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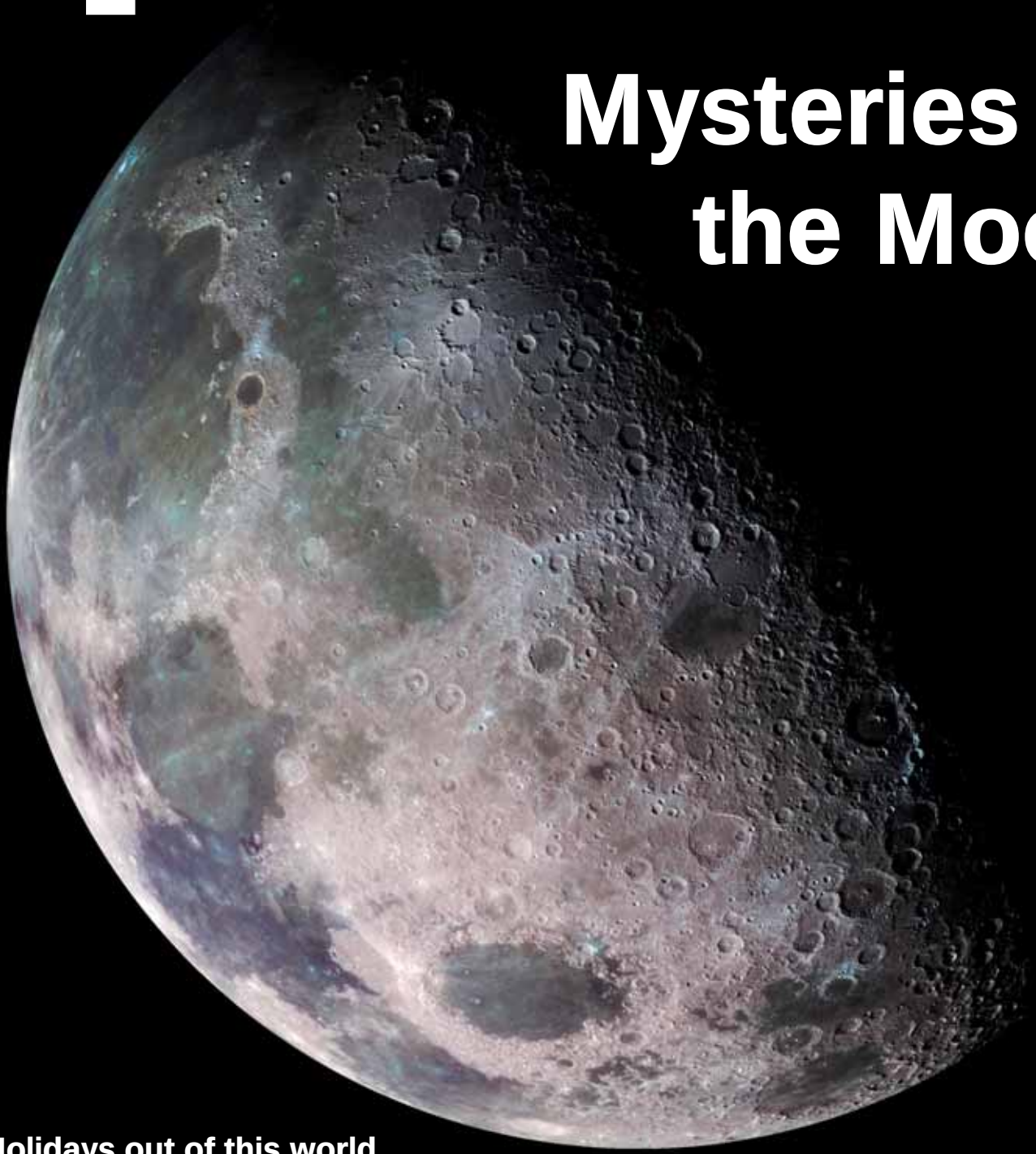
space:uk



Mysteries of the Moon

Holidays out of this world
New UK-built navigation satellites

UK space history: pull out poster

Plus: New space agency, Rosetta's final farewell, top space spin-offs and space to help save the rainforest…

BNSC
BRITISH NATIONAL SPACE CENTRE
www.bnsc.gov.uk

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Front cover image
Credit: NASA

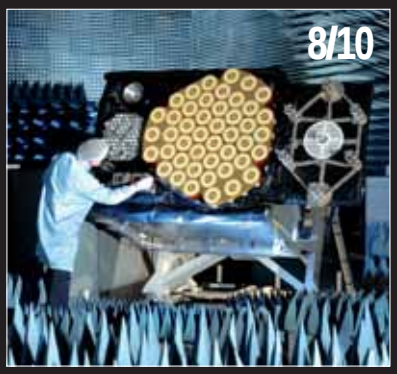
FROM THE EDITOR

Are we at the dawn of a new space age? I certainly can't think of a more exciting time for space in the UK. In this issue we've got the announcement of a new UK space agency, we visit the next generation (UK built) navigation satellites and feature the (UK) scientists studying Moon rock. That's not to mention the spaceplane, ice mission or camera to help save the rainforest.

As a result of your feedback, we've made quite a few changes to *space:uk* which I hope you like. We've not done anything too radical, as comments were overwhelmingly positive, but you'll see that we've now got an extra page of news and three features instead of two. All on the same amount of paper! We'll keep trying to improve the magazine as long as you keep sending us your comments and suggestions.

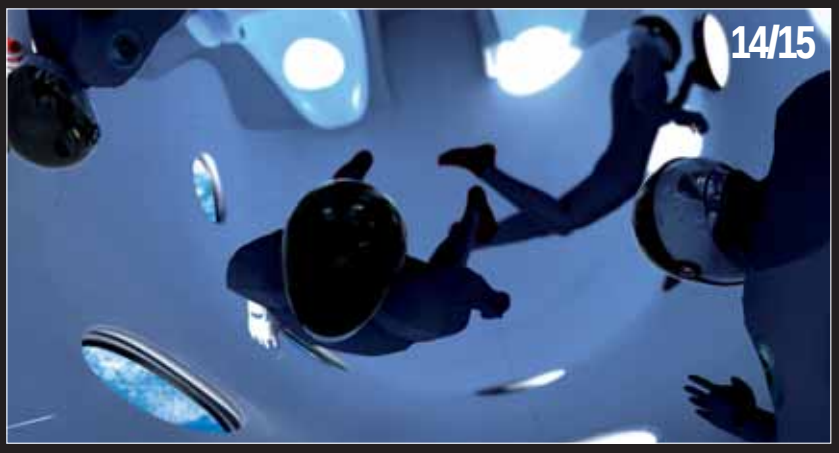
The readership survey also revealed how widely read *space:uk* is. It turns out people as far away as the Middle East and South East Asia enjoy the magazine. I'm glad so many of you share my fascination in space science, technology and exploration.

Richard Hollingham
Editor



Credit: Astrium UK

Credit: ESA



Credit: Virgin Galatic

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GOODBYE EARTH

A European spacecraft on a ten-year trek to rendezvous with a comet has made a final visit to Earth. Rosetta skimmed past our planet on 13 November at some 13 kilometres per second. It used the planet's gravity to boost it on the final stage of its epic 7100 million kilometre journey to comet 67P/Churyumov-Gerasimenko where it's due to arrive in 2014.

During the fly-by, Rosetta passed south of the Indonesian island of Java sending back spectacular images including close-ups of an anticyclone. "It was our final farewell to the spacecraft!" Rosetta project researcher Dan Andrews from the Open University told *space:uk.*

Rosetta is a European Space Agency (ESA) mission comprising an orbiter and a small lander, Philae. This lander will anchor itself onto the comet's icy, dusty surface. But, said Andrews, they're not taking any chances: "Philae will freefall from orbit to the surface under the influence of the comet's tiny gravity, then at the first touchdown signal we'll fire a harpoon with a cable attached, then a second harpoon, whilst also securing the lander's three feet with ice screws – it is more akin to a docking than a landing".

One of the key instruments on board – a mass spectrometer called Ptolemy – was built by a team from the Open University and the Rutherford Appleton Laboratory in the UK. This miniature laboratory will analyse the comet's chemical composition. Comets hold clues to the origins of life on Earth. It is likely that our planet's water and even the complex organic molecules that form the basis of life came from comets. "Among other things, Ptolemy will fingerprint the water on the comet and compare it to the Earth's water so maybe we can match the two," Andrews said.

Having left the Earth, Rosetta is now on its way to asteroid Lutetia which it is due to encounter in July this year. Then in 2011, the spacecraft will go into hibernation before it reaches its final destination three years later. Andrews admits the mission is incredibly ambitious: "It'll be the first spacecraft to orbit a comet nucleus followed by the first soft landing on a comet."

Credit: ESA

Rosetta captured this image of part of South America and Antarctica as it flew past the Earth

SPACE:UK NEWS

WELCOME

BNSC Director General David Williams looks back over the past 12 months and ahead to another exciting year in space…

It's been quite a year, with a lot to celebrate during 2009, and much to look forward to in 2010. I would just like to highlight a few events to give you a feel for the range of activities.

The successful launch of the Herschel and Planck space observatories was a major highlight. Herschel has already started sending back fantastic images of the birth of stars and of cold gas clouds near the plane of the Milky Way. And as a bit of trivia, Planck will be the coldest point in the Universe with a temperature close to absolute zero!

The selection of Major Tim Peake as the first Briton to join the European Space Agency (ESA) astronaut corps created quite a stir and the quote from the Science Minister Lord Drayson sums this success up very well, "I have always known Britain has the right stuff. This proves it." We'll be keeping you up to date with Tim's progress as he continues his training at the Astronaut Centre in Cologne, Germany.

A key Earth observation mission to measure soil moisture and ocean salinity (SMOS) was launched by ESA. Early results suggest the mission is working well.

In July, we opened the ESA facility at Harwell and welcomed Martin Ditter as its first head. Not only is this the first ESA facility in the UK, it is novel for ESA as a facility within an existing large science and technology environment.

The announcement on 10 December by Lord Drayson of the decision to create an executive space agency rounded the year off very nicely. This will create a lot of work in the next few months as the details are agreed.

So what's coming up in 2010? The Innovation and Growth Team on Space will publish a report setting out a strategy on the next 20 years for the British space industry, and how government and industry can work together to further strengthen UK capabilities and create new business. The CryoSat-2 ice mission is due to launch to monitor changes in sea ice thickness, as well as looking at variations of ice sheets on land. And might this be the year that we find there is life on Mars? What can I say other than keep reading and watch this space… Finally, I'd like to wish all our readers a happy and prosperous 2010.

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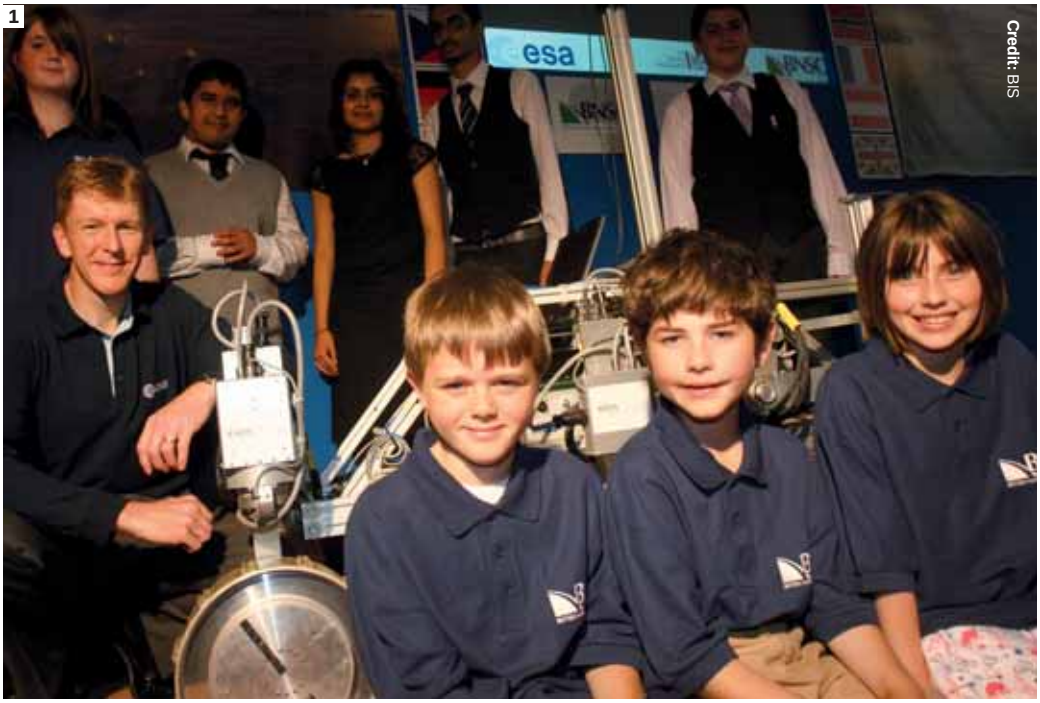


Credit: BIS

2

Credit: BNSC

1. UK astronaut Tim Peake with students and Britain's prototype Mars rover

2. BNSC Director General David Williams

SPACE AGENCY FOR UK

A new space agency is to be set up to strengthen the UK's growing space sector and help drive economic recovery.

Announcing the Government's plans, the Science and Innovation Minister Lord Drayson said: "The new space agency is about making sure that the UK fully exploits its competitive advantage in satellites, robotics and related technologies."

The new agency will replace BNSC and bring together the partners that currently oversee the organisation of space science, technology and policy in the UK. Speaking at the Appleton Space Conference, the Minister said that space has been one of the UK's unsung economic success stories, worth some £6.5 billion a year to the economy.

"Our space sector hasn't missed a beat during this recession. This is the classic story of outstanding UK science and entrepreneurship continuing to create jobs and achieve exceptional growth."

The announcement follows a public consultation into how to fund and organise the civil space sector to deliver the greatest benefits. "The creation of a UK space agency represents a significant step forward for both British industry and academia," said Colin Paynter, head of the UK's biggest space manufacturer, Astrium UK. "A UK space agency will bring greater coordination across government and, crucially, create a centre of expertise to help maximise the benefits of space for all UK citizens."

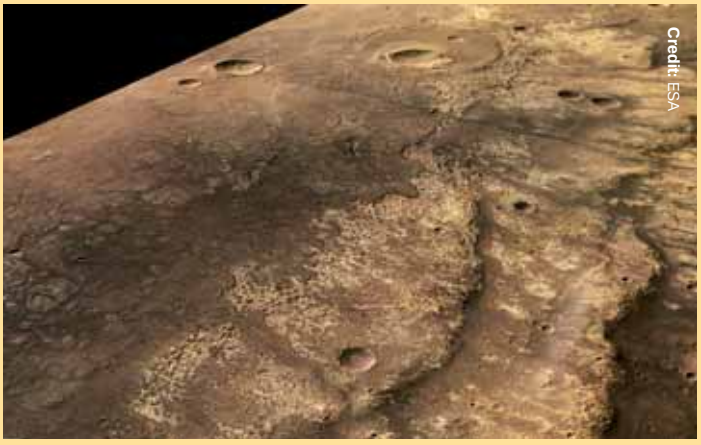
Bob Cockshott, an expert in satellite navigation at the National Physical Laboratory, described the news as "extremely exciting". He said: "Information from satellites touches nearly every aspect of our lives from weather forecasting, to maps, communication and satellite navigation."

Updates on how the agency is progressing will be published on the BNSC website and, of course, in *space:uk*.

Exploring space

A panel of leading space scientists has published a report into how the UK can best contribute to the exploration of the Solar System. BNSC's Space Exploration Review includes economic analysis from London Economics and outlines options for UK participation in international projects to explore the Moon and Mars.

The report identifies several areas where the UK can make significant contributions including in robotics and with advanced spacecraft such as Skylon (see page 7). The possible economic benefits to the UK economy are given in the report, which also examines the relative merits of funding UK astronauts. The review will be used to help decide future space policy.



Mars captured by ESA's Mars Express

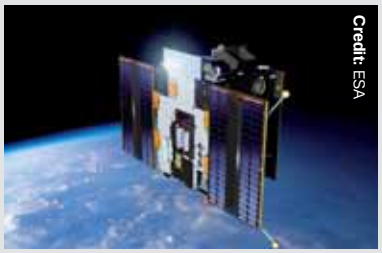
You can download a copy of the full report from the BNSC website.

SPACE:UK NEWS

NEWS IN BRIEF

Testing times

A European satellite launched on the same rocket as SMOS is performing well. Proba-2 was built to test out technologies for future missions and is packed with new systems and instruments. Equipment on board the satellite includes a new type of solar panel and instruments to investigate the Earth's magnetic environment.



Credit: ESA

Proba-2 is crammed with new technology

Mars mission

Later this year, at a previously top-secret Russian research centre, six people will be shut inside a space station for 520 days. The aim is to simulate a real mission to Mars, including a month on the Martian surface. In reality, the six will live and work inside a sealed isolation facility in Moscow so researchers can study the psychological, medical and physical challenges of a long-duration space mission. Mars500 is being conducted by ESA and Russia's Institute of Biomedical Problems in preparation for future human missions to the Moon and Mars.

Credit: ESA

The outside of the Mars500 space station

Space in Korea

More than 2000 scientists, engineers and government space experts from around the world gathered in Korea in October for the annual week-long International Astronautical Congress (IAC). The theme of this year's IAC was 'Space for Sustainable Peace and Progress'. For BNSC and the UK companies exhibiting, the IAC is an important business and networking opportunity. The event also provides an ideal backdrop to raise awareness of the vast capability and knowledge that exists within the UK space sector.

EARTH'S NEW STAR

After a successful launch, Europe's new climate satellite has unfurled its star-shaped antenna arms in preparation for its first observations. ESA's Soil Moisture and Ocean Salinity (SMOS) satellite will measure moisture levels in the soil and the saltiness, or salinity, of the oceans.

Global measurements of salinity and soil moisture will improve our understanding of how water is transported around the Earth and how it circulates through the oceans. They will also lead to more accurate weather forecasts and climate simulations.

BNSC Director General, David Williams, said: "Satellites such as SMOS are vital for predictions of how our climate is changing and British scientists and engineers are world leaders in using data from space to improve our understanding of the Earth."

Credit: ESA

The night launch of SMOS and Proba-2

SMOS was launched at night on a Rockot launch vehicle from the Plesetsk cosmodrome in northern Russia on 2 November. A day later, ground controllers deployed the satellite's three arms. These carry a total of 69 small antennae which will measure natural microwave emissions from the land and oceans. The satellite will obtain measurements covering the entire globe every three days.

SMOS will begin its first scientific observations in the spring. Meric Srokosz from the National Oceanography Centre in Southampton was involved in proposing the mission with colleagues in France and Spain eleven years ago. "I am absolutely delighted that the launch has gone to plan and am looking forward to using data from the satellite in my research," he said.

For more on all the missions featured in *space:uk* see the missions pages of the BNSC website.

HERSCHEL HIGHLIGHTS

Herschel witnesses star formation at the heart of the Eagle nebula

ESA's Herschel and Planck missions are well on their way to fulfilling their promise. Launched together in May, the satellites have already produced superb images and generated valuable scientific results.

Planck is measuring Cosmic Microwave Background radiation – ancient light left over from the Big Bang. It has now completed more than half its first survey. One of Planck's instruments has detectors operating at just 0.1 degrees above absolute zero, making it the coldest known object in space.

The first scientific results from Herschel were presented at a special conference in Madrid in December and the observatory's work has now started in earnest.

"It's clear that it will be even more successful than we hoped before launch," said Matt Griffin of Cardiff University, principal investigator for the UK-led SPIRE instrument. "Scientists working on the mission have been amazed at the high quality of the data at such an early stage."

For more on Herschel see the Mission File on page 20.

CRYOSAT COUNTDOWN

Artist image of CryoSat-2

"…we're again on the threshold of adventure."

Preparations are underway for the launch of Europe's ice mission, CryoSat-2. The satellite is due to be launched on a Dnepr rocket from Baikonur in Kazakhstan at the end of February.

CryoSat-2 will measure the thickness of ice at the Earth's poles to help scientists monitor the impact of climate change. The science team for the mission is being led from the UK.

The original CryoSat was lost in 2005 after a failure in the launch vehicle. "It's been a long wait since we lost the first CryoSat four years ago," said Project Manager, Richard Francis. "But now the tempo is stepping up and we're again on the threshold of adventure."

The Dnepr launcher is a converted SS-18 Intercontinental Ballistic Missile and is launched from an underground silo. Before its engines are ignited, the rocket is blasted from the silo on a jet of steam.

You can find more details about the mission – including links to podcasts – on the BNSC website.

SPACE:UK NEWS

NEWS IN BRIEF

GOCE going great

Europe's gravity mission, GOCE, has started its operational phase to map the Earth's gravitational field in unprecedented detail. The dart-shaped satellite, which employs an electric propulsion system built in the UK by QinetiQ, was launched in March 2009 but had to be tested and calibrated in orbit before it could begin its measurements. The data GOCE gathers will be used to improve our understanding of ocean circulation and climate.

Space worms

As well as a new British astronaut, the UK can also claim its first astroworms. Scientists from the University of Nottingham sent 4,000 tiny *C. elegans* worms in the Space Shuttle Atlantis to help investigate how the body builds and loses muscle. The worms, each measuring just a millimetre long, experienced the same weightless conditions that can cause dramatic muscle loss in astronauts. The worms have much the same genetic material as we do. So by studying muscle in worms, the researchers can learn more about humans.

space:uk was disappointed to learn that the worms were not issued with individual spacesuits

Broadband from space

A new satellite designed to bring high-speed broadband services to rural areas is being prepared for launch. Hylas has been partly funded by BNSC and is designed and built for Avanti Communications by Astrium UK. The satellite is due to be launched later this year and will serve hundreds of thousands of Internet users.

Award for space pioneer

The founder of Surrey Satellite Technology Limited, Sir Martin Sweeting, has been awarded the Faraday Medal – the Institution of Engineering and Technology's most prestigious award. He received the accolade for his outstanding contribution to the advancement of satellite technology.

EYE ON THE JUNGLE

A UK-built camera will be used to help detect the illegal destruction of the world's largest rainforest. The instrument, which will fly on Brazil's Amazonia-1 satellite, is being developed at the Rutherford Appleton Laboratory (RAL) in Oxfordshire after the intervention of Prince Andrew, the Duke of York.

"Deforestation is one of the major causes of the increase in greenhouse gases and therefore human-induced global warming," said the Director of Space Science and Technology at RAL, Richard Holdaway. "With Amazonia being by far the largest rainforest in the world, any deforestation there has a significant impact on our climate."

The Amazonia-1 satellite will be operated by the Brazilian government and will be able to spot illegal logging, before it's too late. "Near real-time satellite imagery can quickly detect these activities and alert local troops who are then more readily able to go into the reported area and stop or significantly reduce the problem." Holdaway explained.

The UK's involvement came about as a result of a visit Prince Andrew made to the Brazilian Space Agency, where it turned out they were looking for a camera for the satellite. When the Prince learned that RAL could provide the necessary technology, he was able to successfully lobby the UK Government to support the project with extra funding.

"The UK is world-leader in small satellites," said Holdaway. "That is why we were chosen by Brazil to build the camera for Amazonia-1." Construction work on the instrument is about to start with the launch of the satellite due in 2012.

Amazonia-1 will help combat illegal logging

STUDENTS REACH FOR THE MOON


Credit: SSTL

SSTL is the world's leading manufacturer of small satellites

Students from across Europe are to help design and build a mission to the Moon. The European Student Moon Orbiter programme is being managed by UK company Surrey Satellite Technology Limited (SSTL) and will place a spacecraft into lunar orbit to map the Moon's surface.

Designed for launch as soon as 2013, the orbiter will involve students working with SSTL engineers on the systems for the spacecraft. The company will oversee the project while training and supervising the students. "This is an extremely exciting 'hands on' opportunity for European students to learn about space," said SSTL's lunar expert, Andy Phipps.

SSTL Executive Chairman, Sir Martin Sweeting, said: "SSTL has had its sights on the Moon for nearly a decade. We have shown many times that success in space can be achieved at a fraction of the cost normally considered."


Credit: NASA

Students are being encouraged to aim for the Moon

NEW SPACEPLANE FACTORY


Credit: Reaction Engines

Looks cool doesn't it?

A new facility for the development of a UK spaceplane has been officially opened at the Culham Science Centre in Oxfordshire. The site will be used to construct components for the SABRE engine being built for Skylon.

The unpiloted Skylon spaceplane is designed to take off and land using a traditional airport runway with the ability to carry over 12 tonnes into orbit. With its sleek design and air-breathing rocket engines, Skylon would provide inexpensive access to space compared with today's costly launches.

With the backing of BNSC, the company behind the project – Reaction Engines – was recently awarded €1 million by ESA to develop new engine technologies for the spaceplane.

"The new production facility is a major step forward in proving that the manufacture of the SABRE engine is a practical proposition," Future Programmes Director, Mark Hempsell, told *space:uk*. "Everyone here is very excited by this development."

"Everyone here is very excited by this development."

Mark Hempsell,
Future Programmes Director

The clock is ticking...

Main image: A Galileo satellite being tested in Astrium's anechoic chamber
Credit: Astrium UK

1. Artist image of the Galileo constellation of satellites
Credit: ESA

2. The first Galileo satellite, GIOVE-A, ready for launch on a Soyuz rocket
Credit: ESA

The first two spacecraft for the world's most accurate satellite navigation system, Galileo, are due for launch later this year. Sue Nelson visited a factory in Portsmouth to see how they were coming along.

There's a part of Portsmouth that wouldn't look out of place in a James Bond film. It's inside one of Astrium's seven, air controlled payload bays where engineers in protective overalls, headgear and rubber shoes are building two Galileo satellites.

To keep the clean room clean, I am similarly dressed, grounded by overshoes so that any static electricity goes into the floor. "It's to protect the equipment from you," says Astrium's lead mechanical engineer Keith Vacher, "not the other way around."

On the ceiling overhead, several storeys high, is a crane to lift the larger, heavier pieces of equipment on and off the satellite (or payload). But up close the spacecraft reveals its impressive technology.

Our timing couldn't be better. By the time *space:uk* is published, the two Galileo IOVs – in-orbit validation satellites – will have been shipped to the Thales Alenia Space facility in Rome for testing and further preparations. Both satellites are due for launch at the end of this year with more following in 2011.

But right now the two outer walls of the payload – the electronic brains of the satellite – have not yet been mated together and you can glimpse the wires, black boxes and silver-wrapped cables inside the central structure.

"That's very sophisticated plumbing," admits Mike Healy, Astrium's head of navigation. "It's the black boxes that contain printed circuit boards, electronics and integrated circuits," he says. "All the things you'd find in a television set, except they are highly reliable because they have to last 10-12 years in orbit."

Galileo's technology is far more state-of-the-art than even the best TV, of course, as Healy points out the atomic clocks that will make Europe's first global satellite navigation system even more accurate than the two existing systems: the American GPS and the Russian GLONASS.

When fully operational Galileo, a joint initiative between the European Commission and ESA, will consist of 30 orbiting spacecraft including three spares.

Each satellite will contain two hydrogen masers and two rubidium atomic clocks. The maser clocks are so precise they lose just one second in 300,000 years. Perhaps not surprisingly the clocks were developed by a Swiss astronomical observatory, the Observatoire de Neuchatel.

continues >

1

“It’s a centre of excellence”

Mike Healy, Astrium’s head of navigation

Galileo
continued

The UK has also shown its strength within the space science industry. “The electronic brain – the payload – is roughly half the value of the satellite and that is being done here at Portsmouth,” says Healy proudly, “so it’s a centre of excellence.”

This explains a poster on the wall showing several arrows missing a bullseye. “Near enough is not good enough,” it says. “Think quality!”

2

Astrium also built one of Galileo’s two test satellites, GIOVE-B. Launched in 2008, it was the first time the maser clocks were used. Surrey Satellite Technology Limited built the first test satellite GIOVE-A, which launched in 2005. “We flew the atomic clocks on GIOVE-A and B and were very satisfied,” an ESA official tells *space:uk*. “Before, Europe had no experience of flying atomic clocks in space and it gives us confidence with the final satellites.”

GIOVE-A and B also secured the necessary frequency for transmission from the International Telecommunication Union. As all the satellites will fly in a high orbit, GIOVE-A and B will continue to perform useful services for Galileo by monitoring the harsh radiation environment at this height.

Galileo will work in conjunction with GPS and GLONASS but because these systems are both over 30 years old, it will also be able to offer a number of new facilities, as well as a better signal and more frequencies.

“This is a search and rescue antenna,” Healy points out. “If you were in trouble out at sea you can hit an alarm button and within a few seconds a Galileo satellite will pick up that alarm and be able to pinpoint exactly where the alarm was raised to within a few metres.”

“It even has a system where it can respond back – so you know if your signal has been picked up. At the moment you don’t know if anyone has heard you,” he says, “which must be discomforting if you’re in the middle of the Atlantic.”

My Bond-style tour concludes with a glimpse of Astrium’s weird and wonderful anechoic chamber. This huge room resembles an enormous torture chamber with giant blue spikes protruding from the walls, floor and ceiling. Fortunately these spikes are made from foamy, radar-absorbent material.

“It masks any exterior radar frequencies in the atmosphere and absorbs any transmissions,” says engineer Keith Vacher.

“This is the nearest thing we’ve got to a space environment from an electromagnetic point of view,” adds Healy. “It allows us to see how the antenna will work in space.”

The Galileo system has had more than its fair share of delays but when all 30 satellites are in orbit, everyone working on the project is convinced the wait will be worth it. And when you use a sat-nav in a few years time – there’s a good chance the signal will come from a British-built satellite.

1. One of the clean rooms at Astrium in Portsmouth
Credit: Astrium UK

2. Galileo will provide accurate satellite navigation services to the whole planet
Credit: ESA

Moon **Rocks!**

A grand total of 382 kg of Moon rock was brought back to Earth by the Apollo astronauts at an estimated cost (at 1960s prices) of some $20 billion. But these rocks have proved invaluable to science and, forty years on, still have many more secrets to reveal. Richard Hollingham has been talking to the UK scientists who have got their hands on a piece of the Moon.

continues >

John Young with the Apollo 16 lunar rover
Credit: NASA

Credit: NASA

Moon Rocks!
continued

"When we opened the first bag it was exactly forty years to the day after Apollo 12 splashed down"
Ian Crawford

November 1969…

"That may have been a small leap for Neil… but that's a long leap for me!"

Apollo 12 astronaut Pete Conrad's words as he stepped down from the lunar module in 1969 may not have been as memorable as Neil Armstrong's but they summed up the spirit of the mission. The tapes from this second lunar landing are full of lively banter between Conrad and his colleague, Alan Bean, as they bounced across the Moon's surface.

After the political fanfare of Apollo 11, the successful landing of Apollo 12 was seen as the first chance to get stuck into the science. The capsule touched down on a flat plain of lava near the Copernicus crater, only metres away from where a robotic mission, Surveyor 3, had landed two years earlier – proving the Apollo pilots' abilities to land with pinpoint accuracy. Thanks to Surveyor 3, the astronauts already knew what to expect and, during two spacewalks, deployed a series of experiments – eventually loading up with around 32 kg of rock samples. A couple of days later, Conrad and Bean were on their way back to Earth.

1

November 2009…

In a laboratory in central London Ian Crawford, Katherine Joy and Joshua Snape have gathered to open a package from NASA: "When we opened the first bag it was exactly forty years to the day after Apollo 12 splashed down," says Crawford. "It was fantastic!"

The Birkbeck College scientists were looking at samples of rock that had been collected by Conrad and Bean. NASA doesn't just hand out Moon rocks like candy. Preserved by NASA's Lunar Science Institute in a special vault, they are only made available to researchers with a good scientific case. "To be there forty years later, working on these samples is tremendously exciting," Crawford says.

So what makes rocks collected during a space mission forty years ago, still worth looking at?

"The scientific value of Apollo has been greatly under-rated. It was a political project to beat the Soviets to the Moon but the scientific legacy has been enormous," Crawford explains. And at the core of that science is the collection of samples. "Over the years, analytical techniques have got so much more precise – there was real wisdom in keeping these samples in pristine condition." In other words, scientists can learn things from these rocks today that were all but impossible when they were collected.

The Birkbeck team (together with colleagues from University College London and the University of Manchester) will be working on fragments of just a few milligrams. Even so, that's enough to investigate some fundamental questions about the nature of the Moon.

"We need rocks to understand the chemistry and age of the Moon and how similar, or

different, it is to Earth," says Joy. She's hoping the samples will reveal fragments of some of the youngest lava flows on the Moon, offering the research team a geochemical 'window' into the lunar interior. "Understanding the age and chemistry of these rocks allows us to work out how other rocky planets might form and evolve, helping us to learn about the Earth's own early geological history," she says.

Meanwhile, in Milton Keynes…

Mahesh Anand at the Open University has also received a package from NASA. He wasn't even born when men walked on the Moon but is every bit as excited as the team in London. "As soon as you get it and open the box, you have the hairs rising on the back of your neck," he tells *space:uk*. "When you think about how these samples were collected and where they were from, you realise how important they are."

Anand is examining samples of solidified lava – or basalt – from the Moon. "These help reveal what is going on inside the Moon and the processes responsible for their formation." He'll be studying these samples using the latest analytical techniques.

One of the biggest questions about the Moon is still unresolved: how did it get there in the first place? The most widely accepted theory is that a Mars-sized body hit the Earth and the impact knocked out a mass of material, which clumped together to form the Moon. But, even though it's based on strong evidence, it's only a theory.

"When you look in detail at that theory, you realise that there are a few things that are not consistent," says Anand. "And once you start looking at those aspects then you have to come up with an alternative hypothesis."

2

The future…

2020 is the year when NASA hopes to return humans to the Moon, just over fifty years after Apollo 12. The date still has a big question mark hanging over it but what is clear is the renewed interest in going back to the Moon. Last year saw the successful completion of the LCROSS mission – slamming an object into the lunar surface to study the resulting plume of debris. Other recent missions include Europe's SMART-1 and India's Chandrayaan-1, both with key UK involvement. 2009 also saw the UK become an international partner (affiliate member) of the NASA Lunar Science Institute.

The Moon is the new destination of choice for space agencies around the world. But for Anand, it never went away. "There are so many legacies of the Apollo programme," he said. "Human beings went out more than 400,000 kilometres just to get these samples and they're constantly providing us with new information."

Visit the BNSC website for links and resources.

3

1. How NASA imagines a future lunar mission might look (and don't the spacesuits look good)
Credit: NASA

2. Apollo 12 samples under the microscope
Credit: UCL

3. Pete Conrad is seen reflected in Alan Bean's helmet as Bean collects lunar soil samples
Credit: NASA

The ultimate holiday

Imagine a holiday that is literally out of this world. All you need is a head for heights, a healthy bank balance and a stomach that can withstand several minutes of weightlessness – astronaut style – in a plane commonly known as a 'vomit comet'.


1

The best, however, is kept until last: a flight into space more than 100 km above the Earth, bringing a whole new meaning to the phrase panoramic view. Congratulations. You are now a fully-fledged space tourist.

Sadly, for those of us who also want to join the high altitude-flyers, space tourism is an elite market. So far, only seven individuals have travelled into space as paying passengers. All of them bought tickets from the Russian Federal Space Agency through the marketing company Space Adventures.

The most recent space tourist, Guy Laliberte, founded the theatre company Cirque du Soleil. His trip, in September last year, included a short stay on board the International Space Station where the circus entrepreneur promptly donned a red nose. The cost, however, is no laughing matter: the Canadian entrepreneur is believed to have paid $35 million for his trip.

At this price, space tourism remains the preserve of millionaires but several companies around the world are vying to offer this experience to a wider market and at a greatly reduced cost. One of them, Virgin Galactic, is planning flights in its spacecraft VSS Enterprise at a relatively cheap £120,000 starting from New Mexico in the USA.

Vomit comet

The experience will involve flight preparations, briefings and that infamous vomit comet – an aircraft that swoops in nausea-inducing parabolic curves to produce up to five minutes of free-floating weightlessness. Day three is the actual spaceflight.

"You will ride up in Enterprise on board a carrier vehicle, White Knight 2," explains Virgin Galactic's Dr Adam Baker. "The drop-off point for the spaceship is 40,000 feet and then Enterprise will accelerate very rapidly at more than three times the speed of sound to 300,000 feet. There you will see the curvature of the Earth – the thin blue line."

Formerly at UK company Surrey Satellite Technology Limited, Baker is one of the many scientists and engineers across the globe helping to realise the dream of space tourism. It is a tantalising prospect and 300 people have already reserved tickets to be the first passengers of the VSS Enterprise.

Unveiled at the end of 2009, Enterprise is the size of a light aircraft. It was designed with technology developed by the innovative aerospace engineer Burt Rutan and built by Scaled Composites in Mojave, California.

Rutan won the coveted US $10 million X-Prize for SpaceShipOne in 2004, after it became the first privately funded spacecraft to enter space twice in a two-week period. Test flights of Enterprise are about to begin but even ticket holders will have to wait until 2012 for their journey between the Earth's atmosphere and the vast expanse of space.

Wider benefits

BNSC recently commissioned a report, written by Richard Crowther, from the Science and Technology Facilities Council, to consider the regulations needed if a company wanted to operate space tourism flights from the UK. He says that while space tourism is always likely to remain the preserve of the few, there will probably be wider benefits.

"Most people won't directly experience the flights," Crowther admits, "but they will probably see the benefits of this potentially mass market. Point-to-point flights are the holy grail of many of these systems. It's not just about going into space, it's about going from one place to another via space."

In the future a flight via space from London to Sydney, for instance, would no longer be termed 'long-haul'.

For Adam Baker, who was turned down by ESA's astronaut programme, it's a second chance to be part of this exciting new challenge. "I'm a rocket scientist at heart and I would certainly jump at the chance of a flight although," he adds, "I would have to get my wife's permission."

"Point-to-point flights are the holy grail of many of these systems"
Richard Crowther

Main image: Want to do this? That'll be £120,000 please!
Credit: Virgin Galatic

1. Space tourist Guy Laliberte
Credit: AFP

2. Artist image of Virgin Galactic's VSS Enterprise
Credit: Virgin Galatic

3. How a future spaceport might look
Credit: Virgin Galatic

Down to Earth

It's hard to imagine living without space technology. It's around us all the time – whether we're watching satellite TV, checking the weather forecast or using sat-nav to find our way around. But there are also a whole load of things with no obvious connection to space, that just wouldn't exist without the space programme. *space:uk* has uncovered a hidden collection of spin-offs that work better thanks to technology that's out of this world.

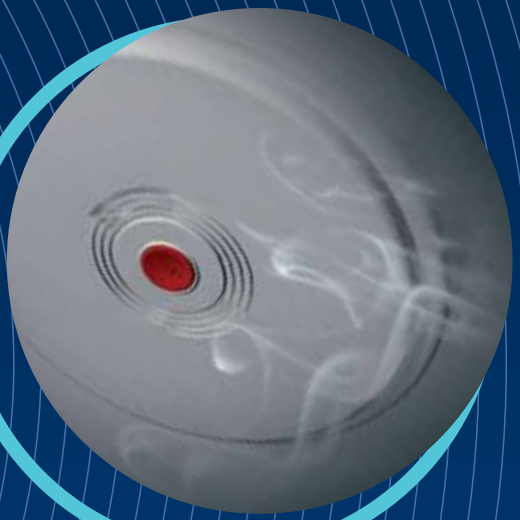
Let's start close to home. You can find smoke detectors in most buildings but the first ones were actually used in the US Skylab space station over 30 years ago. Back then the sensors detected toxic gases. Now, using the same technology, smoke detectors can spot a fire early-on giving people time to get to safety.

Clothes next. It might be hard to believe that anything in your wardrobe is influenced by space technology, but it's true. Just take your trainers. The reason they're so comfy is down to the way they're designed – especially the shock absorbers in the mid-sole. Those little beauties were originally used in moon boots.

A bit further away from home? It stands to reason that technology developed for space travel could work just as well on Earth. Formula 1 racing is a perfect example of this. Most F1 cars can reach speeds of over 300km an hour and competition is fierce. Racing teams are always striving to make their cars go faster.

Weight slows down any car and the Pescarolo Sport Team has shaved off crucial pounds by adopting the same lightweight carbon material that's used to build satellites. Thermal insulation designed for launcher engines protects the car's petrol tank from the heat of the engines and exhausts, and insulates the driver's cockpit. Space technology also helps reduce friction and the weight of the wheels.

It's not just cars getting the space treatment. High-speed trains, for example, can adapt equipment originally used to cut vibrations in the International Space Station – meaning the trains can go even faster and still keep the passengers comfortable. Some life rafts also use the same self-righting technology



developed for spacecraft making splashdown landings. So they're much less likely to tip over in rough seas.

Space technology is also being used in medicine. Take the catchily-titled gas chromatograph mass spectrometer. Originally intended to search for life on Mars as part of the UK's Beagle 2 mission, the kit is being adapted to diagnose tuberculosis in the poorest parts of the world. The disease is deadly and can be hard to detect. This new technology means cases can be spotted much more easily and cheaply.

Space kit is also being employed on a much larger scale to prevent disasters across the globe. A new scanner to spot weaknesses in dams and dykes is being used on the Danube and in the Netherlands. The instrument scans the ground and measures the amount of water in the soil. Very wet areas can be a sign of structural weakness. This technology was designed for ESA's Soil Moisture and Ocean Salinity mission launched in November (see page 4). Another type of scanner developed with ESA technology claims to be able to spot plastic landmines which conventional detectors can't see.

This list doesn't even scratch the surface. Space agencies have dedicated teams looking at how their technology can be used on Earth. BNSC and its partners (including the Technology Strategy Board) are always looking out for new spin-offs from the space industry. Future European projects include pyjamas that could help prevent cot deaths in small babies and intelligent clothes that communicate via satellite.

What will they think of next?

Stick to the facts

But what about Teflon and Velcro? It's a complete myth that non-stick frying pans and shoe fastenings come from space technology – although many people think they do!

Ask the experts

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

All the questions in this issue come from students visiting the National Space Centre in Leicester.

Sue Nelson

Science writer and broadcaster

Jamie Sloan

National Space Centre Education Team

Chris Welch

Principal Lecturer in Astronautics, Kingston University

How does a rocket get things into space?

Space starts 100km above the Earth's surface. To get things into space we use rockets to provide a force, or thrust, to counteract the force of gravity. In most rockets, this thrust is generated by using the energy from a chemical reaction. The gases produced are then accelerated to high velocity by passing them through a nozzle. As long as the rocket produces more thrust than its weight, it will move upwards.

The rocket has to carry with it all the chemicals it will need to burn on the trip. So the faster it is, the shorter the trip time and less propellant is needed. But if the rocket only goes straight up, when it runs out of propellant and the thrust comes to an end, it will eventually fall back to Earth.

If we want our payload (such as a satellite or space capsule) to stay in space, then we must ensure it doesn't fall down but falls around the Earth, without ever hitting the ground. In other words: so it ends up in orbit. To do this the rocket has to gradually start travelling horizontally as it ascends, so that when the propellant runs out it is at the right altitude, pointing in the right direction and travelling at the right speed to enter the orbit required.

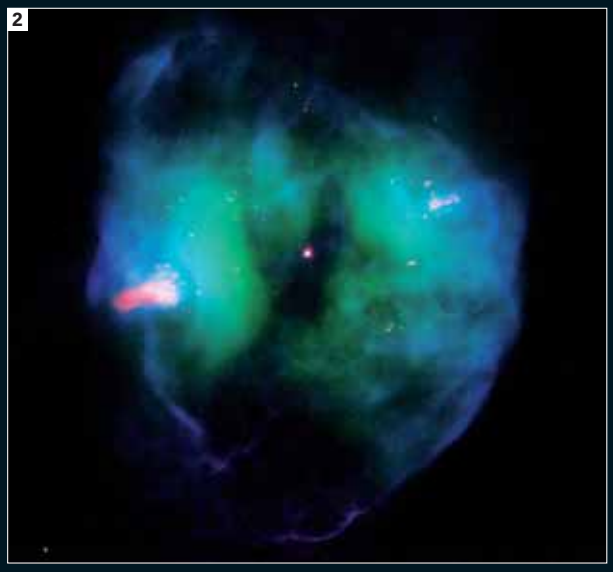
Chris Welch

1. Europe's Ariane 5 blasts into space
Credit: Arianespace

2. Hubble image of a bubble of gas and dust encircling a dying star
Credit: NASA/ESA

3. Astronaut Michael Fincke (left) and space tourist Richard Garriott (right) in the International Space Station
Credit: NASA

2



When stars die do they form a black hole?

Some do, but luckily, most don't. Stars shine because of a process called nuclear fusion in their cores. Hydrogen is changed into helium and this releases energy. This energy produces a force pushing outwards to hold stars together.

When stars run out of fuel and begin to die, different things happen depending on how big they are. When medium sized stars – like our own Sun – reach this stage they swell up and turn into red giant stars. Eventually they throw off most of their material into space, leaving behind only the core. But don't worry, we've got about 5 billion years until this happens to the Sun!

Stars with a much bigger mass than the Sun can have a much more dramatic end. Without nuclear fusion holding them up, gravity takes over and the stars collapse in on themselves. Material falls into the core, which gets denser. Eventually it all becomes too much and the stars explode in a supernova. The core is often left behind. This time it is a tiny neutron star only ten kilometres across but containing more mass than the Sun!

When extremely large stars collapse, these neutron stars can get squashed even further to become black holes. These are objects so dense and with such an intense gravitational field that even light itself can't escape.

Jamie Sloan

For more on black holes, see the back page

Do astronauts have to wear spacesuits all the time?

In space, without a spacesuit, you would black out in 15 seconds. This is probably just as well, because no one wants to be conscious when the absence of atmospheric pressure causes the fluids in your body to heat up and boil.

Even without this problem you might freeze or fry anyway – as temperatures in space have a range of some 500 degrees. Then, there's that other important issue to consider: the lack of air.

Not surprisingly, a spacesuit offers far more than a supply of oxygen. It maintains pressure against the body and protects the astronaut from extreme temperatures and the harsh environment of space. Out on a spacewalk, or when leaving the Earth in a rocket or shuttle, spacesuits are essential for protection, safety and life-support.

Fortunately, spacesuits have evolved since the uncomfortable, hot silver outfits worn by the first astronauts. Today's suits are more flexible for the wearer, multi-layered and made from materials specially selected to prevent the growth of fungus or bacteria. The outer layer of a spacesuit contains woven Kevlar (used for bullet proof vests) and visors protect against micrometeoroids and solar radiation. There are even controllable fingertip heaters inside the gloves.

But if you are inside a pressurised spacecraft with a supply of air and constant temperatures, like inside the International Space Station, then you don't need a spacesuit. Astronauts tend to put on comfortable casual wear and – unless there's a leak – leave the spacesuits on standby.

Sue Nelson

3

learning :zone

Mission File… Mission File… Mission File…

Herschel Space Observatory

Main image: Herschel reveals star birth thousands of light years from Earth
Credit: ESA

1. Artist impression of Herschel
Credit: ESA

Mission…
Launched in 2009, Herschel is the largest-ever infrared space observatory. This European Space Agency mission is looking at some of the coldest and most distant objects in the Universe.

Operations…
Herschel is examining the birth of stars and galaxies. Stars form inside big clouds of gas and dust. By detecting infrared radiation (otherwise known as heat), Herschel can peer through these clouds to witness what is going on inside.

Objectives…
Herschel's major objectives are to discover how the first galaxies formed and evolved. It is also investigating star formation in our galaxy today. Herschel is observing clouds of gas and dust where new stars are being born, disks out of which planets may form and the atmospheres of comets.

Technology…
With a diameter of 3.5 m, Herschel has the largest mirror ever flown in space. It carries three scientific instruments. To make measurements at infrared wavelengths, parts of the instruments have to be cooled to as near absolute zero (-273.15 °C) as possible.

UK involvement…
One of the three instruments on board, SPIRE (Spectral and Photometric Imaging Receiver), was designed in the UK and is led by a scientist at Cardiff University.

Success so far…
The first scientific images from Herschel are stunning. They include the first ever pictures of stardust – the stuff that galaxies, stars, planets and even people are made of.

CAREER FILE

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

Debbie Clifford is a scientist at the National Centre for Earth Observation

What does your job involve?

I work at a computer using data gathered from all over the world. I study ways of combining the observations we make – including measurements from space – with computer simulations. The aim is to understand the world better and improve forecasts of what's going to happen in the future. It's a real challenge to work out how best to use all the information. I'm sure there is so much more to discover!

What got you interested in space?

A school project aged about 7! I knew from about 14 that I wanted to study engineering but didn't really think about being able to work in the space industry until I graduated from University.

What sort of information can satellites give us?

My PhD was about measuring snow from space. To see where snow is, you can use satellites that take pictures in visible frequencies – seeing just like your eyes do. But just as you can't tell how deep a snowpack is only with your eyes, you need to look at the snow with different frequencies – using microwaves for instance. Unfortunately, we haven't yet got a reliable way of doing this across the whole globe.

Another way of getting information from space is to use radar. A pulse is sent down to the surface from space, and by examining how that pulse looks when it gets back to the satellite you have information on what the surface is made of. CryoSat-2, due for launch in the next few months, will use the same technique for measuring sea ice.

Why is it important?

Changes to the cryosphere – the frozen parts of the globe including snow, sea ice, glaciers, permafrost and so on – are showing some of the earliest signs from climate change and need to be monitored thoroughly. Many people around the world depend on snowmelt for drinking water so forecasting when it will melt next spring, or how much there will be in a decade's time, is directly relevant to people's lives.

What are the highlights of your work?

I have so much freedom to think about interesting problems and come up with my own solutions. I'm part of something that will have a long legacy; individuals make small contributions but our combined effort leads humanity to new and exciting discoveries – ones that can make a real practical difference to people.

What advice would you give someone considering a career in space?

Give maths a chance! It can come across as dry, which is a shame, because really it's the language the world is written in. Being able to speak that language unlocks many fascinating secrets about how the world is put together.

1. Envisat image of summer ice in the Arctic
Credit: ESA

2. NASA image showing the Earth's snow and ice
Credit: NASA

3. Artist image of CryoSat-2
Credit: ESA

guide

SPACE TRAVELLER'S GUIDE

BLACK HOLES

Imagine something with a gravitational force so strong that nothing – not even light itself – can escape. More than 200 years ago, John Michell in England and Pierre Simon de Laplace in France, did exactly that. They called this imaginary object an invisible star.

Centuries later Einstein's General Theory of Relativity also predicted a small, dense object with an extremely strong gravitational field. Einstein thought such a thing impossible – as for anything to escape it would have go faster than the speed of light.

This fired the imagination of German astronomer Karl Schwarzschild and so, while a soldier during the First World War, he solved Einstein's equations.

Schwarzschild's solution was a spherical object that didn't rotate, had a central point and an invisible boundary. It wasn't until the late 1950s that John Wheeler gave this "invisible star" another, more familiar name: a black hole.

The mathematician Roy Kerr produced another solution in 1963 – a rotating black hole with a central spinning ring – and it is this form that is most likely.

Black holes are created when stars run out of fuel, collapse and die. But not all dead stars become black holes. Some form white dwarfs while larger stars may explode as a supernova or become neutron stars.

Stellar black holes occur when stars 3-15 times the mass of our Sun explode and collapse. They create a 'singularity' at the centre of zero volume and infinite density.

A black hole has a gravitational boundary called the event horizon. Its radius at this point is called the Schwarzschild radius. Outside this radius you are relatively safe. Inside, you would be pulled into the black hole and ripped apart.

Although black holes can't be seen directly, astronomers know they are there. As dust and gas spirals into the black hole it forms an accretion disc and emits X-rays. Cygnus X-1 is one of the brightest sources of X-rays in the sky. Discovered in the 1960s, it was one of the first suggested stellar black holes.

Since then the Hubble Space Telescope has detected much larger, supermassive black holes at the centre of galaxies. These have a mass millions to billions of times larger than our Sun. There is evidence for a supermassive black hole at the centre of our galaxy, the Milky Way.

1

Background image: Artist's impression of the Milky Way based on astronomical information about our galaxy
Credit: NASA/JPL-CALTECH

1. The crowded heart of the Milky Way seen by the Chandra Space Observatory
Credit: NASA

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UK SPACE HISTORY

From the earliest days of astronomy to the latest advances in space technology, the UK has been at the forefront of space exploration.

1668 Sir Isaac Newton builds the first reflecting telescope – technology that will transform astronomy and eventually be used in the Hubble Space Telescope.

1668

1675 The Royal Observatory at Greenwich appoints its first Astronomer Royal, John Flamsteed.

1675

1705 Edmund Halley predicts that a comet seen in 1682 will reappear 76 years later. Halley's Comet is visible from Earth every 75-76 years and turns out to be the same comet featured in the Bayeux Tapestry. It will next be seen from Earth in 2061.

1705

1857 Scottish Physicist James Clerk Maxwell proves that Saturn's rings are made up of many different particles.

1857

1919 Astrophysicist Arthur Eddington proves Einstein's prediction that gravity bends light.

1957 Launch of the UK's first Skylark sounding rocket. Equipped with scientific experiments designed to investigate the atmosphere, Skylark is capable of ballistic (but not orbital) flight.

1957

1957 The Jodrell Bank MK1 radio telescope in Cheshire becomes operational. It is the only scientific instrument in the world capable of tracking the progress of the first satellite, Sputnik 1.

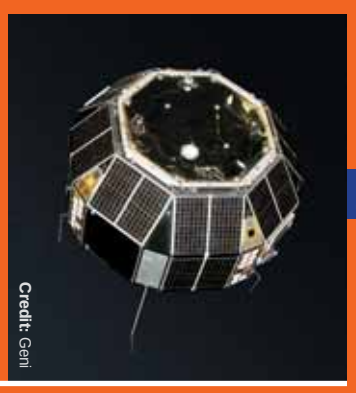
1962 The first international satellite, Ariel 1, is launched. Built by NASA, it contains six instruments developed by British scientists.

1967

1967 The first all-British satellite, Ariel 3, is launched. Manufactured by the British Aircraft Corporation (now part of UK satellite company Astrium), it lays the foundations for the present-day UK satellite industry.

1969 Launch of Skynet 1A – the first in an ongoing series of British secure military communications satellites. Unfortunately, the satellite fails within a few months of deployment.

1971 Launch of Prospero – the first (and, so far, only) British satellite to be launched on a British rocket. The Government cancels the Black Arrow launch vehicle project in the same year.

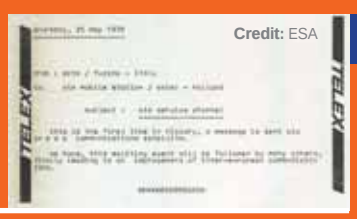


1971

1975 The European Space Agency is established with the UK as one of the founder members.

1975

1978 Successful launch of the OTS-2 communications satellite after OTS-1 was lost during launch. Led by a team in Stevenage, OTS formed the basis of modern European communications satellites.



1978

1981 Tiny University of Surrey spin-off, Surrey Satellite Technology Limited (SSTL), launches its first satellite, UoSAT-1. Today, the company is a world-leader in small satellites.

1986 The UK-built Giotto spacecraft passes close to the nucleus of Halley's comet to send back unprecedented images and data.

1986

1990 Launch of the international Hubble Space Telescope. UK space scientists worked on the development of one of Hubble's four cameras.

1991 Britain's first astronaut, 27-year old Helen Sharman from Sheffield, is blasted into orbit.

1991

1997 The Cassini-Huygens spacecraft is launched to Saturn. Many of the key components on board are built in the UK and backed by UK science teams.

1997

2002 The first satellite in the Disaster Monitoring Constellation (DMC) is launched. Built by SSTL, the DMC is designed to provide satellite images in times of crisis.

2002 The largest Earth Observation spacecraft ever built, Envisat, starts its mission to monitor the Earth's environment. UK engineering teams built the main platform and radar for the satellite.

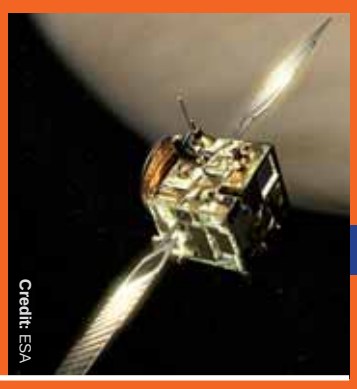
2002

2005 The Huygens probe begins its descent through the atmosphere of Saturn's moon Titan. The first component to touch the moon's surface is made in the UK.

2005

2005 Launch of GIOVE-A, the first satellite in Europe's Galileo satellite navigation system. GIOVE-A and much of GIOVE-B (launched in 2008) are built in the UK.

2006 ESA's Venus Express arrives at its destination. The mission is conceived by UK scientists and developed with UK participation.



2006

2009 Launch of the European Herschel Space Observatory and the Planck Surveyor – designed to answer some fundamental questions about the birth and evolution of the Universe and its galaxies. UK scientists and industry make major contributions to these two outstanding space telescopes.

2009 Test pilot, climber and caver, Major Tim Peake becomes the first Briton to be selected into the European Astronaut Corps.

2009

The UK in space

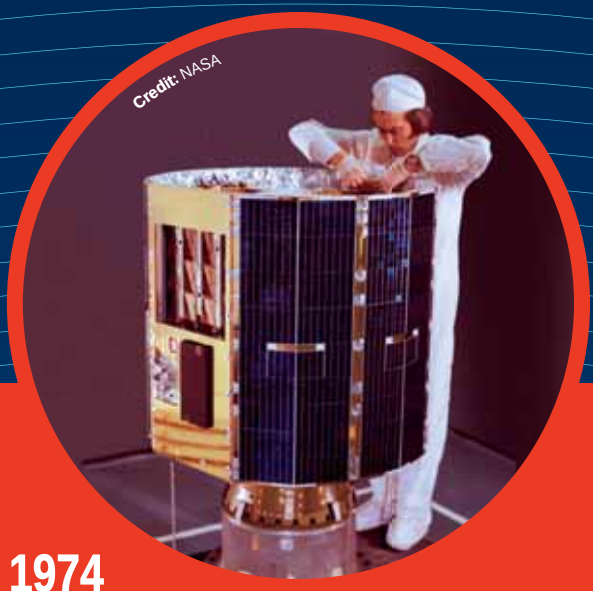
From the invention of the first reflecting telescope by Sir Isaac Newton to the advanced instruments being built in the UK for the next generation of space observatories, Britain has been at the forefront of space exploration since the earliest days of astronomy.

Today, British science teams are involved in missions to understand the Universe, explore the Solar System and monitor the Earth. UK built-satellites provide advanced global communications and the UK space industry contributes some £6.5 billion to the economy.

BNSC
BRITISH NATIONAL SPACE CENTRE
www.bnsc.gov.uk

1874

The British Government sent five expeditions to different parts of the world to view the transit of Venus. Observations of the planet crossing the disc of the Sun enabled astronomers to make accurate measurements of the distance between the Sun and the Earth.



Credit: NASA

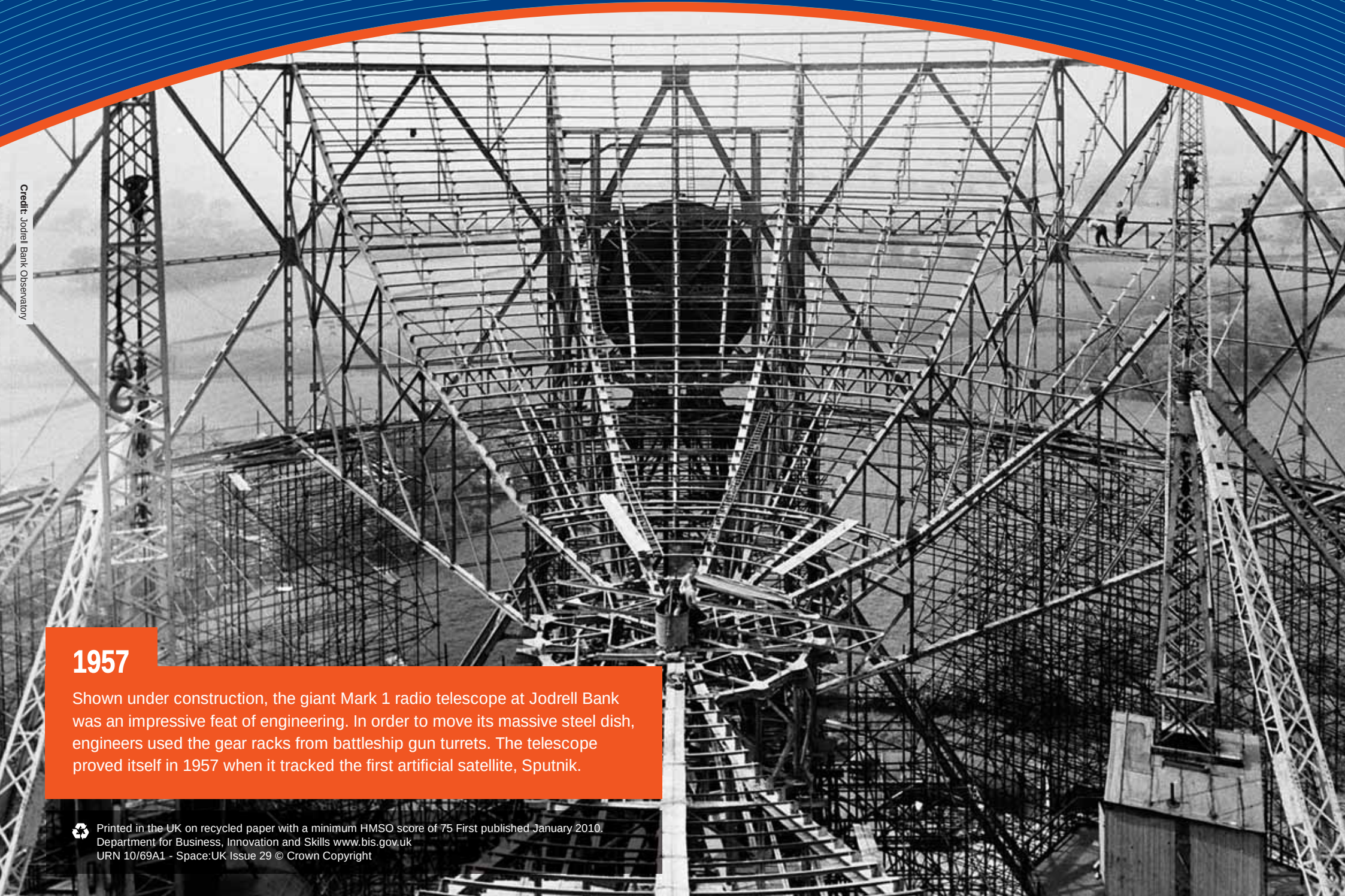
1974

A technician works on Ariel 5. A joint UK-US mission, Ariel 5 was built to observe X-rays. The Ariel satellites were the first missions to involve international collaboration and Ariel 5 was so successful that it continued to operate until 1980.

Credit: ESA

2009

UK scientists and industry contributed to two outstanding space telescopes with the launch of the Herschel Space Observatory and the Planck Surveyor in May 2009. These satellites will give us fundamental insights into the birth and evolution of the Universe.



Credit: Jodrell Bank Observatory

1957

Shown under construction, the giant Mark 1 radio telescope at Jodrell Bank was an impressive feat of engineering. In order to move its massive steel dish, engineers used the gear racks from battleship gun turrets. The telescope proved itself in 1957 when it tracked the first artificial satellite, Sputnik.

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