Spring 2012 Issue 34

space:uk

Green planet:
the satellites saving the trees

Freefall science:
the joys of microgravity research

Ripples in space and time:
UK satellite investigates

Plus:
Satellites to investigate Earth's magnetic field, UK scientists in Mars mission, Envisat anniversary and Venus pull-out poster

UK SPACE AGENCY

Contents

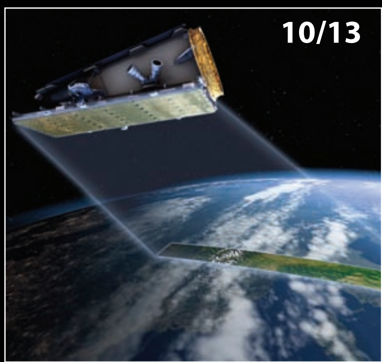
From the editor

I recently got a close up view of Swarm, Europe's latest scientific satellites. These three spacecraft will make the most accurate measurements ever of the Earth's magnetic field. The satellites are masterpieces of precision engineering, made up of components brought together from across Europe. Their structures, for instance, were made in Stevenage, one of the precision instruments comes from the Czech Republic and the finished satellites have been tested in Germany.

Swarm is an example of just how international space has become. There are good reasons for this, not least the cost. Only by cooperating can nations afford to put together such ambitious missions. But there is more to it than that. The engineering and scientific benefits from collaborating in space are enormous, resulting in new technology and better science.

Every mission featured in *space:uk* involves nations working together – from saving forests and understanding science in microgravity, to figuring out ripples in space and time. Also in this issue, we continue our series of posters on the Solar System with a look at Venus, and contemplate how long it will take humans to get to Mars. When that does happen (and I really hope it does), you can bet there will be an international crew on board the spacecraft.

Richard Hollingham
Editor



Credit: SSTL

Credit: Astrium

Credit: ESA

Credit: ESA, NASA

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Front cover image: The Aurora seen from the International Space Station
Credit: ESA, NASA

UK delivers for new space telescope

A key UK instrument for a massive new international space telescope has been completed. Destined for Hubble's replacement, the James Webb Space Telescope, MIRI (Mid-InfraRed Instrument) is designed to observe star formation and search for planets.

"We're expecting to ship it out in the first week of May," said MIRI's European Principal Investigator, Gillian Wright from the UK Astronomy Technology Centre in Edinburgh. "It will be unpacked at NASA's Goddard Space Flight Center."

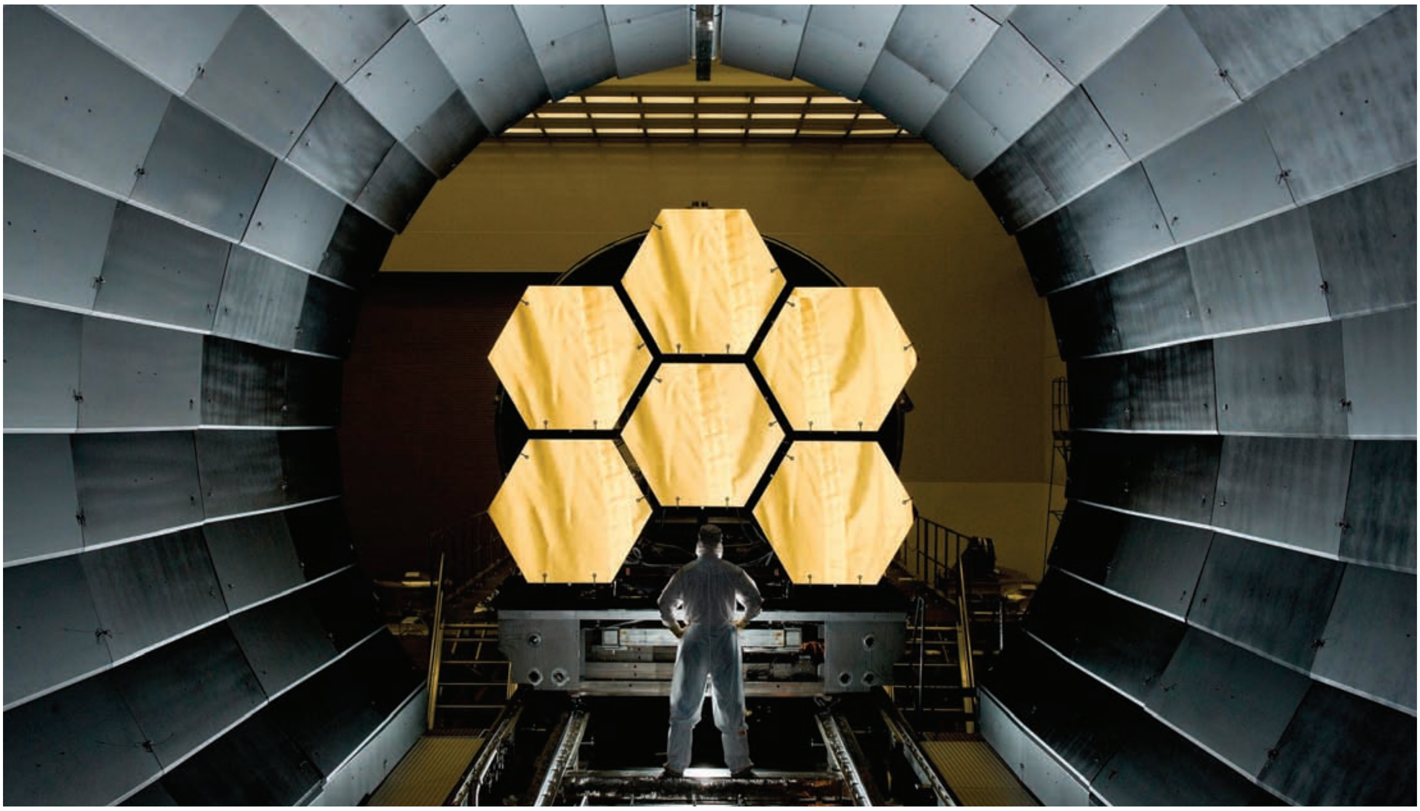
Scheduled for launch in 2018, the James Webb Space Telescope (JWST) will be around six times the size of Hubble, with a 6.5 metre diameter mirror and a sunshield as big as a tennis court. The space telescope will search for the earliest galaxies formed after the Big Bang, enabling scientists to study how they evolved into galaxies like our own. It will also investigate planets forming around stars to gain a greater understanding of Earth-like planets and the necessary conditions for life, as well as distant comets plus the hundreds of icy objects in the Kuiper Belt beyond Neptune.

JWST, an international project between ESA, NASA and the Canadian Space Agency, will contain four instruments able to study the infrared. It will be sited 1.5 million kilometres away from Earth in deep space, on the opposite side of the Earth from the Sun. This is where it will be cool enough for the instruments to obtain the measurements that will help decipher our Universe.

A consortium from Europe and the United States built MIRI with the UK – funded by the UK Space Agency – leading the European collaboration. It contains a camera and a spectrograph that can observe light in the mid-infrared region of the electromagnetic spectrum.

MIRI is been undergoing a final series of vibration tests at the Rutherford Appleton Laboratory in Oxfordshire. It has already passed similar tests that subjected the instrument to the equivalent of 80 times the force of gravity, proving that it is able to withstand the launch.

"It's almost ready to go," said Wright. "We had a big review of all our test results led by independent experts at ESA and they concluded we're in really good shape." As the first of the telescope's instruments to be delivered, this is an important stage for the scientists who have worked on MIRI and, speaking to space:uk, Wright was understandably excited: "The whole team is on a high!"



Credit: NASA

The first six JWST mirror segments being prepared for testing. The telescope will have 18 segments in total, which gives an idea of its vast size

Welcome

Emma Lord, Director of Policy and Operations for the UK Space Agency, looks forward to the year ahead:


Credit: Warren Allot

Competition winner Patrick Galvin

2012 is shaping up to be a busy year for the UK in space and there have already been some noteworthy events. A personal highlight was in February when I met ten-year-old Patrick Galvin who won an art competition on the theme of space and aeronautics. The prize is literally out of this world, as Patrick will have one of the Galileo satellites named after him. Galileo is Europe's satellite navigation system, with satellites being launched in phases over the next few years. Patrick is an inspirational young man and destined for an exciting career.

Still on the satellite theme, 1 March marked the 10th anniversary of the European Space Agency's Envisat. Launched in 2002, Envisat was initially intended to operate for five years but, not only has it shown exceptional reliability in space, the data acquired have proved essential in enabling scientists to understand the long-term changes happening to our planet (see pages 8 and 9).

Looking ahead, there are a number of big projects during 2012. As we reach the end of our first financial year of operations, the finance team is working hard to put together the annual accounts. This is a significant piece of work and links to a number of other priorities such as risk management and resource planning.

Running the operational side of an Agency might not sound as exciting as launching satellites but did you know that the UK Space Agency is also responsible for licensing spacecraft? The text of the Outer Space Act states that 'UK nationals and companies intending to launch or procure the launch of a space object, operate a space object or carry on any other activity in outer space need a licence before they can do so,' and that licence application is handled in the regulation section of the Agency. It's a technical procedure and several months of work are required to process each application.

In April we celebrate 50 years of the UK in space. 1962 saw the launch of the first British satellite, Ariel-1, making the UK only the third country to operate a satellite. From such beginnings industries grow. The latest figures show that turnover in the UK space industry has reached £7.5 billion and the sector employs nearly 25,000 people. The next issue of *space:uk* will celebrate the achievements of fifty years of the UK in space.

Moving through the calendar, the Agency is pleased to be attending the Farnborough International Airshow in July. Our communications section is putting together the space zone programme for the week, which will cover issues such as space and the growth agenda, emerging technologies, as well as a careers day for students and teachers. I'm looking forward to meeting people at the event to talk more about the work of the UK Space Agency and some of its international partners.

Finally, the European Space Agency (ESA) Ministerial meeting takes place at the end of 2012. This large project involves colleagues across the Agency working with industry, academia, and government in preparing the UK position. Ministerial meetings take place every four years when ministers from the 19 ESA Member States come together to agree future priorities in space.

I hope to meet some of you at Farnborough in July and, as always, you can keep up to date with the latest news and events on our website or through social media, including Facebook and Twitter.

www.bis.gov.uk/ukspaceagency


Credit: Swindon Advertiser

"1962 saw the launch of the first British satellite, Ariel-1, making the UK only the third country to operate a satellite"

Emma Lord,
UK Space Agency Director of Policy and Operations


Credit: ESA

The UK and Ireland as seen by Envisat

Swarm science

Credit: ESA

The three Swarm satellites folded up – two in their launch positions – in the clean room at IABG, the centre in Germany where they were tested

A European mission to map the Earth's magnetic field with unprecedented accuracy is being prepared for launch. Swarm will measure every aspect of the magnetic field, from the core to the crust. It will also investigate the magnetic 'bubble' surrounding our planet, known as the magnetosphere.

Swarm is made up of a constellation of three identical satellites, each resembling a giant mechanical insect. Astrium built the structures for the ESA spacecraft in the UK and, to ensure Swarm takes accurate measurements, meticulous care had to be taken to eliminate any magnetic contamination. Tools, components and even the glue that holds the satellites together were tested to ensure they were not magnetic.

The Earth's magnetic field is vital for life on Earth, protecting us from the stream of charged particles from the Sun called the solar wind. But the field is continuously changing and appears to be weakening by some 10% each year. It may even be going into reverse.

"The magnetic field is like a dipole magnet," explained Richard Holme, Professor of Geophysics at the University of Liverpool. "But there is an area in the southern hemisphere known as the South Atlantic Anomaly that is weakening the overall strength, and that is growing. So trying to understand that will give us an idea whether things are going into reverse or not."

The three Swarm satellites will fly in a triangular formation, in three different orbits to tease out the various components of the magnetic field. They are due to be launched together in July, on the same Rockot launch vehicle, from Plesetsk in northern Russia.

Space education takes off

School children across the UK are a step closer to space, thanks to two new initiatives.

The National Space Academy, launched in February, will use space to help bring science, maths and geography to life. Its network of teachers and space scientists will deliver masterclasses, careers events and teacher training. The academy will also offer a space engineering course with Loughborough College.

The project is being run by the National Space Centre, with funding from the UK government, ESA and UK industry. It was established after a successful three-year pilot in the East Midlands.

A second programme, Mission X: Train Like An Astronaut, is using astronauts to show children how important fitness and nutrition is on Earth. Its aim is to get students more active, improve their diet and understand the science behind fitness and health. The UK is one of 16 nations taking part.

The UK challenge is supported by the UK Space Agency and over 40 schools are involved. They are led by Mountfitchet Mathematics and Computing College in Essex, which piloted the programme last year.

Ed Vine from Hockerill Anglo-European School in Bishops Stortford said his school has already got a lot out of the programme. "Mission X has provided us with new energy, inspiration and an opportunity to develop new learning materials, "he explained." Classes of children have been voluntarily turning up after school for extra activities."

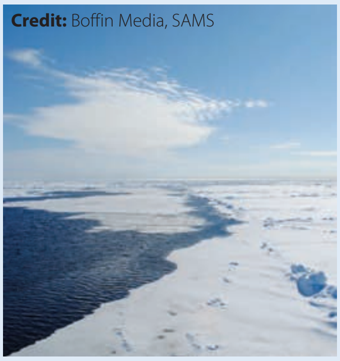
The UK will host an event in London in April giving students the chance to share their experiences and compare them with athletes' preparation for the Olympic Games.

Credit: UK Space Agency

Training like an astronaut is proving a big hit in schools

News

Arctic bulge


Credit: Boffin Media, SAMS

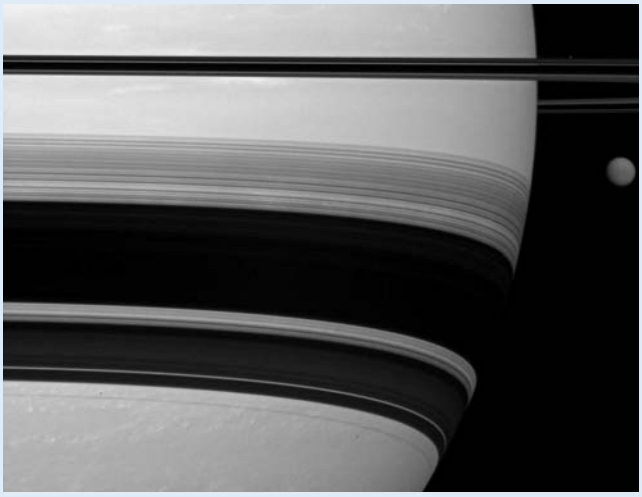
The Arctic Ocean is bulging

UK scientists have discovered that the amount of fresh water in the Arctic Ocean has increased. The team used two ESA satellites, ERS2 and Envisat, to determine that a huge dome of fresh water had risen by about 15 cm since 2002. The fresh water bulge, around 1000 km across, is found north of the Canadian coast in a rotating circulation system known the Beaufort Gyre. "The Arctic Ocean is covered in sea ice and as it moves around and breaks up it exposes bits of the ocean," said Katharine Giles, from the Centre for Polar Observation and Modelling at University College London. "The satellites are sensitive to those bits of the ocean and can see them from space and measure how high they are.

Off the shelf satellite

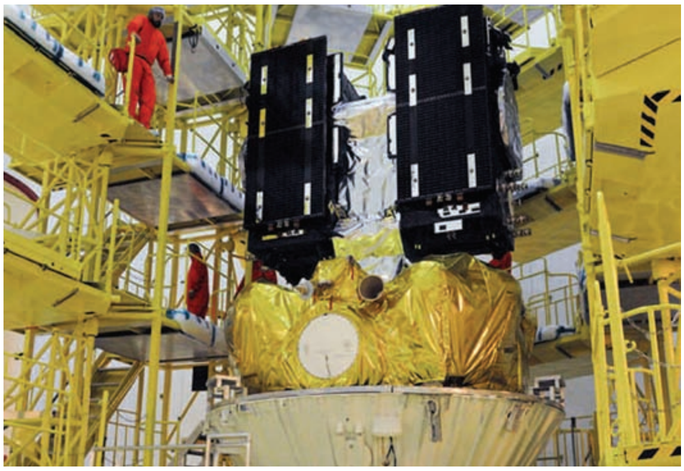
Astrium UK has started building the Sentinel 5 Precursor (S5P) satellite, three months after signing a £40 million contract with ESA. The spacecraft will monitor air quality, ozone, solar radiation and pollutants such as nitrogen dioxide, methane and carbon monoxide. An 'off-the-shelf' low cost design, previously used on Mars Express and Venus Express, allowed engineers and scientists at the company's Stevenage site to adapt the spacecraft to Earth observation.

Fellowship of the rings


Credit: ESA

This is our favourite space picture so far this year here at *space:uk*. Captured by the Cassini spacecraft, this infrared image shows Titan in the shadow of Saturn's rings. The international Cassini mission has been investigating the Saturn system since 2004 and continues to send back incredible images and valuable scientific information. In 2005, the Huygens probe descended to the surface of Titan and the first man-made component to touch the moon's surface was made in the UK.

Testing Galileo


Credit: ESA

The two Galileo IOV satellites positioned in the upper stage of the Soyuz launch vehicle before it's attached to the rest of the rocket

Over the past six months, the first fully operational satellites for Europe's new satellite navigation system have been put through their paces – and they're coming through the tests with flying colours. The two Galileo In Orbit Validation (IOV) satellites were launched in October and teams of engineers have been assessing their performance ever since.

The payloads for the IOV satellites – the sections that contain the navigation equipment – were made by Astrium in the UK. These include atomic clocks that are so precise they will lose just one second in 300,000 years. But when just one billionth of a second error equates to a positioning error of 30cm on the ground, every fraction of a second counts.

The testing process has been taking place at Redu, ESA's satellite ground station in the Ardennes region of Belgium, where a new dish has been built to receive the Galileo signals. Here, an international team has been assessing every aspect of the satellites' functions. Another group at ESA's technical centre, ESTEC, in the Netherlands uses a working copy of the IOV satellites to verify the system's performance.

"Its such a relief that the first launch went well and these first two satellites are delivering good signals," said Mark Bacon from the UK Space Agency. "The Galileo programme has had a difficult birth but we're now starting to see the results of years of hard work by UK companies."

When it's fully operational, Galileo will consist of a constellation of 30 satellites and will be the only global positioning system under civilian control. The payloads for the next two IOV satellites will also be made in Britain by Astrium and Surrey Satellite Technology Limited is building the payloads for a further 22 Galileo satellites, after winning a second major order in February. Other UK firms, such as Logica, have secured major contracts for the development and operation of Galileo.

Mars science laboratory

UK scientists will be among the first to view images and data from NASA's Mars Science Laboratory mission when its Curiosity rover lands on the Red Planet in August.

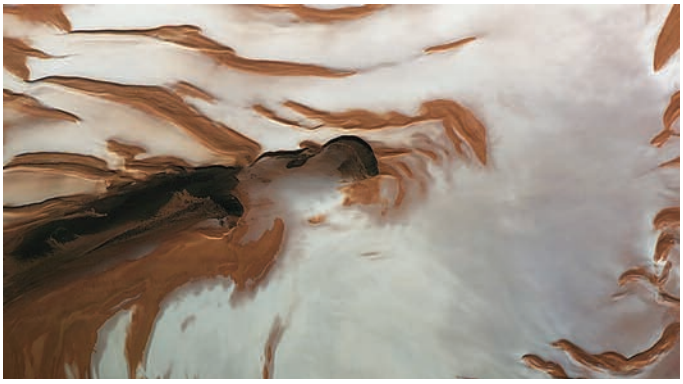
"One of the first images might be of the Mars Science Laboratory coming in to land on its parachutes taken from the Mars Reconnaissance Orbiter," said John Bridges from Leicester University's Space Research Centre. "Then there will be images from the descent imager where we capture the first glimpse of the landing site and the great mountain of sediments that fills the centre of the crater," he added. "These early images will help us work out exactly where in the 20 km landing ellipse we have landed."

Two UK teams will work as participating scientists on the mission, which launched in November 2011. Bridges is leading a team of scientists from the University of Leicester, the Open University and CNES, France. His group will focus on the presence of water in the clay-rich sediments identified by the Mars Reconnaissance Orbiter inside the Gale crater where Curiosity will land.

"The more we learn about Mars the more we realise how important water has been in shaping its landscape and altering its crust," said Bridges. "We intend to find those clays on the ground and determine if they formed through deposition in long standing lakes or through hydrothermal fluids percolating through the crust. We want to find out if Mars ever had conditions which were habitable for microbial life."

Credit: NASA

Artist's image showing the sky crane concept being used for the descent of the Curiosity rover



Credit: ESA

Europe's Mars Express has already transformed our understanding of the Red Planet. This image from the spacecraft shows a part of the northern polar region of Mars

Mars history

The other UK team is from Imperial College London, working with collaborators at University College London. Its Principal Investigator is geologist Sanjeev Gupta. "I study ancient sedimentary rocks so I'm applying my skills from Earth to looking at Martian rocks and trying to reconstruct ancient environments at the sites where the rover is going."

Curiosity is much larger than any previous rover – around the size of a Mini Cooper. It will spend 23 months on the Martian surface travelling around a crater that is 154 km (96 miles) wide and filled with interesting geological features.

"As the rover progressively climbs up the mountainside in the crater it will be able look at the individual layers to find clues for the action of water and wind preserved in these rocks, from billions of years ago," said Gupta. "What we can do is reconstruct the evolution, the environmental change through time, and get a glimpse of early Mars history which we've never been able to do before."

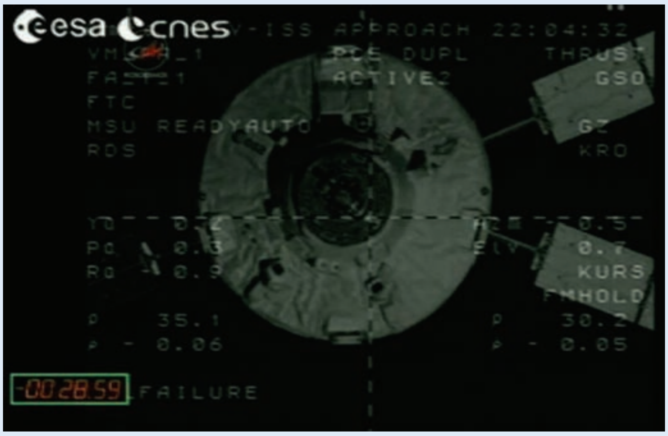
Curiosity will be the first rover to examine sedimentary rocks in detail. Its arrival, at exactly where scientists want it to go, will depend on different landing technology to what's been used before. "Previous landers used a conical aeroshell and parachutes to enter the upper atmosphere and start slowing down," said Bridges. "However, the last parts of the descent involve the new Sky Crane system."

Sky Crane will use eight small rockets, after the parachute has separated, to slow the descent and use cables to gently drop the rover, whose wheels are deployed, onto the surface. "There's no point in going to Mars if you're not going to see anything interesting," said Gupta. "If it works, future missions will use this."

Not surprisingly, both UK team leaders are excited about the mission. Not only that, the world will be watching.

UK sensors help dock European space truck

Sensors built by UK company e2v have safely guided ESA's Edoardo Amaldi spacecraft to a docking port on the International Space Station (ISS). The Edoardo Amaldi is the space agency's third Automated Transfer Vehicle (ATV) and brings much needed supplies to the six astronauts on board the ISS. The unmanned ATV was launched on an Ariane 5 rocket from French Guiana and hauled almost seven tonnes of cargo to the ISS. The spacecraft is the most powerful automatic spacecraft ever built and is equipped with its own propulsion and high-precision navigation system. The imaging sensors supplied by e2v are a key component, enabling the ATV to dock successfully.



Video still taken from the ISS of ATV Edoardo Amaldi approaching the station
Credit: ESA

Yes for Yahsat

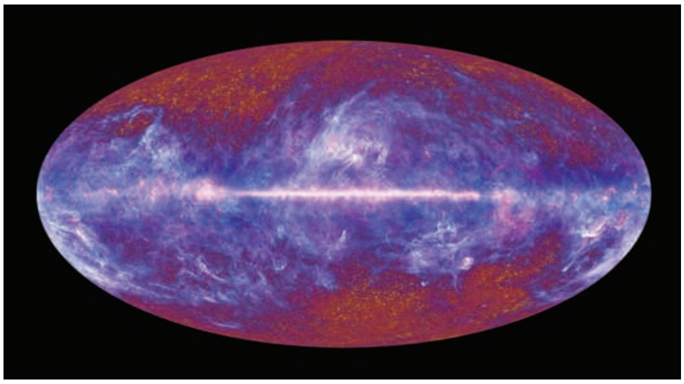
A sophisticated new communications satellite – most of which has been built in the UK – is being prepared for launch. Yahsat Y1B will provide broadband and telecommunications services to the Middle East. The service module, including the propulsion system for the satellite, is made by Astrium in Stevenage. The UK company also manufactured the structure and thermal management system. This has to cope with a temperature range in orbit of between 150° C in the Sun and -150° C in the shade.

Sat Nav competition

A competition for anybody with an idea that utilises satellite navigation technology is open for entries. The UK leg of the European Satellite Navigation Competition is supported by the UK Space Agency and is aimed at encouraging and supporting new business proposals. The winner of the competition will receive a £10,000 development fund and has the chance to compete for the top European competition prize.

www.nottingham.ac.uk/grace/ukesnc

Cool science mission ends



Credit: ESA

How Planck sees the entire Universe. The image was derived from data collected by the spacecraft during its first all-sky survey of microwave radiation

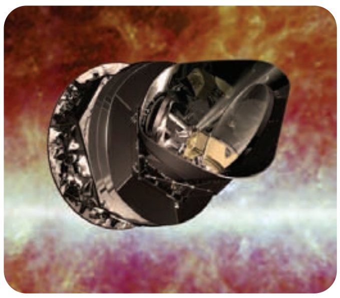
The main instrument on the European Planck spacecraft has exhausted its coolant gas supply, bringing the primary mission to an end. ESA's Planck has been observing the afterglow of the Big Bang, known as cosmic microwave background radiation, since 2009. The mission is designed to help answer fundamental questions about the nature of the cosmos, such as how did the Universe and galaxies form.

Despite an original mission lifetime of a year, the spacecraft has been operating for almost three years. Now though, Planck's High Frequency Instrument has run out of the gas needed to keep it at its operating temperature of just 0.1 degrees above the coldest possible temperature, absolute zero (-273.15). The second instrument on board Planck, the Low Frequency Instrument, does not need to be kept so cold and so will continue to operate for at least another year.

"Planck is giving us the best ever view of the early Universe," said Planck Survey Scientist George Efstathiou from the University of Cambridge. "While the High Frequency Instrument is coming to the end of its mission, we have a wealth of data to analyse over the coming months and years."

The UK is playing a major role in the mission, from instrument development to analysis of data. Recent results from Planck include the discovery of clouds of cold gas and a mysterious haze of microwave emissions in our own galaxy, the Milky Way.

"It has been a privilege to be part of the Planck team," said Efstathiou. "The satellite has performed flawlessly since launch and has returned data of exceptional quality. I am sure we will soon have exciting science results on the early universe."



Artist image of the Planck spacecraft
Credit: ESA

New climate satellite

A new satellite to monitor the climate and help forecast the weather is due to be launched in May. MetOp-B's instruments will measure a whole host of weather phenomena – from the temperature of the atmosphere to snow cover and soil moisture. It will also monitor sea ice and detect gases in the atmosphere. Its long-term data will be used to help investigate and predict climate change.

The weather satellite is the second in a series of three, partly built in the UK, funded by ESA and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The 4100 kg satellite is around the size of two family saloon cars and will join MetOp-A, which has been helping to predict the weather since 2006.

The MetOp satellites are even designed to save lives. "The two search and rescue instruments onboard MetOp-A delivered 2,635 distress signals, leading to the rescue of over 10,000 people," explained Astrium UK project manager Lyn Mason.

The company is responsible for manufacturing the Microwave Humidity Sounder (MHS) on MetOp-B, which will look into the Earth's atmosphere and scan the emitted radiation. "From this it can determine the water vapour content, or humidity, at various altitudes in the atmosphere," said Mason.

The UK Met Office has said that information from MetOp-A has been more important to its work than any other satellite – helping to reduce forecasting errors by 25 per cent. The third satellite in the series, MetOp-C, is scheduled for launch in 2016.

Credit: ESA

Final testing of MetOp-B at the launch facilities at Baikonur

Catapult for space sector

Credit: Clyde Space

Working on solar panels at Clyde Space, the company is a beneficiary of the National Space Technology Programme

Twenty-nine space projects are to share £2.5 million from the UK Space Agency's National Space Technology Programme. The grants will be used to develop commercial products and services using space technology or space-derived data.

These fast-track projects are part of the 'Space for Growth' competition, and each will last between six and nine months. They focus on satellite telecommunications, sensing, position, navigation and timing, robotics and exploration, and access to space. Additional funding from the Technology Strategy Board (TSB), the South East England Development Agency, and matched-funding from the businesses involved brings the total value to nearly £5 million.

In an extra boost for the space sector, a new centre to help UK business develop satellite-based products and services has also been announced. Due to open in autumn 2012, the Catapult Centre in Satellite Applications is being set up by the TSB with support from the UK Space Agency. It will focus on applications in communications, broadcasting, positioning and observation.

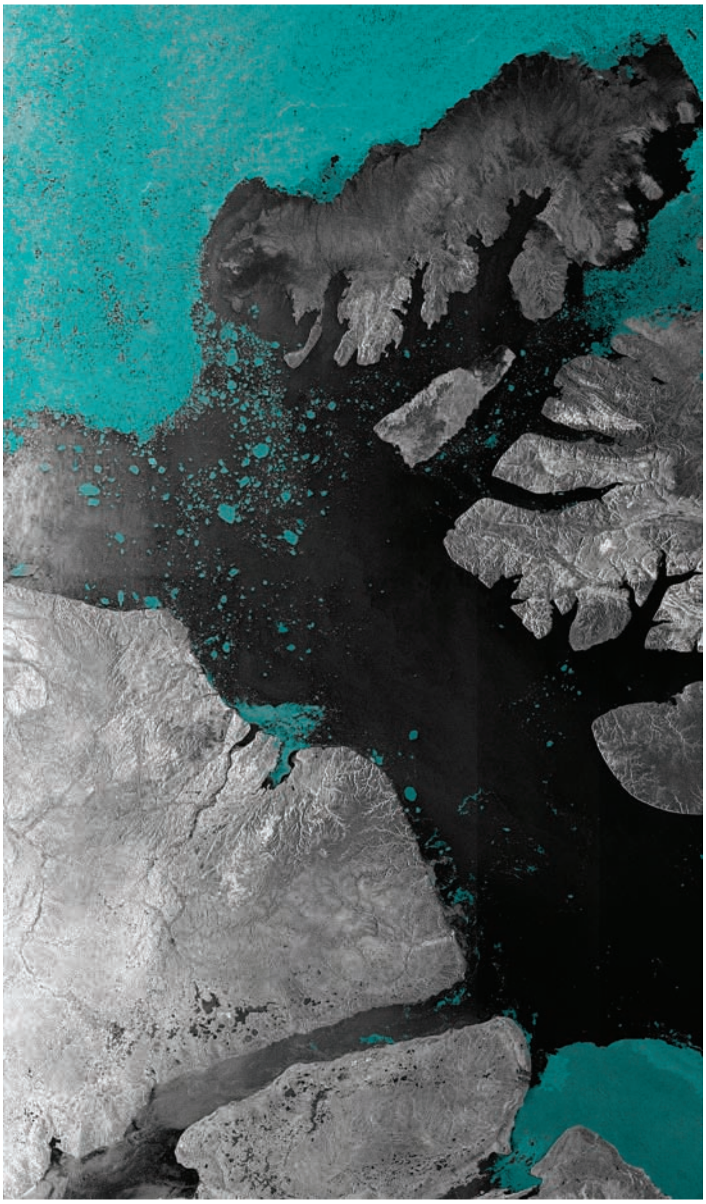
"The Catapult will help UK businesses create many new products and services across a wide range of areas, such as distance learning, telemedicine, urban planning, precision agriculture, traffic management and meteorology," said the Chief Executive of TSB, Iain Gray.

Amazing Envisat

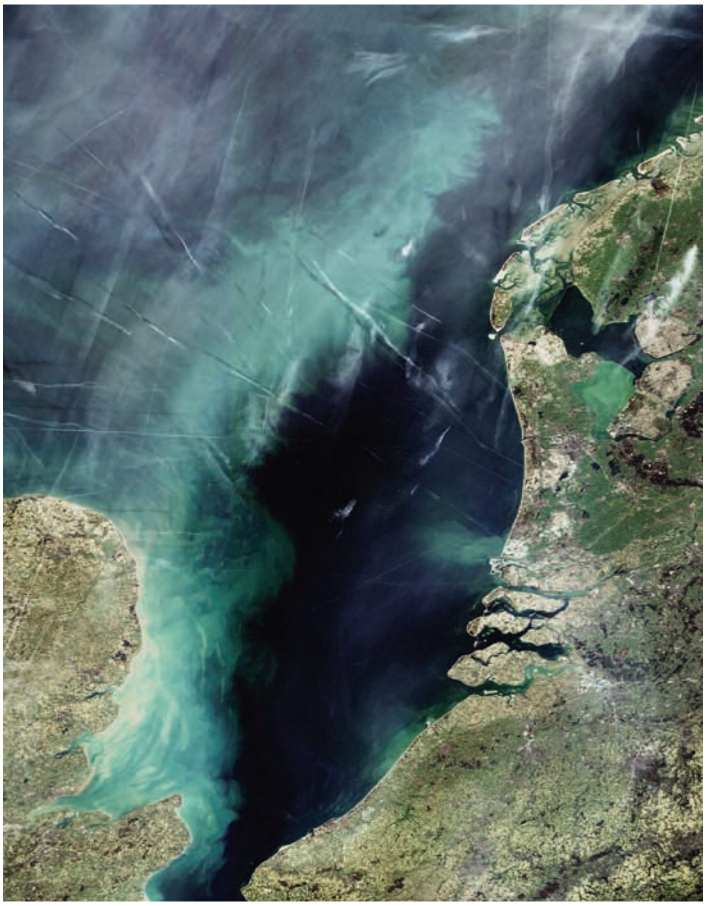
The European Envisat satellite is celebrating ten years in space. The size of a double-decker bus, it is the largest Earth observation satellite of its kind. Envisat carries ten instruments to monitor the health of our planet – from air to oceans and land to ice.

UK scientists and industry partners have been at the forefront of the satellite's design, construction and operation, with much of the satellite being built in Britain. Many UK teams are also involved in collecting and analysing data from Envisat. There are more than 1,200 scientific projects across Europe using data from the mission.

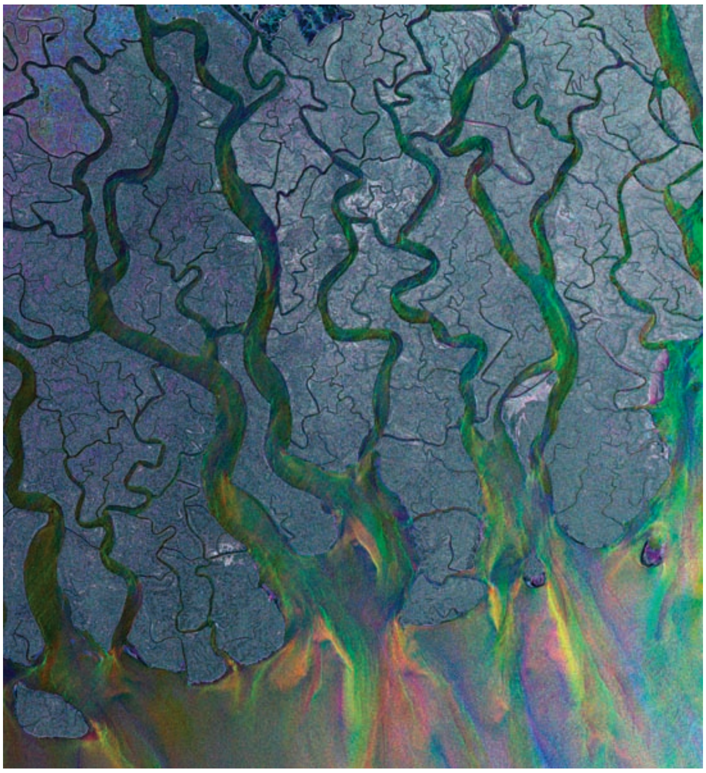
To celebrate the anniversary, here are some of our favourite pictures of the Earth taken by Envisat:



Envisat found the Northwest Passage in the Canadian Arctic to be clear of ice in 2007

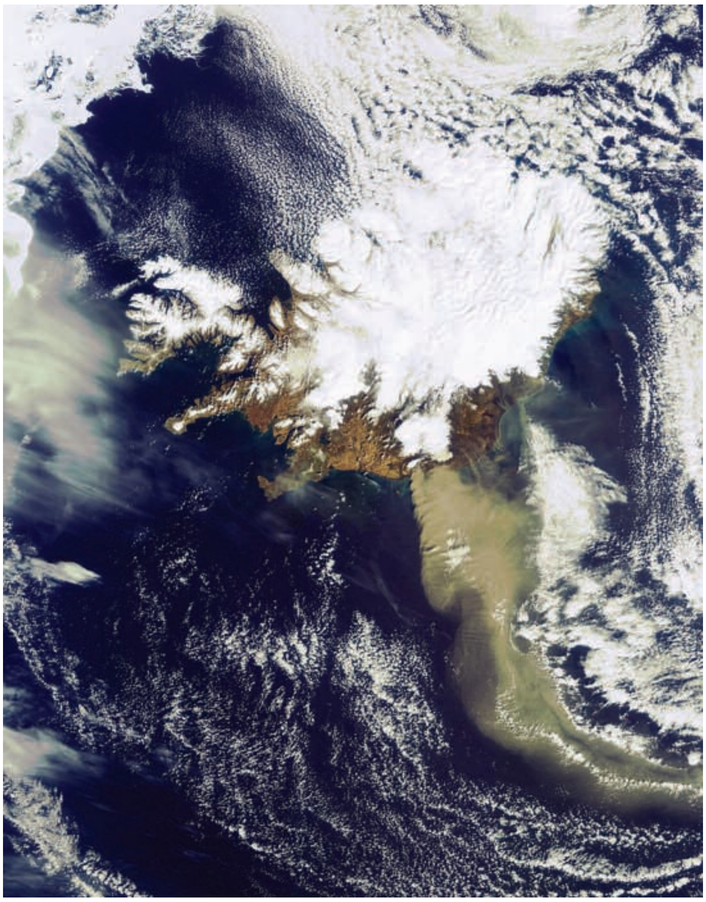


Aircraft contrails between eastern England and mainland Europe

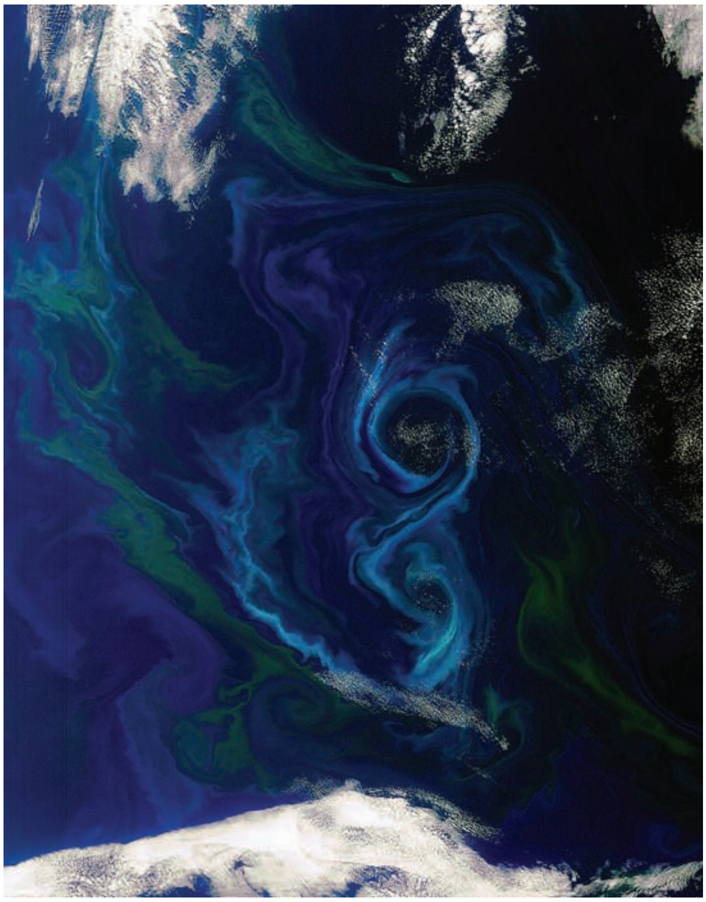


This picture of the Ganges Delta in Bangladesh was put together from three different images obtained by Envisat's radar instrument

All 6 images **Credit:** ESA

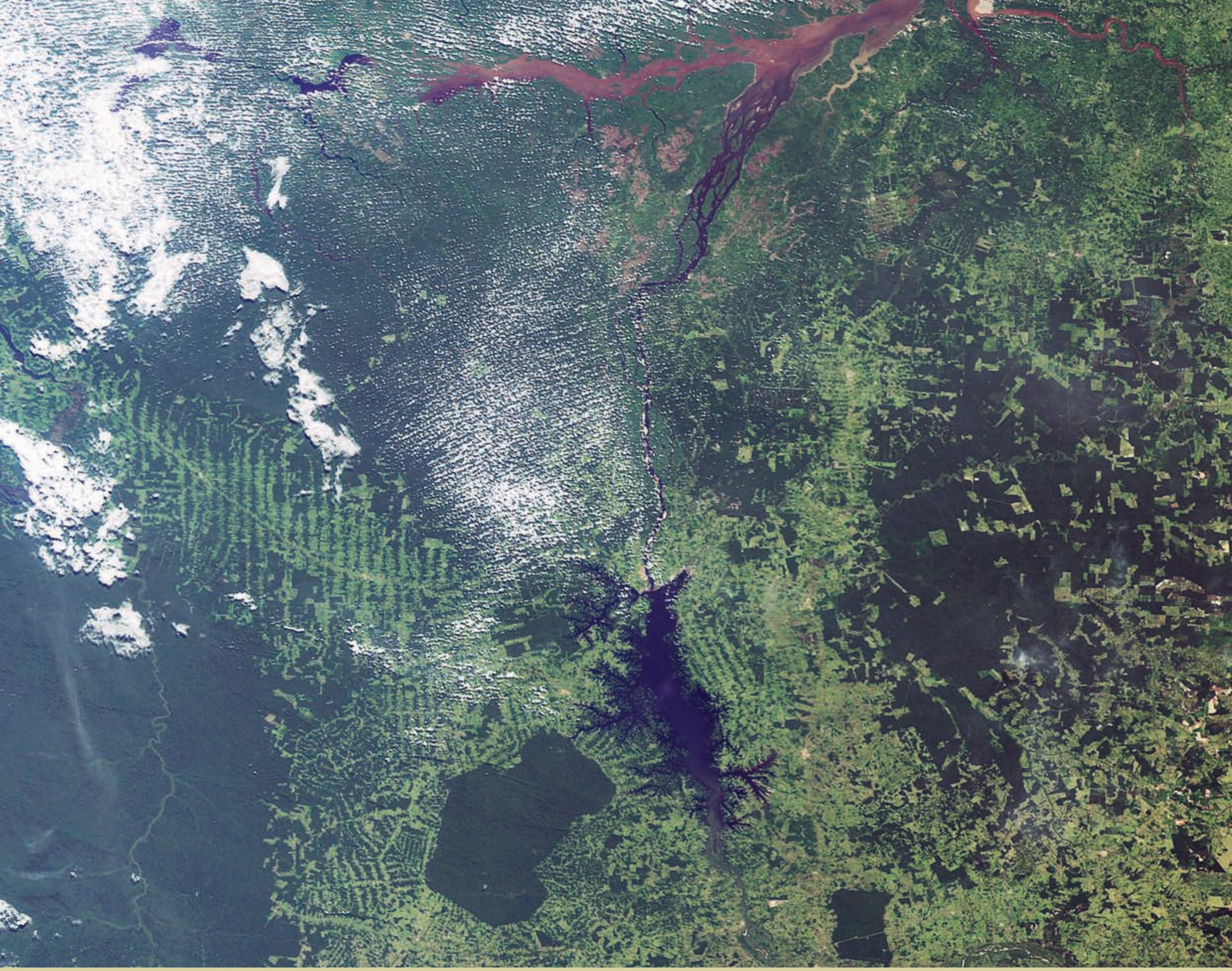


The plume of ash from the Eyjafjallajoekull Volcano in Iceland responsible for grounding flights across Europe



A figure of eight swirl of phytoplankton in the Southern Ocean, some 600 km east of the Falkland Islands

Europe from space, built up from a series of Envisat images



Green planet

Main image: Envisat image of part of Brazil's Amazon basin. Dark green areas are rainforest; the lighter green shows where forest has been lost to agriculture
Credit: ESA

Saving one of the Earth's most valuable resources could also benefit the UK economy. Richard Hollingham reports on how space technology is being used to preserve the forests:

From the pine forests of Siberia to the tropical rainforests of Africa and South America, our planet is remarkably green. Almost a third of all land on the Earth is covered in trees.

Forests have an essential role in regulating the climate by removing carbon dioxide from the atmosphere and adding oxygen. They also support a vast wealth of plants and animals and the livelihoods of some two billion people. Without all these trees we would be in big trouble. Nevertheless, every year around 13 million hectares of forest are lost to agriculture or development.

So how do we safeguard what's left?

"Space has a vital role to play," says Ruth Boumphrey Head of Earth Observation for the UK Space Agency. "Satellites are already used to monitor and map forests from space to detect illegal logging but information from satellites can also help governments better manage forests for the future."

When it comes to tackling illegal logging, space technology has an impressive track record. The UK's Disaster Monitoring Constellation (DMC) satellites, for instance, have been monitoring the Amazon rainforest since 2005.

The information they gather has enabled the Brazilian government to target law enforcement at the areas where illegal loggers are operating, and stop them. As a result, the country has seen a significant drop in the rate of deforestation.

New satellites

Brazil is now developing the Amazonia-1 satellite, which will carry a new camera built by UK group RAL-Space. These types of sophisticated satellites can see into even the most remote and inaccessible areas. But cameras in space have their limitations – particularly over rainforests.

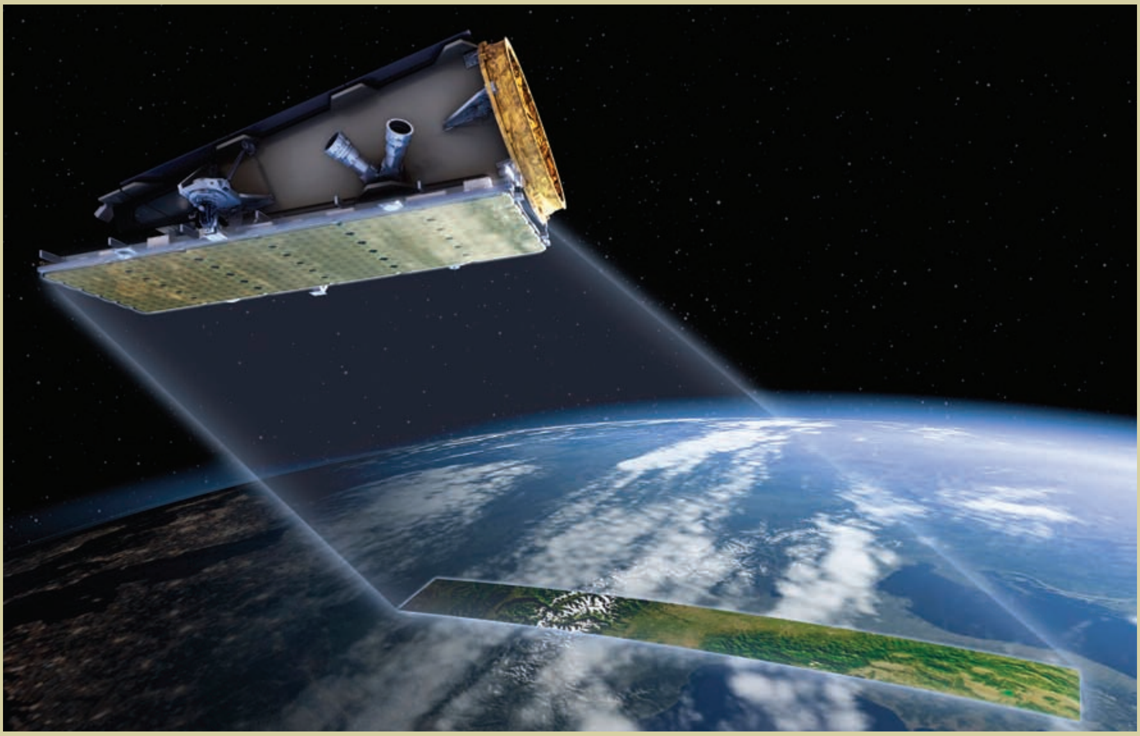
"Most tropical forests are subject to a lot of cloud cover," explains Rachel Bird from Surrey Satellite Technology Limited (SSTL), "which means that often the forest is hidden from view."

A new satellite should solve that problem. Bird is the Mission Analyst for NovaSAR, a Synthetic Aperture Radar (SAR) satellite backed by a £21 million investment from the UK Space Agency. SAR can be used to capture images day and night for a wide range of applications – from monitoring pollution to combating marine drug trafficking.

"The key advantage of SAR is that it has the ability to image through cloud. For forestry, that means you can capture images more frequently," says Bird. "By comparing images taken a few weeks or months apart you can see if there have been changes caused by fire, logging or disease."

With construction of the first satellite about to get underway, the aim is for NovaSAR to eventually form part of a satellite constellation. "With three satellites, we could map the entire Amazon rainforest every three weeks or revisit a smaller area every couple of days," says Bird. "It's something we've been hoping to build for a number of years – it's very exciting!"

Image below: Artist image of the NovaSAR satellite
Credit: SSTL



"Forests are valuable carbon stores for the world"

Ruth Boumphrey, Head of Earth Observation

continues >

Green planet
continued

Image top righ: Satellites are used to track forest fires. This image shows smoke over Moscow in 2010
Credit: ESA

Timber trade

Tackling illegal logging through better monitoring is one approach to the problem. The other is to reduce demand by limiting access to markets for illegally harvested timber. An increasing number of governments (including the UK government) and companies around the world have policies to use wood from sustainable sources – from forests that are re-planted and not permanently cleared for agriculture or development. Many rely on the independent Forestry Stewardship Council (FSC), which promotes and certifies forest management. You can find FSC branded timber in many DIY and furniture stores as well as on the books and magazines that you read (*space:uk* is printed on sustainable forestry paper).

The FSC scheme has been extremely successful in tackling illegal logging but relies on surveys taken on the ground and data provided by forestry companies. However, with the backing of the UK Space Agency, Charles Crosthwaite-Eyre is leading an ESA project to use information from space to enhance the sourcing of sustainable timber.

"Many forests by their very nature – particularly in parts of Africa and Siberia – are very isolated and difficult to get to, so how can anyone establish with confidence that what's happening on the ground is what the forestry companies claim?" Crosthwaite-Eyre's solution is to use satellites. "As an auditor on the ground in a forest, all you might be able to see is trees, the idea of satellite mapping has caught on because it can provide a map at a specific point in time and it's an independent source of information." The bottom line is that with satellites, it's difficult to cheat.

So far, the project has been able to demonstrate the accuracy of forestry mapping and where logging is taking place. "We can monitor high conservation value forest and see where trees have been cut down and whether replanting is taking place. We can even identify different species within the forest. "The next stage is to integrate satellite maps and information into the FSC certification scheme.

Top image: DMC image of deforestation
Credit: DMCii

Hidden value

However, it's not only illegal logging that is threatening the world's trees. Governments have themselves sanctioned much of the loss of forests for grazing cattle or growing crops like palm oil or soybeans. So how do you save a forest when it makes more money to cut it down? The secret is to make them more valuable to keep.

"Forests themselves are increasingly being seen as assets in their own right," says Boumphrey. "Forests are valuable carbon stores for the world and protecting them is vital for tackling climate change. But they also give hidden value to the people who live there – providing food, materials or regulating the water supply."

This is the principal underpinning a new United Nations scheme called REDD+, designed to offer incentives to developing countries to preserve forests as a global resource. This too is being underpinned by satellite technology because if you don't know what's there and how much it's changing, you can't possibly say how much it's worth.

"If countries are being paid to keep carbon locked up in their forests then, before making any payments, you need to ensure they're sticking by their agreements," says Richard Brook who's working on developing a UK strategy to apply satellites to the challenges of climate change. A likely outcome will be delivery of relevant information through what are called 'Climate Services'. "Rather than have someone walk around vast areas of forest, the quickest, cheapest and easiest way is to do it is from space."

These new technologies could also benefit the UK economy. "The role of space when it comes to tackling climate change is one of the areas the UK aspires to lead in," says Brook. "The UK wants to be the best at the science involved, a leader in setting policy and a leader in the commercial activities that follow from this." And data derived from satellites revealing the extent of forests where carbon is locked away, is potentially valuable information and part of a growing commercial market.

"The global market for what's called 'Carbon Markets Intelligence' is worth about £30 billion per year. If you look at how much of that is associated with deforestation it comes to around £3 billion a year," says Brook. "New space technologies should be able to provide increasingly cost-effective and competitive services into that growing market."

In short then, there is money to be made from saving trees. All of which should be good news for preserving the world's forests.

Space, time and LISA

Main image: LISA Pathfinder is due to be launched on a Vega rocket
Credit: ESA, Arianespace

Detecting ripples in space and time may sound straight out of Doctor Who but this is real science, not science fiction. Predicted by Albert Einstein nearly 100 years ago, scientists now want to directly observe these gravitational waves, as Sue Nelson reports:

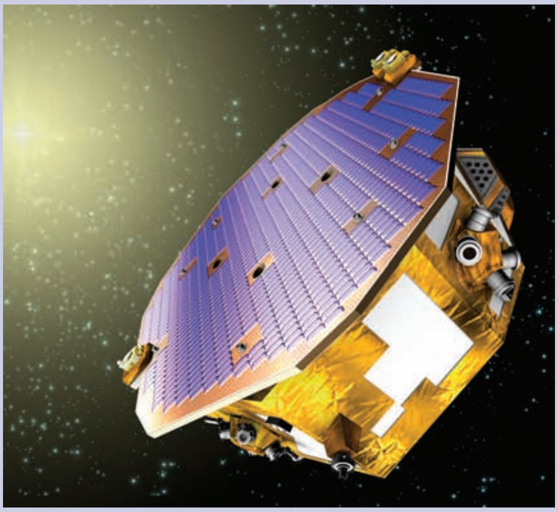
Gravitational waves are produced by some of the most violent events in the Universe, from exploding stars to colliding black holes.

"Gravity waves come right from the heart of these events in the Universe virtually undisturbed. If we can detect them we can understand how the Universe came to have the form and structure that it has," explains Glasgow University's Harry Ward.

"Being able to study them would provide important insights into the evolution of stars, neutron stars and black holes. It promises to open a completely new window on the Universe, quite unlike any window we've ever had before."

But it's not going to be easy. Unfortunately, by the time they reach us these ripples in space-time are weak and difficult to detect. Therefore, before building a gravitational wave observatory in space, you need to prove that the necessary state-of-the-art technology will work. The LISA (Laser Interferometer Space Antenna) Pathfinder spacecraft, a technology demonstrator, will do just that – with UK space scientists and industry taking the lead in this exciting new mission.

"Technically LISA Pathfinder is a masterpiece of precision engineering," says the UK Space Agency's David Parker. "In order to create the super-stable, super-quiet laboratory needed for gravitational physics, Astrium UK is building a spacecraft quite unlike any other."



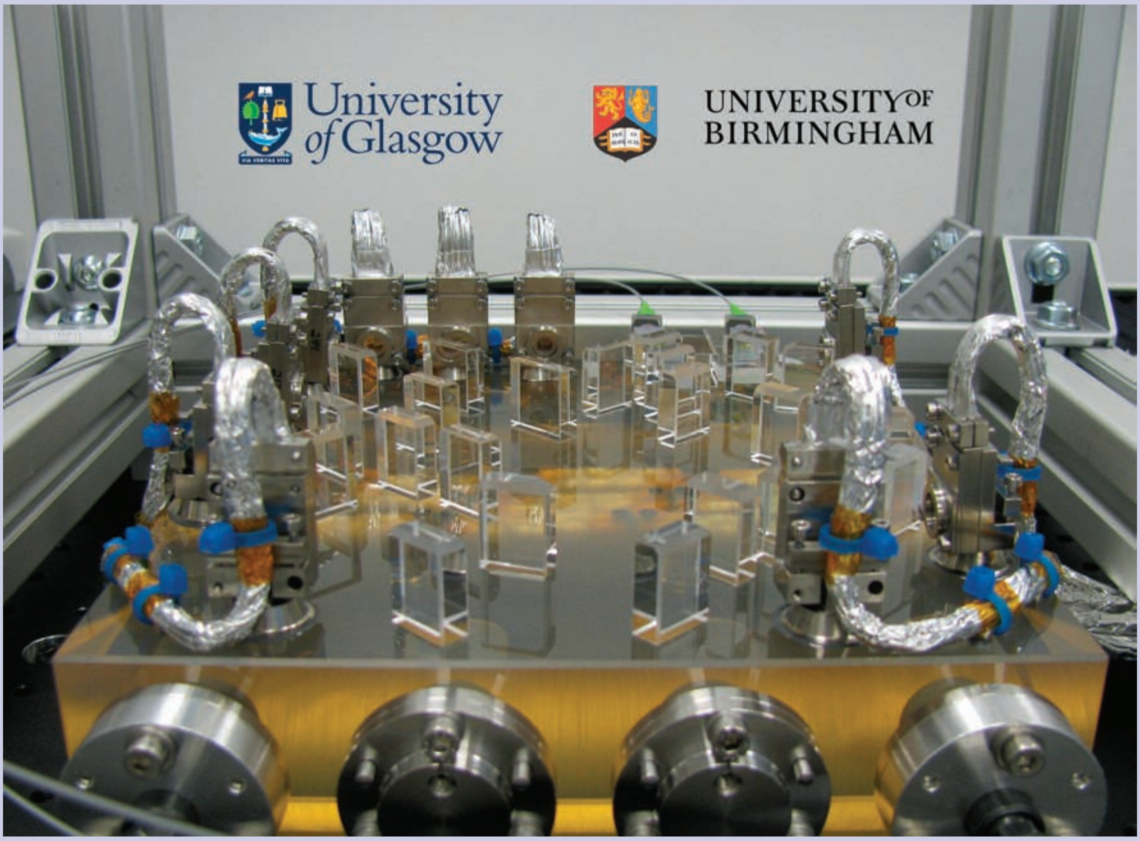
Unique spacecraft

Due for launch in 2014, the spacecraft can currently be found in one of Astrium's clean rooms in Stevenage among an assortment of other spacecraft and satellites that will also go into space. As befits a mission that requires never-been-used-before technologies, the science spacecraft stands out. Unlike the generic metal box that goes into space, it is an unusual, octagonal-shaped slice of hardware about a metre across.

"It's a very compact spacecraft and it's almost complete," says Ralph Cordey from Astrium UK, the lead contractor for LISA Pathfinder. "The avionics have been installed and it's just waiting for the payload and the European micropropulsion system."

Image top right: Artist's impression of LISA Pathfinder and its propulsion module after separation
Credit: ESA

Image below: LISA Pathfinder uses instruments provided by Glasgow University and the University of Birmingham
Credit: Glasgow University



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Space, time and LISA
continued

Top image: The satellite and members of the proud team that worked on it
Credit: Astrium

Image below: LISA Pathfinder is a masterpiece of precision engineering
Credit: Astrium

"There's some really exciting science you can do with this spacecraft even though that wasn't its original purpose"
Ralph Cordey, Astrium UK

The payload will consist of two 46mm gold and platinum alloy cubes, known as test masses. To eliminate any other gravitational influence (from, for example, planets or stars) these cubes must achieve near perfect gravitational freefall in space.

LISA Pathfinder's destination is therefore 1.5 million kilometres away at a place called the L1 Lagrange point, where the gravitational effects of the Sun and the Earth balance each other out.

The motion of the cubes must also be controlled and measured extremely accurately. This requires sensors, laser measurement, drag-free control and micropropulsion systems. The two micropropulsion systems – one from the United States, the other from Europe – will need to protect these test masses using previously unknown levels of minute forces.

"A block of 1kg on Earth gives a downward force of about 10 Newtons and we're talking about things here that are capable of producing forces about 10 million times less than that," explains Cordey. "So that's a very gentle force, extraordinarily small and precise, manoeuvring this half tonne spacecraft about, protecting these test masses from disturbances."

The aim is to ensure that the test masses are only affected by gravitational waves and to reduce the impact of any other forces to a minimum. "The spacecraft cannot protect them completely from the outside world," admits Timothy Sumner from Imperial College London. "Even a spacecraft in deep space will be continually bombarded by high energy particles, cosmic rays and particles from the Sun which are capable of getting right inside the spacecraft. If they do that they cause the test mass to become charged."

Imperial College's solution is a charge management system. "We're providing hardware that will deliver the opposite charge to the test masses, to neutralize them following the effects of cosmic rays and solar particles."

Imperial College London is one of three UK universities, along with Glasgow and Birmingham, who are contributing essential parts of the spacecraft's instrumentation. Within industry, apart from Astrium's spacecraft and micropropulsion system, SciSys UK has developed the satellites' on-board software. "This project is a great example of how UK engineers are helping create new technology that's going to help European scientists do totally fresh science," says Parker.

Exciting science

Precision measurement is an integral part of the LISA Pathfinder mission and the University of Glasgow has built the ultra-stable interferometer that will monitor the test-mass motion. "Laser interferometry uses the wavelength of light as the measurement stick," explains Glasgow University's Ward.

"It turns out you can do much better than wavelength of light, which is a millionth of a metre," he says. "We can do a millionth of a millionth of a metre. To do this you need a complicated optical system to prepare and then position and direct the laser beam. It's that optical system that Glasgow has built for Pathfinder."

Not surprisingly there is great excitement at the prospect of the potential new science ahead as well as the demonstration of new key technologies. All that remains is the launch and that too is looking more than promising after Europe's new Vega rocket recently made its maiden flight from the European Space Agency spaceport in French Guiana.

"It's fantastic that we've got a successful launch because that's the rocket that's been planned for this mission," says Ralph Cordey. "That's another step, another tick in the box."

The next stage, assuming LISA Pathfinder's successful launch and technology demonstration, is not so cut and dry. The spacecraft will demonstrate the technology needed for the proposed New Gravitational wave Observatory (NGO, formerly known as LISA). However, NGO is competing against two equally impressive missions – one to Jupiter's moons and the other detecting X-rays – for selection by ESA's Science Programme Committee as the flagship of its so-called Cosmic Vision plan. A decision will be made in June but the competition doesn't seem to phase those involved with LISA Pathfinder.

"Technically LISA Pathfinder is a masterpiece of precision engineering"
David Parker
UK Space Agency

"Whether or not NGO is selected this year, a gravitational wave observatory like it is almost certain to be built eventually so the experience gained from LISA Pathfinder won't be wasted," says the UK Space Agency's Parker. "As a stepping stone to the first gravitational wave observatory in space, it's a great achievement."

Ward agrees. "This precision measurement technology, while driven by pure science, has wider applications. We see the same measurement approach for the next climate-monitoring mission Grace 2," he says. "So for Earth, planetary and Moon mapping you'll see these techniques being used more and more in the future."

According to Ralph Cordey, the drag-free platform that has been developed will also be useful for other fundamental physics experiments that need a well-protected environment.

"There's some really exciting science you can do with this spacecraft even though that wasn't its original purpose," Cordey says. "This is new technology for the world."

Image below: The spacecraft is tested in a chamber that simulates the harsh conditions of space
Credit: Astrium

Free fall science

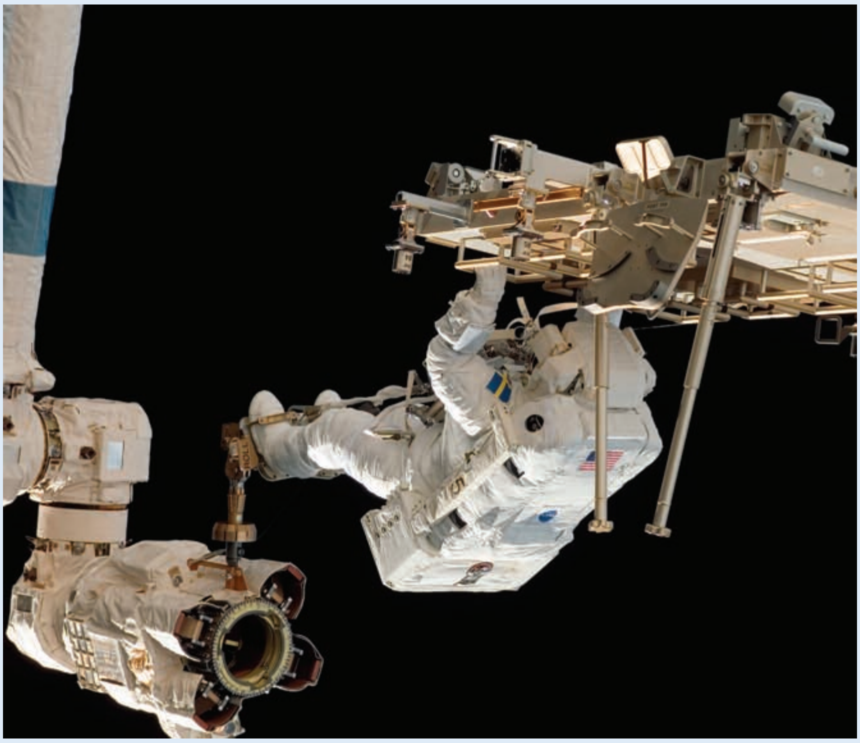
Kate Arkless-Gray investigates the marvels of science in microgravity:

Main image: UK astronaut Tim Peake during a parabolic flight
Credit: ESA

"It's a wonderful feeling, going into weightlessness - it felt very natural to me," says British astronaut Tim Peake, recalling his first experience of microgravity. "It's very hard not to smile and laugh and enjoy yourself!"

The first UK citizen to be admitted to the European Astronaut Corps, Peake's training includes time in a special plane, sometimes known as the 'vomit comet', to simulate short periods of weightlessness. "You can tell that it will take a while for the body to adapt to microgravity," he says. "I can appreciate how the astronauts on board the space station need that first week, maybe two weeks, to adapt so that their bodies are completely ready to work in the space environment."

As well as being a member of ESA's 2009 astronaut class, Peake is also the ambassador for UK microgravity science. So what exactly is microgravity?



Gravity constantly pulls us towards the centre of the Earth but the ground stops us from falling into its molten core. You might think astronauts float in space because they have escaped the Earth's gravitational field but this is not actually the case. The term microgravity is used because although you can never be completely free of gravity, you can remove the feel of it.

Astronauts feel weightless on the International Space Station (ISS) because they, and the space station, are in free fall. The ISS constantly falls towards Earth due to the pull of gravity but it travels at such a speed that it misses the ground and continues travelling – in an orbit – around the Earth. As the astronauts fall at the same rate as the space station, things appear to be floating. Douglas Adams described a similar idea in the Hitchhiker's Guide to the Galaxy when one of the characters learns how to fly: "The knack lies in learning to throw yourself at the ground and miss".

Image above: Which way is up? An astronaut grapples with equipment during a spacewalk
Credit: ESA, NASA

Image below: The view along the aircraft cabin during an ESA parabolic flight
Credit: ESA

"The aim is to galvanise the microgravity community so that we can speak with one voice"
Tim Peake

continues >

Free fall science
continued

Image top right: Astronauts on the ISS have to exercise twice a day
Credit: ESA

Image below: ESA astronaut André Kuipers recording his brain waves on the ISS. The goal is to understand if the brain processes tasks differently in space
Credit: ESA

New medicines

Floating around in space sounds like a lot of fun but there's a serious side to microgravity as Christer Fuglesang, Head of the Science and Applications Division at ESA, astronaut and holder of a galactic frisbee record* explains: "Microgravity research is important because it gives us a unique insight into how materials behave, how fluids behave, and how our bodies behave," he says. "This knowledge, which cannot be gained in any other way, can be utilised to improve processes to make stronger materials, find new medicines and help us understand our world and universe in a better way."

Scientists on Earth use control groups to see which variables in an experiment have an effect on the results. You might choose to control for temperature, light, or the presence or absence of a drug, for example, but what about gravity?

"Fundamentally, gravity stops you understanding how some things work in the body – and the physics of many materials – as it is always there," says David A Green, from the Centre of Human and Aerospace Physiological Sciences at King's College London. "In order to find out how gravity affects a system, you need to remove the effect of gravity on the experiment and carry out observations."

Hugh Montgomery, a member of University College London's Centre for Aviation, Space and Extreme Environment research, has a practical example: "Osteoporosis – bone loss – is common here on Earth but hard to understand because it develops over a long period. Studies are also muddied by interaction with a variety of environmental factors."

When astronauts are in space, the main difference is that they don't feel the effect of gravity. "This leads to very rapid bone loss," says Montgomery. "As such, this environment can offer unique opportunities for osteoporosis research."

David A Green agrees. "We can really control what food, sleep and exercise an astronaut gets. All these things are really hard to control on Earth, so really astronauts are the planets' Guinea pigs," he says. "If we can learn to keep a few astronauts healthy we can use that knowledge to help people with a range of problems across the globe."

Muscle wastage and loss of bone density pose a problem for astronauts on long-duration spaceflights but much work has been done to develop special exercise techniques, or 'countermeasures', to lessen the effect. "We've learnt an awful lot and astronauts are in a much healthier situation today when they conduct these countermeasure exercises on board the space station," says Peake. "What we're learning in terms of how to prevent bone density loss is invaluable for osteoporosis health care and in care for the elderly."

** Christer Fuglesang holds the World Flying Disc Federation Galactic Record for Maximum Time Aloft (20.52 seconds). Unfortunately, since the attempt took place on Space Shuttle Discovery during STS-116, the Federation deemed it could not be listed as a World record!*

Rockets and towers

Improved understanding of medical processes is just one example of what can be achieved with microgravity research. Christer Fuglesang has another. "During IMPRESS – a project using experiments in microgravity – they learned how to make new alloys of titanium aluminium. They found a very lightweight and strong alloy which is now used in aircraft as it allows you to build lighter aircraft and that will save fuel."

From practical applications that directly benefit our lives on Earth, to helping us understand how the Universe evolved, microgravity research could offer the key to unlocking many mysteries. Unfortunately, it's very expensive to fly experiments on the ISS. But luckily there are several other options that scientists can use to create a microgravity environment that don't require putting things in orbit. Rockets known as 'sounding rockets' which carry instruments straight up and then fall back down to Earth, offer researchers up to 13 minutes of microgravity but the cost is still high.

Cheaper options include special drop towers, such as the ZARM Drop Tower at the University of Bremen in Germany, or parabolic 'zero-G' flights. These flights consist of repeated climb-then-dive manoeuvres (which gave rise to the 'vomit-comet' nickname). These parabolic flights give you between 22 and 30 seconds of microgravity. Research flights will do around 30-60 parabolas before landing. "You need a skilled pilot to fly the aircraft," says Peake, "because they need to be able to maintain very accurate levels of G throughout the manoeuvre."

Due to the costs involved, international collaboration is important in the field of microgravity research. The European Programme for Life and Physical Sciences in Space (ELIPS), run by ESA, aims to push the boundaries of science and technology through microgravity research. "Joining ELIPS is like being a member of a club, it gives you access to these facilities," says Peake.

But ELIPS is a club that Britain is not currently part of, which means UK science could be missing out. The UK Space Agency identified this problem last year and this is where Peake's role as ambassador for UK microgravity science comes in.

"The aim is to galvanise the microgravity community so that we can speak with one voice and put forward a business case for joining, for example, the ELIPS-4 programme," he says. "We're trying to remove the historical stigma that the UK doesn't do human spaceflight or doesn't do microgravity research."

The creation of a UK Microgravity Working Group makes Peake hopeful that the UK can join. "In the course of the last 12 months I've had the privilege of working with many very highly qualified and skilled UK scientists who are all crying out to do microgravity or space environment work," he says. "We should be a leading nation in several areas of microgravity research."

"If we can learn to keep a few astronauts healthy we can use that knowledge to help people with a range of problems across the globe"

Centre of Human and Aerospace Physiological Sciences

Image below: The ZARM Drop Tower at the University of Bremen
Credit: ZARM, University of Bremen

Ask the experts

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

Questions this time come from year 6 students at Notley Green Primary School in Essex:

Laura Thomas
Outreach Manager for Mathematics and Physics, Queen Mary, University of London

How big are stars?

Stars are some of the largest individual objects in the Universe. The only things that are bigger are the gassy nurseries that they are born in. The Sun is around 100 times larger than the Earth (the Earth is around 12,600 km across). But stars come in a range of colours and sizes: the smallest stars are red and just over one tenth the size of the Sun and the largest stars are blue and over 150 times larger than the Sun. To get an idea of the difference, imagine that the Sun is an orange. Compared to this, the smallest stars are less than the size of a grape and the largest are similar to the size of a London bus.

Just like us, stars change shape during their lifetime. Stars start off as a cloud of dust and gas, but when they grow large enough, they can switch-on and start to burn their fuel. As they burn hydrogen into helium their size remains steady, but as they get older and their fuel starts to run out they can expand to many times their original size. These older stars are called Red Giants. This is expected to happen to our sun in 5 billion years and when it does, it will be so large that it will fill the space all the way out to the Earth's orbit. We're not exactly sure how this will affect the Earth, but we've got plenty of time to work it out.

When a star is born…Hubble image of a star-forming region in the Cygnus constellation. **Credit:** ESA, NASA

Mike Grocott
Callington Space Centre, Cornwall

What animals have been into space?

What a great question! Most people think that the first animals in space were dogs: Laika a Russian dog being the first animal to orbit the Earth. However, before Laika the Americans had been launching spiders, mice, frogs, guinea pigs and even goldfish into space. The difference with these animals was they did not orbit the earth like Laika. After Laika, lots of animals where launched into space, some to see the effects of radiation on them before humans flew, others to see how they adapted to life in weightless conditions.

The last animals to fly in space were two Golden Orb spiders named Gladys and Esmerelda and some fruit flies (although they were to feed the spiders!) They flew on the last flight of the Endeavour (STS 134) Space Shuttle mission.

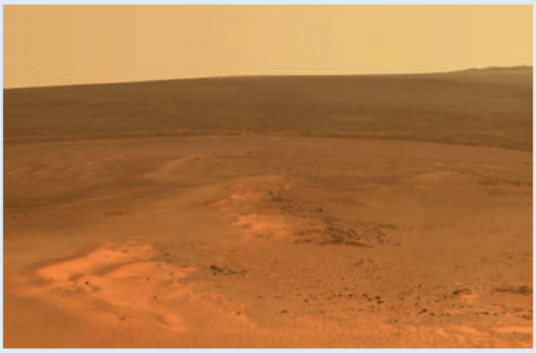
Gladys and Esmerelda continued to live in space after Endeavour returned to earth and actually had a global following with people tweeting about them. NASA provided live video of the spiders spinning their webs so people around the world could be involved.

The spiders only lived in space for 45 days but Skylab – an American space station in the 1970's – had a spider called Arabella, which lived on the station for 57 days before returning to earth.

How long does it take to get to Mars?

Of all the planets in the Solar System, none has captured the human imagination as much as the Red Planet. All over Mars we see tantalising clues that billions of years ago it was a warmer and wetter world with rivers, seas, a thicker atmosphere and much better conditions for the evolution of life.

This is why a human mission to Mars is such a high priority. Although we are confident that we are not going to find intelligent tentacled monsters on the Red Planet, it's possible that primitive organisms such as bacteria may have existed on Mars billions of years ago – and might still today.



Mars as seen by the Opportunity rover. **Credit:** NASA

Robotic explorers including NASA's Viking missions of the 1970s and ESA's Mars Express have transformed our understanding of Mars but have raised as many questions as they have answered. The distance that the Mars rover Opportunity has travelled over a period of nearly eight years is similar to that covered by the two astronauts on the final Apollo mission over a period of three days. So, although it's clear that robots are a fantastic way to explore Mars initially, there is no substitute for having humans on the ground.

But getting to Mars isn't easy. The shortest possible distance to the Red Planet is 56 million kilometres – that's over 140 times the distance from the Earth to the Moon! Using this route would take a rocket far larger than anything ever built and so the clever way is to take a longer, slower route along what is called a 'Hohmann Transfer' orbit. This relies on Earth and Mars being in the right relative positions, and means that we only get opportunities to go to Mars (launch windows) every two years.

Travelling along a Hohmann orbit means a journey time of around eight months. The astronauts would have to endure long periods of isolation from the rest of humanity (even radio signals would take several minutes to reach Earth so no real-time Facebook updates or phone calls). They would also have to survive the radiation dangers posed by interplanetary space and either spend three hours a day exercising to prevent their muscles withering away, or have a rotating spacecraft to generate an artificial gravity effect. This is not beyond human biology, science and engineering, but it will push our ingenuity to the limit.

Having travelled for so long, the team of astronauts would spend at least a month on the surface and would then have to contend with an equally challenging journey home. So if you want to visit Mars, be prepared to spend between one and a half to two years cut off from civilisation – as did the recent Mars 500 astronauts in the simulation conducted by ESA and the Russian Space Agency – not to mention the years of training building up for such a flight.

Current planning will see an international mission of humans visiting Mars sometime in the 2030s. This means that right now there are young people currently in primary school classrooms across the world who, in three decades, may be taking humanity's next giant leap into the cosmos. Who knows, it could be you!

The crew of Mars500 spent 520 days locked away during a simulated mission to Mars. **Credit:** ESA

Anu Ojha
Director, National Space Academy

Teaching resources

Image: A teacher gets to grips with Mars science during a workshop at Daresbury Laboratories in Cheshire **Image Credit:** ESERO UK, Cliff Porter

Is there anyone out there?

"I just wanted to say what a wonderful resource this is. I can safely say that every child thoroughly enjoyed the time working with this and that even the 'cool' kids showed amazing enthusiasm!"

These comments were made by the Head of a North Yorkshire primary school who recently took part in a trial of *Is There Anyone Out There*? This new education resource is funded by the UK Space Agency and developed by ESERO-UK and CIEC Promoting Science.

The resource is based on the quest to discover more about the Solar System through space projects such as ESA's Aurora programme and NASA's Curiosity mission. The children take on the role of space scientists or space engineers to discover more about Mars.

The activities are organised into three themes: Life, Landscape and Landing. The investigative activities in each theme help the children to explore features of the planet Mars in practical ways that involve the use of key skills. They introduce the children to a range of challenges requiring the use of enquiry, discussion and problem solving that are consistent with the curriculum.

In the first theme, children consider the criteria essential for life and discuss what form it might take. They go on to compare and test samples of 'soil' for the possible presence of microorganisms. The Landscape section encourages children to study images from Mars to note significant features and make hypotheses about their formation. They carry out and evaluate practical tasks to mimic crater formation, lava flow, and the creation of channels and deltas.

Children study data to find the best landing site for a Mars rover. They estimate the age of landing sites and identify landscape features such as craters or canyons and interpret data and images. The class then discusses the most appropriate location.

The resource was officially launched at the Association for Science Education's annual conference in January. Further workshops held at the National Science Learning Centre and the Science and Technology Facility Council's Daresbury Laboratories – attended by another fifty primary teachers – have provided opportunities for evaluation of teachers' responses after using the activities. The feedback has been overwhelmingly positive, with all agreeing there is tremendous value in using space to teach STEM subjects.

www.esero.org.uk

Made in the UK

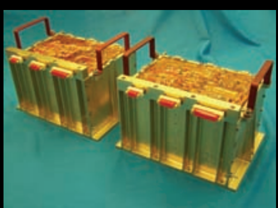
ABSL Power Solutions in Culham, England, produces lithium ion batteries for spacecraft, satellites and spacewalks. Battery Business Development Team Manager Nick Simmons tells *space:uk* all about it.

Nick Simmons
Battery Business Development Team Manager

Image top left: Nick Simmons
Credit: ABSL

Image bottom left: ABSL is developing new laser instruments for spacecraft
Credit: ABSL

Image below: The battery modules for BepiColombo
Credit: ABSL



Which missions have used your batteries?

So far we've supplied batteries for 85 space satellite systems – from Earth observation spacecraft and science probes to telecommunications satellites and the South Korean launch vehicle, KSLV-1. Science missions that use our batteries include Mars Express, Venus Express and Rosetta and we are on the Herschel and Planck space observatories. We also make the batteries that power life support systems for US astronauts when they do their space walks. It's in the backpack at the bottom.

What size are they?

For the spacewalk it's the size of a brick. Typically, our batteries are the size of a shoebox but for a larger spacecraft some of them can be over 80 kilos, similar in size to a large suitcase.

Why are lithium ion batteries suited for the space environment?

The main advantage is their energy density. In space you don't want to take more mass that you have to into orbit. With lithium ion batteries you can pack as much energy as possible into the smallest mass. Also if you charge them up they stay pretty much topped up for months on end.

Where are your batteries made?

The batteries are bespoke for each mission and we manufacture them here on our site in Culham, Oxfordshire. Most of the cells are from Sony in Japan but the construction is undertaken here in the UK. Most of the testing we do is in-house too. But for vibration testing we either go to the Rutherford Appleton Laboratory nearby or to one of Astrium's sites in the UK.

What are you working on now?

At the moment we're making the batteries for Galileo – Europe's new satellite navigation system – and for the Sentinel 1, 2 and 3 spacecraft. We're also doing batteries for the BepiColombo mission to Mercury and for the Earthcare spacecraft. Most of those are European science missions but we also do batteries for telecommunications satellites as well.

Do you make anything other than batteries for space?

We have a range of products that support instrumentation. For some measurements that a spacecraft makes, such as sea surface temperature for instance, the instrument needs to be calibrated before it makes any measurements. We make calibration sources so that the instrument provides accurate and reliable data.

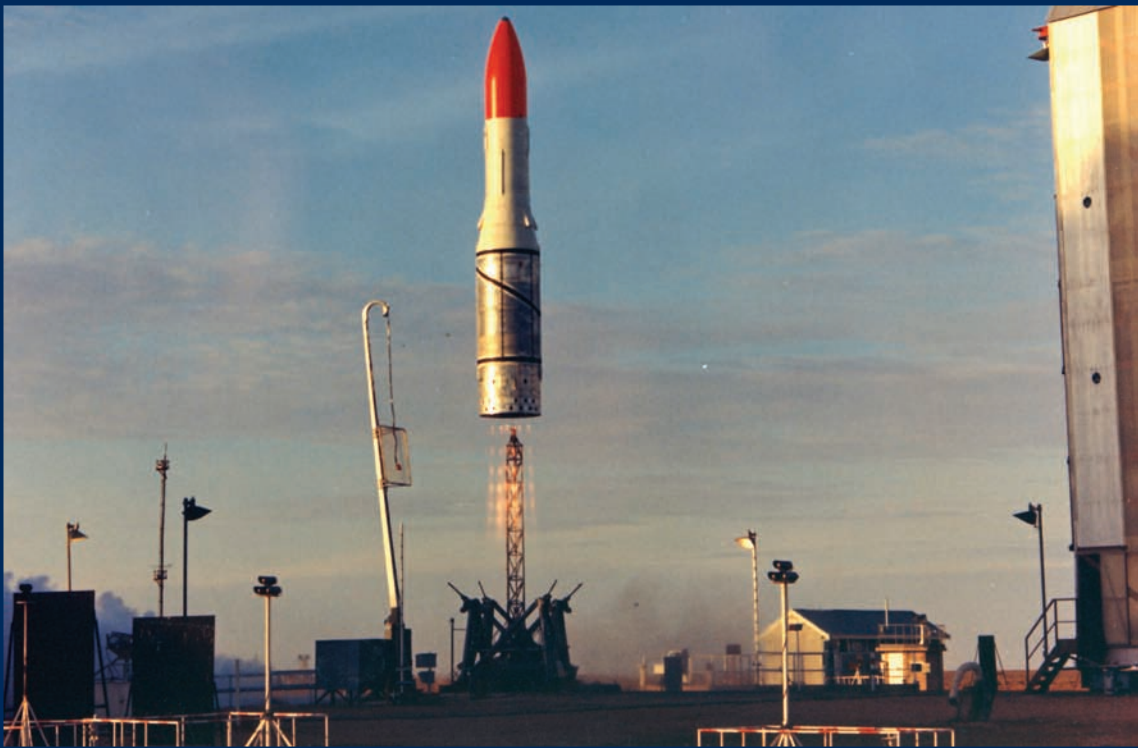
What sort of people do you employ?

Seventy people work here and they are primarily engineers with degrees in either mechanical or electrical engineering. For some of the development work we look for degrees in physics or electrochemistry.

What's next?

We've currently got contracts for a further 50 batteries and are working on new cells for improved batteries. We also have two new product developments. One is imaging LIDAR, using a scanning laser to map out a surface in 3D. If you were heading for Mars or the Moon and looking for a good place to land, for example, first of all you have to look at the surface. So we're currently developing a prototype and we've just performed our final test for the European Space Agency. We're also developing our capabilities in deployable structures – things that unfurl when in orbit such as antennas and booms.

Black Arrow



The launch of Black Arrow from Woomera in Australia **Credit:** UK Space Agency

The UK's Black Arrow rocket was developed during the 1960s.The project culminated in the successful launch of the Prospero satellite in 1971.

After the Second World War, the UK had a series of missile and rocket programmes. Black Arrow was the only one to carry a satellite into space. The launcher was designed at the Royal Aircraft Establishment in Farnborough. The basic design included powerful engines developed for the experimental Black Knight missile.

Resembling a giant bullet, Black Arrow incorporated three separate rocket stages to give it enough power to reach orbit. The small satellites it was designed to carry were protected behind the red casing at the top. The construction and detailed design of the Black Arrow launchers was led by Westland Aircraft on the Isle of Wight and they were tested in the west of the island near the Needles.

During testing the rockets were held to the ground in gantries and an exclusion zone – on land and sea – was enforced around them. Engineers controlled the tests from concrete bunkers and, as the rockets fired, their exhaust was doused with thousands of litres of water that sent clouds of steam cascading down the steep cliffs.

Once successfully tested, the rockets were shipped to Woomera in the Australian Outback for launch. The first trial in 1969 had to be destroyed in mid-flight owing to a damaged electrical circuit. The next test launch was perfect but the third – and the first orbital attempt – failed owing to a leak in the second stage engine pressurisation system and the rocket plunged into the sea.

Everything was prepared for the fourth launch in October 1971 but in July that year the Government announced the cancellation of the Black Arrow project. However, as everything was already in place, the launch went ahead anyway and the UK-built Prospero satellite was blasted into orbit. Prospero became the first satellite to be launched on a UK launcher. And the last.

Prospero remains in orbit to this day and the fifth Black Arrow is now displayed in the Science Museum in London.

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