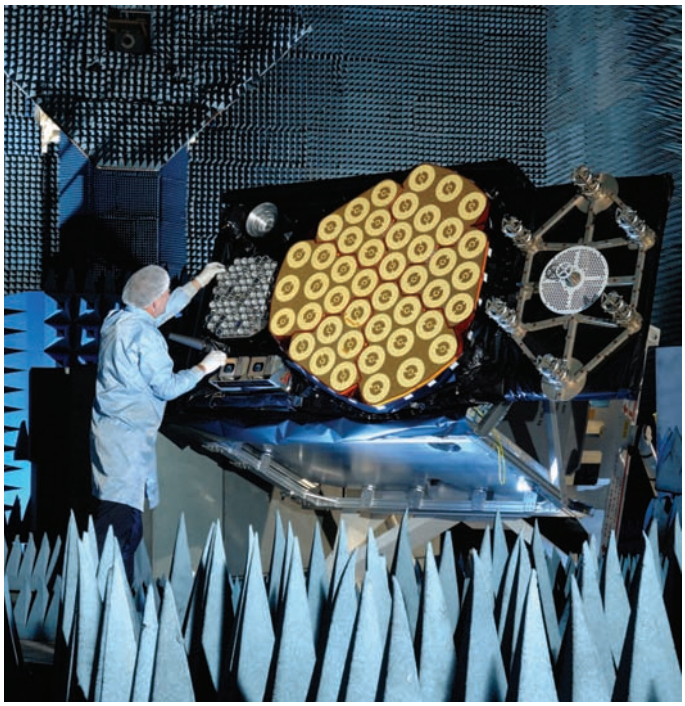
A UK team from space technology company Astrium will lead a key contract for Galileo – the new European global satellite navigation system scheduled to begin operations in 2013.

The European Space Agency (ESA) and European Union contract, worth €73.5 million, is for the ground control segment facilities. These will operate the constellation of Galileo satellites, the first of which is due for launch in October.

"Astrium's success in this contract is recognition of the UK's track record of excellence in a dynamic sector of the European economy," said David Willetts, Minister of State for Universities and Science. "New uses for satellite navigation data are being developed every day, and here in the UK we are building the infrastructure to take advantage of the opportunities that involvement in the Galileo programme can bring."

Galileo's constellation began with the launch of GIOVE-A (Galileo In-Orbit Validation Element-A) in 2005. Built and operated by Surrey Satellite Technology Limited, it was joined in 2008 by GIOVE-B with a payload from Astrium UK. These demonstrator satellites are still operating successfully.

"Astrium's team in the UK has been the leading European player in satellite ground control systems for over 20 years," said Colin Paynter, Managing Director of Astrium in the UK. "Winning this contract will enable us to further develop our expertise in this field and to contribute to the timely delivery of the Galileo system."



Credit: Astrium UK

One of the new Galileo satellites being tested at Astrium

Welcome

David Williams, Chief Executive of the UK Space Agency, talks about recent highlights and looks forward to the months ahead…

Welcome to the summer edition of *space:uk*. I am proud to write to you this quarter as Chief Executive of the UK Space Agency – now formally an executive agency of the Department for Business, Innovation and Skills. I don't think any of us anticipated quite how much work was involved in establishing the Agency from practical issues such as setting up the IT infrastructure, to the processes such as clearing Parliamentary Orders. It was a tremendous achievement to meet the 1 April deadline and took time and effort from colleagues within the Agency, within BIS, and across Government – a real team effort and thank you to everyone involved.

After all the excitement, we need to focus on setting a clear direction for the Agency. That is why we have been running a consultation on a new strategy to define aims and ambitions over the coming years. The draft strategy is brief and draws on the Space Innovation and Growth Strategy for its inspiration by taking growth as the main overarching theme. The strategy sets out what the UK Space Agency will do to achieve the ambition of each of six key themes. I hope to be able to report on preliminary messages from the consultation in the next issue.

The Agency continues to generate interest and enthusiasm from schools, which are always keen for people to visit and talk to children about space. Space continues to inspire and fascinate all generations, and we continue to make new discoveries and produce eye-catching pictures. Some of the recent work includes the research into black holes where UK researchers and technology were involved in measuring one of the biggest and brightest bangs ever recorded as a star ventured too close to a black hole and – sadly for the star – came off second best.

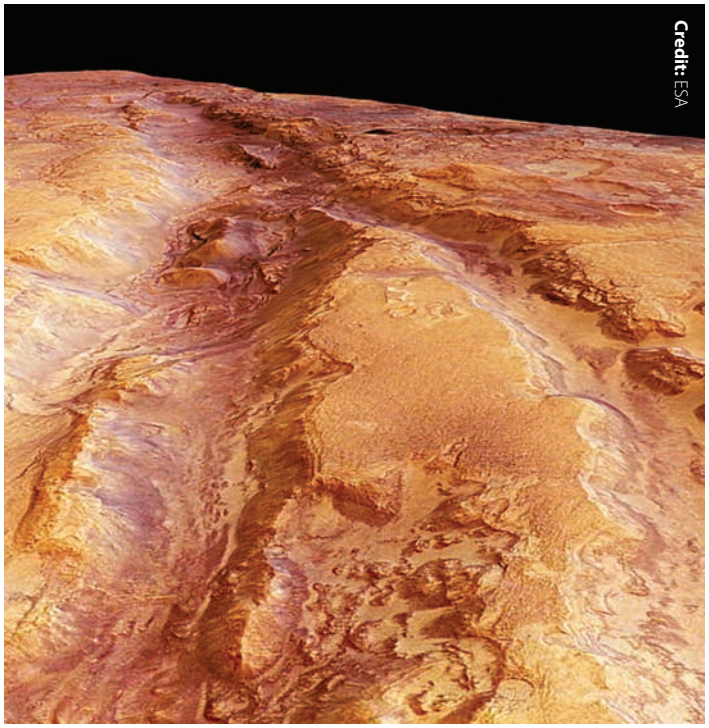
I'm always pleased that children show a keen interest in Earth observation work, particularly in respect of its importance to measuring climate change. In May, the UK took over as Chair of the International Charter: Space and Major Disasters. The Charter is an agreement that coordinates space agencies worldwide in gathering vital satellite images of disaster-stricken regions – providing the images to civil protection authorities to inform their response efforts and save lives. At our first meeting as Chair, the UK gained agreement on providing universal access to such satellite images during natural emergencies. This will enable any country to draw upon the data provided by the Charter. This is just one example of the international collaboration which is increasingly crucial to helping others in times of need, and planning the best means of protecting our planet and using resources responsibly.

www.bis.gov.uk/ukspaceagency

Credit: UK Space Agency

"I'm always pleased that children show a keen interest in Earth observation work"

David Williams,
Chief Executive
of the UK Space Agency



Credit: ESA

Images like this one – from ESA's Mars Express – fascinate and inspire

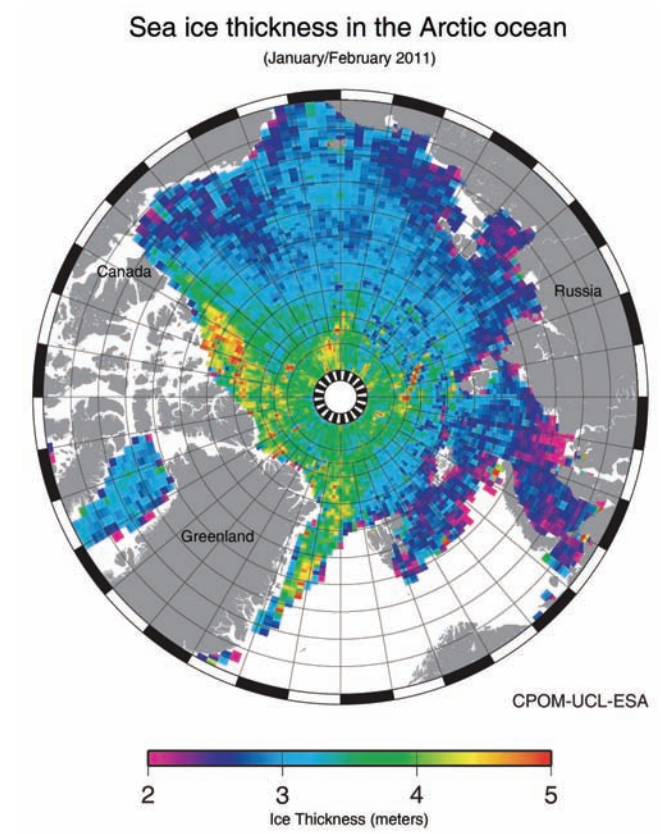
First map from ice satellite

The UK-led science team behind ESA's CryoSat mission has produced the first maps of ice thickness and ocean circulation using data from the satellite. CryoSat bounces radar signals off the ice and snow in the Earth's polar regions and is designed to provide an accurate picture of the planet's ice cover and how it's changing.

Seymour Laxon, head of the Centre for Polar Observation and Modelling at University College London (UCL) told *space:uk* that the satellite was performing well. "This is the first time such an instrument has been flown in space and it therefore takes time and careful analysis to tune the processors to deliver accurate data."

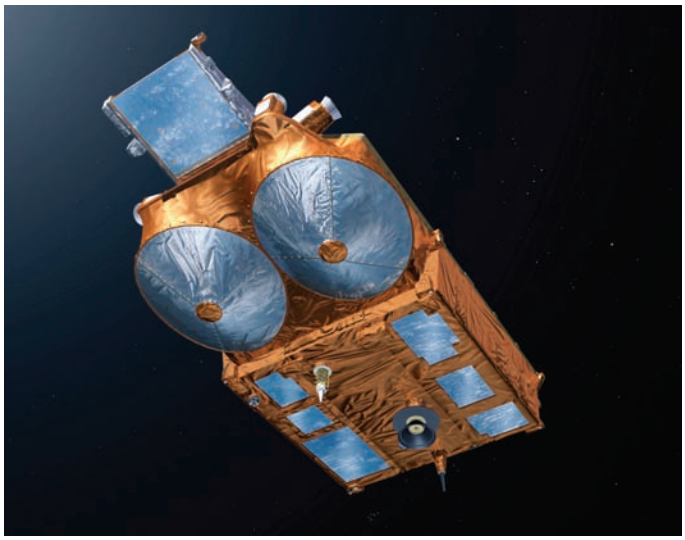
The information from CryoSat, used to produce this new map, has proved to be highly detailed. But in order to accurately interpret the data and gather detailed information about the ice and snow being measured, CryoSat scientists have also been carrying out fieldwork in the Canadian Arctic.

The ambitious project included dragging a radar instrument on a sledge across previously unexplored ice floes. Laxon, who has recently returned from the expedition, explained: "By taking a ground radar, similar to Cryosat, onto the ice we can measure both how the radar behaves and at the same time gather detailed information about the snow."



Credit: ESA

The first map of sea ice thickness generated from CryoSat data



Credit: ESA

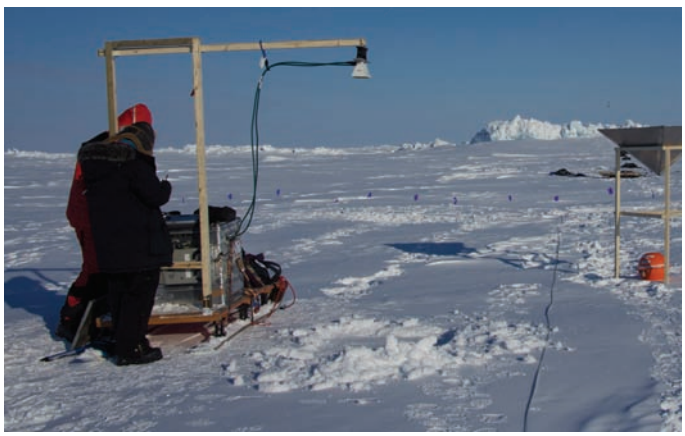
Artist image of CryoSat in orbit

"We achieved a lot in a very short space of time!" said Katharine Giles, also from UCL. "Our plan was ambitious from the outset, involving long days on the ice – eight hours in -30°C – collecting as many measurements as possible."

"The results from the Arctic will help us to understand how well CryoSat can see through the snow to the sea ice," said Giles. "We will look at how changes in the snow's properties, such as density and wetness, affect the ability of the radar to see through it to the ice beneath."

"The data we have gathered is already proving valuable but we now have several months of painstaking analysis to understand the precise implications for Cryosat data," Laxon added. And over the next few years, the scientists will use CryoSat to build up an accurate picture of the Earth's ice cover and how it's changing.

Read more about what it was like working on the ice on page 21.



Credit: Laxon

At work on the Arctic ice

Conference News

Space Act reform

In his speech at the UK Space Conference, David Willetts said he was taking action to reduce insurance costs for satellite operators to make the UK more competitive. Under the UK's Outer Space Act, anyone in the UK who launches or operates a satellite has to carry compulsory third party liability insurance in case the launch or operation goes wrong. The Minister announced that this cost will be reduced from €110 million to €60 million for the majority of missions. He said he was also considering proposals to amend the Act to include an exemption for the liability in-orbit for very small satellites such as CubeSats (see page 10).

"The UK's space sector is a crucial driver of growth and is worth around £7.5 billion annually," said the Minister. "We have real strengths in satellites and telecommunications and this will help put UK operators on a level playing field with their international competitors."

Credit: UK Space Agency

David Willetts with young people at the UK Space Conference 2011

Space for the NHS

The NHS could benefit from new technologies being developed for space missions. Speaking at the opening of the UK Space Conference 2011, the Minister for Universities and Science David Willetts announced that the UK Space Agency is backing nine projects adapted from the European Aurora space exploration programme.

These Aurora Technology Exchange projects will apply space technology being developed for missions to Mars for use in a wide range of applications on Earth. They include a study to identify applications for the NHS and a scheme to develop space navigation technology for use in cars.

"Most people don't realise that space technology is all around us and that most of us use space technology every day," said UK Space Agency Chief Executive, David Williams. "The Aurora programme spin-outs are a great example of how industry, academia and government can work together to maximise the output of space research."

Credit: Astrium UK

Technology being developed for the exploration of Mars could have many potential benefits here on Earth

The two-day UK Space Conference 2011 brought together a wide variety of prominent figures from both the UK and wider international space industry, together with senior policy makers, academics and space enthusiasts from around the world. As well as the Minister, speakers included the Director General of ESA and the President of Virgin Galactic.

Arthur awards

This year's Sir Arthur Clark Awards, sponsored by the UK Space Agency, were presented during in a special ceremony at the UK Space Conference. The 'Arthurs' celebrate notable contributions to UK space science from commerce, the media, research, education and outreach.

"They are generally regarded as the space equivalent of the Oscars," said Awards Director, Jerry Stone. "This year I was very impressed by the nominees. We had a lot of trouble in several categories deciding who should be shortlisted."

The awards were presented by UK ESA astronaut Tim Peake. And the winners were…

- Unlimited Theatre for Mission to Mars, a play written to inspire children about space
- University of Strathclyde Advanced Space Concepts Laboratory for Achievement in Space Research
- Clyde Space for Achievement in Space Commerce
- Clive Horwood, the Chief Executive of UK publishing company Praxis, for Achievement in Space Media
- Chris Brunskill from the University of Surrey won the Space Student Achievement Award
- David Thompson from Orbital Sciences Corporation won the International Space Achievement award
- David Southwood, who has spent a lifetime working in space science, won the award for Exceptional Space Achievement

UK space camera

Credit: ESA, Nespoli

The new camera will be mounted on the International Space Station

A UK lab is building a high definition camera to provide a live video feed of the Earth from space. The camera, a joint venture between the UK, Canada and Russia, is to be installed on the International Space Station (ISS) within the next twelve months. The announcement that the camera is being built at the Science and Technology Facility Council's RAL Space in Oxfordshire was made at the UK Space Conference.

The high-resolution camera, operated by Canadian company UrtheCast (pronounced 'Earthcast'), will offer a video image with a resolution that is comparable to much of Google Earth. The web platform also gives users the capability to constantly track the location of the ISS, anticipating the exact time when it will pass over a particular geographic location.

"We're both delighted and excited to be involved in this international project that is at the cutting edge of technology," said Director of RAL Space, Richard Holdaway. "It will provide a new and intriguing connection between space and the rest of the world."

Reviving Prospero

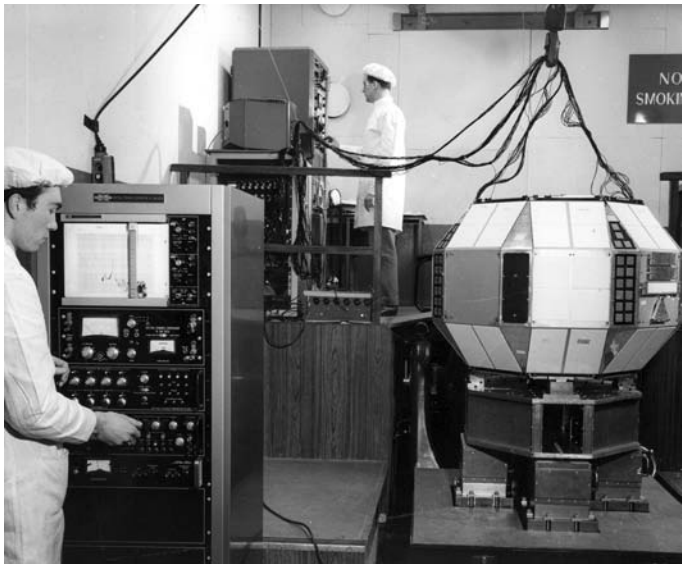
Plans have been unveiled to attempt to communicate with a British satellite after it's spent almost 40 years in space. A group led by a team at University College London's Mullard Space Science Laboratory (MSSL), is hoping to hear from Prospero – the only UK satellite ever launched on a UK rocket.

Prospero was blasted into orbit on 28 October 1971 on a Black Arrow launch vehicle. It carried a series of experiments to investigate the effects of the space environment. These included a micrometeoroid detector and a 'thermal surfaces experiment'. This consisted of panels made of different materials and painted in a variety of colours, designed to assess the types of surfaces satellites needed to deal with the extreme temperatures of operating in space.

The Black Arrow launcher programme was cancelled by the Government shortly before the launch was due. However, as the rocket was ready the programme team decided to go-ahead anyway. Prospero operated successfully until 1973 and was reactivated annually until 1996. It has not been heard from since.

The aim is to send a signal to the satellite on its 40th anniversary. "What we will first try to do is turn on the transmitter and induce some basic telemetry," said Roger Duthie from MSSL. "There is also the idea that we might try to probe the state of the satellite more fully and have a look at the experiments it carried."

An attempt to talk to Prospero will be made before October. If it works, then a further public attempt will be made for the anniversary.



Credit: MSSL, Astrium UK, UK Space Agency

Prospero being tested ready for launch

Skylon success

As NASA's fleet of Space Shuttles heads for retirement, the British Skylon spaceplane has passed an important technical review by the UK Space Agency. The Agency commissioned ESA to assess the unpiloted and reusable spaceplane currently under development by Reaction Engines Limited at Culham, Oxfordshire. The independent review also examined Skylon's air-breathing rocket engine (SABRE) and rated both as "a success attracting wide interest by the international aerospace community." Skylon will combine jet and rocket technology, take off and land like an aeroplane and offer a way to transport satellites and payloads into space at a much lower cost than the Space Shuttle.

See also feature on page 16.

Credit: Reaction Engines Limited

UK and India space deal

A new agreement has been signed between the UK Space Agency and the Indian Space Research Organisation. The UK and India have already worked together on a number of projects including the Moon mission Chandrayaan-1 and, most recently, HYLAS 1. The Memorandum of Understanding identifies future areas of collaboration including a series of satellite programmes, Earth observation projects and the use of information from space to help predict future climate change.

Credit: ISRO

The Moon seen from Chandrayaan-1

Scholarship

UK satellite company Avanti Communications has launched a space scholarship scheme to encourage young people to pursue a career in the UK's rapidly growing space industry. It aims to target students with an interest and flair in sciences in an attempt to encourage them to pursue university studies in space related degrees. Details are available on the careers section of the Avanti website: **www.avantiplc.com**

New space podcast

A new podcast covering space from a UK And European perspective has been launched at the UK Space Conference. Co-presented by *space:uk* Editor, Richard Hollingham, the Space Boffins podcast features lively conversation, interviews and features on all aspects of space. It is hosted at **audioboo.fm/spaceboffins**

Space industry growth plans

Credit: Arianespace

The launch of a UK-built HOTBIRD satellite

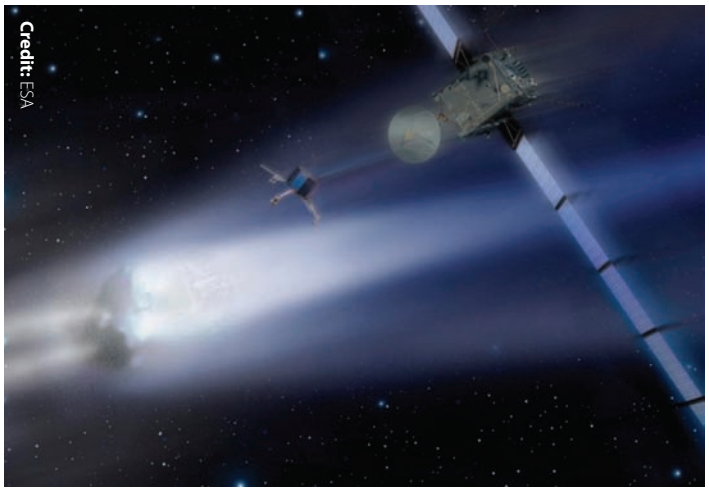
A strategy to further boost the growth of the UK space industry has been published by an advisory group to the UK Space Agency. The Space Leadership Council's report highlights the importance of space to the UK. It also supports the Innovation and Growth Strategy's suggestion that revenues in the space sector could increase from the current £7.5 billion per year to more than £40 billion by 2030 if the UK grows its share of the global space economy.

"The UK's space sector is a key driver of economic growth," said the Minister for Universities and Science and co-chair of the Space Leadership Council, David Willetts. "I am confident [this strategy] will provide our space sector with the advice and guidance it needs to truly flourish."

The strategy – developed through a six-month process – stresses the importance of research and development and the benefits of investment by Government in developing new technologies. It follows a £10 million Government investment, announced in the budget, to start a national space technology programme. This amount will be matched by industry and the fund co-ordinated by the UK Space Agency.

Sir Keith O'Nions, Chairman of the group that produced the strategy said: "I look forward to this strategy being nationally owned and implemented because doing so is going to be critical to achieving the growth in the sector to which we all aspire."

Rosetta sleeps



Credit: ESA

Artist's impression of Rosetta releasing its lander

Rosetta, a spacecraft packed full of UK science and engineering, has gone into a deep sleep – in deep space – during the final leg of its decade long journey towards comet 67P Churyumov-Gerasimenko.

"Rosetta really has earned this break," said David Parker, Director of Science, Technology and Exploration at the UK Space Agency. "Rosetta's primary mission hasn't even started yet but since the launch in 2004 it has been on a non-stop cosmic 'road-trip', busily providing us with a wealth of information about our solar system."

The ESA mission went into hibernation mode in June. It will reawaken in January 2014, at a distance some 1000 million kilometres from the Earth. When it arrives at its destination in May 2014, Rosetta will become the first spacecraft to make a long-term, close-up study of a comet. The craft will orbit the comet for two years and a small lander called Philae will help complete the detailed survey.

Comets hold clues to the origins of life on Earth and help scientists understand the conditions during the formation of our Solar System. UK science and industry has played a significant role in the mission from the spacecraft's design, platform and scientific instruments to the lander's helium storage tanks and batteries. UK scientists are also involved in ten of the 21 experiments that will be carried out during the ambitious project.

Artist's impression of Rosetta orbiting Comet 67P Churyumov-Gerasimenko
Credit: ESA

Supporting disaster efforts

A new agreement means that any country in the world will be able to access satellite images following natural disasters. The UK received backing for the deal after taking over as Chair of the International Charter Space and Major Disasters. The Charter coordinates space agencies worldwide in gathering satellite images of disaster stricken regions. These can prove vital in aiding rescue and relief efforts.

"The Charter is a great example of the enormous benefits space can bring to our everyday lives," said the Minister for Universities and Science David Willetts. "It provides invaluable and immediate satellite images during times of crisis, from tracking extreme weather to dealing with the aftermath of earthquakes and tsunamis - as we saw very recently in Japan."

Since it was set up in 1999, the Charter has helped in more than 300 disasters for more than 100 countries including the UK. So far this year alone, the Charter has been activated for the flooding in Australia, Brazil, Mozambique, Namibia and the midwest United States, as well as for hurricane Yasi and earthquakes in Pakistan, New Zealand and Japan.

At a meeting in May, the UK took over Chairmanship of the Charter for six months. This makes it responsible for implementing Charter Strategy and policy. Assistant Director of Earth Observation for the UK Space Agency, Alice Bunn, said: "The Charter is an impressive demonstration of space agencies around the world working together to provide a humanitarian response to disasters, providing data quickly and free of charge."

Credit: ESA

The Charter is activated after natural and man-made disasters such as the Gulf of Mexico oil spill in 2010. This Envisat image shows the extent of the oil slick

Killer black hole

Credit: University of Warwick

Artist impression of a star being ripped apart

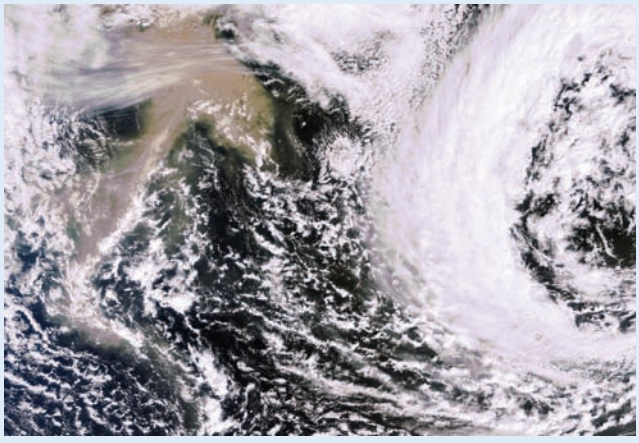
A UK astronomy team led by the University of Warwick has discovered evidence of a star, 3.8 billion light years from Earth, being torn apart by a black hole. The resulting devastation has generated one of the biggest and brightest flashes ever recorded – about as bright as a hundred billion Suns. The research was based on observations from space telescopes and the Swift satellite, which is designed to detect gamma ray bursts and their afterglow. "It's rare for stars to get very close to the black holes in the centre of galaxies," said Nial Tanvir from the University of Leicester, "but when they do, they will always come off second best!"

Imagination to reality

The British Interplanetary Society is hosting the country's first 'space convention' based on the Society's own motto - *From Imagination To Reality*. The aim of the event is to showcase what British scientists, engineers and writers have achieved over the years and look at the future of space research in the UK. With a wide range of fascinating speakers, the convention is aimed at anyone with an interest in space or science fiction. It is being held on 17 and 18 September 2011 at the Milton Keynes campus of the Open University. Details at **www.bis-space.com**

Iceland eruption

The ash plume from the latest Icelandic volcanic eruption has been monitored from space. As Iceland's Grímsvötn volcano spewed ash high into the atmosphere, satellite observations have provided essential information to advisory centres assessing the possible hazards to aviation. Satellite measurements offer an excellent means to follow the spread, extension, concentration and movement of volcanic plumes. Flights to and from Scotland and the north of England were cancelled or delayed as a result of May's eruption.



Credit: ESA

Envisat image of the plume – seen snaking towards the bottom left of the image

Broadband from space

The first customers are benefiting from a new UK satellite providing high-speed broadband services to remote rural areas of Europe. Following its launch in November last year HYLAS 1 underwent a series of orbital tests before being handed over to its operator, Avanti Communications, who have now begun services. The satellite is being used by people in remote areas or 'not spots' (areas without high speed internet – the opposite of 'hot spots') who were previously reliant on slow dial-up internet connections.

HYLAS 1 was designed and built by Astrium, at its factories in Portsmouth and Stevenage, and the Indian Space Research Organisation in Bangalore. It was developed with funding from the UK Space Agency and Technology Strategy Board and features an innovative system for providing the best possible service to users.

Unlike most other communications satellites, HYLAS 1 can automatically allocate power and bandwidth to different regions within its footprint, responding to peaks and dips in demand. This means that up to 300,000 users across Europe can be online via the satellite at the same time.

The role that satellite operators can play in delivering broadband to remote communities in the UK has been outlined in a new report from an advisory group made up of space communications companies, the UK Space Agency and Government. The Satellite Broadband Steering Group recommends further investment in satellite broadband technology. It argues that, in many cases, satellites can provide people in not-spots with broadband quicker and cheaper than other options such as fibre-optic cables.

Chief Executive of Logica and co-chair of the Space Leadership Council, Andy Green, said: "the report paints an excellent picture of the role satellites can play in broadband delivery to the benefit of UK Citizens and the steps the industry can take to deliver the faster broadband speeds that the communities of the future will need."

Satellite technology is bringing broadband to Europe's 'not-spots'

The first spaceman

Credit: RIA Novosti/www.visualrian.com

Gagarin in his capsule prior to launch

On 12 April 1961, Yuri Gagarin became the first human to leave the Earth's atmosphere. His flight on a Vostok rocket lasted just 108 minutes but was a remarkable feat of science and engineering. When Gagarin returned to the ground, he was the most famous man on the planet.

In the months following his flight, Gagarin toured the world. He travelled to Manchester and London in 1961. His trip included lunch with the Queen and a visit to Karl Marx's grave in Highgate cemetery.

Gagarin never flew in space again but his bravery is remembered and his memory evoked every time a cosmonaut or astronaut blasts into orbit. He proved it was possible to live and work in space – setting the scene for spacewalks, space stations, the Moon landings and the Shuttle.

Credit: NASA

Gagarin laid the foundations for today's space endeavours. Here, astronaut Mike Fincke spacewalks from the International Space Station

Earlier this year the UK and Russia signed a joint statement agreeing to share expertise, knowledge and innovation in space science. The UK-Russia Year of Space 2011 puts in place an agreement for enhanced collaboration in space science research.

Credit: NASA

John Glenn was the first American to orbit the Earth – his flight was in February 1962

To mark the 50th anniversary of human spaceflight, a statue of Yuri Gagarin was unveiled on the Mall in London on 14 July. The statue is a gift from the Russian Space Agency to the British Council and will be installed on the Mall for 12 months.

Credit: RIA Novosti/www.visualrian.com

Following his flight, Gagarin toured the world – here he is being welcomed by crowds in London

Details of other events, being held across the UK, are available at: yurigagarin50.org

Bigger on the inside

Main image: Artist image of a CubeSat in orbit
Credit: Astrium UK

As the UK's first CubeSat mission starts to take shape, Richard Hollingham discovers just how much science you can fit into a *very* small satellite…

UK SPACE AGENCY

The UK i

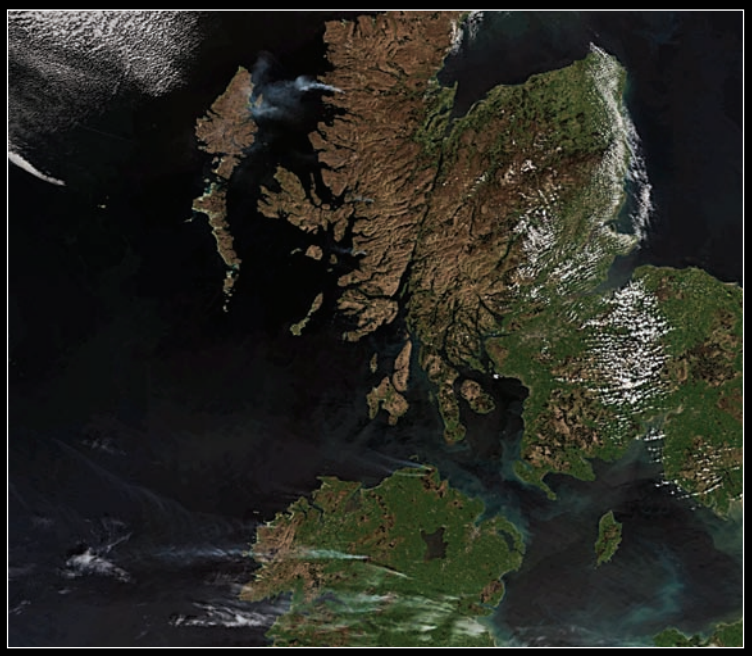
The UK is involved in missions to monitor our changing planet and investigate the Solar Syst navigation on Earth and the space sector provides many other benefits to all our lives. The U space industry. The Agency works to maximise the practical benefits of space and to inspire

Earth Observation

Earth observation (EO) enables us to monitor changes to the environment and patterns of land use. It has revolutionised weather forecasting and the way we monitor the Earth's climate. EO has also transformed disaster prediction and response. Over the years, satellites have allowed us to accurately map the world and track pollution. They have also enabled us to witness the felling of rainforests, the advance of deserts and retreat of the ice sheets.

Current EO science missions with important UK contributions include CryoSat, Envisat and GOCE. CryoSat, which is led by a UK science team, is measuring the ice cover in the polar regions. Since 2002, the vast Envisat satellite has been carrying out an extensive programme of environmental monitoring. GOCE (Gravity field and steady-state Ocean Circulation Explorer) is mapping variations in the Earth's gravitational field.

In times of crisis, pictures from the UK-built Disaster Monitoring Constellation satellites are used to help rescue efforts following disasters. Between them, these satellites can acquire detailed images of anywhere on Earth at least once a day.



Envisat image of Scotland and Northern Ireland **Credit:** ESA

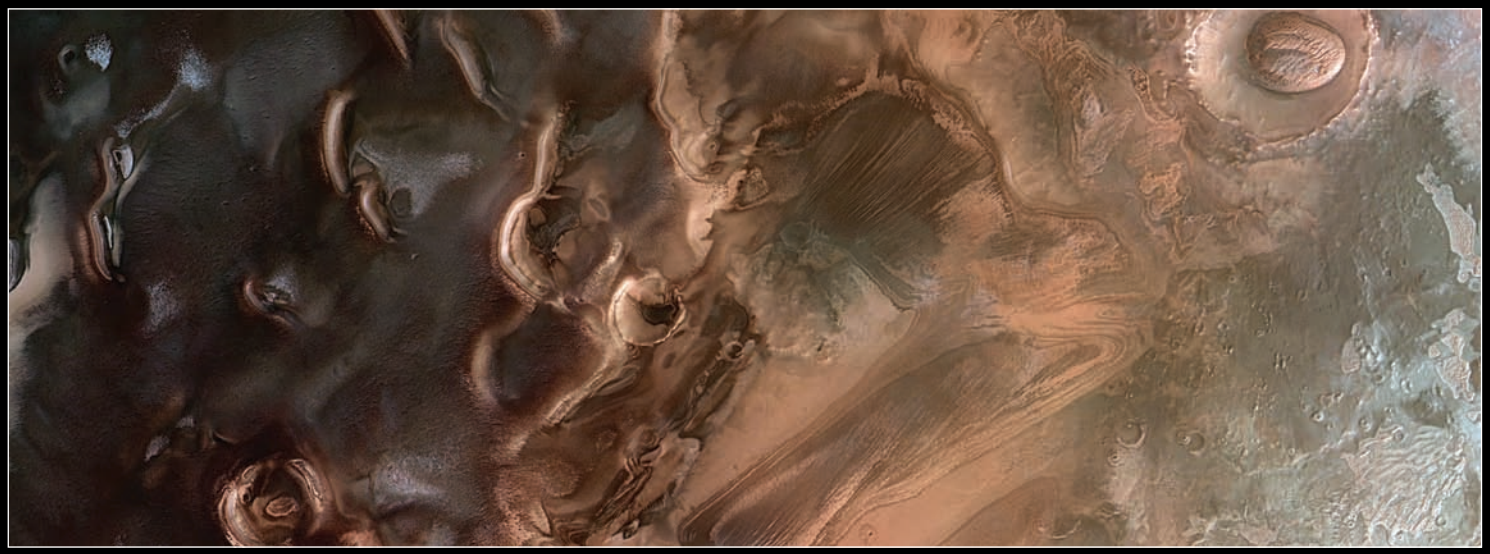
Space science

UK science and engineering teams are involved in more than twenty active missions to explore the Solar System, investigate the galaxy and understand the Universe. Not only do these missions increase our knowledge of the cosmos, they help us better appreciate processes on Earth and lead to the development of new expertise and technologies.

The UK is collaborating with its international partners on missions to the Sun, Mercury, Mars, Venus and Saturn. UK research teams are also working on space observatories including Herschel, Planck, XMM-Newton and Hubble; as well as future missions such as LISA Pathfinder and the James Webb Space Telescope.

Recent highlights include a survey of the entire Universe by ESA's Planck telescope. This mission is measuring ancient light left over from the Big Bang and is designed to help answer fundamental questions about how the Universe and Galaxies form. The UK is playing a major role in the mission, from instrument development to analysis of results.

The UK is leading the science team for one of the three instruments, SPIRE, on board Herschel. The largest space telescope ever launched, Herschel is examining some of the coldest and most distant objects in space. The UK is also providing one of the key instruments for the successor to Hubble, the James Webb Space Telescope.



Buried ice deposits seen by ESA's Mars Express **Credit:** ESA

in space

tem and Universe beyond. Advanced UK-built satellites improve communications and UK Space Agency coordinates UK civil space activity, supporting academic research and the the next generation of scientists and engineers.

Communications and navigation

Satellites built in the UK are being used to provide global broadband services, TV broadcasts and secure communications systems. UK technology is also at the heart of Europe's new global positioning system, Galileo.

The UK is home to the world's largest global mobile satellite communications provider. Inmarsat currently provides broadband coverage to some 85% of the world's landmass. The satellites have largely been built by Astrium UK in its Stevenage and Portsmouth factories.

The UK-built HYLAS 1 satellite is now providing thousands of people living in remote rural communities with broadband services. Partly funded by the UK Space Agency, HYLAS 1 automatically allocates varying amounts of power and bandwidth to the different regions within its footprint reacting to dips and peaks in demand. This enables up to 300,000 users to be online via the satellite at the same time.

The first test satellite for the Galileo satellite navigation system was designed and built in the UK by SSTL. The payload and ground system for the second was built by Astrium UK. Astrium is also building the four 'In Orbit Validation' satellites for the system. These include clocks so precise they lose just one second in 300,000 years. SSTL will design and build all the navigation payloads onboard the next 14 satellites.

The launch of HYLAS 1 on an Ariane 5 rocket **Credit:** ESA, Arianespace

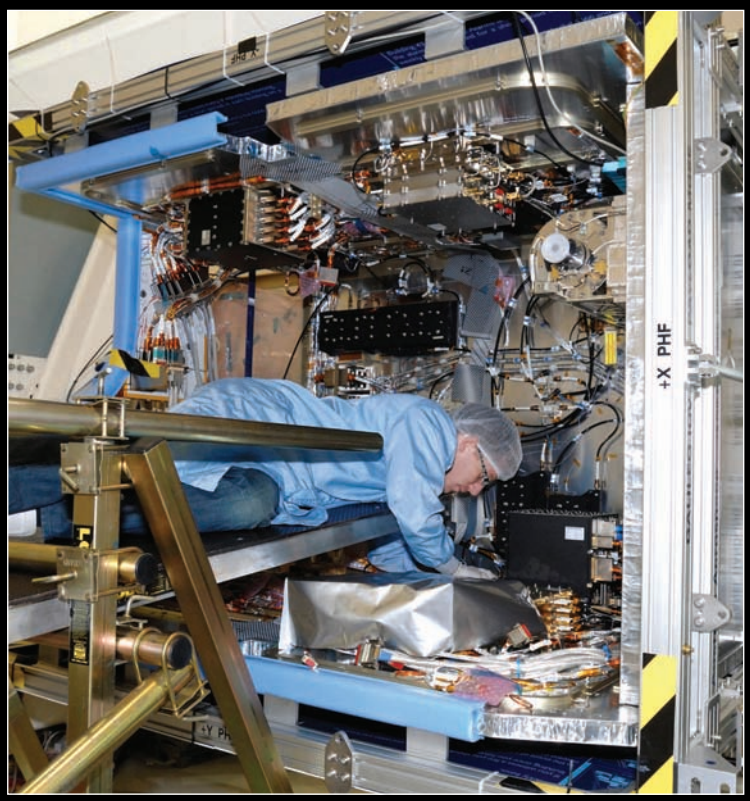
Industry

The space industry is a successful and important hi-tech sector of the UK economy. According to a recent study, the UK's thriving space sector contributes £7.5 billion a year to the UK economy. It directly employs 24,900 and supports a further 60,000 jobs across a variety of industries.

The industry covers a broad range of areas, ranging from satellite manufacturers and software designers, to satellite operators and service providers. The UK Space Agency is also supporting the development of the Skylon spaceplane, which could transform access to space.

Space is also an important driver of economic growth: developments in space technology are finding new applications and generating new business opportunities. The UK Space Agency, in partnership with the Technology Strategy Board, has worked with industry to encourage, strengthen and seek funds for the future development of the space sector.

The UK space industry is made up of highly qualified people with long experience and deep knowledge. Space acts as a beacon to attract a new generation of engineers, scientists and entrepreneurs into activities that are both vital in solving the challenges faced by society and in generating the economic activity needed to drive sustainable growth.



One of the new Galileo satellites under construction at Astrium UK **Credit:** Astrium UK

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The UK from space

The UK Space Agency is at the heart of UK efforts to explore and benefit from space. This image of the UK and Ireland was captured by ESA's Envisat – one of many satellites with key UK involvement in the design, construction and operation.

Credit: ESA

UK SPACE AGENCY

"This is the beginning of the personal space revolution allowing ordinary people to participate in space research"

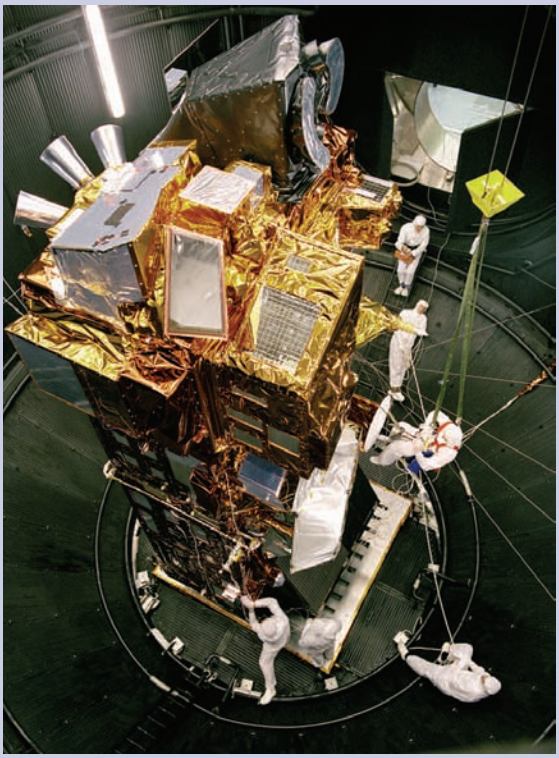
Michael Johnson, UKSEDS

Here's the challenge: first, find yourself a box around the size of a shoebox. Then, fill it with as many things as you can. If you don't manage to include a device to measure space weather, camera to take pictures of the Earth from space and sophisticated computer and communications system, you've failed the challenge. Did I mention that it also has to generate its own power and gets launched into orbit in around twelve months time (or less)? This is the challenge facing the teams involved in the UK's first CubeSat, UKube-1. It doesn't, as they say, get tougher than this.

"It's a very exciting project," says Martin Dunn, the project manager at Glasgow-based Clyde Space. "We're talking about getting a satellite that's just an idea on a bit of paper to launch in a year and a half, which is immensely fast, and trying to do it for a cost that's magnitudes cheaper than the cost of launching a conventional satellite."

Ever since the first satellite, Sputnik, was launched in 1957, they have tended to become bigger, more complex and expensive. Europe's Envisat for instance, is around the size of a double-decker bus and cost €2.3 billion (ten years ago). CubeSats are not only smaller but also much cheaper to build, typically costing tens of thousands of pounds. The basic CubeSat unit is just 10cm across on each side, UKube-1 will be the size of three of these units stuck together. With around thirty CubeSats currently in orbit, research groups around the world are already benefiting from the technology.

"Space programmes have had a tendency in recent years to get bigger, fatter and slower," UKube-1 programme manager Ronan Wall from Astrium tells *space:uk*. "For a very small budget, CubeSats enable you to do some very cool stuff." And UKube-1 (UK Universal Bus Experiment 1) is being packed with scientific experiments.



Small satellite, big science

Earlier this year the UK Space Agency ran a competition inviting academics and the space industry to come up with payloads for the new satellite. The results were announced in March with five experiments selected (see side panel on page 12). Among them are a spacecraft within a spacecraft: myPocketQub. The director of space projects for UKSEDS (Students for the Exploration and Development of Space), Michael Johnson, calls it a "pocket spacecraft". Measuring just 10cm x 10cm x 26mm and weighing 300g, myPocketQub consists of five sub-payloads.

"Perhaps the most exciting one is what we call open space365," says Johnson. "It's an open source computer with half a dozen sensors which we hope will allow up to 365 people to have the use of a spacecraft for the day."

With multiple experiments on board, one of the biggest challenges is providing enough power to keep them all operating. Satellites in orbit generate electricity using solar panels – the larger the solar panels, the greater the power. But with small satellites, the surface area of solar cells might not be big enough to power all the experiments. "There are a lot of components and a small surface area so one of the challenges is to get as many solar panels onto the satellite as possible," says Dunn.

Image bottom left: Minister for Universities and Science, David Willetts, in the clean room at Clyde Space
Credit: Clyde Space

Image top right: CubeSats are a fraction of the size and cost of large satellites like Envisat seen here under test
Credit: ESA

Image below: Working on solar panels at Clyde Space
Credit: Clyde Space

continues >

Bigger on the inside
continued

Image above: A computer design drawing showing how the satellite will be packed with experiments
Credit: Clyde Space

The UKube-1 designers have got round this problem by giving the satellite wings – solar panels that stick out either side of the shoebox. These are folded away for launch and then deployed once the satellite reaches orbit. And Clyde Space, who are building the satellite platform, have used an unusual design to make this happen. "Essentially it's a bit of fishing wire that's burnt through," Dunn explains. "The panels are held in place under tension against the sides of the CubeSat. Then we'll initiate a command to burn through a piece of wire and the panels will fall down." At least, that's the theory. "We're testing it quite heavily in the lab. What we've also done is calculate the worst case and enable the satellite to function even if the panels don't deploy."

Big Ambition

UKube-1 is being built right now and will be constructed and tested by the end of the year. The aim is to launch the satellite as early as possible in 2012, 'piggybacked' on the launch of another satellite. If successful, it could be the start of a full national CubeSat programme.

"If it doesn't work or only half works, it's still worth it," says Wall. "With this we'll have the three levels of spacecraft sorted: the big stuff that Astrium do, the medium sized satellites produced by SSTL and now the small satellites. For the budget, this represents an excellent return for the UK."

And for some, like Michael Johnson from UKSEDS, this could be the start of something even bigger…or perhaps smaller. "At the moment the satellites that fly in space are the equivalent of the old mainframe computers, the CubeSats are much cheaper but are still the equivalent of old mini computers of the 1980s – which were cheaper but still very expensive," says Johnson. "The core purpose of our payload is to kick-start the personal spacecraft, the pocket spacecraft."

"This is the beginning of the personal space revolution allowing ordinary people to participate in space research."

"For a very small budget, CubeSats enable you to do some very cool stuff"
Ronan Wall, Astrium

UKube-1

The project is a collaboration between the UK Space Agency, industry and academia. It carries five experiments:

Janus
Astrium's Janus payload is designed to demonstrate the feasibility of using cosmic radiation in orbit to generate random numbers in satellites. Generating random numbers is a crucial part of any secure telecommunications system.

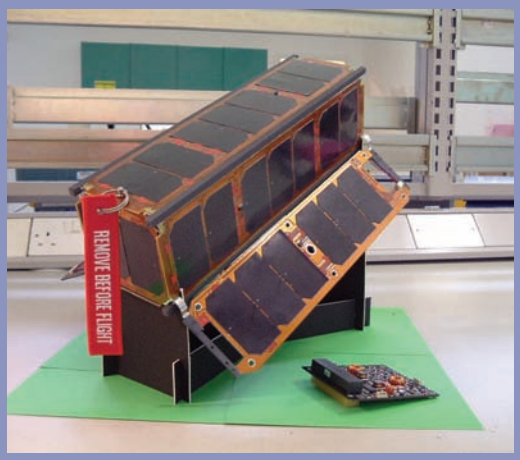
CMOS Imager Demonstrator
This Open University project is based on new sensor technology, which is being developed and evaluated for use in space. It will take pictures of the Earth and test the effect of radiation on instruments in space.

myPocketQub
This will carry a stack of different experiments that, if successful, could allow students, hobbyists and members of the public to take part in a space mission.

TOPCAT
Developed by the University of Bath, TOPCAT will be the first GPS device aimed at measuring space weather conditions in the plasmasphere – the area of space just beyond the Earth's atmosphere.

FUNcube
Funded by volunteer members and friends of AMSAT-UK, FUNcube consists of a radio transmitter for science education and a materials science experiment for schools.

Free support is also being provided by the following companies: Isotron, Xilinx, DS SolidWorks Corp and Invotec Group.



The outer shell of Ukube-1 showing how the solar panels will unfold
Credit: Clyde Space

The ultimate in cool science

continues >

If you want to gaze into the distant cold depths of space, search for planets and observe the formation of new stars, then no ordinary camera will do. But MIRI the mid-infrared instrument that will fly onboard the James Webb Space Telescope – is no ordinary camera.

Main image: Inspecting one of the JWST primary mirror segments, there are 18 in total
Credit: NASA, Chris Gunn

The ultimate in cool science
continued

Image below: Hubble image of a pair of interacting galaxies called Arp 273. The JWST is the successor to Hubble
Credit: ESA, NASA

MIRI will not only detect faint light sources about 10,000 times faster than any previous mission, it can also operate at minus 266°C. It is, undoubtedly, the ultimate in cool science.

"MIRI is extremely important," agrees NASA's John Mather, senior project scientist for the James Webb Space Telescope (JWST). "It is by far the most powerful tool ever built for exploring the Universe in its wavelength range," says Mather. "The sensitivity is amazingly good so it can see farther out into the distance and farther back in time."

The JWST is, says Mather, "the next big thing for space astronomy". Due for launch from 2014 onwards, it is an international collaboration between NASA, ESA and the Canadian space Agency. Its 6.5 metre primary mirror, more than double the size of the mirror used by the Hubble Space Telescope, will be achieved by a folding array of beryllium hexagonal mirrors.

Search for new planets

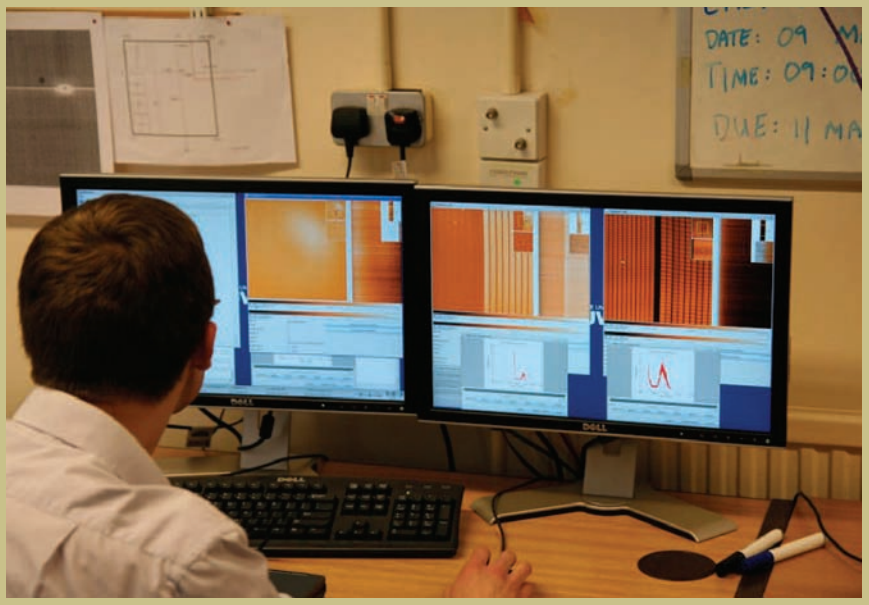
MIRI is one of four instruments onboard but it is far more than an imaging camera. It also contains a spectrometer to analyse the distant light and a coronagraph to search for planets orbiting other stars.

"The coronagraphs block the very bright light from the star so that we can see the planets," explains JWST-MIRI European Principal Investigator, Gillian Wright. "Because MIRI is more sensitive we can look for smaller planets than current instruments can, planets that are more like the Earth in size and mass, or planets that are much closer to their stars."

"The spectrometers break up the light into a spectrum for every point in an image," she adds. "The spectra tells us about the chemical elements and materials and because we also have spatial information we will be able to look at the distribution of materials."

This information could help scientists understand how the distribution of different types of ice, for example, affects how planets form or, by studying hot regions within galaxies with black holes at their centre, the process of star formation.

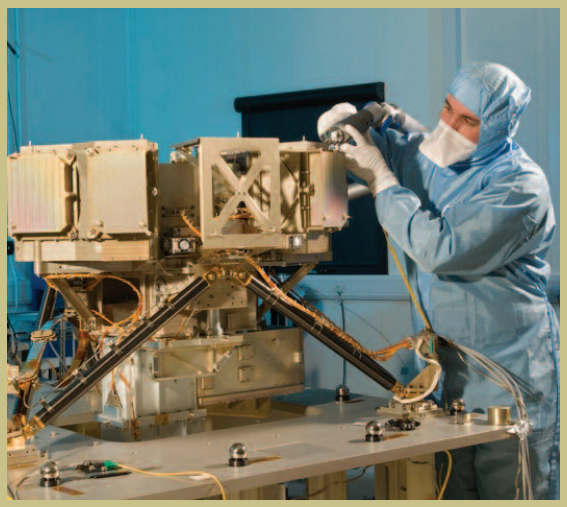
"I'm delighted and all the tests suggest we've built a fantastic instrument"
Gillian Wright



Although Wright is based at the UK Astronomy Technology Centre (UK-ATC) in Edinburgh, at the moment she is more likely to be found at the STFC Rutherford Appleton Laboratory (RAL) in Oxfordshire. MIRI is half way through a vigorous three-month test period at RAL using a space test chamber that cools MIRI to its minus 266°C (7 Kelvin) operating temperature inside specially designed shrouds that simulate the temperature and brightness of the background 'sky' that MIRI will see when it is in space.

These detailed tests also check that all instrument parts work at these cold temperatures and the same flight software is used that will command MIRI in space. As a result a team of around 40 scientists, from the 11 countries that contributed to the instrument's development, are working 24 hours a day, seven days a week.

"It's going extremely well," says Wright, laughing with relief. "I'm delighted and all the tests suggest we've built a fantastic instrument. As well as the work at RAL, the UK-ATC built the integral field units for MIRI's spectrometer, the University of Leicester constructed the main structure that holds different parts of the instrument in the correct position and Astrium UK are responsible for systems engineering and project management."



World class science

Wright's delight is understandable. MIRI has been more than ten years in the making and these are among the final stages before it is delivered to NASA's Goddard Space Flight Center later this year. "You work on something for so long and you don't know until you get to the tests whether it's ok or not," admits Wright. "Working at these cold temperatures means that small mistakes can cause big problems, so technically it was very challenging."

David Parker, director of science, technology and exploration for the UK Space Agency, is also pleased with MIRI's progress. "It's great news that the first calibration images showed the instrument behaving just as predicted," says Parker. "MIRI is a flagship programme for UK space science because it is one of the most complex and sophisticated instruments ever built for a space observatory."

"MIRI places the UK at the heart of the largest and most expensive space observatory ever built," Parker adds. "It shows how the UK can lead the science, technology and management of a world-class space project – one that involves dozens of universities and research labs across Europe. It may see the 'first light' from the earliest generation of stars and help us find answers to cosmic questions such as the history of black holes, the evolution of planets and the conditions that might support life elsewhere in the Universe."

NASA's John Mather is equally excited about the JWST mission: "Glorious discoveries await!"

He's right – and the UK is playing a key role in this cool cosmic adventure.

Image top left: Artist image of the JWST
Credit: NASA

Image bottom left: MIRI undergoing alignment testing
Credit: STFC

Image top right: MIRI's first images at the STFC Rutherford Appleton Laboratory space test chamber
Credit: STFC

Credit: Reaction Engines

Skylon: the best of British

The slender sleek curves, pointed nose cone and twin engines resemble science fiction rockets from the 1950s. But don't be fooled. As Sue Nelson discovers, the British Skylon spaceplane is a vision of the future.

Currently under development at Culham in Oxfordshire, and fresh from passing a technical review by the UK Space Agency, the unpiloted 84m long Skylon combines both jet and rocket technology. It will take-off and land like an aeroplane but at considerably less cost than a Shuttle or conventional rocket transporting payloads, such as satellites and telescopes, into space.

"It's a return to the sort of challenges people were facing in the 1950s and 60s," says Alan Bond, "where it was assumed we would fly higher and faster until one day we would find ourselves in orbit."

Bond is one of Reaction Engines Limited's three founding directors. Based at Culham Science Centre, on the site of a former Royal Naval Air Station, it is a fitting location for Skylon's development since the wide central driveway approaching the building used to be a runway.

Air breathing

Bond's engine, which combines plane and rocket technology, is at the heart of Skylon's design. It's called SABRE - Synergetic Air Breathing Rocket Engine – and combines oxygen from the air with liquid hydrogen for the first part of its ascent, before switching over to liquid oxygen to leave the atmosphere for the final stage into space.

"An ordinary jet engine can't get above around 2.75 times the speed of sound," says Bond, "so we have to cleverly engineer it so that the liquid hydrogen fuel on board can cool the incoming air and help us get up to Mach 5 and beyond so that the rocket can take over."

There is one crucial stage to overcome. Air enters the engine at about 1.5 kms per second and the temperature of its gases reaches over 1000 degrees celsius. "The first thing you've got to do is cool all the air to a very low temperature, down to minus 140 degrees celsius, before we start compressing it to put into the rocket engines. And that's the trick," Bond adds. "Using hydrogen fuel to cool the air so you can compress it, then you can use it in the same combustion system that the rocket will use later on."

It is more than a trick, of course. The engine requires new technology in the form of a heat exchanger that weighs just over 1.25 tonnes. "If that was a nuclear power station heat exchanger it would probably weigh 200 tonnes."

Air also contains moisture and so phase 1 of Skylon's development concentrated on frost control technology for the heat exchanger. Cylinders containing hundreds of lightweight nickel alloy tubes, less than a millimetre in diameter, sit in some of the workshops.

Secret design

Across the hall is a workshop containing a wind tunnel and there's a testing facility outside but no photographs are allowed and exact details must be kept secret. If successful the project could be worth billions, although it's the technology of the engines and heat exchangers that seems to most excite Bond. "They're impressive by anyone's standards," he says proudly.

Models of Skylon, on show for potential investors or the public, are always black and panther-like. This is because the skin of the spaceplane will be made from black carbonfibre embedded in glass.

"It has to be aerodynamically and structurally efficient and as light as possible," says fellow director Richard Varvill, who specialises on the airframe. "But the most crucial difference is the fact that you get it back. A normal rocket launch vehicle does just one flight and either breaks up on re-entry or can't be reused. As a result, it costs of the order of $100 million plus."

By comparison, Skylon, will carry payloads of up to 12 tonnes at around a tenth of the price of an expendable rocket – a big saving to potential customers. It also aims to be 1000 times more reliable with a lifetime of 200 flights. "Skylon is like an airplane so what goes up does come down, then you can refurbish it and start all over again."

This fast turnaround time is an important factor. "Expendable rockets literally arrive at the launch site as a kit of parts that have to be built together. It's a technically precise operation that takes a long time," says Varvill. "Then you have to test it and integrate the payload and this takes at least three months. Skylon could fly again within days."

Breakthrough

Passing the technical assessment was a huge boost. Commissioned by the UK Space Agency, using ESA experts, the report stated that success on the future engine test would mean "a major breakthrough in propulsion worldwide."

"It was enormously important," concedes Varvill. "This was an independent technical audit by ESA and it was an important signal to the finance community that we knew what we were about and that it was technically viable."

Most of Skylon's funding is from the private sector. "It's nice to feel Britain is able to do that these days," Bond says. "Not only have we got strong private investment but we've also got the Government behind us, helping us get the legislation right."

Skylon is currently in technology demonstration programme phase 2, which includes a construction test of the pre-cooler or heat exchanger. "This is the single key novel technology in the whole system," states Varvill.

Phase 3, costing about £200 million, begins at the end of the year and includes the detailed design of SABRE, its small-scale construction and a ground demonstration. Ten test vehicles will be built, each about 9m long. "They look like a miniature version of Skylon and are rather missile-like," says Varvill. "They'll be flown off a rail with no undercarriage."

Reaction Engines companies Brite Spark, a precision engineering firm based in Berkshire, and the Oxfordshire-based Crossman Engineering, for example, will manufacture parts. Phase 3 will end in 2014 with plans for Skylon to enter service in 2020.

"We're 100% confident," Varvill states.

Confident that Skylon's novel technology will surpass offerings from other, larger companies, Bond is even more emphatic. "In a very real sense, we don't have any competition."

Image 1 below: Artist impression of Skylon in orbit
Credit: Reaction Engines

Image 2 below: The unpiloted Skylon combines aircraft and rocket technology
Credit: Reaction Engines

education & careers

Ask the experts

If you have a question about space, we'll track down the right people to answer it.

Duncan Forgan
An astronomer at the University of Edinburgh. He is taking part in the public engagement project 'Wish you were? Searching for exoplanets'

What is the likelihood of life on Gliese 581 d?

Lyle, S5 pupil at Cumnock Academy

Some 20 light years away from Earth, the Gliese 581 system is probably one of the most interesting planetary systems we know of. We have strong evidence for four planets (and some evidence for up to six) around this star, which is an 'M Dwarf'. This is astronomer's jargon for a small, cool star. It is about 100 times less bright than our Sun. Gliese 581 d is the third planet to be discovered (Gliese 581 'a' is the star itself), and is a Super-Earth – at most about 13 times the mass of our planet. This means that it is likely to have a much thicker atmosphere, as its stronger gravity can collect larger quantities of gases than our planet. If the atmosphere has the right mix of chemicals then it could keep quite warm despite its cool star, thanks to a greenhouse effect. The discoverers of Gliese 581 d think it could be an 'ocean planet', where the entire surface is covered with water.

Amongst the more than 500 planets now known to orbit stars other than the Sun, Gliese 581 d is considered the best candidate to host life forms similar to that on Earth. However, attaching any probability would just be a reflection of our prejudice, rather than being based on evidence. We currently neither know the exact ingredients and conditions required for life to develop, evolve and sustain, nor do we know whether it will emerge once it could. Our knowledge about life is quite limited by the fact that Earth is still the only place in the Universe known to host it. Planets like Gliese 581 d make good candidates to actually search for the signatures of life and, should we find them, we can only imagine what could be learnt about life on Earth, ourselves, our origins, and our future.

Duncan Forgan **Martin Dominik**

This Hubble image shows more than 10,000 galaxies – how many (if any) have planets supporting life?
Credit: ESA/NASA

Martin Dominik
A Royal Society University Research Fellow at the University of St Andrews

Are there any heath effects to living in zero gravity for an extended period of time?

Jenna, Grange Academy

This is a great question – and a great opportunity to clear up a major misconception. There IS gravity in space – gravity is the mysterious attraction that every bit of mass, or 'stuff', in the Universe has for every other bit of stuff. It's a force that gets weaker and weaker with distance, but you can never fully escape from its clutches.

So, imagine throwing a ball – the faster you throw it, the further it will go but it still curves towards the ground under the influence of gravity. If I throw it fast enough – at a speed of five miles every second – then it will fall in a curve, but at the same rate as the Earth curves away underneath it. As it's falling on a path that matches the curve of the Earth, it never hits the surface. It's orbiting the Earth. Since one of the peculiar things about a gravity field is that it accelerates all masses equally, this means that anything inside the ball will also fall along exactly the same path. That's why, if you were a passenger inside the ball, there'd be no relative motion between you and the ball – so you feel as if you are floating rather than falling around the Earth at a colossal speed! From a space science perspective, we call this seemingly-gravity-free situation a 'microgravity' environment.

Back to the question in hand…For all the joys and freedoms associated with being able to float around, the fact that life has evolved for billions of years under the influence of a gravity field means there are significant health risks that would-be astronauts need to be aware of.

Tiny chalk-like particles called otoliths in the inner ear tell the brain which way is up and which way is down. In a microgravity environment, the otoliths float in random directions. However, our eyes will tell the brain something completely different and this conflict between what the eyes and ears are telling the brain – neurovestibular confusion – results in more than half of all astronauts experiencing what's known as Space Adaptation Syndrome within the first few hours of reaching orbit. This can include repeated vomiting, sometimes diarrhoea and has been known to incapacitate astronauts for the first few days of a mission.

As time in orbit goes on, other effects appear. With very little demand on the muscles, they tend to lose mass and strength, so astronauts spend up to three hours per day exercising to try to reduce this muscle loss. Also, the redistribution of fluids from the lower body to the chest cavity and face means that not only do astronauts have a much puffier look to their faces, the brain interprets this fluid shift as meaning that the body is over-hydrated. The kidneys go into overdrive – astronauts report significantly increased urine output and dehydration is a major concern. An unfortunate additional consequence of over-urination, coupled to the lack of load on human bones, is that the body will start to leach away calcium from bone structure. Primarily excreted through urine, this can amount to a bone loss of as high as 1% of bone mass per month. Although exercise can help reduce this, there is no complete safeguard against a reduction in bone strength after spending a long time in space.

Anu Ojha

Anu Ojha
Director of the Space Academy at the National Space Centre

Image bottom left: Micro-gravity can also do crazy things to your hair – this is NASA astronaut Cady Coleman on the International Space Station
Credit: NASA

Image top right: Which way is up?
Credit: NASA

education & careers

Teaching resources

Image: Inspecting the mirror of the Herschel space telescope. Herschel is providing new insights into the nature of the Universe
Image Credit: ESA

ESERO-UK, the UK space education office, held a dedicated space CPD day at the UK Space Conference 2011. The free event was attended by more than 100 primary and secondary teachers and featured a range of interactive workshops designed to showcase some of the resources and facilities – such as the Faulkes Telescope and the National Schools' Observatory – that are available to help promote space education. All the presentations from the day will soon be available to download from the National STEM Centre eLibrary, which is accessible through the ESERO-UK website.

The day formed part of the dedicated outreach programme that ESERO-UK is undertaking in an attempt to support teachers in their understanding of space and how they could use it as a context for learning in their schools. Another important part of this mission is to link schools with local space industries and explore how they can work together.

The UK Space Industry is thriving, yet conversely according to a recent CBI/EDI Education and Skills Survey, businesses are still struggling to recruit adequately STEM-skilled graduates. It is therefore vital for industry to forge closer links with local schools. It could do this by visiting them to offer talks; providing inspirational role models (such as those available through the STEM Ambassadors scheme run by STEMNET); arranging site visits; or even working on joint projects. These partnerships can make a big difference in opening up students' eyes to how rewarding and exciting a space industry-related career can be.

ESERO-UK is happy to facilitate the creation of links between schools/colleges and industry. We are always interested to know of any businesses seeking to make closer contact with their local schools. For more information, contact the ESERO-UK Project Manager Allan Clements: (a.clements@nationalstemcentre.org.uk)

www.esero.org.uk

Resource spotlight

We have recently added a collection of Royal Astronomical Society resources to the eLibrary (our online repository of quality STEM teaching resources). These resources, produced by the Society and other eminent organisations, will help teachers and students gain a greater understanding of astronomy and astronomical techniques. The collection explores topics ranging from 'Stonehenge and Ancient Astronomy' to 'Infrared Astronomy'.

The collection can be found here:
http://stem.org.uk/cxte

I work in space

Fancy a job in space? In every issue of *space:uk* we talk to someone who has a career in the UK space industry…

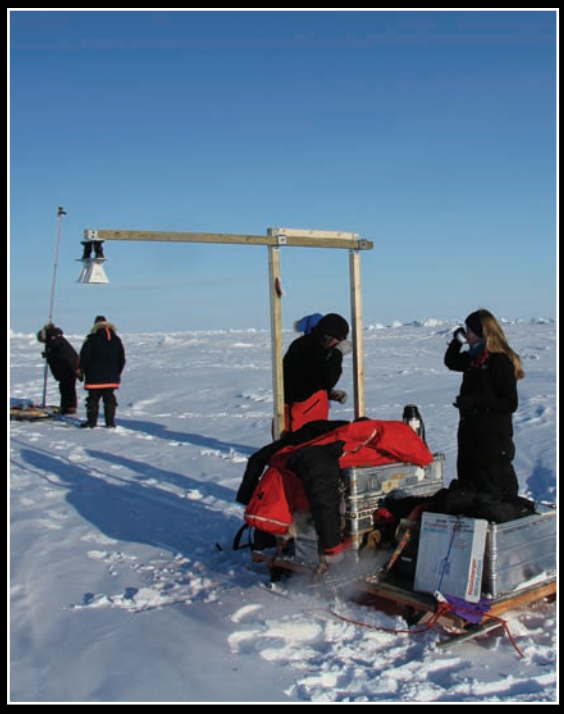
Rosemary Willatt is a PhD student at the Centre for Polar Observation and Modelling based at University College London. She has recently returned from an expedition to the Arctic.

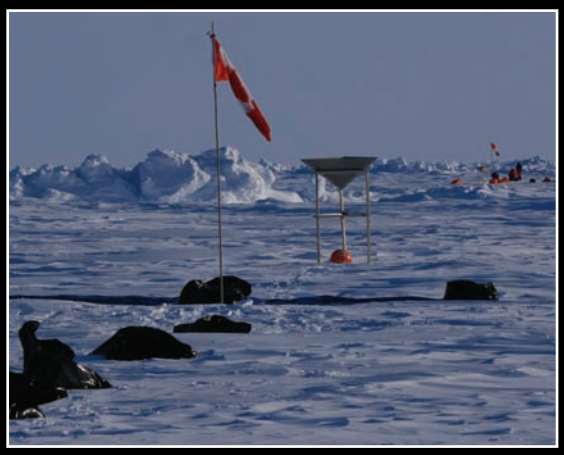
Images show the team's experiments on the ice floe
Credit: Laxon

What does your job involve?
Our group uses satellites to look at how the polar regions are changing. Radars on the satellites shine down from space onto sea ice (frozen seawater) to estimate its thickness. Sea ice is like a giant thermometer and can tell us how the polar climate is changing. I'm interested in looking at what happens when there is snow on top of the ice - how well can the radars see through the snow?

What mission are you working on at the moment?
CryoSat is the newest satellite we use to study ice from space. CryoSat allows us to look at changes in ice thickness over several years and across huge areas like the Arctic Ocean. But before we can understand what the CryoSat radar is telling us, we need to make measurements on the ground and from aircraft.

What did this fieldwork involve?
To reach different ice types we used skidoos and a Twin Otter plane to allow us to get hundreds of kilometers from the north coast of Canada. The sled-based radar we used lives in a big box with a heating system to keep it warm and is pulled by hand across the ice - it's not easy as it weighs around 100 kg!





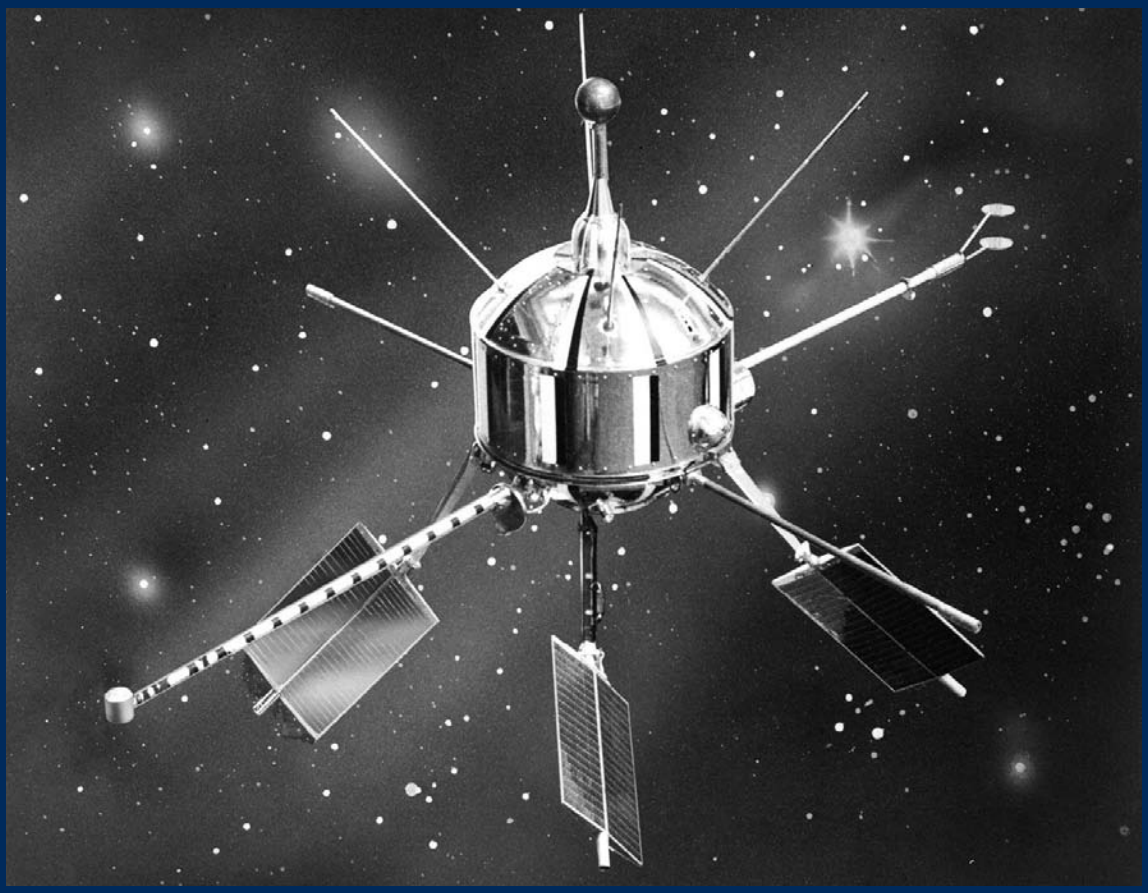
Sounds exciting?
Every day was exciting, wondering what we would see and how cold it would get! A few highlights were landing on sea ice in the plane - the pilots test out suitable landing sites by touching down briefly before heading up again. Each site is tested several times before they finally land on it. We also saw a pack of Arctic wolves that lived near the base where we stayed. They were white and magnificent. They would sit looking very regal in the snow and liked stealing things, for example my colleague's backpack!

What is the best part of your job?
I love the exploration aspect of being a scientist. I think scientific study is driven by curiosity and a desire to understand, as well as we can, the world around us. For me, when I receive a new dataset I am excited to think of all the information it contains about the Earth, and how I can get that information out. Of course, another aspect that I really enjoy is travelling to remote and relatively unexplored areas of the Earth, such as the Arctic and the Antarctic.

What advice would you give someone considering a career in space?
If you are curious about space, the Earth, or other scientific questions then think about what excites you most and pursue that, although it may well change as you learn more as it did for me. A-levels and a degree in maths, physics or something similar are useful for almost all scientific space-related jobs. Don't let anyone tell you physics is boring - just wait until you get into its explanations of how the world around you works!

UK SPACE PIONEERS

Ariel 1



Artist impression of Ariel 1 in space **Credit:** NASA

Ariel 1 was the world's first international satellite. Launched in 1962, it was designed and built by NASA and carried six UK experiments.

Ariel was named after the sprite in Shakespeare's *Tempest* – a sprite is a legendary or magical creature that can appear at will. The satellite was conceived in 1959 at an international meeting on space research, when Britain took up an offer from the United States to launch scientific satellites with experiments from other countries.

Research using Ariel 1 focused on investigating the space environment. It carried UK experiments designed to study the ionosphere – the electrically charged outer layer of the Earth's atmosphere – and radiation coming from the Sun. Equipment onboard was sophisticated for the time and included a tape recorder, designed to store scientific data when the satellite was out of communications range.

Following its 26 April launch on a Thor Delta rocket from Cape Canaveral, the satellite performed well. But this was not to last. In July 1962, the US military conducted a high-altitude nuclear test explosion called Starfish. By September 1962, radiation damage to Ariel 1's solar panels severely impaired the satellite's functions. It continued to operate erratically for another two years but the mission was finally ended in 1964. The satellite burnt up on re-entry to the Earth's atmosphere in 1976.

Despite its brief existence, Ariel 1 produced useful scientific data and laid the foundations for the UK satellite programme. It was followed by Ariel 2 in 1964 and the first all UK-built satellite, Ariel 3, in 1967.

You can find a podcast featuring an interview with Ken Pounds, a scientist who worked on Ariel 1, on the UK Space Agency website. Search for 'space 50 podcasts'.

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