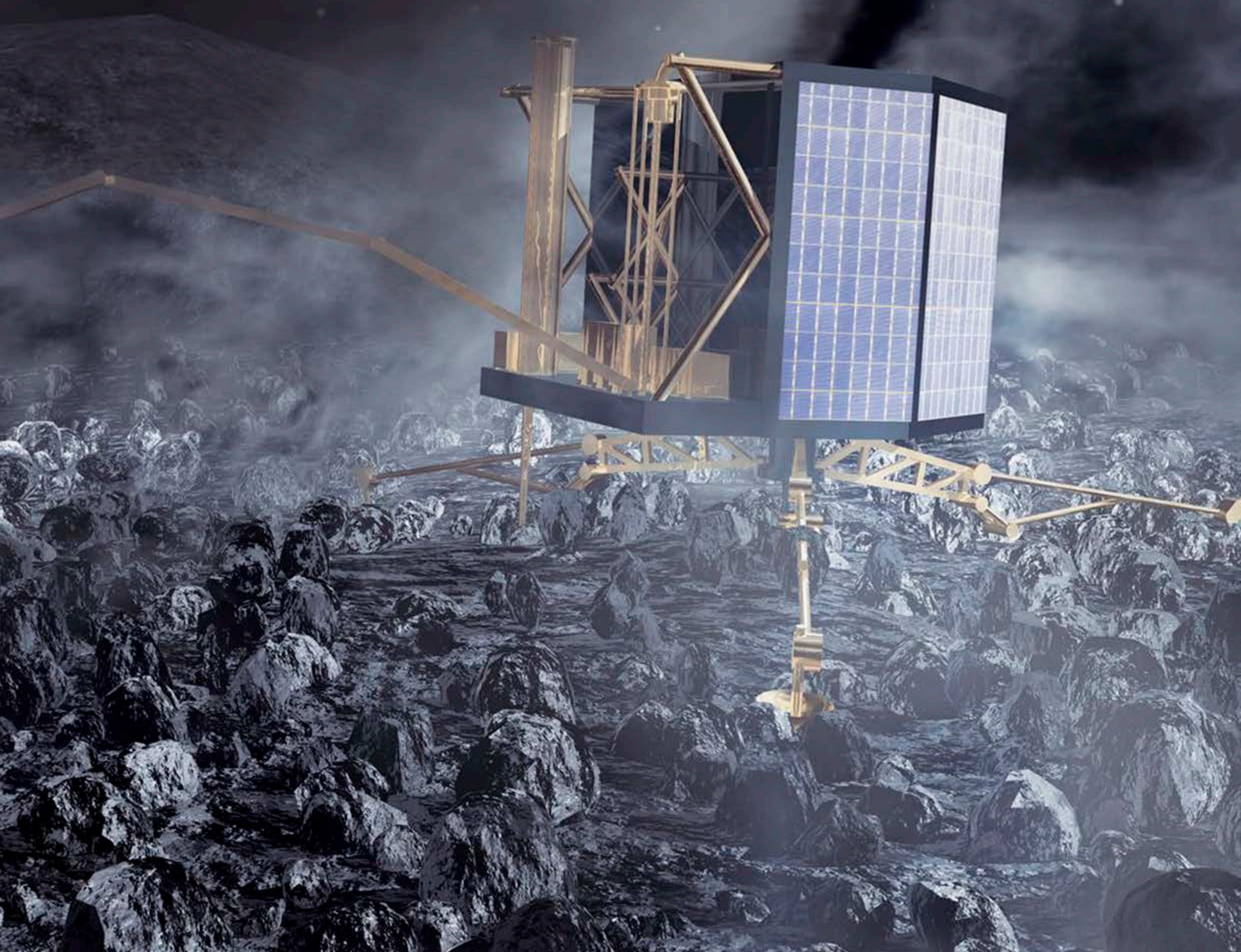
Winter 2013 Issue 39

space:uk

How to land on a comet
Exploring the Earth from space
The satellites that keep us connected



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UK SPACE AGENCY

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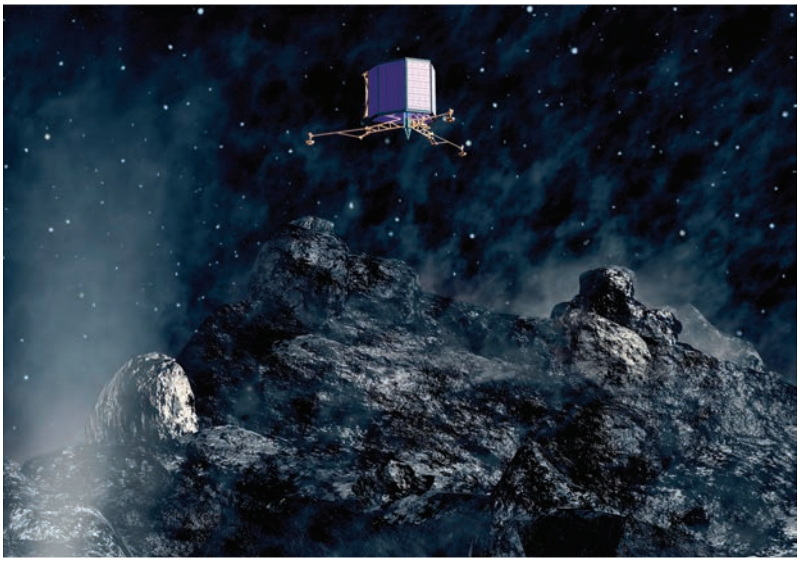

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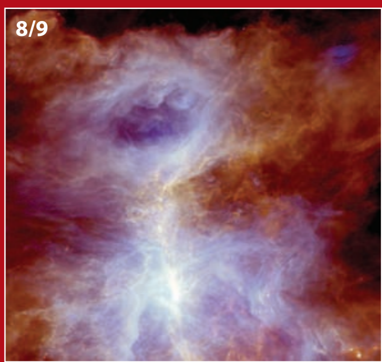


Credit: ESA

Credit: ESA

Credit: Inmasat

Credit: ESA, NASA

Front cover image Artist's impression of ESA's Philae lander descending towards comet 67P/Churyumov–Gerasimenko
Credit: ESA

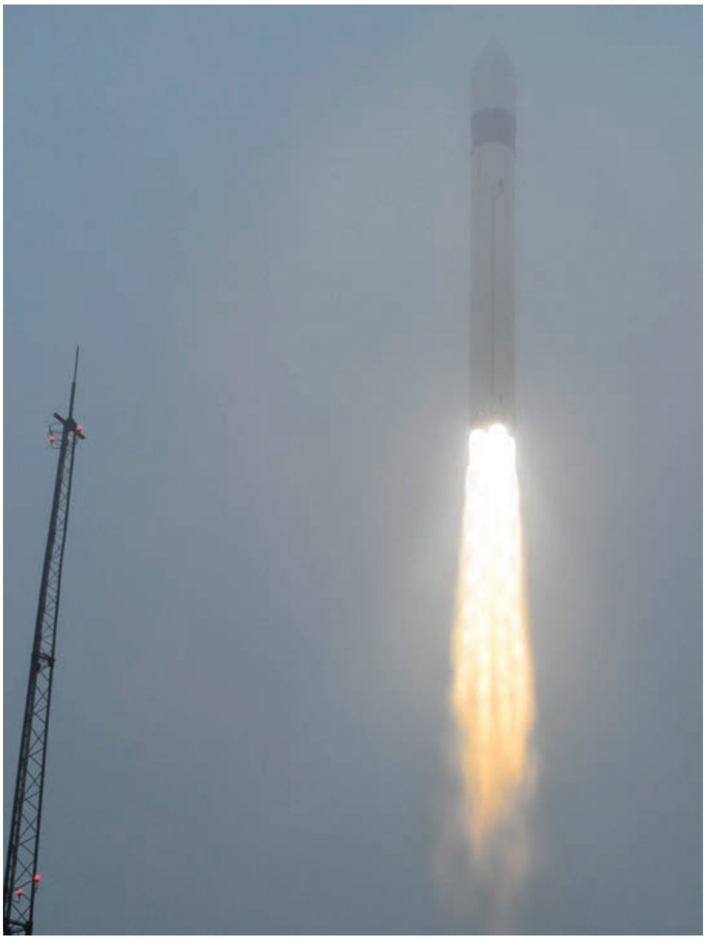
Swarm to map magnetism

Europe's Swarm mission, designed to map the Earth's magnetic field with unprecedented accuracy, has been launched into orbit. The three Swarm satellites were blasted into space on the same Rockot launcher from the Plesetsk Cosmodrome in northern Russia on 22 November. A day later, the spacecraft successfully unfolded their four-metre long booms, which carry the sensitive measuring instruments.

Swarm is made up of a constellation of three identical satellites, each resembling a giant mechanical insect. Flying in different orbits, they are designed to measure every aspect of the magnetic field, from the core to the crust.

The satellites will also investigate the magnetic 'bubble' surrounding our planet, known as the magnetosphere. The magnetosphere is vital for life on Earth, protecting us from the stream of charged particles from the Sun called the solar wind. But the magnetic field is continuously changing and appears to be weakening by some 10% every century. It may even be going into reverse.

"I'm thoroughly relieved that the Swarm satellites made it into the correct orbits," said Richard Holme, Professor of Geomagnetism at the University of Liverpool and a scientist working on the mission. "If the orbits had gone wrong, then a lot of the science of the mission would have been lost."



The launch of Swarm into an overcast sky **Credit:** ESA

Artist image of Swarm in orbit **Credit:** ESA

The structures for the European Space Agency (ESA) spacecraft were built by Astrium UK in Stevenage 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.

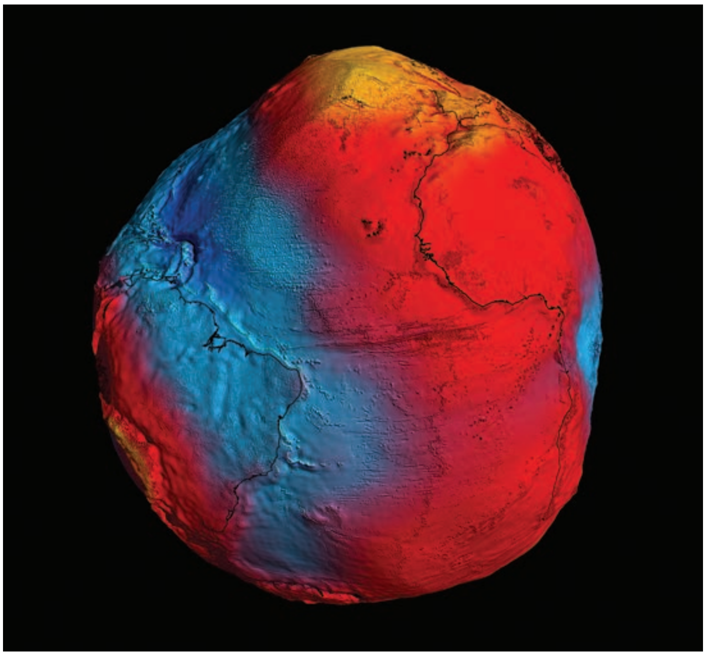
"Swarm was particularly challenging as the all carbon fibre structures were the first ones we designed and built in the UK," said Swarm Project Manager at Astrium, Andy Jones. "Another first for us was the cold gas propulsion system, which was equally challenging. "This system is also being used on the Gaia space telescope, due for launch in December 2013. "It's great to see it working on Swarm," Jones added.

Jones also admitted to being pleased that the booms had deployed without any problems. "The icing on the cake for me was the deployable boom, key to the mission as it carries the instruments, "he told *space:uk*. "We designed a novel double-hinged mechanism which has worked perfectly in orbit."

Data from Swarm will be used to help predict the effects of solar storms on critical infrastructure, such as satellites in orbit and power systems on the ground. Scientists also hope to develop a better understanding of how and when the magnetic field changes. This is vital information, used for navigating ships and aircraft and by the energy industry for oil and gas exploration.

"What we want is to be able to say is: this is the magnetic field now, what's it going to be like in five years time? "Holme explained. "With the improved understanding we're getting of the changes within the field, we hope to be able to predict what it will be like in the future."

Gravity mission falls to Earth



GOCE's geoid model of a distinctly bumpy Earth **Credit:** ESA

Its mission completed, ESA's GOCE satellite made a spectacular, but otherwise uneventful, return to Earth on 11 November. The spacecraft burned up over the South Atlantic and was caught on camera from the Falkland Islands at 9.16pm local time (the image can be viewed on the ESA website).

Since its launch in March 2009, the Gravity field and steady-state Ocean Circulation Explorer has mapped the Earth's gravity in unprecedented detail. The mission has been used to produce the best-ever picture of the Earth's 'geoid' – a model of the ideal global ocean surface shaped only by gravity in the absence of tides and currents. Its data will also help to improve our understanding of ocean circulation.

According to Helen Snaith from the National Oceanography Centre in Southampton, even at the very end, GOCE was still able to deliver valuable data. "As the orbit decayed and it got closer to the Earth, it will have started to 'feel' even shorter wavelength features in the geoid," said Snaith. "We are looking forward to seeing the impact of this very last data."

GOCE's sleek, aerodynamic form, unusual for a space vehicle, was designed to reduce drag in the very thin atmosphere at its operating orbit of 224 kilometres above the Earth. When the fuel for its ion motor finally ran out, the satellite could no longer maintain altitude.

GOCE became the first European satellite to make an uncontrolled re-entry since Isee-2 in 1987. The risks of the re-entry were judged by ESA to be extremely low. No serious injury or significant property damage has ever been attributed to de-orbited satellite debris. But if any parts of GOCE did make it all the way through the atmosphere, they are likely to now be at the bottom of the Atlantic Ocean.

Alphasat ready for action

Following its successful launch, and four months of testing in orbit, the sophisticated Alphasat communications satellite is ready for service.

Around the size of a double-decker bus, and packed with innovative technology, the mission represents a major achievement for UK space companies.

Alphasat was built in a partnership between ESA and UK satellite operator Inmarsat and is the first flight of the Alphabus satellite platform. Much of the satellite was designed and built by Astrium in the UK, with involvement from more than 100 other UK space companies.

"Alphasat is 6.6 tonnes of success for Europe and the UK," exclaimed Chief Executive of the UK Space Agency, David Parker, after the 25 July launch. "Thanks to strategic UK investment and UK expertise in the area of telecoms, this world-leading project will help keep the British space sector at the top of its game."

With solar arrays spanning some 40 metres, and an 11 metre wide reflector, Alphasat is positioned above the Earth in geostationary orbit. It is fitted with an advanced processor, allowing it to perform trillions of operations per second and adjust its signal according to demand.

The new satellite will be used by Inmarsat to enhance its global communications network, providing improved services for the company's mobile broadband customers across Europe, Africa and the Middle East. It is also giving ESA the opportunity to test new space hardware. The spacecraft is fitted with several instruments, including a laser communications terminal to investigate the possibilities of laser communication between satellites.

See feature on page 14

The launch of Alphasat on 25 July 2013 **Credit:** ESA, Arianespace

Waking Rosetta

Controllers at the European Space Operations Centre (ESOC) in Germany are preparing to wake up the Rosetta comet-chasing mission.

Rosetta was launched almost ten years ago, on 2 March 2004, and has since been on an extensive tour of the Solar System to catch up with comet 67P/Churyumov-Gerasimenko. This ambitious ESA mission includes the Philae lander, which will detach from the main structure to land on the comet's nucleus. The first time such a complex manoeuvre has been attempted.

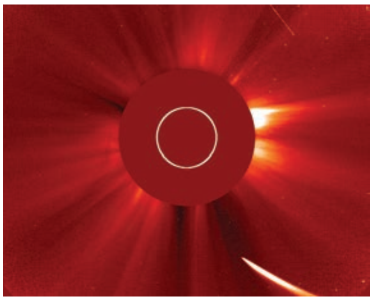
"Rosetta is about to make history," said Chris Castelli, Head of Space Science at the UK Space Agency. "It becomes the first spacecraft to orbit a comet's nucleus, giving us a front seat view of this giant snowball's journey towards the Sun."

Much of the spacecraft was built in the UK and British scientists are also involved in ten of the 21 experiments that Rosetta carries. One of the main instruments on the Philae lander, Ptolemy, is being led by a team from the Open University. Ptolemy will be used to measure the comet's chemical composition.

Comets are often referred to as time machines because they contain ice, gas and dust from the Solar System's distant past. Comets are also thought to be responsible for bringing water to the early Earth. By studying the nature of a comet close-up with an orbiter and lander, Rosetta will help scientists understand the role of comets in the formation of the Solar System.

"The scientific results will keep our community at the forefront of the study and evolution of cometary bodies," said Castelli, "helping us to unlock the secrets of how our solar system evolved."

In order to reach the comet, Rosetta has had to fly a convoluted path around the Solar System, using the gravitational fields of Earth and Mars to help it on its way. Rosetta has also visited asteroids Steins and Lutetia and was able to capture close-up images of these space rocks.



Another cometary close-encounter: comet ISON seen by ESA's SOHO spacecraft, passing close to the Sun on 28 November **Credit:** ESA

Rosetta's systems were put into hibernation mode in July 2011 for the final, and most distant, leg of the journey when it passed near to the orbit of Jupiter.

The spacecraft is set to wake at 10 am GMT on 20 January 2014. "It has on board alarm clocks," explained Ian Wright, who is leading the Open University Philae team. "At that point we start to get a feeling about whether the spacecraft is still working, whether it's where we expect it to be and we can also begin the long campaign of starting to observe the comet."

After wake-up Rosetta will still be nine million kilometres from its destination, giving controllers at ESOC several months to switch-on and check over the instruments. Assuming everything goes to plan, Rosetta is due to execute a major course manoeuvre in May 2014 and will arrive at the comet in August, with the lander release scheduled for November.

For more on comets, see feature on page 10 and the pull-out poster.

The main control room at ESOC in Darmstadt, Germany **Credit:** ESA

Satellite reveals Arctic ice loss

New data from Europe's CryoSat mission reveals that the volume of Arctic sea ice has declined to a new low. Launched in 2010, and with a science team led from the UK, CryoSat is equipped with a unique stereo radar system. This enables it to assess both the extent and thickness of the world's ice cover.

"CyroSat continues to provide clear evidence of diminishing Arctic sea ice," said Andrew Shepard from the University of Leeds, speaking at ESA's Living Planet Symposium in Edinburgh. "Some parts of the ice pack have thinned more rapidly than others but there has been a decrease in the volume of winter and summer ice over the past three years."

Scientists will use results from CryoSat to help understand whether this thinning is due to natural variations or climate change. Whatever the cause, significant losses of Arctic sea ice could have a major effect on the Earth's climate.

CryoSat has revealed a loss of Arctic ice **Credit:** Boffin Media, SAMS

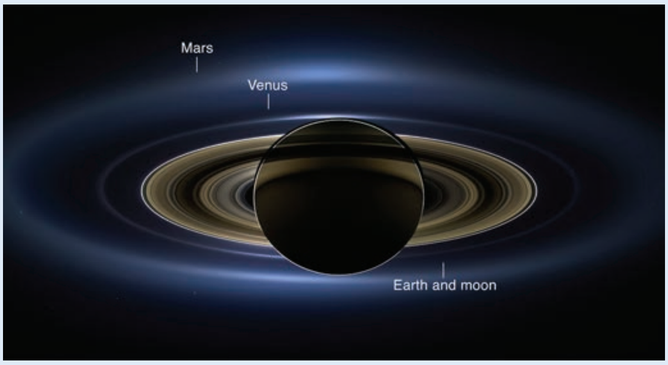
Gaia ready for launch

Final preparations are underway for the 19 December launch of ESA's Gaia mission to map the Milky Way. The launch was delayed by a month to allow engineers to replace a key component.

Gaia, which will generate a wealth of new scientific data, is expected to discover new planets, asteroids and supernovae. The UK is heavily involved in the mission, which contains two optical telescopes and three scientific instruments.

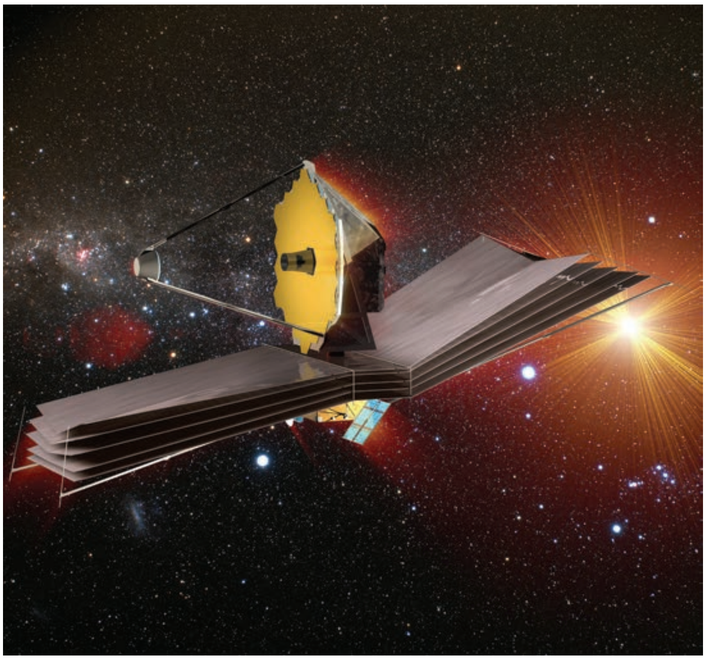
Lord of the rings

An incredible new image of Saturn has been captured by the Cassini spacecraft. The picture, processed from 141 different wide-angle images, even shows the Earth, Mars and Venus – although you have to look really closely to see them. A joint project between NASA and ESA, the Cassini-Huygens mission has been in orbit around Saturn for almost ten years.



Credit: NASA

New telescope takes shape



Artist's image of the JWST **Credit:** ESA, NASA

The successor to Hubble, the James Webb Space Telescope (JWST), has moved a step closer to launch following successful testing of the first of its four main instruments.

At NASA's Goddard Space Flight Center, the UK-built Mid InfraRed instrument (MIRI) has been installed on the core spacecraft chassis and put through its paces in a huge vacuum test chamber. MIRI passed with flying colours, proving perfectly aligned and focused when tested with simulated starlight. A second instrument and guidance package, supplied by the Canadian Space Agency, has also been installed.

Bigger than Hubble, with a massive 6.5-metre wide mirror, the JWST is due for launch in 2018. MIRI will allow the telescope to reveal light from the very earliest galaxies, early stages of planetary system formation, and information about the atmospheres of planets outside our solar system, known as exoplanets.

A UK-led consortium of 15 institutions in 10 countries combined their expertise to develop MIRI, which was delivered to NASA's Goddard Space Flight Center in 2012. "In terms of UK science, the fact that we are technically leading this instrument is kind of unique – it's been seen by NASA and ESA as key to our success on MIRI," said Instrument Scientist Alistair Glasse.

MIRI is also notable for its sensitivity. "Hundreds of times better than any competing instrument," according to Glasse. This sensitivity, and very fine spectral resolution, will enable scientists to study the atmospheric composition of many larger exoplanets by looking at light filtered through their atmospheres.

The safer way to drive on Mars

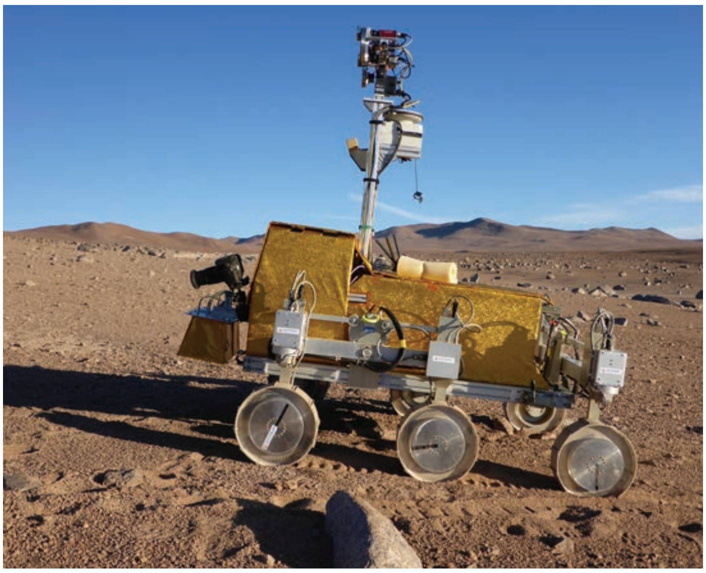
UK space scientists gained invaluable mission experience in October by remotely operating a Mars rover across dry, red, rocky terrain. The Mars-like scenery, however, was not on another planet but in South America as the field trials took place in the Atacama Desert in Chile.

"The Atacama Desert is like Mars in many respects," said Open University geologist Susanne Schwenzer. "You have a barren landscape, huge boulders that are made from basalt, a pavement which is finer grain and very little water. So you have this rough, very dry landscape that resembles many places on Mars."

The team behind the rover's movements, led by the Science and Technology Facilities Council's RAL Space, was based in a convincing mission control centre at the Satellite Applications Catapult, Harwell, Oxfordshire. Large screens showed aerial photographs of the rover as well as ground views from its camera. Only a blue sky above the 'red planet' reminded those present that this was part of the European Space Agency's (ESA) Sample Acquisition Field Experiment with a Rover (SAFER) project and not the real thing.

"In terms of the rover, there are quite good analogues to a real mission," said trials coordinator and engineering manager Lester Waugh from Astrium UK. "We are introducing delays between the time we issue instructions, the time they arrive at the rover and the time that they're executed."

Astrium UK built the ExoMars prototype rover, called Bridget, and Waugh helped site the machine in a pristine part of the desert. "The way we operate rovers is bit like being a blinkered horse in that you can't see everything around you," he said. "The only view is the camera's, which means you have a very constrained view. So operating with a limited data set through that narrow visual channel is a very good discipline and learning how to do that is very important for future missions."



The Bridget rover in the Chilean desert **Credit:** ESA, RAL Space

The other end of the experiment: the control room at Harwell **Credit:** Boffin Media

The experimental rover contained three scientific instruments: a camera to take close-up images, a sub surface sounding radar called Wisdom and a 3D panoramic camera, PanCam. "When we get all this data back we need to fuse it all together from different sensors and, by interpreting the data, we're able to make stronger inferences about the environment in which the rover's operating," said Waugh, "and that helps us to make those operational decisions."

"There's real pressure," said the leader of the PanCam team, Andrew Coates, "but this is what we enjoy. You can see we're actually getting the context for the entire rover mission and from the start this has been something that's hugely exciting."

The final ExoMars rover will contain many more instruments when it launches in 2018. But with a mission involving multiple academic institutions and organisations, teamwork is crucial. "This is the first small stepping stone in bringing people together, learning how to do it, learning what are the problems, what are the issues," said David Barnes from the University of Aberystwyth.

"Never mind the Martian dynamics, engineering and science instruments, we've got human dynamics and the team need to get together and know one another. We've had meetings about science collaboration. It's one thing talking about it," said Barnes. "This SAFER field trial is great because we're actually doing it."

Their work will also lead to potential spin off technologies. "There are two reasons why we're interested in space exploration," said Sue Horne from the UK Space Agency, the second largest contributor to ExoMars and whose subscriptions to ESA helped fund the trial.

"One is that it delivers important science to understand the Mars environment and whether it might have supported life in the past," said Horne. "The other is it develops important technology on autonomous and intelligent systems and this is technology that we want to use on Earth."

Typhoon response from space

Satellites are being used to aid rescuers after the massive typhoon that hit the Philippines in November. More than 5000 people were killed and 2 million people displaced after typhoon Haiyan devastated vast areas of the country.

Satellite images, provided for free under the International Charter on Space and Major Disasters, have been used by rescue teams to survey the damage so that aid can reach the areas where it is most needed. The image below was captured by Astrium's Pléiades high-resolution satellites on 13 November and shows before and after images of the city of Tacloban.

Credit: Astrium

New exoplanet mission

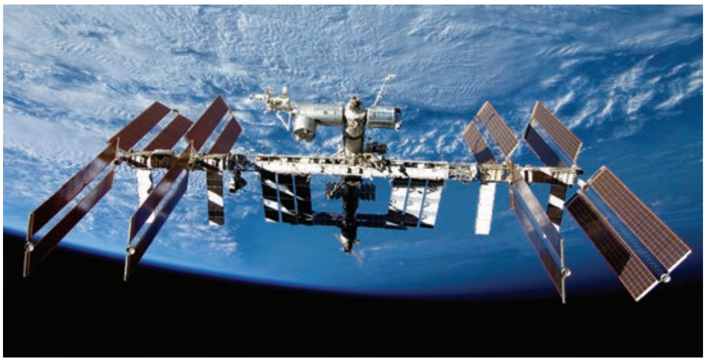
ESA has selected UK company Surrey Satellite Technology Limited to design a satellite to investigate exoplanets – planets orbiting stars outside our solar system. The mission, known as the Characterising Exoplanets Satellite, will measure the orbit and radius of known exoplanets to help scientists assess whether they could be suitable places for life to exist. The spacecraft is part of ESA's small mission programme, designed to provide a high scientific return at a relatively low cost.

Space sector action plan

The UK space industry has set out a plan to deliver new jobs and growth for the sector, with the goal of growing the UK's share of the global space market to 8% in the next six years, on the way to reaching a £40bn sector by 2030. The plan outlines ways that the UK could develop an even more supportive business environment, in which space companies can deliver real benefits to the national economy.

The Action Plan comes three years after the Space Innovation and Growth Strategy (IGS), published in February 2010. The new report can be downloaded from the UK Space Agency website and the Government will publish its formal response in early 2014.

UK cameras reach station



The cameras will be fitted to the outside of the ISS **Credit:** ESA, NASA

Two UK-built Earth observation cameras have been delivered to the International Space Station (ISS) by a Russian Progress spacecraft. The cameras will be fitted to the outside of the ISS to provide users with the world's first live video feed from space.

The cameras, which include a steerable high-resolution camera, were designed and built by engineers at RAL Space in Oxfordshire for Canadian start-up UrtheCast (pronounced Earthcast). Once installed, the live video stream from orbit will be free to watch, with a premium service provided for a range of customers such as businesses and scientific institutions.

An unmanned Progress supply mission carrying the cameras launched to the ISS on 25 November. It also brought food, fuel and Christmas cards to the crew on board the station, who will be spending the festive season in orbit. The Progress successfully docked on 29 November and work has now started with unloading. The cameras had to be specially designed to allow the cosmonauts to fit them through the narrow hatches on the station.

"Following the successful launch and docking, RAL Space is looking forward to a successful space-walk by the cosmonauts to install the cameras in late December," said Director of RAL Space, Richard Holdaway. "We are eagerly anticipating the first images back from the cameras, which will see the culmination of a lot of hard work and expertise from the team working on this challenging and unique project."

The RAL Space team with the High Resolution Camera before it was shipped to Russia for launch **Credit:** RAL Space

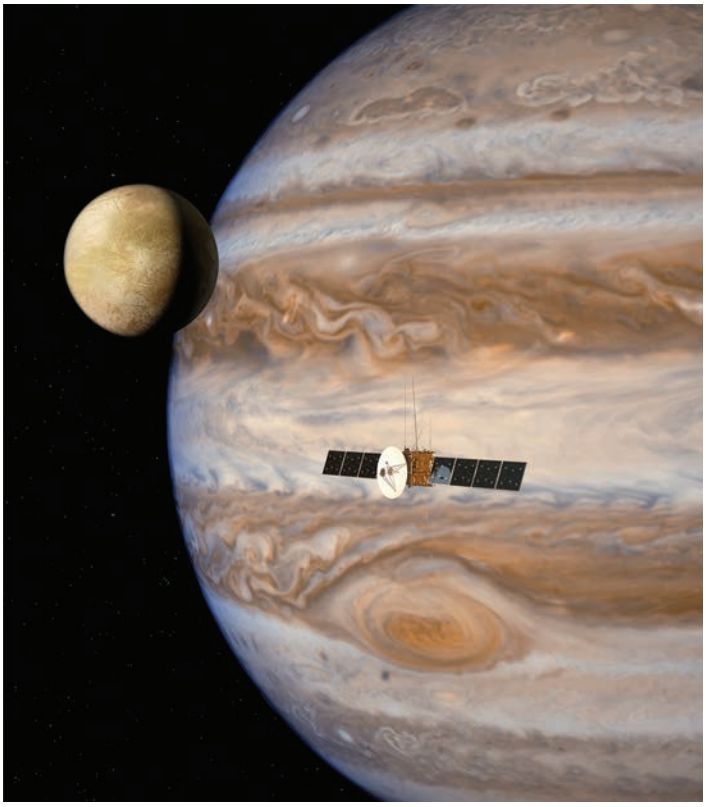
Hot mission chosen

ESA has selected to investigate the 'hot and energetic Universe' and gravitational waves for two of its future large, or L-class, missions. A broad plan to build spacecraft to address fundamental questions about the nature of the Universe was agreed at a meeting of ESA's Science Policy Committee, which includes delegates from the UK Space Agency.

The first mission will consist of a large X-ray space telescope to study hot gas in the Universe. This will help astronomers better understand how stars and galaxies form. The team that proposed the mission includes UK scientists from the Universities of Leicester and Cambridge.

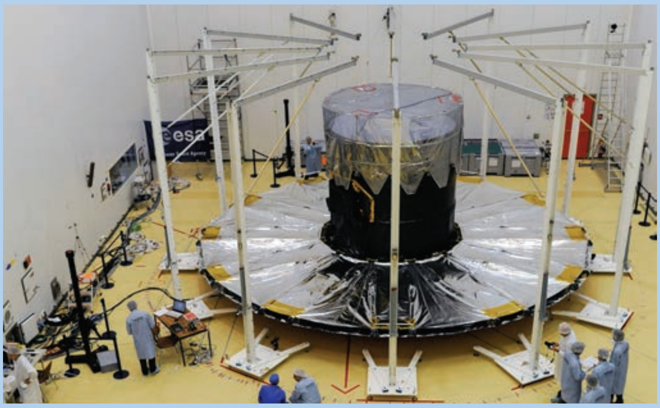
A second mission will involve building an observatory to investigate gravitational waves. These ripples in the fabric of space-time are predicted by Einstein and permeate out from some of the most violent events in the Universe, from exploding stars to colliding black holes. It is likely that this mission will employ technology that has been developed in the UK for ESA's Lisa Pathfinder spacecraft (see issue 38 of *space:uk*).

Neither of these missions will be launched for at least 15 years but the long lead time is necessary to develop the technology. The Agency's third L-class project, the JUpiter ICy moon Explorer, or JUICE, was given the go-ahead last year and is due for launch in 2022. With considerable UK involvement, it will be the first mission ever to go into orbit around a moon at the outer planets and will investigate if they have conditions suitable for life.



JUICE was given the go-ahead last year **Credit:** ESA

Agency update



Gaia's heat shield being tested, the ESA spacecraft is due for launch in December 2013
Credit: ESA

The end of 2013 has been extremely busy for the UK Space Agency with events, announcements and programmes taking centre stage. Aside from the successful launch of Swarm and the upcoming launch of Gaia, the Agency helped ESA deliver the extremely successful, and high-profile, Living Planet symposium in Edinburgh. This gathering of the Earth Observation (EO) research community brought together 1800 scientists from around the world to discuss the latest in ESA EO programmes.

In December's Autumn Statement, the UK Space Agency was handed an £80m fund to create opportunities around the world for UK expertise in small satellites, satellite telecommunications and applications of space data, opening international markets to UK business.

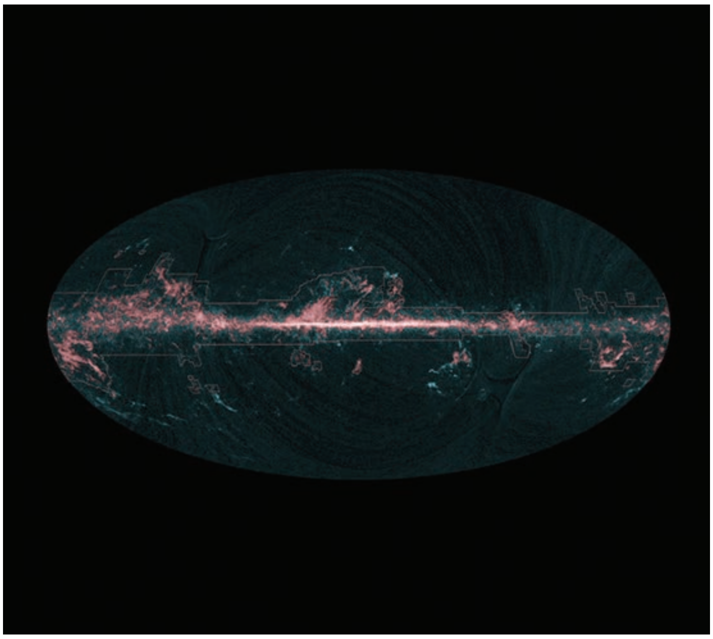
This new five-year Global Collaborative Space Programme will allow the Agency to increase its international portfolio by fostering projects of mutual interest with other national agencies. This includes countries where space services can help aid social and economic development.

The programme will also address a key recommendation of the ambitious Space Innovation and Growth Strategy's Action Plan (see page 6), designed to enable the UK to develop an even more supportive business environment for space companies to deliver growth and benefits to the national economy.

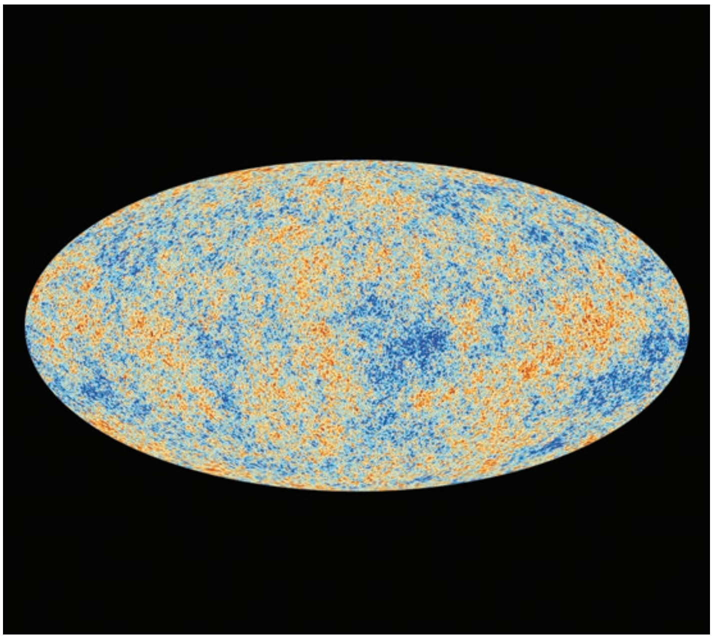
As part of the Action Plan, the space sector asked for the Government to review the legislative landscape to help make the UK the best place in the world to do space business. In December, the UK Space Agency announced its commitment to reform the Outer Space Act 1986 by capping the unlimited liability currently imposed on UK operators. The Government's response to the Outer Space Act consultation has been published on the UK Space Agency web site, setting out the intent to proceed with legislation that will cap the unlimited liability requirement to €60 million for the majority of missions.

The final frontier

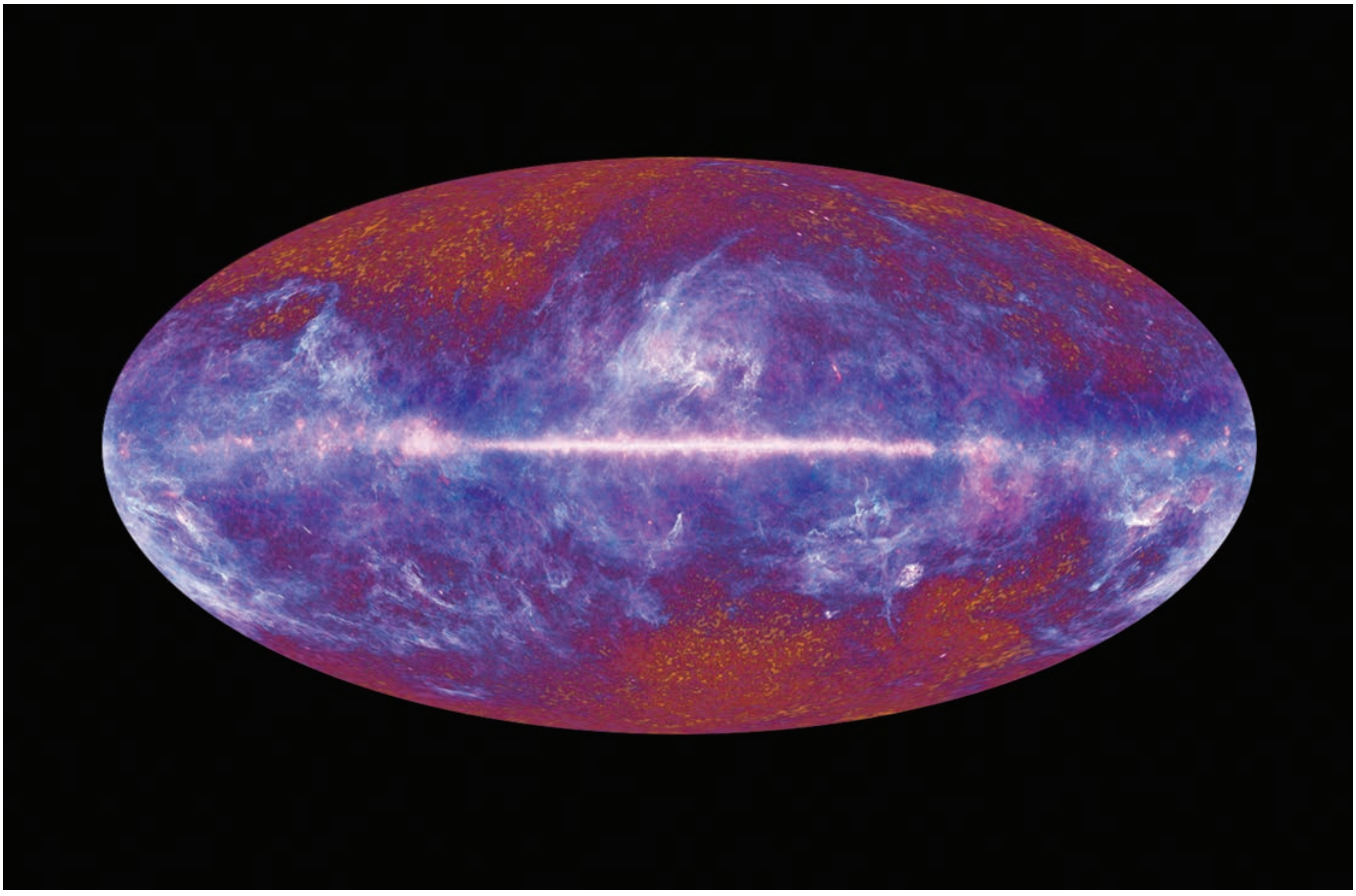
In 2009, ESA launched two remarkable space observatories: Herschel and Planck. It is no exaggeration to say that, between them, they have transformed our view of the Universe. In the last few months the missions have come to an end, an excuse for *space:uk* to look back at some of their achievements:



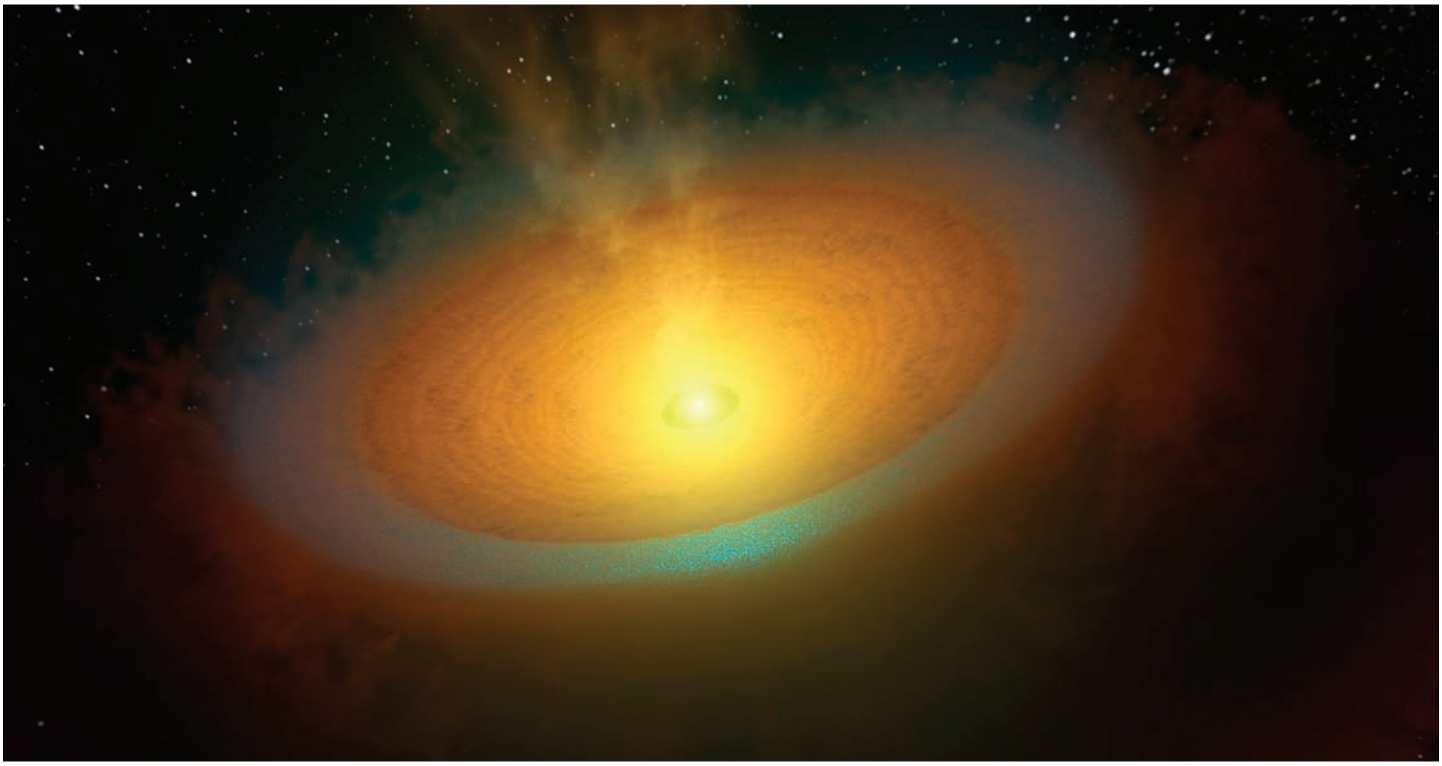
This image from the Planck space observatory shows the distribution of carbon monoxide throughout the cosmos. Carbon monoxide is a constituent of the cold clouds that populate the Milky Way and other galaxies. Predominantly made of hydrogen molecules, these clouds provide the reservoirs from which stars are born.



This map from Planck is the most precise view of the Universe ever produced. It shows the afterglow left behind around 380,000 years after the Big Bang. At this point in time there were no planets or stars, simply a hot dense state of protons, electrons and photons (light particles).

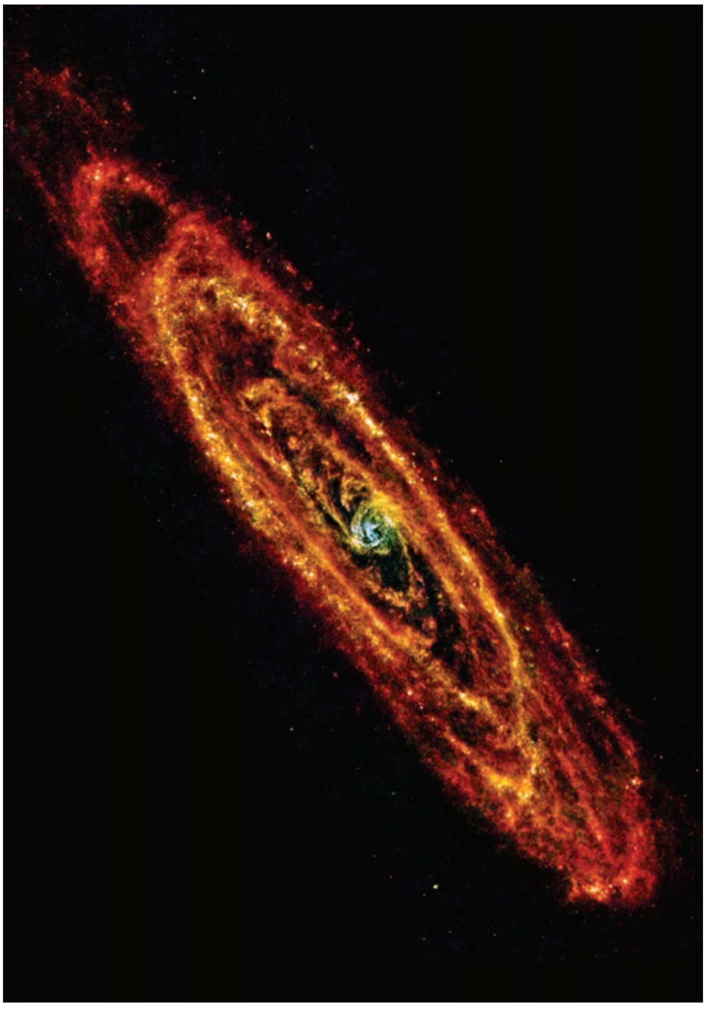


Planck's first survey of the Universe. Planck has discovered that only 5% of the Universe is made up of normal matter. The rest is dark matter and dark energy – a mysterious force thought to be accelerating the expansion of the Universe. Several UK universities, institutes and companies contributed to the instruments on board Planck and are now involved in the Planck data processing centres. Although the mission has ended, this data will be studied for years to come.



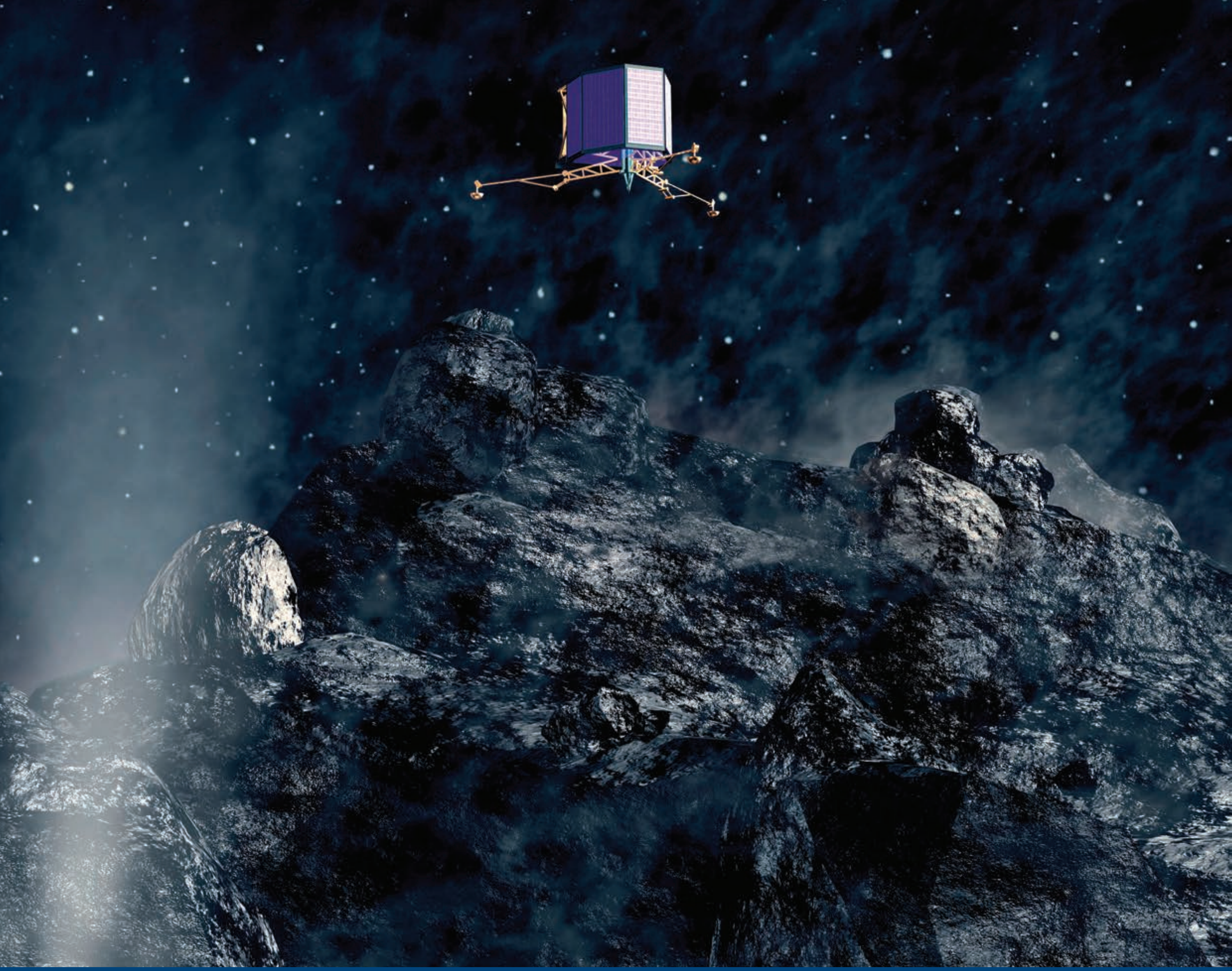
Herschel made the first discovery of massive quantities of cold water vapour in the disk of dust and gas surrounding a young star. Disks of material around stars coalesce to form planets and the implication of the finding is that water-covered planets like Earth may be common. The star with this waterlogged disk is 10 million years old and located about 175 light years away from Earth in the constellation Hydra.

The Herschel space observatory was the largest and most powerful infrared telescope ever built. The spacecraft has been examining some of the coldest and most distant objects in space. This image shows formation of stars in the Orion nebula.



Herschel's view of the Andromeda galaxy. During its highly successful four-year mission, the spacecraft produced a wealth of scientific information on the origin and evolution of stars and galaxies. The UK led the science team for one of the three instruments, SPIRE, on board.

Credit for all images: ESA



How to land on a comet

Image above: Artist's impression of ESA's Philae lander descending towards comet 67P/Churyumov–Gerasimenko
Credit: ESA

In 2014, after ten years in deep space, a European mission will attempt to make history. Sue Nelson meets the UK team that is helping to make Rosetta possible:

Rosetta is one of the most ambitious space missions ever conceived. Its aim: to rendezvous and land on a comet. Launched in 2004, after multiple planetary flybys and close encounters with asteroids, the spacecraft is now closing in on its destination. Rosetta is currently in its most recent stretch of deep space hibernation but on January 20th 2014, at 10 am GMT, it will reawaken. And then, after an epic journey across the Solar System, the real excitement will begin.

"It's a bit like the film Armageddon but without Bruce Willis and the nukes," says Dan Andrews, talking to me in the Open University's Rosetta operations room in Milton Keynes. "We're going to intercept, rendezvous with and enter orbit around a comet nucleus," he explains. "We'll spend six months getting to know the comet in great detail. We'll then pick a landing site about the size of Wembley stadium and drop Philae, which is a washing machine sized lander, onto the surface."

This Philae lander, according to Andrews, contains all the kit you would give to a geologist working in the field. This includes a drill – to take samples 20 to 30 cms below the comet surface – and the Open University's Ptolemy instrument. "Ptolemy is about size of a shoebox, weighs about four kilos and uses the power of a low energy light bulb," says Andrews, showing me an exact scale replica.

Chemical nose

At first glance, Ptolemy resembles a building's fire alarm but this sophisticated instrument will heat samples from the comet and then separate and analyse the resulting gases. What look like alarm bells are in fact two small tanks, provided by the UK's Polyflex Space Limited, that store helium gas to push the sample gases through the system.

"Ptolemy is a chemical nose," explains Andrews. "It will take samples from above, on and beneath the surface of the comet."

Since comets contain water ice and are believed to carry the primitive building blocks of life, the Rosetta mission will shed light on the early Solar System and even, perhaps, the origins of life on Earth.

"We want to understand if there's a relationship between the comet's water and water on Earth," says Ptolemy's Principal Investigator, Ian Wright. "If there is, then we can assume that comets brought water to the Earth." Another theory they plan to explore is that the ingredients of life also came to Earth from comets. By examining any organic compounds in the comet, the science team hopes to investigate this idea in detail.

Image below:Artist's impression of the Rosetta spacecraft with the Philae lander attached to the side **Credit:** ESA

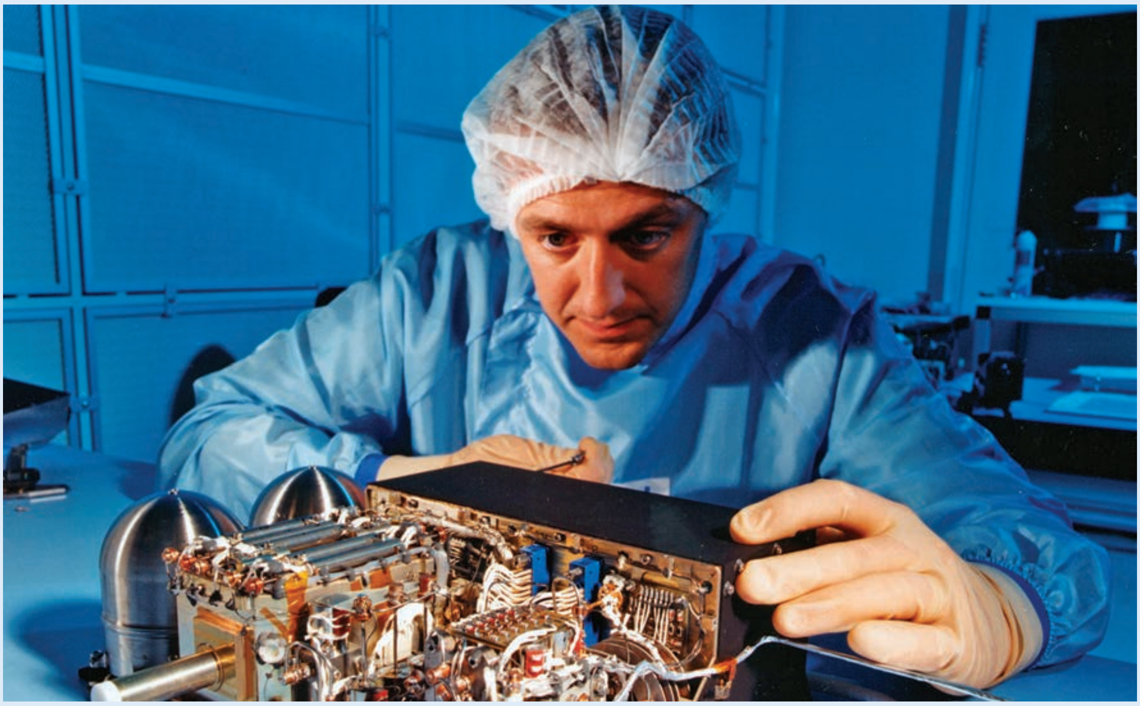
"It's cutting edge Hollywood big bang for your buck stuff"
Dan Andrews
Open University

continues >

How to land on a comet
continued

Top image: Simon Sheridan of the Open University carrying out final checks on the Ptolemy instrument
Credit: RAL Space

Bottom Image: Rosetta captured this image of Earth during its 2007 flyby
Credit: ESA



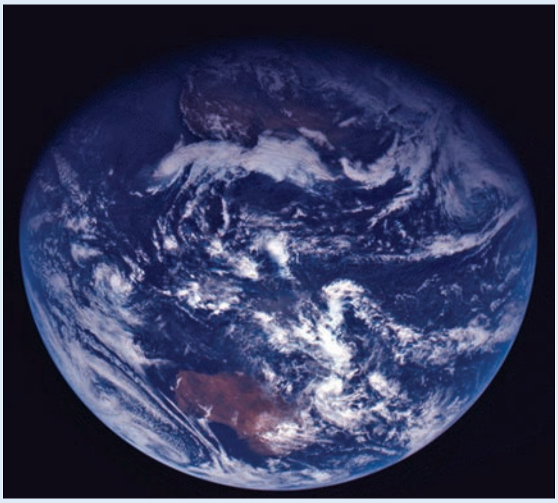
Catching a comet

Wright was at the launch of Rosetta in 2004. "That was an amazing experience. Since then it's been going round and round the solar system, winding itself up to get faster and faster so that it can be flung out into deep space, which is where it is now, to get a fast enough speed to catch the comet up."

"We'll spend six months getting to know the comet in great detail"
Dan Andrews
Open University

The comet in question is 67P/Churyumov–Gerasimenko, a dirty rock of ice, dust and gas that orbits the Sun every 6.6 years between the orbits of the Earth and Jupiter. When it is nearer the Sun, the heat melts some of the ice to produce a comet's distinctive trailing tail.

In order to catch up with this comet Rosetta performed three Earth flybys, and one past Mars, using the planet's gravitational force to increase velocity, a technique known as slingshot gravitational assists. In doing so, it reached speeds of over 100,000 km per hour. It also flew by and took pictures of two asteroids on the way, Steins in 2008, and Lutetia in 2010.



When Rosetta wakes up, about 9 million km away from the comet, it will warm up its navigation instruments and stop spinning. It will then point its main antenna at the Earth in order to let the ground team know it is still alive, before running checks on its onboard instruments.

"We are very excited to have this important milestone in sight," says ESA's Rosetta mission manager Fred Jansen. "But we will be anxious to assess the health of the spacecraft after Rosetta has spent nearly ten years in space."

Unique science

By May, Rosetta will be two million kilometres from its target and during that month the first images of the comet are expected. Closer still, during August and September, Rosetta will study the comet's gravity, mass and shape.

"This unique science period will reveal the dynamic evolution of the nucleus as never seen before, allowing us to build up a thorough description of all aspects of the comet, its local environment and reveal how it changes even on a daily basis," says ESA Rosetta project scientist Matt Taylor.

During this period a team from Imperial College London and University College London's Mullard Space Science Laboratory (MSSL) will also examine the comet's plasma tail.

Comets have two main tails: one made from dust up to 10 million kilometres long; and a plasma tail, that is often blue because it contains carbon monoxide ions. The Sun's ultraviolet light breaks down the gas causing its ions to glow. The plasma tail can reach tens of millions of kilometres long and, in rare cases, almost 100 million.

Scientists will use all the information gathered by Rosetta to select a suitable landing site for the lander. Philae will fire a harpoon to anchor itself to the comet with ice screws to prevent it from escaping the comet's extremely weak gravity. The lander will then touchdown on the four kilometre wide comet nucleus in November 2014 to obtain direct measurements from the surface – an astounding achievement.

UK expertise

For the many UK scientists involved in this mission the build up to landing on the comet in November will be exhilarating. Their expertise can be found almost everywhere on the spacecraft, lander and on ten of the 21 instruments on board.

The main Rosetta spacecraft, for instance, was built at Astrium UK's Stevenage site and scientists form UK companies such as AEA Battery Systems Limited provided innovative lightweight batteries, while Logica created the software technology for the mission. Scientists at the Science and Technology Facilities Council's RAL Space were also involved in miniaturising instruments to ensure that the necessary science can be done in as small a space as possible. Surrey Satellite Technology Limited designed a wheel to stabilise the probe when it descends and lands on the comet.

It is no understatement to say that Rosetta is an extraordinarily exciting mission and the world will be watching.

"If you don't try, you don't achieve," exclaims the Open University's Dan Andrews. "It's cutting edge Hollywood big bang for your buck stuff."

It is indeed.

Discover more:

- For facts on comets, see the poster in the centerfold of this issue
- More information on the Rosetta spacecraft can be found on the UK Space Agency website in the missions section
- Details of the Ptolemy instrument are on the Open University website
- For the latest news on the status of the mission, visit the ESA website
- To hear a longer interview with Dan and Ian, search for the July 2013 edition of the Space Boffins Podcast hosted on the Naked Scientists' website

"We are very excited to have this important milestone in sight"

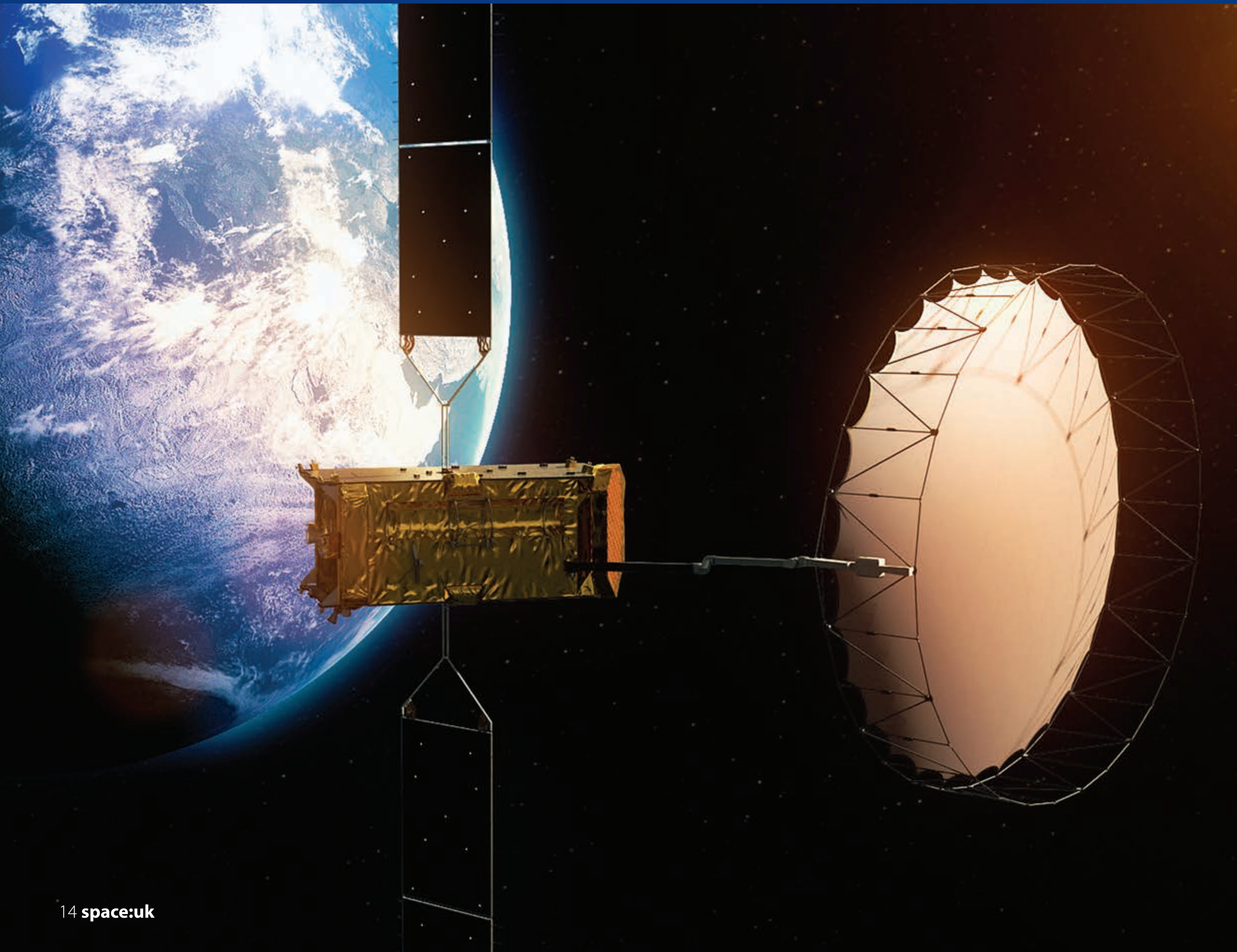
Fred Jansen
ESA's Rosetta mission manager

Bottom Image: This new ESA tracking station in Argentina will be used to keep in contact with Rosetta **Credit:** ESA

Connecting the Earth

Artist's impression of Alphasat in orbit
Credit: ESA

Want broadband internet in the middle of the Sahara desert, up a Himalayan mountain or during a storm in the Pacific Ocean? No problem, as Richard Hollingham discovers when he visits a UK mission control centre:



Top image: Inside the Inmarsat control room
Credit: Inmarsat

Bottom image: Télécoms Sans Frontière uses Inmarsat services to enable victims of Typhoon Haiyan in the Philippines to contact their families and friends
Credit: Télécoms Sans Frontière

Inmarsat's modern offices on a busy roundabout in central London might seem an unlikely location to control a fleet of spacecraft. But go inside and it soon becomes apparent that this is no ordinary corporate headquarters.

"This is the nerve centre of Inmarsat," says the company's Chief Technology Officer, Ruy Pinto, as he shows me around the company's Network Operations Centre. Staffed 24 hours a day, 365 days a year, it is exactly how a space mission control room should look, with banks of computer monitors arranged in a circle around a central console and a vast five metre long map of the world covering the main wall.

"That map shows the status of every single service we provide," explains Pinto. "It shows the status of all of our satellites, how good the service is we're providing and whether our customers are getting the data and connectivity they need."

Inmarsat's ten satellites provide broadband internet and phone services to users across almost the entire planet. The only places on Earth not in range of the company's satellites are the extreme points of the north and south poles. People using the network range from reporters sending TV pictures from war zones to aid workers in isolated regions of Africa or the crew on ships at sea sending emails to friends and family at home.

"The current generation of Inmarsat satellites exploit UK technology developments"
Peter Aspden
Astrium

Connecting the Earth
continued

Image bottom left: The Cape of Good Hope is an extremely busy area for shipping – and satellite communications
Credit: ESA

Image bottom right: Geostationary satellites are positioned far above the Earth. This image was captured by Europe's weather satellite, Meteosat-2
Credit: ESA

Giant map

The Operation Centre's giant map is divided into hexagonal cells, which represent the two-way communications beam between satellites in orbit and users on Earth. Each of these cells has a number at its centre, which tells controllers how many users are online in a particular area at any particular time. The number changes constantly and as we watch, the figure in a cell covering a remote area of the Sahara Desert changes from zero to two. That means, even in this remotest part of Africa, two people have started using satellite phones.

Further south, at the tip of the Cape of Good Hope, there are dozens of Inmarsat users. "At this exact moment in time, we know exactly how many ships, planes and vehicles are using our services and from where people are sending emails, logging on to Facebook, sending data back to their headquarters," says Pinto, who explains that it is the controllers' job to ensure that the satellite capacity is there to meet demand.

"It's dynamic, every couple of seconds or so we will monitor traffic and provide the service. Right now on this satellite alone, we have in excess of 10,000 users logging in and transmitting data."

They even monitor the BBC news channel to keep ahead of events. "If there is an event somewhere in the world, say a natural disaster such as an earthquake," says Pinto, "we start to increase capacity before the media or the aid agencies get there, so that when they get there for emergency communications they have the services they need immediately."

All this effort to maintain the robustness of the system is aimed at ensuring that users take its reliability for granted. The last thing they want to think about is the control systems, ground infrastructure or satellites that make this all possible. Nevertheless, the space technology behind the ability to make a phone call from the middle of the Sahara is incredibly sophisticated.

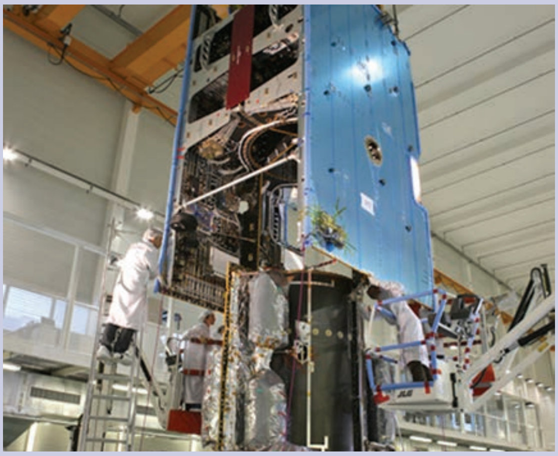
36,000 Kilometres High

The idea of using multiple satellites in geostationary orbit to form a global communications network was first proposed in 1945 by Arthur C Clarke. The orbit is sometimes referred to as the Clarke Orbit in memory of the science fiction writer and space visionary.

It took almost 20 years from Clarke's prediction for the first successful geostationary satellite, Syncom 3, to be launched by NASA. The satellite transmitted live coverage of that year's Olympic games in Tokyo to TV stations in North America and Europe.

Spacecraft in geostationary orbit also include weather satellites, such as Europe's Meteosat series. The first spacecraft to observe Earth from geostationary orbit was America's SMS-A in 1975; Meteosat 1 was launched in 1977.

Today there are more than 300 working satellites in geostationary orbit. These include three generations of Inmarsat communications satellites, the UK's Skynet 5 military communications system and Meteosat 10, which provides Europe and Africa with the latest weather information.



Double-decker bus

The spacecraft that supply Inmarsat's services are known as geostationary (or geosynchronous) satellites. These are stationed some 36,000 kilometres above us, in an orbit that allows them to travel at the same speed as the Earth rotates. As a result, the satellites remain at a fixed point above the planet. In theory three satellites could provide coverage for the entire Earth. However, the global demand for satellite communications is so high that there are currently around 300 active geostationary satellites, and more are being built all the time.

Communications satellites range from relatively simple spacecraft that act as a relay – bouncing a signal to and from fixed points on Earth – to broadcast satellites, such as the ones that supply Sky TV customers. Many nations also operate secure military communications satellites, like the UK's Skynet constellation.

Inmarsat's latest satellite, Alphasat, was launched in July and is bristling with new technology. Around the size of a double-decker bus, this vast spacecraft is the most powerful commercial telecommunications satellite ever built in Europe. Developed in partnership with ESA, it is built around the new Alphabus satellite platform. This provides all the core systems such as power and propulsion. The satellite also carries an advanced digital signal processor enabling it to regulate the amount of bandwidth in a particular area, depending on user demand.

The UK Space Agency is the largest contributor to Europe's satellite technology development programme and much of Alphasat was designed, built and tested in Britain by engineers at Astrium's facilities in Portsmouth and Stevenage.

"The current generation of Inmarsat satellites exploit UK technology developments," says Peter Aspden, Astrium UK's Telecommunications Satellites Marketing Manager. "The UK really punches above its weight in manufacturing telecommunications satellites and we are still benefiting from government investment made from the 1980s onwards."

"It's a very successful business for Britain," Aspden adds, "we currently have around 20% of the global market." Which, given that each satellite can cost around £100 million (excluding launch and insurance), is a good high-tech business for a country to be in.

However, this is much more than just a business. Communications satellites are an increasingly important part of global infrastructure. Without communications satellites there would be no live global news or sports coverage. Crew on ships at sea would no longer be able to talk to home. Aircraft would be unable to be warned of bad weather. Troops on patrol in war zones would lose contact with their commanders. Without communications satellites, those two people using Inmarsat phones in the Sahara Desert would be completely isolated. Above all, lives depend on them.

"Our staff know that it's not just about making money from communications," says Pinto. "They are very much aware that there are circumstances in which we have a social responsibility function. We provide the last resource for vital communications in some parts of the world and our staff are quietly proud of that."

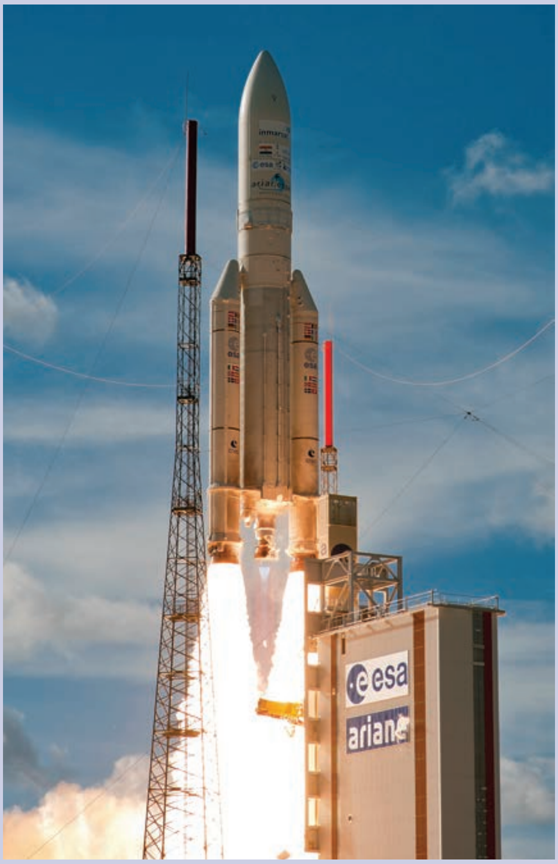


Image top left: The two parts of the massive Alphasat spacecraft being joined together
Credit: ESA

Image bottom right: The launch of Alphasat in July
Credit: ESA, Arianespace

"At this exact moment in time, we know exactly how many ships, planes and vehicles are using our services"
Ruy Pinto
Inmarsat

Mission profile: observing the Blue Planet

Image above: This picture of Earth from space was taken by an astronaut on the International Space Station (ISS)
Credit: NASA

Pictures taken of the Earth from space have transformed our understanding of the natural world. *space:uk* profiles the European missions designed to investigate our changing planet:

The most famous image ever taken of the Earth almost didn't happen. It was Christmas 1968, and Apollo 8 was on its fourth orbit of the Moon when one of the astronauts glanced out of the window. The view he saw was astounding and the onboard sound recordings reveal the crew scrambling for a camera as they spot the vivid blue and white marble of the Earth, rising above the monochromatic surface of the Moon.

Apollo 8 astronaut Bill Anders later famously summed up the importance of that moment, which became one of the enduring legacies of NASA's Apollo programme. "We came all this way to explore the Moon," he said, "and the most important thing is that we discovered the Earth."

This 'Earthrise' image would change our view of our planet forever, placing the Earth in the context of the inhospitable vastness of space. That one picture galvanised the environmental movement and inspired generations of scientists and engineers working on today's Earth observation missions.

Earth observation satellites are fitted with cameras, sensors and instruments to track weather, investigate climate, measure ice cover and study ocean currents. There are also British-built satellites – the Disaster Monitoring Constellation – which provide images of the Earth following man-made or natural disasters. Together, all these satellites can monitor short-term events, track long-term trends and give us new insights into our changing world.

"Earth observation is fundamentally important to our understanding of the planet," says Ruth Boumphrey, the UK Space Agency's Head of Earth Observation. There are currently at least twelve Earth observation missions with UK involvement and several more in development. The UK, through the UK Space Agency, is the second largest funder of ESA's Earth observation programmes but it also works with other global partners, such as the European Organisation for the Exploitation of Meteorological Satellites and NASA, to develop missions.

"We work with global partners to coordinate the measurements we take and to build up a big picture of the Earth," Boumphrey explains. "All these missions not only make a big difference to our understanding of our planet but have wider benefits for all of us who live on it." These benefits range from better weather forecasting to improved climate prediction, from monitoring pollution to forest protection.

A major new European programme, Copernicus, includes a series of Sentinel missions, the first of these will be launched in 2014. Copernicus brings together observations from a wide range of satellites for environmental monitoring and security applications. Most of this data will be free to users, the idea is to stimulate growth in the European remote sensing services industry. UK companies have already won key roles in processing and distributing the vast amount of data generated by these missions.

The UK Space Agency recently published its Earth Observation Strategy, which outlines what actions the Agency will take to maximise the benefits from these missions for the environment, society and the UK economy. "We face massive societal challenges in the 21st century, such as population growth, energy supply and climate change," says Boumphrey. "Having the ability to look at our planet during this time of massive change is fundamental to the way we manage resources."

Over the next two pages, we profile European science missions that have important UK involvement:

Image below: Earthrise witnessed by the Apollo 8 astronauts in 1968
Credit: NASA

continues >

Mission profile: observing the Blue Planet
continued

Top image: Swarm will produce an accurate map of the Earth's magnetic field
Credit: ESA

Middle image: The Himalayas and the Tibetan Plateau, as seen from the ISS
Credit: ESA, NASA

Bottom image: The UK from space, Earth observation has transformed the way we look at the Earth
Credit: ESA

ESA Earth Explorers

The ESA Earth Explorer missions are investigating fundamental physical properties of our planet. CryoSat is studying the Earth's ice sheets and how ice cover is changing; SMOS measures the moisture of soil and salinity of the oceans; GOCE has been investigating the Earth's gravity; and Swarm will provide an in-depth profile of the Earth's magnetic field.

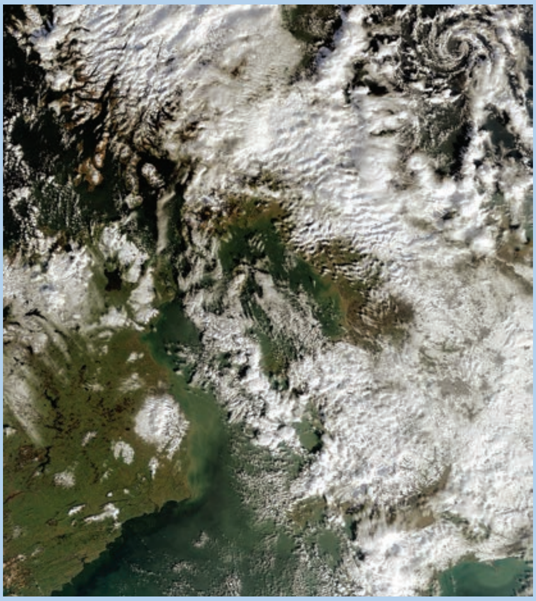
Led by a UK science team, CryoSat has been in orbit since 2010. The satellite is fitted with an advanced stereo radar system, which enables it to measure the shape and thickness of Arctic and Antarctic ice with unprecedented accuracy. During its three years of science operations, the spacecraft has witnessed a year on year decline in the amount of Arctic sea ice. The loss of this polar ice has serious implications for ocean circulation patterns, global sea level and climate.

The first Earth Explorer satellite to be successfully launched, GOCE, recently completed its mission to map the Earth's gravitational field (see page 2). Our planet may look round but GOCE has shown that our gravitational field is distinctly bumpy and varies across the Earth. Data from the satellite has also been used to produce a new map of the boundary between the Earth's crust and mantle and, because of its low orbit, GOCE has even been able to detect sound waves from the massive earthquake that hit Japan in March 2011.

The Soil Moisture and Ocean Salinity (SMOS) satellite is making global observations of the Earth's surface soil water content and the salt in the oceans. Soil moisture and air humidity are connected. If soil becomes dry, due to drought for example, then less water evaporates into our atmosphere. The salinity of the sea affects ocean currents and changes in ocean salinity, due to alterations in weather patterns or melting of polar ice, have a major impact on the Earth's climate.

The final Earth Explorer satellite, Swarm, was launched in November (see news page 1). Swarm will measure the magnetic field from the centre of the Earth to the outermost reaches of the magnetosphere – the protective bubble that shields us from dangerous solar particles and radiation. Results from the mission will be used to predict the effects of solar activity, helping to protect our power and communications infrastructure.

Swarm will also investigate why the Earth's magnetic field is weakening. The mission is made up of a constellation of three identical satellites and Astrium built the structures for the spacecraft in the UK.



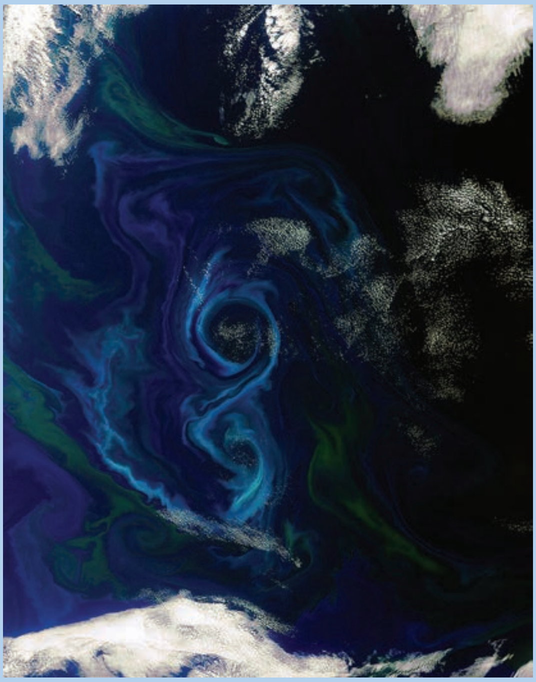
Europe's future missions

Top image: This Kompsat-2 image, acquired on 6 July 2012, shows the Amazon River in the heart of northern Brazil's rainforest.
Credit: KARI, ESA

Middle image: A figure of eight swirl of phytoplankton in the Southern Ocean, some 600 km east of the Falkland Islands
Credit: NASA

Bottom image: This Envisat image of the Amazon Basin highlights the contrast between the rainforest (dark green areas) and sprawling land cultivation (the fishbone-like patterns)
Credit: ESA

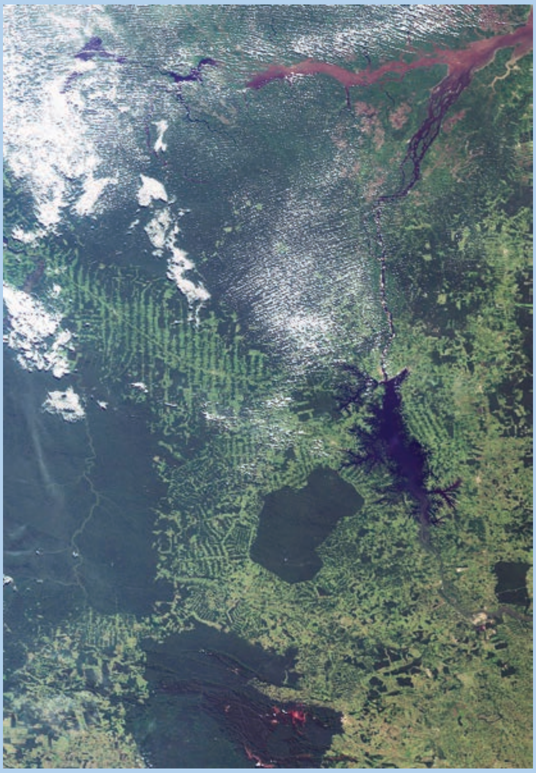
By its very nature, Earth observation is a global endeavour involving cooperation between nations, agencies and institutions. Europe's new Copernicus programme is designed to use satellite data (as well as observations from other sources, such as airborne observatories) to provide governments, businesses and scientists with reliable and up-to-date information on how our planet is changing.



A crucial part of the Copernicus system is a new series of European satellites called the Sentinels. Astrium UK is the prime contractor for the Sentinel 5 Precursor satellite. This low cost satellite is based on a design previously used on ESA's interplanetary Mars Express and Venus Express missions.

As part of its Earth observation strategy, the UK Space Agency is providing £21 million to assist in the development of a new Synthetic Aperture Radar (SAR) satellite, NovaSAR. SAR can be used to capture images day and night, in all weather conditions, and is useful for a wide range of applications – from maritime surveillance of drug-trafficking and oil spills, to environmental monitoring of deforestation and flooding. The first of these new SAR satellites is currently being built by Surrey Satellite Technology Limited.

The UK is also leading the science team for ESA's Biomass mission. This satellite will measure the amount of carbon and living material, or biomass, stored in the Earth's forests. As well as providing crucial data for climate scientists, it is hoped that the mission will underpin the knowledge base for the United Nations' REDD programme. This international effort is aimed at reducing carbon emissions from global deforestation.



Discover more:

Profiles of all the missions mentioned can be found on the missions section of the UK Space Agency website, where you can also download the Agency's Strategy for Earth Observation from Space.

For news on ESA Earth observation missions, visit the ESA website. The site also contains images, videos and animations of all the Earth Explorer satellites.

For the latest images of Earth from the Disaster Monitoring Constellation (DMC) visit: www.flickr.com/photos/dmcii

Ask the experts

Our questions this time come from students at St John Vainney's Primary School in Blackpool. They were visiting Spaceport, the space-themed attraction at Wallasey, across the Mersey from Liverpool.

Ian Crawford
Department of Earth and Planetary Sciences
Birkbeck College London

Why does the Earth have a moon?

The Earth is unique as a planet in the inner Solar System, having a large natural satellite. Mercury and Venus do not have moons, and Mars' two very small moons are probably captured asteroids, yet Earth has a moon that is comparable in size to itself. Indeed the Earth and Moon almost form a double planet.

Clearly something unusual has happened to give the Earth such a large Moon. Early explanations included the Moon spinning off from a very rapidly rotating early Earth (the 'rotational fission' theory), or the Earth gravitationally capturing the Moon after it had formed elsewhere in the solar system (the 'capture' theory). However, both of these theories have unsolved physical difficulties that make them unlikely.

The currently preferred 'giant impact' theory proposes that the Moon formed as a result of a collision between a Mars-sized body and the early Earth. This collision would have resulted in a disk of debris in orbit around the Earth from which the Moon could form. This proto-lunar disk would consist of debris from both the impacting body and the Earth's mantle.

The giant impact theory was proposed to account for the composition of the Moon and was based on the study of lunar materials returned by the Apollo missions. Analysis of Moon rocks revealed that the Moon has a composition similar to that of the Earth's mantle, but lacks volatile elements. These would be expected to have evaporated and been lost in the heat of the giant collision.

Subsequent studies have largely supported the giant impact theory for the origin of the Moon. However, it is far from proved. Indeed, in some ways the Moon's composition is too similar to the Earth, given that part of it should be derived from the impacting body rather than the early Earth. Solving the riddle of the Moon's origin will probably require a return to the Moon to collect a wider range of samples for analysis than the Apollo astronauts were able to bring back

We are still not completely certain why the Earth has a Moon **Credit:** NASA, ESA

How cold is space?

The answer to this question really depends on whereabouts in space you are. In the vacuum of space there is only one way that heat can be transferred and that is by radiation. If you are near an object that radiates heat, then you can absorb some of that heat and get warmer. For example, a spacecraft in orbit around the Earth will experience extreme differences in temperature depending on whether it is in sunlight (and can therefore absorb radiated heat) or in the shade, where it radiates its own heat away. In direct sunlight, metal in space can reach temperatures of around 260˚C. However, in the shade, the temperature can drop to as low as -100˚C.

The very coldest an object could ever get is absolute zero, or -273.15˚. Space never gets this cold though. At the edge of our solar system the temperature can be as low as -240˚C and the interstellar gas between stars can get as cold as 10˚ above absolute zero. The coldest that space can ever be is -270.45˚C, or 2.7˚ above absolute zero. This is the temperature that results from the background radiation, radiation left over from the big bang. So, the temperature of space depends on where you are, whether there are sources of heat nearby, and whether that heat can radiate to you.

Space is cold. Really cold **Credit:** ESA, NASA

Sophie Allan
Physics Teacher
National Space Academy

How many people can you fit in a space rocket?

It is a constant source of disappointment to me that, unlike the Tardis, spacecraft are invariably smaller on the inside. Rockets are vast but the sections that carry humans into space are tiny in comparison.

The capsules used to carry the first men and women into space were only big enough to carry one person, crammed into a couch and surrounded by control consoles. The Soviet Union's next generation spacecraft, Voskhod 1, could just about hold three cosmonauts but only if they didn't wear spacesuits. This was quite a risk but as one of the crew had worked on building the spacecraft, his bosses concluded this was a good way of ensuring it worked properly!

UK astronaut Tim Peake in the Soyuz capsule simulator **Credit:** ESA

The Apollo spacecraft that took men to the Moon was considerably larger. The command module sat three astronauts in relative comfort and the lander carried two of then down to the lunar surface. When these sections were joined together, during the journey to and from the Moon, the astronauts had plenty of room to move about.

The largest spacecraft ever to carry astronauts into space was the Space Shuttle. Seven astronauts could live and work on the Shuttle for several weeks at a time. It even boasted a toilet.

There are only two spacecraft currently certified to take astronauts into orbit – the Russian Soyuz and Chinese Shenzhou. Both are very similar. Designed more than forty years ago, the Soyuz consists of two sections: a cramped re-entry capsule, where astronauts sit for launch, docking and landing; and a living area, which is not much bigger than an aircraft toilet cubicle.

The next generation of spacecraft, including NASA's new Orion capsule, will be more comfortable and suitable for longer duration missions. Unfortunately, anything bigger on the inside is a long way off.

Richard Hollingham
Editor *space:uk*
Space Boffins presenter

Quality in space education

Meet the team:

Allan Clements
ESERO-UK Manager

Tom Lyons
ESERO-UK Teacher Fellow

Alice Coates
STEM Project Officer

Image opposite: An picture of the Earth taken from a high altitude balloon flown by Queen Elizabeth's Grammar School, a Leading Space School
Credit: QEGS

The Space Education Quality Mark (SEQM) is an award given to schools that have shown significant use of the context of space in STEM subjects, have worked with other organisations, shared resources and used space to enrich the curriculum.

The Quality Mark is funded by the Science and Technology Facilities Council and is run by the European Space Education Resources Office in the UK, ESERO-UK. The SEQM comes from the legacy of the Leading Space Education Programme, which has been developed by ESERO-UK with a view to increasing the number of secondary schools achieving the Quality Mark and extending the programme into primary schools.

There are many benefits of taking part in the Space Education Quality Mark:

- Gain recognition for your achievements
- Raise the profile of quality science teaching within the school
- Inspire children to take STEM subjects
- Encourage further engagement with parents, other schools and the wider community
- Take part in Continuing Professional Development
- Forge links with space professionals and organisations
- Share good practice and resources with schools across the UK

For further information on how your school can sign up to work towards the SEQM, go to **www.esero.org.uk** and look under the October 2013 news.

"The levels of motivation and student attitudes have been raised, evidenced by the MA research project of a member of staff. Students' attainment has increased year on year, evidenced by increased end of KS3 levels. More students have taken part in science-related extra-curricular activities as a direct result of extending the space theme."

Shoeburyness High School

Made in the UK

Aetheric Engineering is a technical consultancy in satellite communications. Its Principal Consultant, Peter Milne, has spent almost 40 years in the UK space industry:

Peter Milne

Image top left: MARECS-A being assembled prior to its 1981 launch
Credit: ESA

Image top right: Installing a ground station in Mogadishu
Credit: Milne

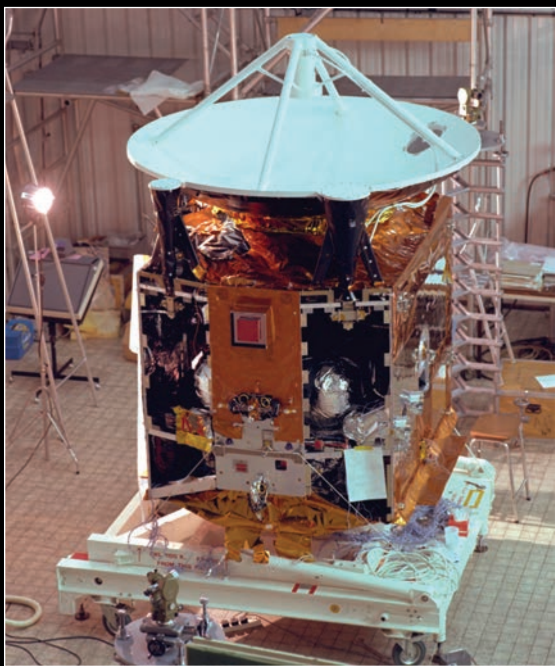
Image bottom right: An Astrium engineer working on a Hotbird communications satellite
Credit: Astrium UK

What does the company do?

We help people to buy satellites. That could involve helping to write specifications, select the contractor or manage the contract on behalf of the client. I work as a technical expert to make sure that our clients get what they want.

Who uses your services?

One example is a current contract with the European satellite operator Eutelsat, who had a peak demand in their workload and wanted some help. That's gone on for six or seven years now. For Eutelsat, I work at Astrium's site in Portsmouth to oversee the construction of their satellites.



What sort of missions do you work on?

Mainly communications satellites but that includes TV broadcast satellites, mobile services – Inmarsat was a previous client of ours – or broadband to the home by satellite. Spacecraft include Hotbird 9 and 10 and KA-SAT, which provides internet services direct to consumers.

How did you get into this?

I started in 1975 in Portsmouth building scientific satellites, including the British scientific satellite Ariel 6. Then I got involved in MARECS, my first communications satellites. Those spacecraft formed part of Inmarsat's first generation network.

Compared to Ariel 6, how much more sophisticated are UK satellites today?

It was all very simple in those days – I think we even had tape recorders on satellites then. Position, for instance, was controlled by using a coil of wire that interacted with the Earth's magnetic field. By adjusting the current in the coil, and therefore the coil's magnetic field, the satellite's position would be changed.

How does the UK perform in terms of international competition?

Certainly in terms of communications satellites, the UK is Astrium's centre of excellence for communications payloads. This means that all Astrium's communications satellites use technology built in Portsmouth.

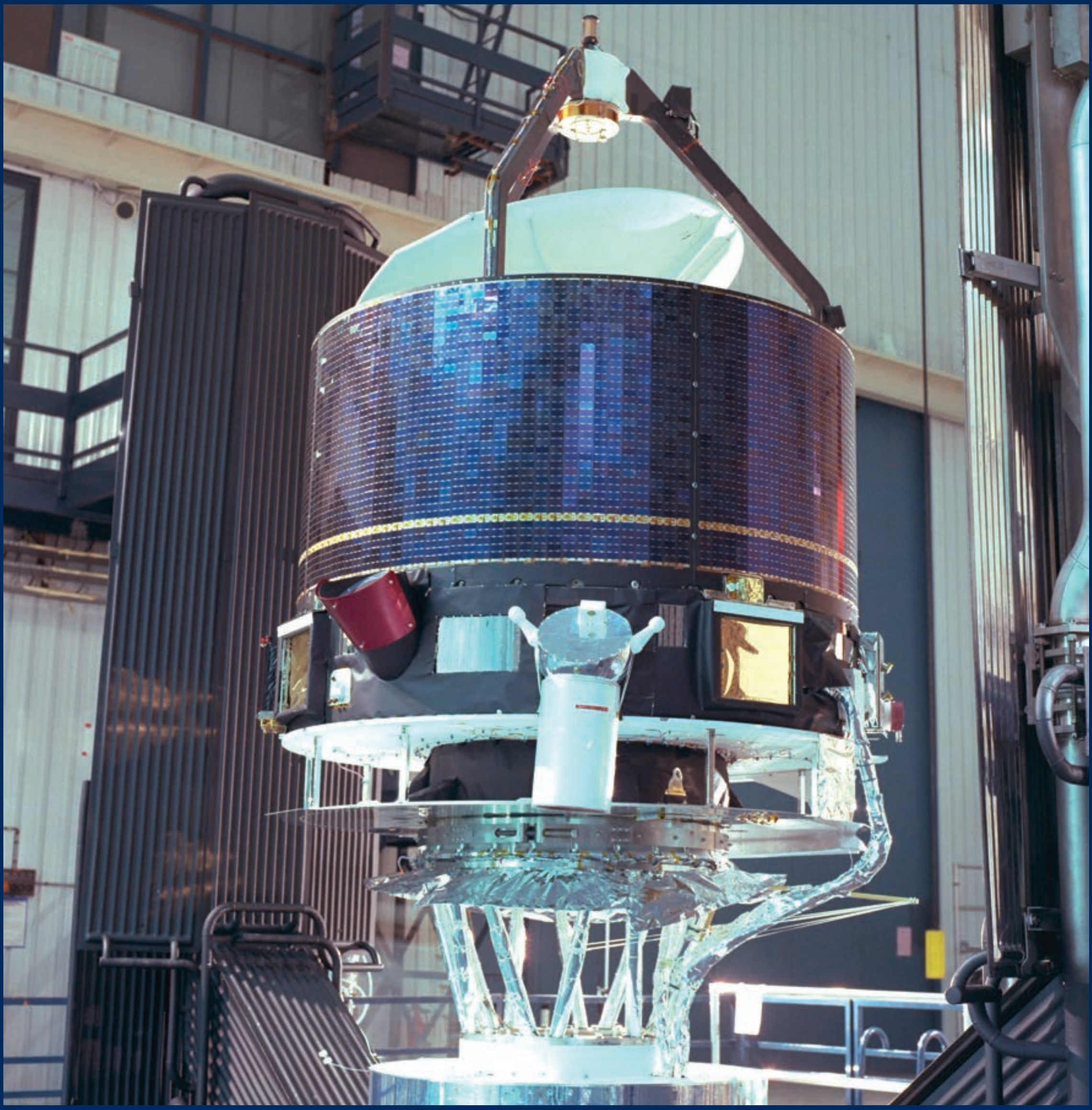
What advice would you have to anyone considering a career in space?

I'd say go for it. There's certainly a strong future and it's something I'm very glad to be involved in. It's one of these jobs where there's excitement, some buzz about it. I'm very lucky to be doing a job I enjoy. I'm not just coming to work because I need the money!

SPACE PIONEERS

Giotto

Giotto being tested prior to its 1985 launch **Credit:** ESA



UK scientists played a part in history with the European Space Agency's first deep space mission.

Giotto was the first ever probe to view a comet at close quarters. Launched in 1985, eight months later it flew within 600 km of Halley's comet and photographed a comet nucleus for the first time. Giotto discovered that this nucleus was dark and measured just 10 by 15 km, emitting bright jets of gas and dust.

Results from the Giotto mission changed people's perception of comets. By measuring its composition, Giotto confirmed that Halley was billions of years old and a primitive remnant of the Solar System. It also found the first evidence of organic material on a comet, complex molecules that could serve as the basic building blocks for life.

Built by British Aerospace in Bristol, Giotto was around two metres in diameter and one metre high. It was fitted with a special dust shield, a layer of aluminium and Kevlar, to protect it from 'sand blasting' by high-speed particles during its encounter with the comet. It carried instruments built by University College London's Mullard Space Science Laboratory and the University of Kent.

Despite almost being destroyed, most of Giotto's instruments survived the encounter with Halley. After its primary mission was complete, the probe went on to collect data from the much less active comet Grigg-Skjellerup in 1992.

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