Spring 2015 issue 42

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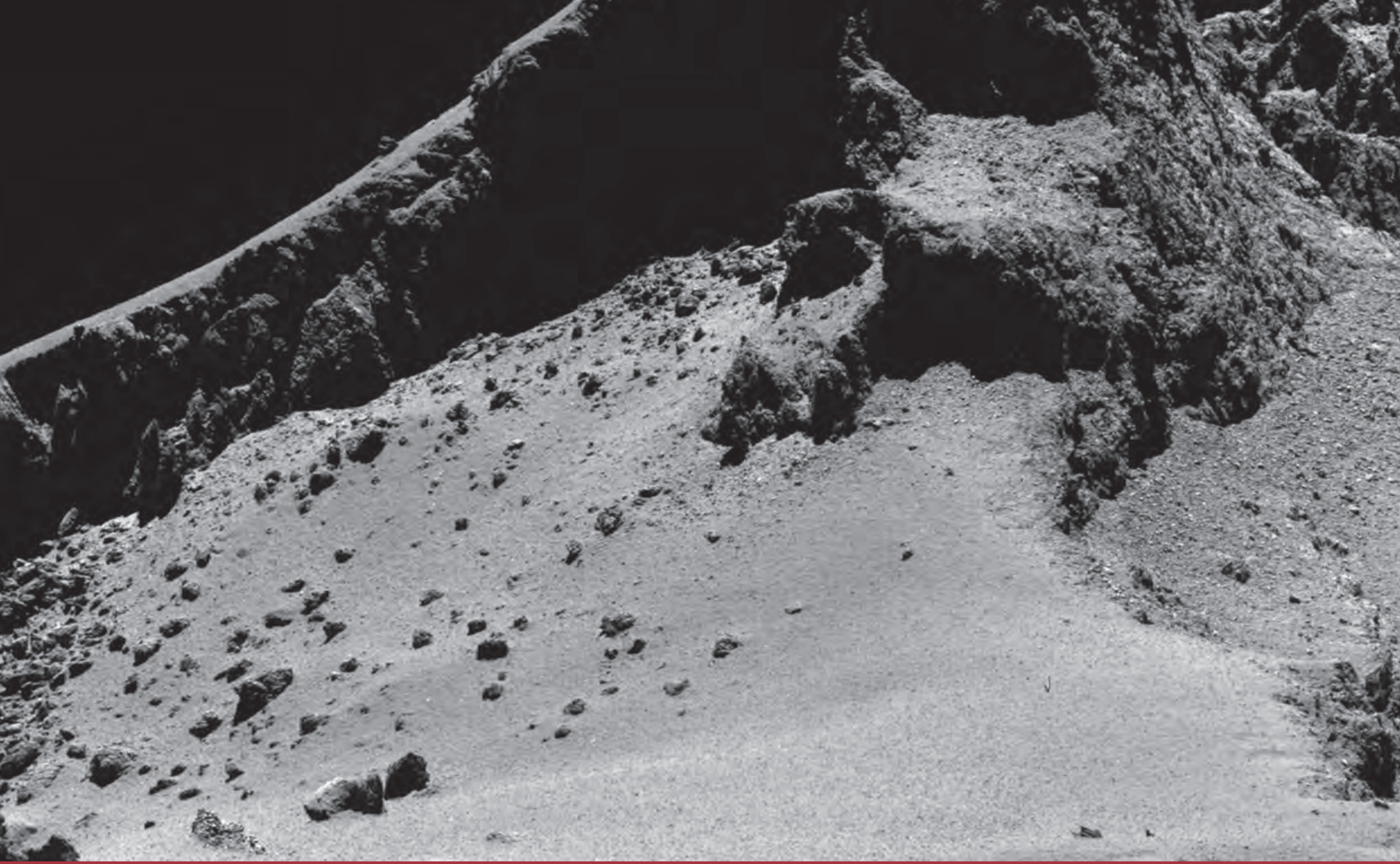
Why space is good for health

UK tech for Mars



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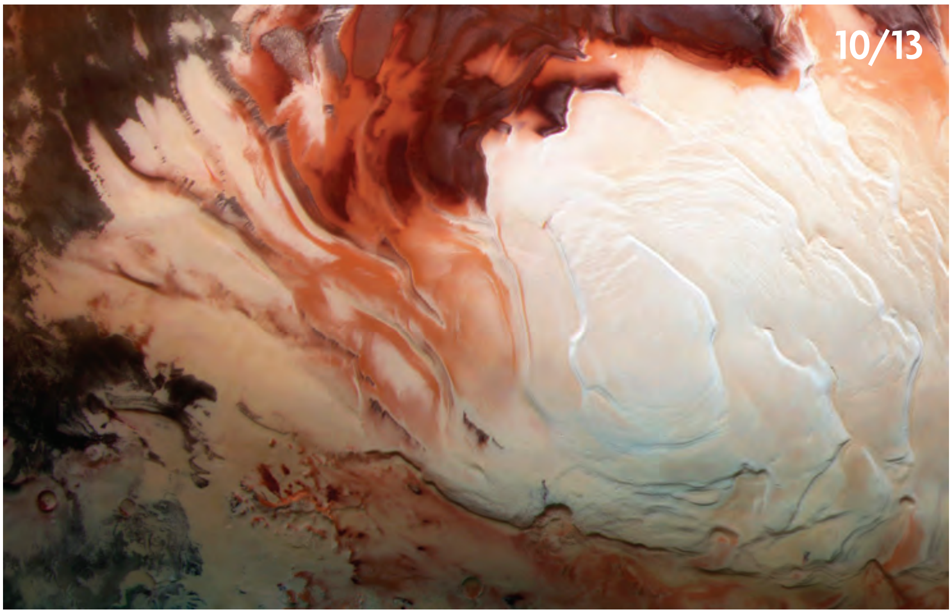

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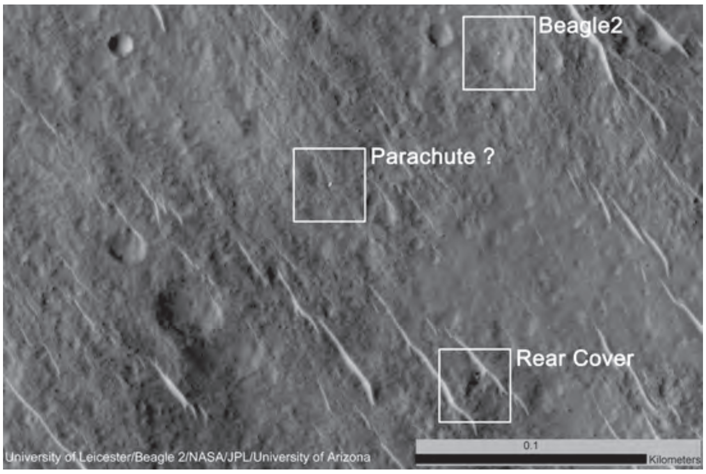
Front cover image Comet 67P seen by Rosetta from 8km away **Credit:** ESA

The Beagle has landed

11 years after the UK-led Beagle 2 Mars lander disappeared, new images reveal the mission landed successfully.

Conceived by the late Colin Pillinger of the Open University, Beagle 2 was built at Astrium (now Airbus Defence and Space) in Stevenage. The small lander was released from ESA's Mars Express spacecraft on 19 December 2003. A few days later, on Christmas Day, it was due to touchdown on the red planet but nothing was ever heard from it.

Until now, it was presumed that Beagle 2 had crashed into the Martian surface. However, analysis of images taken by the HiRISE camera on NASA's Mars Reconnaissance Orbiter shows clear evidence that Beagle 2 successfully landed and started to deploy its solar panels. For some reason, it seems the lander never fully unfolded, preventing its antenna from sending data back to Earth.



The various components of Beagle 2 on the Martian surface

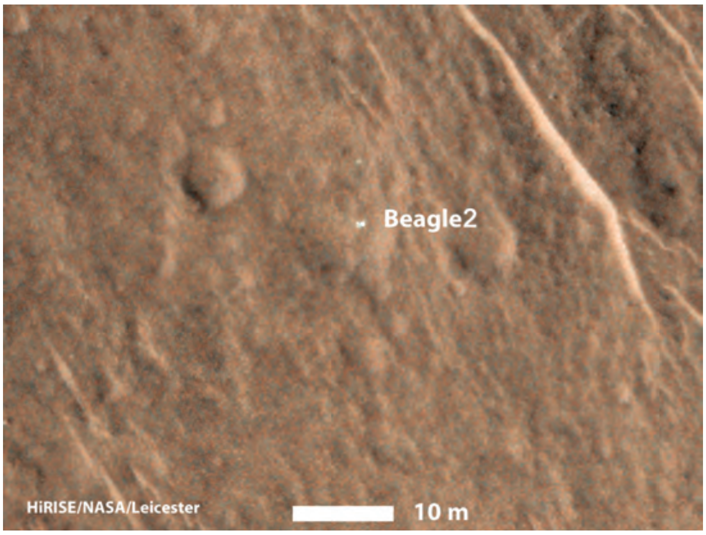
"I'd never completely written the mission off," Beagle 2 Mission Manager, Mark Sims from the University of Leicester admitted to *space:uk*. "I am delighted that Beagle 2 has finally been found."

"The highly complex entry, descent and landing sequence seems to have worked perfectly," he said. "Only during the final phases of deployment did Beagle 2 unfortunately run into problems. These images show that we came so close to achieving the goal of science on Mars."

Tantalisingly close

As well as carrying instruments designed to investigate signs of life on Mars, on landing Beagle 2 should have played a special recording made for the mission by the band Blur. It is now possible that not only did this music play on the red planet, the lander may also have taken pictures of the surface.

"It was tantalisingly close to a huge mission success," said Andrew Coates, Lead Investigator for the stereo camera system on the mission. "There's a possibility that there are images on Beagle 2 waiting to be downloaded to Earth."

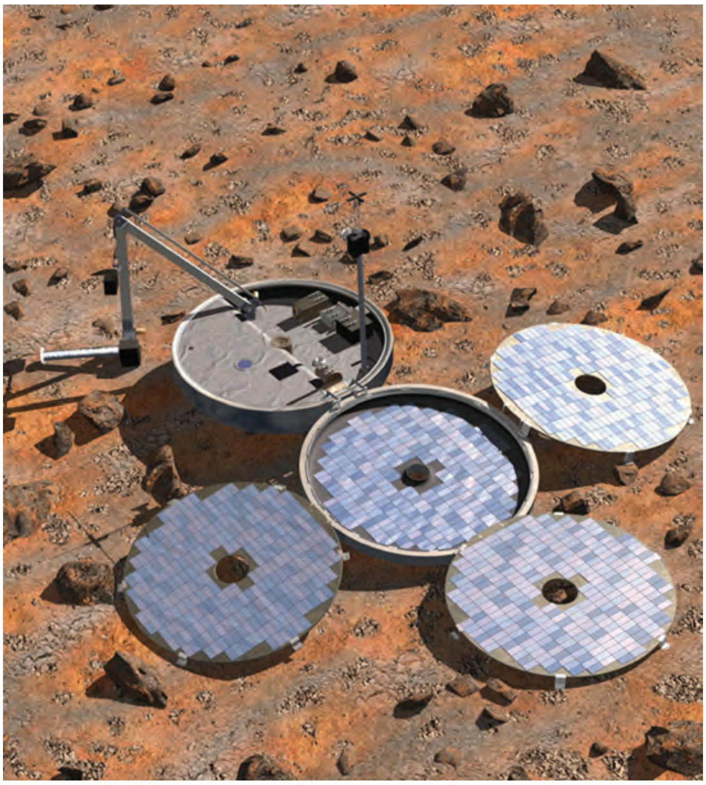


A colour image of the, seemingly-intact, Beagle 2 lander on Mars

Jim Clemmet who led the design and construction of Beagle 2 at Astrium, said: "Now we know that Beagle 2 was the first European mission to land on another body in the Solar System. I am proud of everyone involved."

The images showing Beagle 2 on the Martian surface were revealed during a packed press conference on 16 January at the Royal Society in London. The event was made bitter-sweet by the knowledge that the inspirational leader of the Beagle 2 project, Colin Pillinger, died in May 2014 never knowing that the landing was a success after all.

"Colin was always fond of a football analogy," his wife, Judith, said. "No doubt he would have compared Beagle 2 landing on Mars, but being unable to communicate, to having 'hit the crossbar' rather than missing the goal completely."



Artist's impression of how the Beagle 2 lander should have deployed
Credit: Beagle 2 team, ESA

Pi for Peake

With just months to go before Tim Peake's mission to the International Space Station, *space:uk* catches up on the British ESA astronaut's latest endeavours:

It is hard to pin Tim Peake down at the moment. If not training in the Soyuz capsule in Russia, you will probably find him at the European Astronaut Centre in Germany, the Johnson Space Centre in Houston or back in the UK promoting the benefits of studying space science, engineering and technology.

UK primary and secondary school students, for instance, can enter the Astro Pi competition. Launched in December, this competition encourages students to code apps and experiments to send into space.

Two Raspberry Pis – inexpensive credit card sized computers – will fly with Peake on his six-month mission to the International Space Station. They will be connected to the new Astro Pi board, which will be loaded with sensors and gadgets such as a camera and gyroscope, as well as the winning code.

Code competition

There are five themes: spacecraft sensors, satellite imaging, space measurements, data fusion and space radiation. Primary school students have until 3 April to come up with an original idea for an experiment or application that can be done on the Astro Pi during the mission. Astro Pi experts will work with the two best teams to interpret their ideas. A team at the Raspberry Pi Foundation will then code the experiments ready for the mission launch.

"I'm really excited about this project," said Peake. "This competition offers a unique chance for young people to learn core computing skills that will be extremely useful in their future. It's going to be a lot of fun."

Secondary school students have the same deadline to enter ideas, with the best 50 in each age category winning a Raspberry Pi computer and Astro Pi board to code their idea on. Students then have until 29 June to develop programs from their original concept. Two winning teams will be selected from three age categories.

Data collected by the Astro Pi computers will be downloaded to Earth from orbit and sent to the winning teams.

Inspiring

UK-born citizens have flown in space before – from the first Brit in space, Helen Sharman, to NASA astronauts Michael Foale and Piers Sellers. However, in November 2015, Peake will become the first British European Space Agency (ESA) astronaut.


Training in the Soyuz simulator at the Gagarin Cosmonaut Training Centre, in Russia **Credit:** ESA

The UK Space Agency has announced a £2 million programme, as part of the Autumn Statement, to support further outreach activities around Peake's mission, particularly to help inspire interest in Science, Technology, Engineering and Maths (STEM).

The UK Space Agency and Economic and Social Research Council are also funding a three-year project to investigate if, as anecdotal evidence suggests, human spaceflight inspires school students to study STEM subjects.

For more info see: www.astro-pi.org

Blue Peter designs Peake patch

Following a competition attracting more than 3000 entries, the winning logo for Tim Peake's Principia mission has been unveiled on Blue Peter. In partnership with ESA and the UK Space Agency, the BBC children's programme asked schoolchildren to design a mission patch for Peake.

Peake's mission name, Principia, had already been chosen after a public vote and refers to Isaac Newton's Naturalis Principia Mathematica, a text describing the principal laws of motion and gravity. An apple helped provide the inspiration, after Newton wondered why apples fell from trees, and an apple features prominently on the winning mission patch. The design, by 13-year-old Troy, also includes a stylised space station and Soyuz rocket.

Announcing the Principia mission logo **Credit:** ESA, Alexander

Brrrrrr....survival training in Russia **Credit:** ESA

Mission X

Tim Peake launched astronaut training at schools across the UK in January with the hugely popular science, education and fitness programme, 'Mission X: Train Like an Astronaut'.

Over 15,000 students and teachers are expected to take part in 2015, with students from Rode Heath Primary School in Cheshire kicking off their Mission X challenge by working with sports scientists from Manchester Metropolitan University. As well as taking baseline fitness tests, the students visited the University's environmental chamber facility to experience the extremes of temperatures that astronauts may need to deal with.

"It is so exciting to see how engaged the children are learning about space," said the school's mission controller Julie Wiskow. "We have created our own mini International Space Station as a learning environment in school. Students are learning not just about their bodies and fitness but also lots of mathematics and science through these fun astronaut activities."

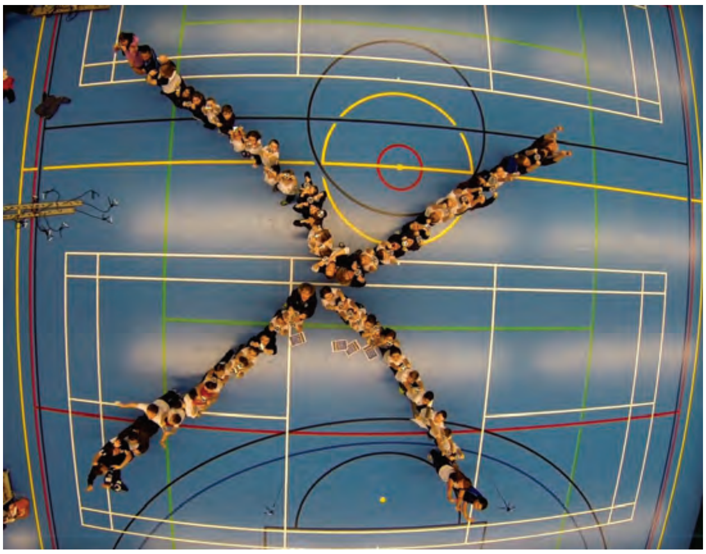
A series of events, supported by the UK Space Agency, will take place across the UK. All schools that participate are being invited to report on their mission progress at an event hosted by the Parliamentary Space Committee at the House of Commons.

Teachers will also be invited to take their astronaut training to a new level with a visit to the human centrifuge facility at QinetiQ in Farnborough. The UK's only centrifuge is used to prepare fighter pilots and astronauts for the high G forces of air combat as well as rocket launch and re-entry.

Micro-gravity causes muscle loss and students will be able to witness the physiological effects of Earth's gravity in the laboratory and how the body is affected.

"I've been amazed by the commitment of teachers and students to the Mission X challenge," said Jeremy Curtis from the UK Space Agency. "The teamwork and enthusiasm for science, will be important to the space workforce of the future."

Tim Peake was equally enthusiastic: "Let's continue to inspire the next generation with fun science, healthy eating and good exercise - go Mission X!"



Credit: UK Space Agency, Alexander

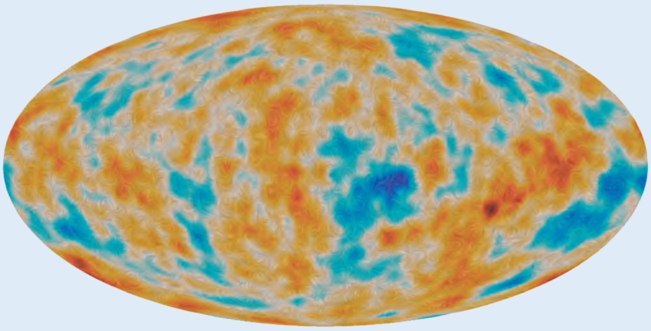
Stars are born

New maps from ESA's Planck satellite suggest that the first stars in the Universe are much younger than previously thought.

Between 2009 and 2013 Planck measured variations in the temperature of the Cosmic Microwave Background radiation, the afterglow of the Big Bang 13.8 billion years ago.

The new research suggests that the first stars burst into life some 550 million, rather than 420 million, years after the Big Bang to bring the first light to the cosmos.

Several UK universities, institutes and companies contributed to the instruments on board Planck and are now involved in the Planck data processing centres.



Planck has mapped the afterglow of the Big Bang **Credit:** ESA

Space conference

The biennial UK Space Conference is coming to Liverpool in 2015.

Taking place from 14-15 July at the Arena and Convention Centre, this year's event will focus on the impact satellite services and the space sector are having on the wider economy, society and education. The conference will be preceded by a complimentary networking reception for delegates on the evening of 13 July at the Royal Liver Building.

Tim Peake speaking at the last UK Space Conference in 2013 **Credit:** UK Space Agency

Regular features such as guest speakers, an exhibition hall, industry announcements and interactive sessions will all feature in a packed programme. The Sir Arthur Clarke Awards and the ESERO-UK Teacher Conference will also run in parallel with the main conference.

The conference website is now live and registration is open, with Early Bird tickets available until 13 March.

www.ukspace2015.co.uk

Success for burst mission

A mission to study the largest and most violent explosions in the Universe has celebrated its tenth anniversary.

In orbit since 2004, Swift – a joint US, UK and Italian satellite – tracks gamma ray bursts. These bright beams of high frequency electromagnetic energy blast across space every few days, illuminating the most distant reaches of the Universe.

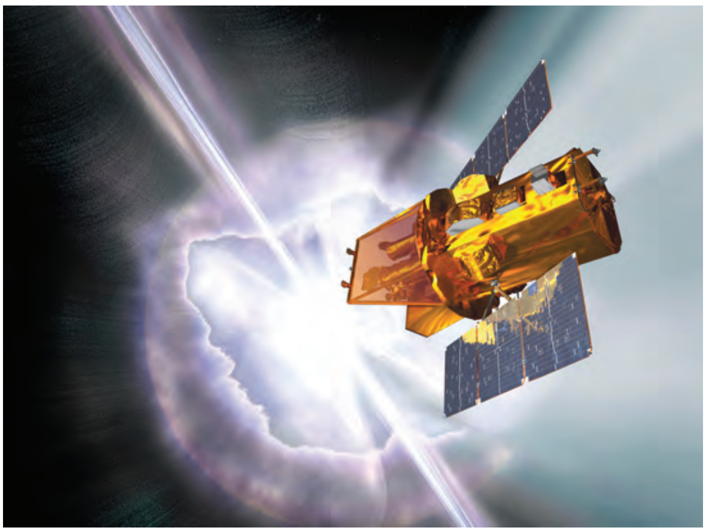
When Swift spots one of these bursts somewhere in its field of view, within a minute or so, the satellite turns to direct its x-ray and optical telescopes in that direction. It also alerts the science team on the ground immediately so they can track the event.

Thanks to Swift, astronomers now have a much better idea of what causes these massive cosmic explosions. Longer bursts – anything over two seconds – are most likely to be triggered by massive stars collapsing in on themselves before exploding into oblivion. Shorter explosions are probably caused by the collision of pairs of orbiting neutron stars.

Anything in the path of a gamma ray burst would be in serious trouble. "Any planet within 100 light years would have its atmosphere blown off," said Neil Gehrels, the mission's Principal Investigator. However, the explosions they represent may also have produced crucial elements such as carbon, nitrogen, iron and even gold.

The UK Space Agency funds Britain's contribution to Swift. The University of Leicester provided key parts of the X-ray telescope on the satellite and hosts the UK Swift Science Data Centre. University College London's Mullard Space Science Laboratory in Surrey built much of the optical telescope on board.

"Swift continues to be a huge scientific success," said Julian Osborne, who leads the Swift team at Leicester. "There's every reason to celebrate its tenth anniversary; it's continuing to discover new things all the time."



Artist's impression of the Swift satellite **Credit:** NASA

Rosetta's close encounter

Rosetta left the Earth in March 2004 **Credit:** ESA

The Rosetta spacecraft had its closest encounter yet with comet 67P/Churuymov-Gerasemenko on 14 February, with a flyby just six kilometres from the surface.

The orbiter is performing a series of flybys, two each month, at distances ranging from between 15 and 250 kilometres. The latest manoeuvres, controlled from the European Space Agency's (ESA) European Space Operations Centre at Darmstadt in Germany, sent the orbiter above the larger lobe or 'tail end' of the duck-shaped comet.

"What we are doing is alternating far passes at relatively low speed, with close flybys with higher speed," said Rosetta's Flight Director, Andrea Accomazzo. "With these different flight conditions we hope to be able to explore completely the environment of the comet."

Peak activity

This next stage of the mission will allow further study of the comet in the months before it approaches its closest point to the Sun, or perihelion, in August as well as during its peak of activity. Rosetta will measure how the activity wanes, to give the fullest picture yet of a comet's life cycle.

UK science and engineering teams are involved in all aspects of the mission and lead one of the instruments on the Philae lander.

So far scientists have measured the comet's size, shape and density. They have also determined the exact signature of hydrogen present in its water. This indicates that the water composition on the comet is not the same as water on Earth.

Continued measurements from the flybys will give a better understanding of the comet nucleus and the exact types of organic material on the comet. Insight into the dust gains can be gained by studying how different wavelengths of light reflect from the surface, while the comet's atmosphere or coma will also be under scrutiny.

"We're looking at where the gas and dust start to accelerate from the surface, how the birth of the coma works and how the coma develops to higher altitudes," said Matt Taylor, Rosetta's Project Scientist. "These will be the first measurements we make in this area and that's a really important target for us."

Lander search

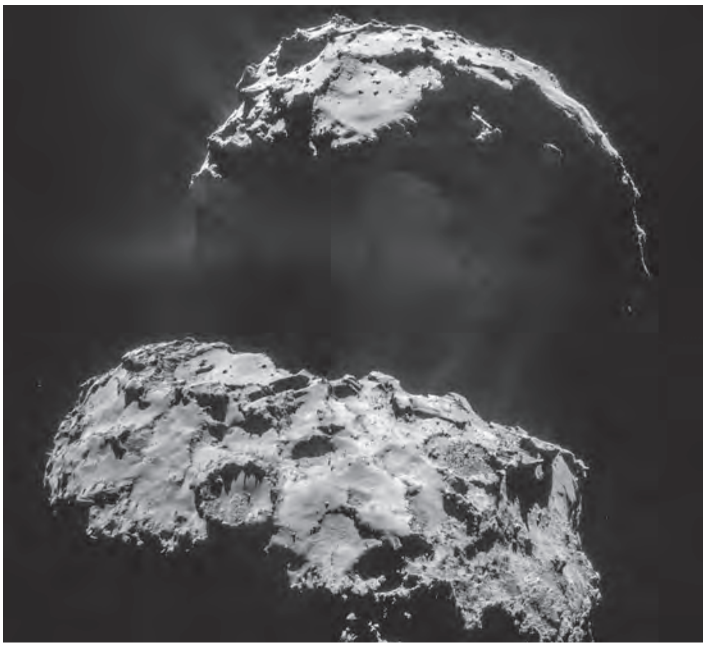
However, the current passes will not be searching for Rosetta's Philae lander. After unexpectedly bouncing several times on landing and sending back data, Philae is now hibernating in an unknown location.

We know from images sent back from the surface that Philae is in the shadow of a rocky overhang but in order to charge its batteries and instruments, the probe's solar panels need to have an unobstructed view of the Sun.

Rosetta has only mapped about 70% of the surface so far because the comet's orbit and rotation have kept certain areas in darkness. This year new regions will come into view and, as the comet gets closer to the Sun, there is a possibility that Philae's solar panels could gain enough power to reactivate.

"Having Philae reactivate is not so likely but it's not impossible," cautioned Accomazzo. "We will see. Maybe we are lucky and the units have survived these months and we reactivate in June or July."

Future flybys will try to pinpoint the lander's location but, for the coming months, it is the orbiter that will take centre stage.



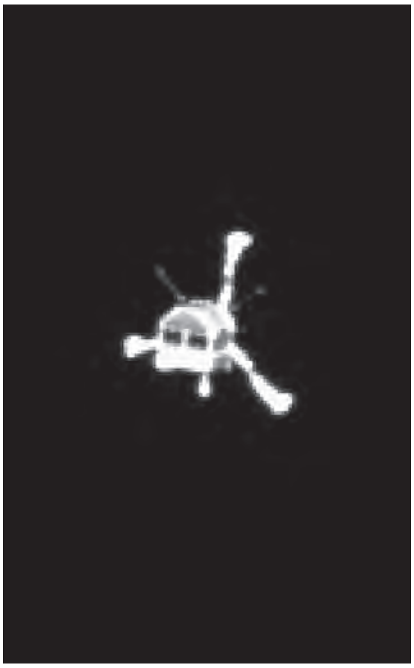
Large areas of comet 67P are in shadow **Credit:** ESA

Comet landing

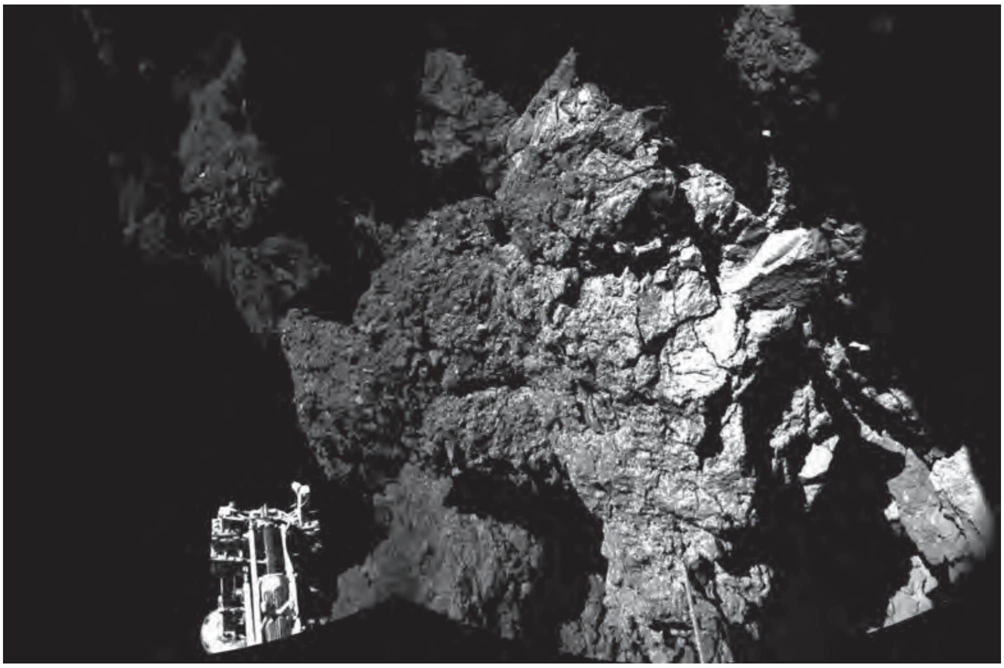
After a ten-year and 6.4 billion kilometre journey, on 12 November ESA's Philae lander was released by its Rosetta mothership towards comet 67P/Churyumov-Gerasimenko.

A few hours later, Philae landed on the comet, bouncing twice before settling in its – still unknown – final resting place where it sent back the first ever images from a comet's surface.

Philae took this parting shot of Rosetta.

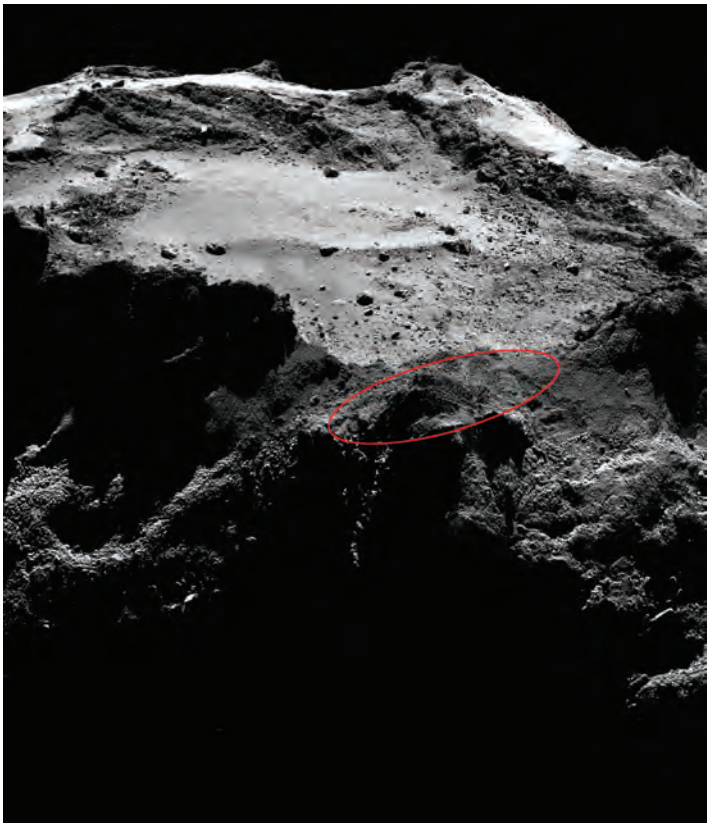


Meanwhile, Rosetta captured this final image of Philae.



After bouncing twice – the first time up to 1km above the surface – Philae arrived safely on the surface of Comet 67P, one of the lander's three legs can be seen in the foreground.

An emotional Rosetta Flight Director, Andrea Accomazzo, at mission control in Germany after the landing is confirmed.



Where's Philae? The lander is likely to be somewhere within the ringed area but seems to be sheltered beneath a cliff. After landing, Philae managed to send back 64 hours of data – including from its UK-built Ptolemy experiment – before running out of power and going into standby mode. The lander signed off on Twitter with: "I'll tell you more about my new home, comet 67P soon... zzzzz."

67P captured by Rosetta's cameras in January 2015. Rosetta will remain in orbit around the comet until at least the end of the year. As the comet nears the Sun it is hoped that light falling on Philae's solar panels will give it enough power to wake up and continue its scientific discoveries.

All credits: ESA

Space funding rocketing

The UK Space Agency is investing an extra £200 million in European space programmes. The Minister for Universities, Science and Cities, Greg Clark, made the commitment at ESA's Ministerial Council meeting in Luxembourg.

The ESA Ministerial Council meeting in Luxembourg **Credit:** ESA

The additional money pledged to ESA will strengthen Britain's role in three major international space programmes as well as other long-term space projects.

The package of funding includes £47.7 million for Europe's 2018 ExoMars mission, guaranteeing that Europe's new Mars rover will be developed and built in the UK (see page 10). The UK also committed an extra £49.2 million to the International Space Station (ISS) and £56.9 million to the development of a next generation communications satellite system.

The Ministerial Council meeting brings together science ministers from the 20 ESA member states to agree funding for different areas of the European space programme.

The UK space industry forecasts that the extra investment will enable it to pursue new markets worth over £1.5 billion, supporting the UK Space Agency's ambition to grow the industry from 11.3 billion today to £30 billion by 2030.

New investment:

At the ESA Ministerial meeting the UK Space Agency agreed:

- **£47.7 million for ExoMars, with the UK taking overall leadership of the 2018 ExoMars rover.**
- **£130 million for the development of telecommunications technologies.**

  This includes £56.9 million for a new 'Quantum-class' communications satellite system and £28.4 million committed to the Integrated Application Promotion programme for the creation and growth of businesses using space data.
- **£49.2 million for the International Space Station including the development of a new UK-built ISS communications terminal.**

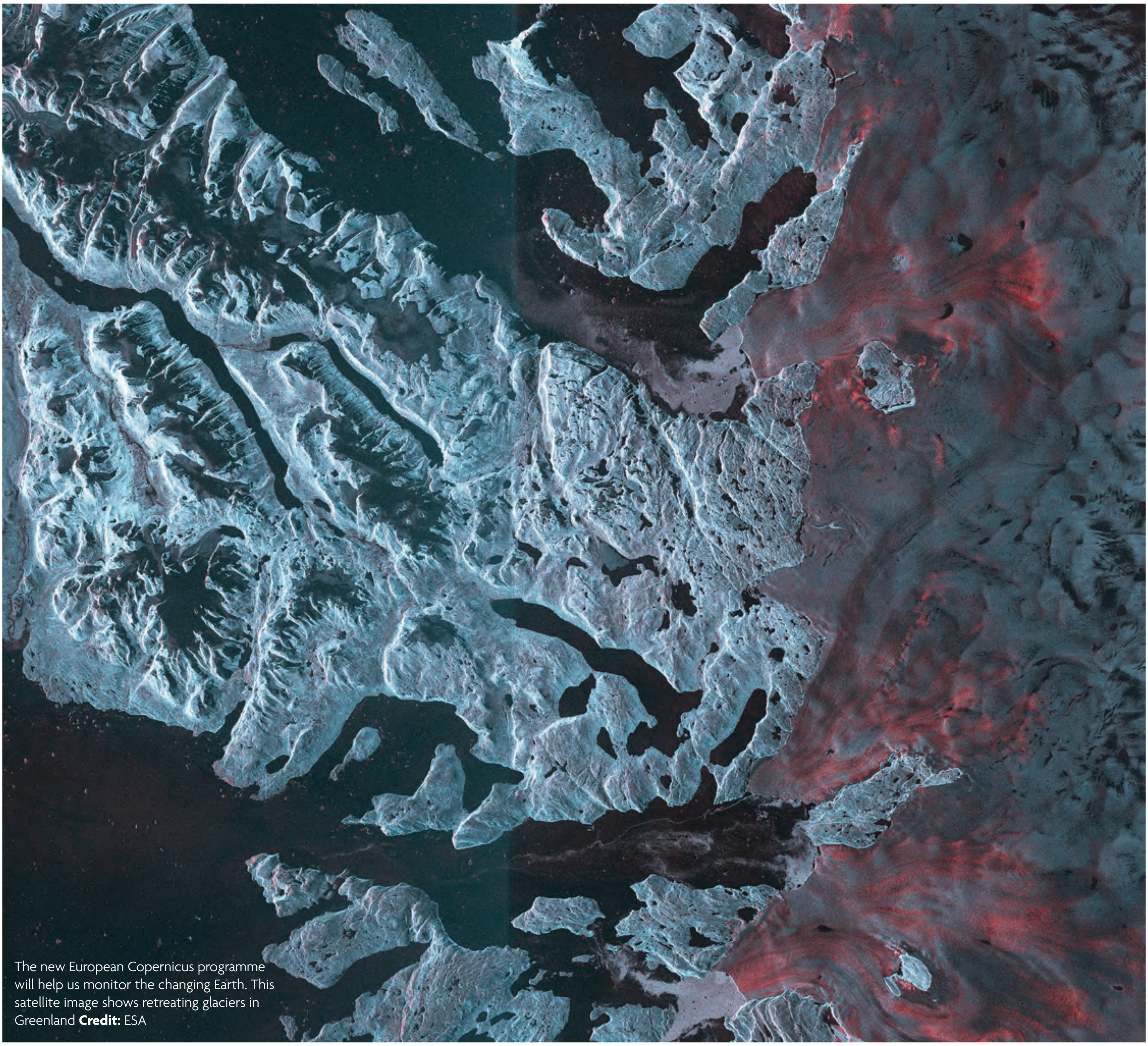
"We have secured the future for the UK in space," said Universities, Science and Cities Minister, Greg Clark. "Our increased commitment to ExoMars means that the UK will be leading this inspirational project and, for the first time, the Union Jack will be flying on the International Space Station as a full partner."

British ESA astronaut Tim Peake will fly to the ISS in November 2015 and the extra funding will secure UK researchers access to the microgravity research facilities on the station. The money will also be invested in the development of a UK-built communications terminal for the European module as well as the early stages of a lunar research programme.

The additional investment in satellite communications will go towards the development of a new type of lower cost telecommunications satellite to help maintain Britain's lead in this important area of the space sector. Airbus Defence and Space in the UK will develop much of the instrumentation for the satellite and the structure for the spacecraft will be built by the UK's Surrey Satellite Technology Limited.

The Ministerial meeting also agreed funding for a new generation of European launch vehicles, Ariane 6. However, the UK does not contribute to ESA's launcher programme.

The UK is a world leader in satellite communications, developing and operating satellites such as AlphaSat **Credit:** Airbus Defence and Space



The new European Copernicus programme will help us monitor the changing Earth. This satellite image shows retreating glaciers in Greenland **Credit:** ESA

From the Agency:

Chief Executive of the UK Space Agency, David Parker, on the outcome of the Ministerial meeting:

The Ministerial was a big success for the UK. We're going to be ensuring our leadership in satellite telecoms and applications of satellite technology. We've also secured the continuation to completion of the ExoMars programme and, more than that, bringing the leadership of the rover to the UK.

What about the UK's ISS contribution?
The UK will be a participant in the programme for the next six years at the level that allows us to have full voting rights in the programme and benefit from the science and technology going forward.

The UK's changed its position about the ISS over the past few years?
We've come a long way in our thinking about all UK space policy, joining up the picture that goes from basic science, through the commercial areas to applications. The involvement in the ISS is a case in point because we built a relationship with the research councils in the UK to exploit our participation in the programme for good science but we're also going to deliver some great technology – such as the communications terminal for the station, which will vastly improve the speeds of the data downlink.

How are the next 12 months shaping up?
We're looking forward to Tim Peake's mission to the ISS, that will galvanise attention on space activities – I hope on the research he will do and the technology. But I can think of many other exciting things such as the huge European Copernicus Earth observation programme, with a whole fleet of satellites to monitor the environment and assist in the aftermath of disasters. The UK's new ESA centre will also open in June at Harwell, so we've got another busy and exciting year.

Inside the control room at Stevenage **Credit:** Airbus, Rayner

Technology to explore

The next few years are shaping up to be an exciting time in space, with the UK supporting ambitious missions to the International Space Station, the Moon and Mars. As Richard Hollingham discovers, technology developed for space exploration not only helps answer fundamental scientific questions, it has benefits back on Earth:

In a nondescript industrial unit, across the windswept car park from the grey concrete walkways of Stevenage station, there is portal to another world. Well… not so much a portal, as a wooden door.

Step through this door and the view is transformed: a desert of rolling sand dunes blends into a hazy red sky; a few jagged rocks protrude from the dirt. Across this dusty monochrome landscape, a six-wheeled metal-framed machine rolls slowly forwards, twin cameras swivelling on a single stalk.

This extraordinary scene has been created by Airbus Defence and Space to test Europe's new Mars rover, which – thanks to commitments made at December's ESA Ministerial meeting – will be designed, built and tested in the UK.

Known as the Mars Yard, the simulated Martian landscape is 30 metres long by 13 metres across and is filled with some 300 tonnes of sand. It is designed to ensure that when Europe's ExoMars mission lands on the red planet in January 2019, the rover performs exactly as planned.

"We have a group of very talented engineers who are motivated to deliver this programme successfully and payback the trust the UK Space Agency has placed in us"
Van Odedra
ExoMars Rover Project Manager

British built

The machine that is currently being put through its paces in the Mars Yard is known as Brian, one of several test versions of the ExoMars rover built to help perfect locomotion and navigation systems.

"The rover is being designed to use its stereo camera system to survey the Martian surroundings and create a three dimensional representation of the landscape, in order to identify safe or dangerous areas like cliffs," explains Marie Campana, ExoMars Rover Mobility Team Leader, "then it will map a path."

This means of autonomous navigation on Mars has never been attempted before. The ExoMars rover will have far more self-driving capability than previous rovers – even including Nasa's Curiosity rover, which is currently exploring the red planet.

At the ESA Ministerial Council meeting in December, the UK committed £47.7 million to the ExoMars 2018 mission. As a result, the UK will lead the development of the rover. This includes important tasks like systems engineering, assembly, testing and responsibility for software. UK scientists are also building PanCam, a stereo camera that will be used to study scientifically interesting targets. This is being led by Andrew Coates from University College London's Mullard Space Science Laboratory.

"ExoMars will be the first mission to look at whether the martian environment is suitable for life but also whether there are signs of life," says Coates. "The key new thing about the rover is that it will be able to drill up to two metres beneath the harsh surface of Mars, which is where you should look for life."

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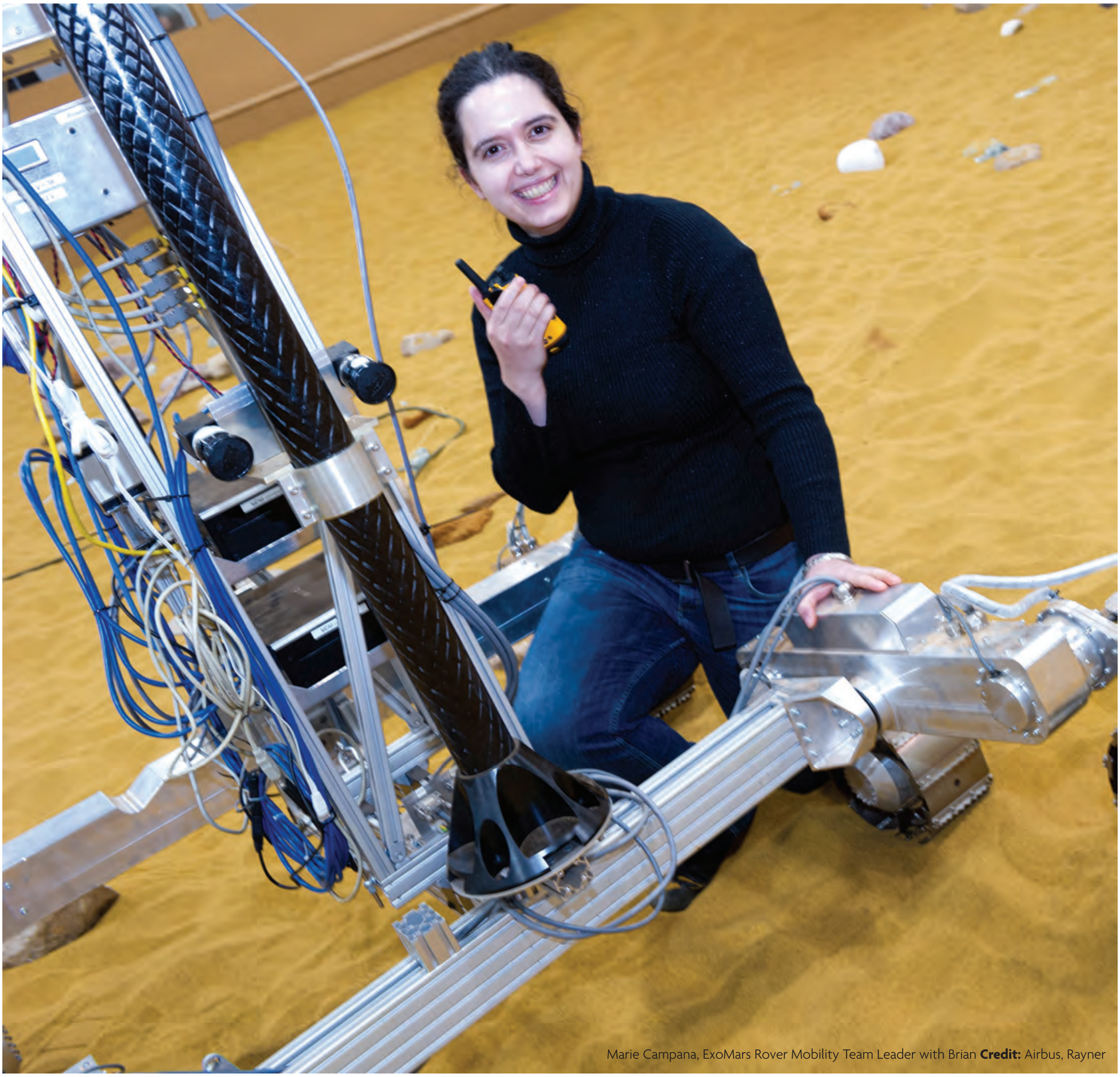


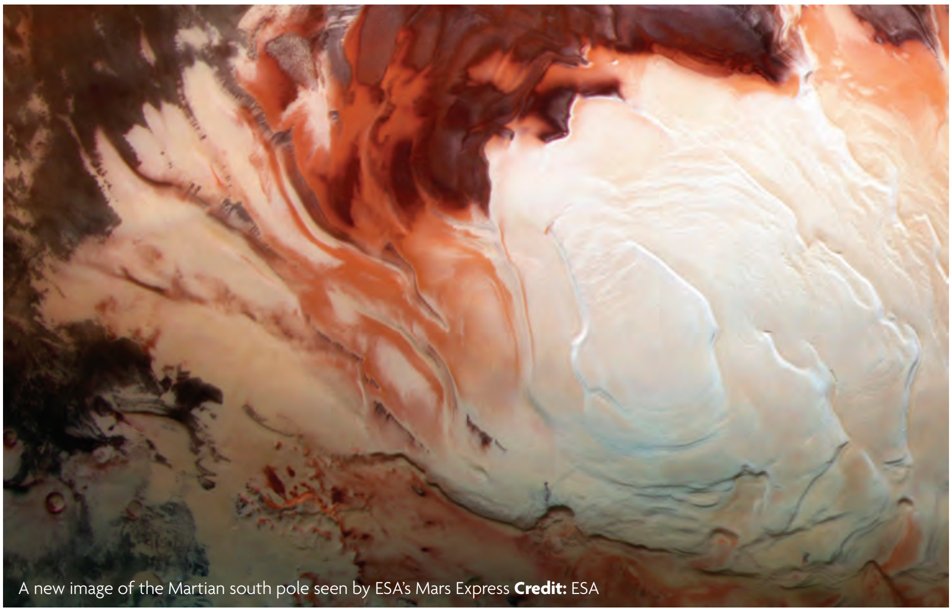
Marie Campana, ExoMars Rover Mobility Team Leader with Brian **Credit:** Airbus, Rayner

Brian rumbles across the Mars Yard in Stevenage **Credit:**

Car technology

Getting all this technology developed, tested and ready in time for its 2018 launch is certainly going to be challenging. All the companies, universities and institutions involved in the mission are also working on many other space projects. ExoMars is only part of a long term UK Space Agency strategy to explore the Solar System with benefits for new science, technology and applications here on Earth.

"A lot of new UK technology will be developed as a result of challenging projects like ExoMars," says Chris Castelli Director of Programmes at the UK Space Agency. "We will see spin-offs into many more terrestrial applications that are going to be important for the future."



A new image of the Martian south pole seen by ESA's Mars Express **Credit:** ESA

"Take self-driving vehicles for instance," Castelli says. "The technology being developed for ExoMars has the potential to make driving safer and, with an aging population, it could give rise to freedoms and mobility that people wouldn't have previously have had."

Other applications from the ExoMars programme, so far, include new software for inspecting tunnels used for water supplies and hazard avoidance technology for the vehicles used in open cast mining.

The economic benefits of investing in space technology are not anecdotal. The latest independent report on the size and health of the UK space sector shows the industry employs some 34,000 people and contributes £11.3 billion to the UK economy each year.

"You never quite know how space technologies are going to be used," says Sue Horne, UK Space Agency Head of Space Exploration. "Some technologies have an obvious high potential for spin-out but sometimes you're taken by surprise about what comes out."

tune

UK SPACE AGENCY

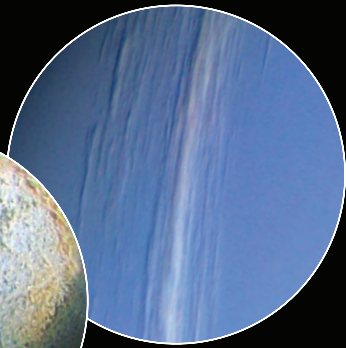
Neptune

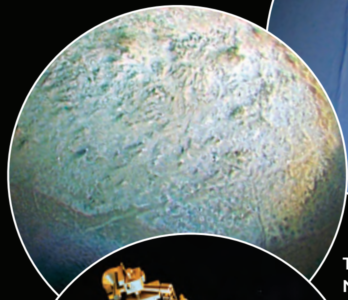
Discovered in 1846, Neptune is named after the Roman God of the sea. The planet is 4.5 billion kilometres from the Sun and takes 165 years to complete a full orbit. This means a year on Neptune is equivalent to 165 Earth years. Because of its elliptical orbit, Neptune is sometimes further away from the Sun than Pluto.

Neptune has an atmosphere of hydrogen, helium and methane. The methane gives the planet its blue colour. The atmosphere merges into a liquid mantle and, scientists believe, a solid core.

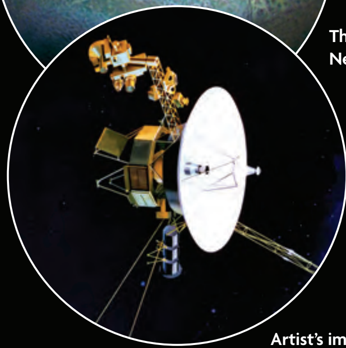
Temperatures in the outer atmosphere are as low as -210˚C but the interior is much warmer. The atmosphere has violent supersonic winds of up to 2000 kilometres per hour.

Streaks of cloud in the upper atmosphere of Neptune





The southern hemisphere of Neptune's moon Triton



Artist's image of one of the pair of Voyager spacecraft

Rings and moons

Neptune has six faint rings made up of a mix of large particles and fine dust. So far astronomers have discovered 14 moons around the planet but there could be more.

Moons include the largest, Triton, which holds the distinction of being one of the coldest objects in the solar system, with surface temperatures of around -240˚C. On its surface are geysers spewing out liquid nitrogen, which freezes and falls back as snow.

Triton is also the only large moon in the Solar System that circles a planet in the opposite direction to the planet's rotation. This suggests it might once have been an independent planet, captured by Neptune's gravity. Eventually, millions of years from now, the planet's gravitational field will drag the moon down, breaking it apart.

Other moons include Nereid, which may be an asteroid or comet captured by Neptune's gravity.

Missions to Neptune

Much of what we know about Neptune is thanks to NASA's Voyager 2 spacecraft, which flew past in August 1989. So far, this has been the only mission to reach the eighth planet.

Passing some 4,800 kilometres above Neptune, Voyager 2 sent back images confirming the planet had rings. The mission also discovered six new moons and measured the clouds and violent storms in the atmosphere.

Since then, astronomers have been able to use powerful telescopes on Earth, and in Earth orbit, to examine the planet. Astronomers studying images from the Hubble Space Telescope only discovered Neptune's fourteenth moon in 2013.

UK SPACE AGENCY

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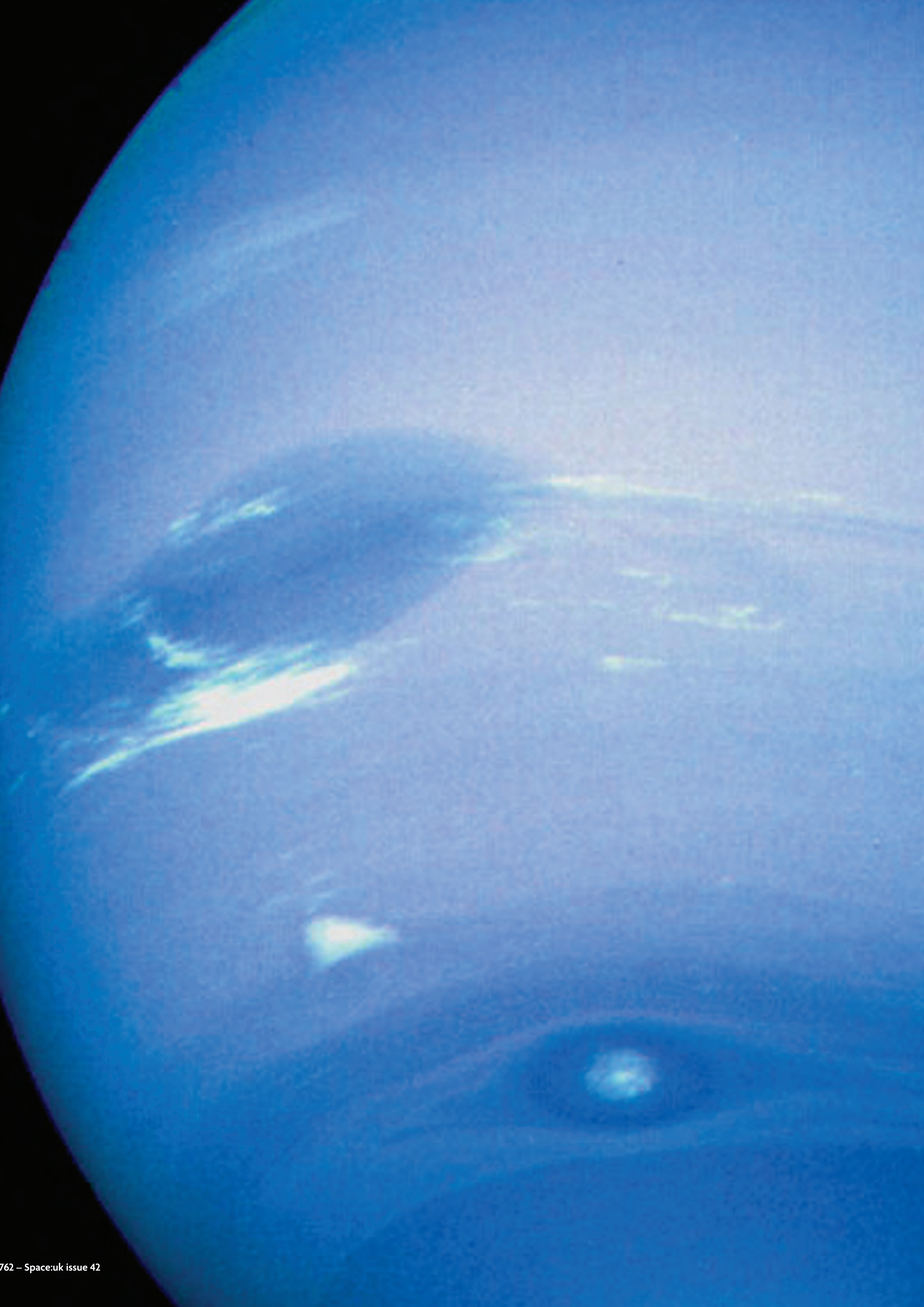
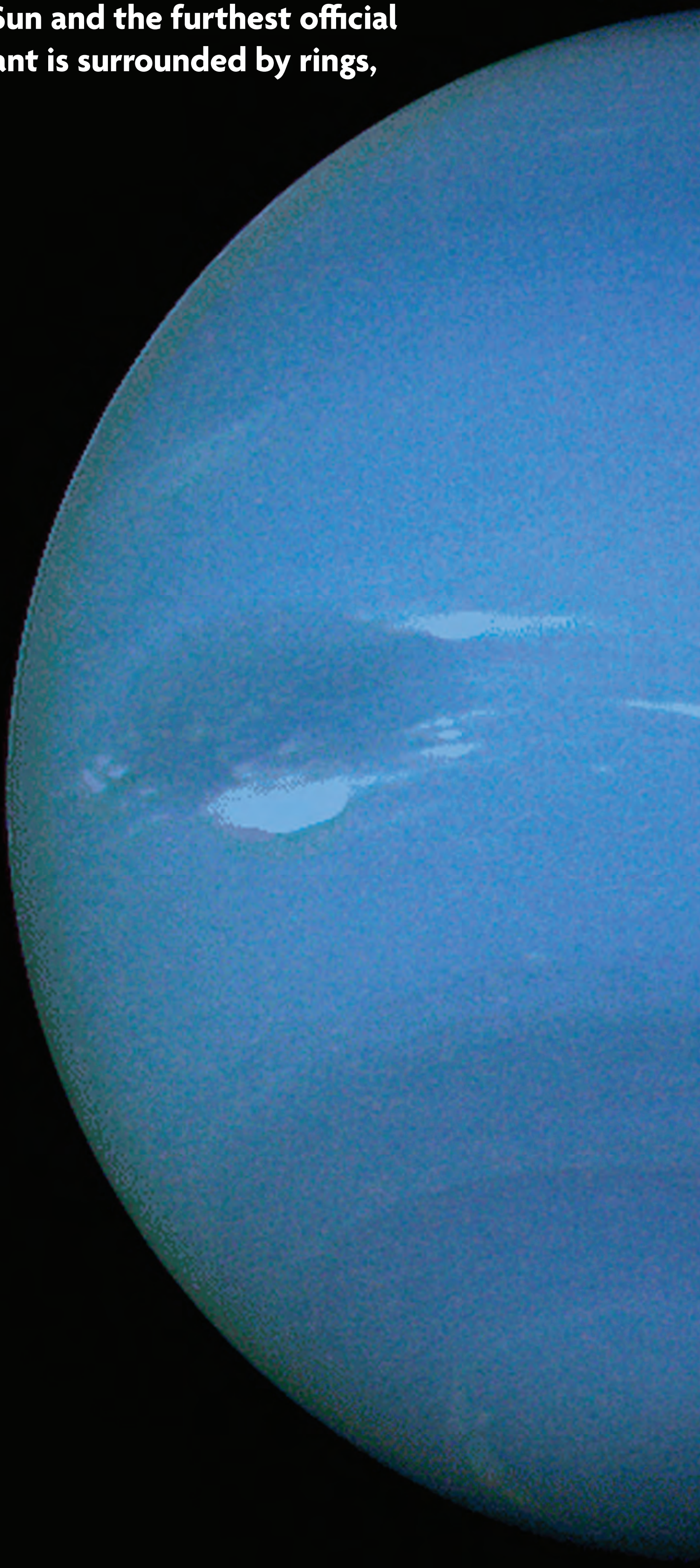
Neptune's Great Dark Spot and high altitude clouds, seen by Voyager 2 All picture credits: NASA



Nept

Neptune is the eighth planet from the Sun and the furthest official planet in the Solar System. This blue giant is surrounded by rings, dust and, at least, fourteen moons.



Voyager 2 captured this image of Neptune in 1989 during the only mission to the planet Credit: NASA

Human exploration

Whereas a few years ago, Britain was only committed to robotic exploration of our planet and solar system, the UK Space Agency now includes human exploration in its strategy. Some of the first to benefit will be the scientists, engineers and educators supporting British ESA astronaut Tim Peake's six-month mission to the International Space Station (ISS) starting in November this year.

Once again science – and the applications of science – are top of the mission agenda. The UK's £49.2 million commitment to the ISS will enable UK researchers to participate in studies using the microgravity environment.

"The ISS as a multidisciplinary facility, operating in microgravity, is quite incredible," says Castelli. "We can really use the unique environment on the ISS to push the limits to develop new lightweight strong materials."

Other research on the ISS includes investigating how bones degrade in microgravity conditions. "This will have applications into better understanding bone loss and aging," says Castelli.

A Russian Soyuz launcher at Baikonur. ESA is working with Russia to develop new exploration missions **Credit:** ESA

ESA is developing a mission to the Moon. This image was taken with the Agency's Rosetta spacecraft during its journey to comet 67P **Credit:** ESA

Moon mission

Both Europe's missions to Mars – the ExoMars 2016 and ExoMars 2018 missions – are being undertaken in partnership with the Russian Space Agency. ESA is also in talks with Russia to develop unmanned missions to the Moon.

"We've got lots of possibilities of how we can work with the Russians to put British technology onto these missions," says Horne. "It's building up a partnership for a future mission to bring back samples of the Moon." The long-term aim of developing a sample return capability is for a mission to bring back to Earth soil and rock from Mars – a project that the UK is keen to be a part of.

"Mars sample return is the ultimate goal," says Horne. "In joining a programme we recognise that not only could this answer a fundamental question about whether there is life on Mars, there's a lot of technology that can be spun-out from a mission like that."

However, as with most areas of research, it is often difficult to predict the wider benefits of exploring space. The first priority of space science missions, whether with humans or robots, is the search for new knowledge and that requires pushing the boundaries of existing technology.

The ExoMars rover, for instance, needs to survive the launch and journey to Mars, land safely, navigate its own way across the red planet with minimal instructions from Earth and drill into the surface to look for signs of life. Every one of which is enormously challenging.

Back in the Mars Yard in Stevenage, the engineers are well aware of the work they have to do in the next three years. "We don't underestimate its complexity," says ExoMars Rover Project Manager, Van Odedra. "We have a group of very talented engineers who are motivated to deliver this programme successfully and payback the trust the UK Space Agency has placed in us."

Space: the health benefits

Hubble image of the Horsehead Nebula – telescope technology has been applied to medical diagnostics **Credit:** NASA, ESA

Sue Nelson discovers how scientists and engineers are using off world technology to save lives on Earth...and help you sleep better:

As regular *space:uk* readers will know, spin-offs from space amount to far more than non-stick saucepans. Scientists from ESA's Rosetta mission to a comet, for instance, will help British submariners breathe more safely. Concepts behind technologies developed for space can detect cancers and bed bugs, and satellites are helping to manage the current Ebola outbreak in Africa.

In fact, science from space has always made an impact in the fields of health and medicine. The digital signal processing used to computer-enhance pictures of the Moon taken during the Apollo programme, for example, contributed to body imaging techniques such as CAT scans and Magnetic Resonance Imaging.

Technology from the Hubble Space Telescope produced advances in a digital imaging breast biopsy system. Other space industry spin-offs include transmitters to monitor a foetus inside the womb and a cool-suit that can treat various medical conditions by lowering the patient's body temperature.

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Nuclear submarines

When the Rosetta spacecraft made global headlines after it successfully orbited comet 67P and deposited its Philae lander onto the surface, one of its British-built instruments also produced an unexpected application for the UK's Trident nuclear deterrent.

"Nuclear submarines are amongst the most complex machines ever devised, patrolling a hostile environment 24 hours a day, 365 days a year, in some of the most remote places known to man," says Mark Scaife, Engineering Manager at BAE Systems Submarines.

Monitoring the atmosphere inside a submarine to keep the crew fit and healthy is therefore extremely important. To improve the existing technology, BAE Systems and the Ministry of Defence turned to the Open University's (OU) Space Instrumentation Group to develop a vital piece of safety equipment to be used on board future Royal Navy submarines.

The OU in Milton Keynes, together with RAL Space in Oxfordshire, had developed and built the Rosetta comet lander's Ptolemy instrument. The size of a shoebox, it analyses the composition of chemicals and isotopes in the comet's nucleus. Technology that turned out to be perfect for submarines.

It is vitally important to measure air quality in submarines **Credit:** MOD

Metal tube

"A submarine is a big metal tube with about 130 people in it and they go under the water for several months at a time. Nothing goes in and nothing goes out so that means they have to make their own air," says Geraint Morgan, who led the OU team.

"Submariners need to be able to measure the quality of the air continuously and be given alarms to sort things out, ranging from having several hours to do something, through to putting on breathing apparatus," says Morgan.

Space scientists applied expertise gained from working on both Ptolemy and another instrument designed to detect gases on Mars – since most of the team had also worked on Beagle 2.

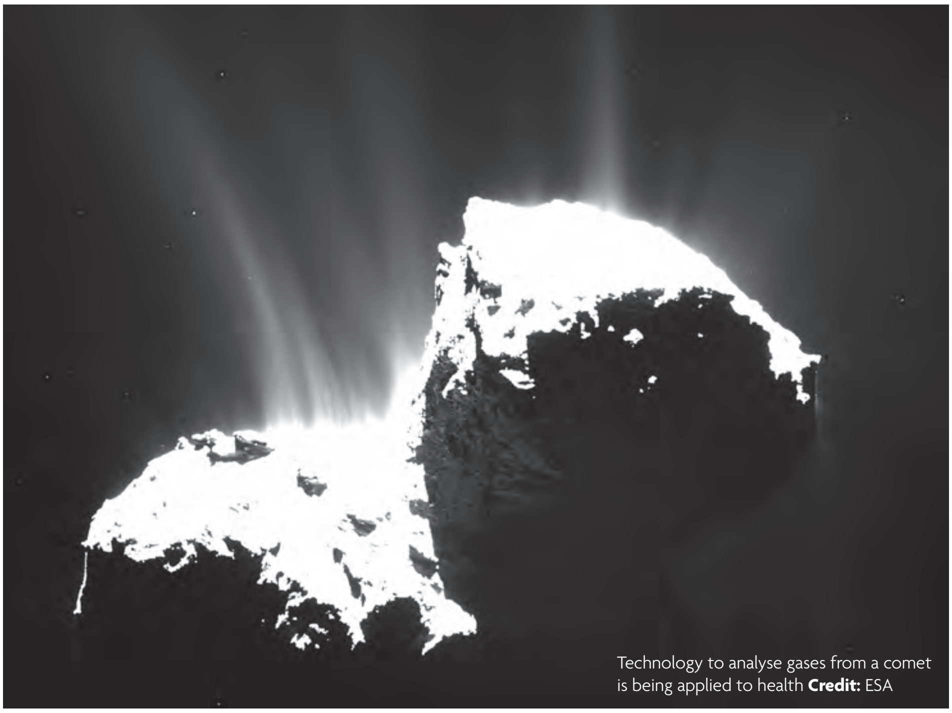
"The link is the challenges, the way we have to think," explains Morgan. "The multi-disciplinary team needed to build a space instrument can apply themselves to challenges such as a submarine."

The application worked. "The Atmosphere Analyser is capable of giving real-time readings to crews so they can react quickly to any dangerous build-up of gases," says Scaife. "It's an invaluable safeguard and one that can potentially save lives."

"The system we've developed is an enhancement on the existing system," says Morgan. "It's smaller, cheaper, better and more importantly it's broken the 30 year American company monopoly on the Western submarine fleet."

According to Morgan, there are economic advantages too. "For the first time, the UK will have its own capability to have an air breathing system and the contract has been placed with UK company Analox to take it forward from our prototype."

The project was also completed in less than 18 months and the system has now become part of the design for the Vanguard replacement programme.



Technology to analyse gases from a comet is being applied to health **Credit:** ESA

Foam used to insulate the Shuttle's external tanks contributed towards better moulds for artificial limbs **Credit:** NASA

Ebola epidemic

Health benefits also result from different areas of space science. The combination of medical technology with simulations of the flow of fluids through rocket engines, for instance, resulted in a temporary heart pump for patients awaiting heart transplants. Even the foam that was used to insulate the Space Shuttle's external tanks contributed towards cheaper and better moulds for artificial limbs.

As an orbiting science laboratory, the International Space Station allows numerous experiments that give us a greater understanding of human physiology and disease. When ESA astronaut Tim Peake flies to the space station at the end of the year, microgravity research will take up a large part of his mission.

The satellites orbiting our planet also make an invaluable contribution to our lives. Satellite images in the immediate aftermath of natural or man-made disasters are already provided for free as part of the International Charter Space and Major Disasters, an international agreement between space agencies including the UK Space Agency.

So far satellites have responded to over 400 disasters in over 110 countries. These include the UK floods in 2007 and the aftermath of Hurricane Katrina in the southern United States in 2005.

In October 2014, the Charter was activated for the first time to assist with the response to a disease – in this case Ebola. The epidemic has claimed over 8,600 lives to date with more than 21,000 reported cases. This has been the worst outbreak since the discovery of the disease in 1976.

Images, including those from the UK-built and operated Disaster Monitoring Constellation of satellites, help international teams deploy medical staff and deliver humanitarian aid.

"We want to do more work on healthcare screening, and we're now working on the next generation of cameras which will be more powerful and more versatile"

Ken Wood, QMC instruments

British armed forces medical personnel preparing to open an Ebola treatment centre in Sierra Leone **Credit:** MOD

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Security screening

Meanwhile a detector, invented by astronomers at Cardiff University, is being considered for security screening at airports. The prototype uses new detectors to image terahertz radiation.

"Terahertz radiation has unique and interesting properies," says Ken Wood from QMC instruments, the company developing the technology. "It goes through clothing, paper and plastics but not through you. Unlike X-rays, it does no damage and doesn't shine anything at you."

Instead, it detects terahertz radiation emitted naturally from the body, as a result of our body temperature. This means it can detect a gun or knife beneath clothing. The device works like a video camera and can also scan people as they are walking, making it much faster than existing screening cameras.

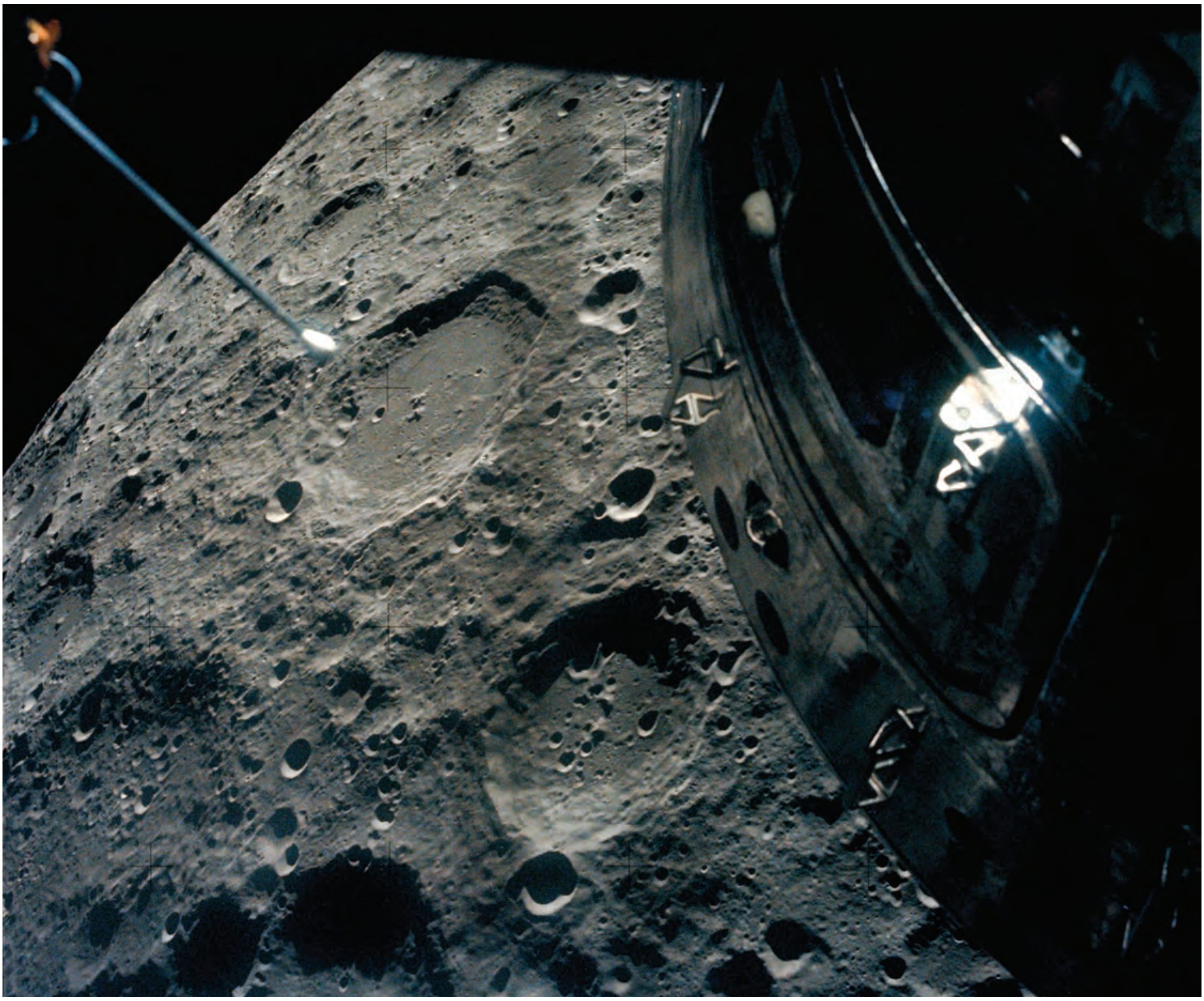
Terahertz radiation may also have another potential use in detecting skin cancer. Scientists believe that the terahertz image contrast between normal skin tissue and a tumour may result from differences in water content.

"We want to do more work on healthcare screening," says Wood, "and we're now working on the next generation of cameras which will be more powerful and more versatile."

The potential of space science applications is endless but it certainly helps to have an entrepreneurial spirit and plenty of ideas – something Gareth Morgan has in no short supply.

He's set up several companies, including Oxford Micro Medical (OMM) based at ESA Harwell. OMM is currently working on producing a more affordable instrument to identify infections caused by *Helicobacter pylori*. This bacterium, which leads to ulcers and gastritis, infects a large number of people all over the world.

The instrument, which is in the form of a breath test, works after a patient takes a urea tablet containing a carbon isotope. If the bacterium is present, the test detects a specific chemical signature in the gas.



The Moon seen through the lunar module window of Apollo 13. Digital signal processing used during Apollo contributed to CAT scans and Magnetic Resonance Imaging **Credit:** NASA

Robot dog

Morgan is also collaborating with Cranfield University and Amersham Hospital to develop new analytical methods and mathematical algorithms that can detect cancer. "Our work on cancer is based on the 2004 findings that suggests dogs can smell cancer," he says, "particularly bladder cancer."

The most important potential application is prostrate cancer. "We might be able to provide the NHS with a non-invasive, relatively quick diagnostic technique that is able to differentiate between benign prostate hyperplasia and prostate cancer."

Morgan and his team are about to validate the technique in partnership with the Oxford University Hospitals NHS trust. "Effectively what we've produced is a robot dog that can work 24 hours a day, 7 days a week, 365 days a year," says Morgan. "Clinicians need to make the best decisions for their patients and this adds another important piece to the puzzle."

Tim Peake undergoing physical tests at the European Astronaut Centre in Cologne, Germany **Credit:** UK Space Agency, Max Alexander

Imagination, it seems, is the only limitation to what can be achieved through space know-how. Even so, detecting bed bugs is not necessarily the first application that comes to mind when you think about space.

Yet Insect Research Systems Limited, which Morgan set up with Jason Littler, a pest controller from Manchester, is developing technology for detecting and monitoring bed bugs in hotel rooms.

Bed bugs produce pheromones and these chemical signatures are key to finding them. "We're doing exactly what we do on the comet. We sniff, we separate, we detect."

The ISS will bring benefits to Earth **Credit:** ESA, NASA

"The system we've developed is an enhancement on the existing system, It's smaller, cheaper, better and more importantly it's broken the 30 year American company monopoly on the Western submarine fleet"

Geraint Morgan,
(OU) Space Instrumentation Group

Farming from space

Max Dafforn (left) and Julian Gold (right) surveying the fields with the help of a tablet computer **Credit:** Boffin Media

Space technology is transforming the way we grow our food:

On a bitterly cold and overcast winter's day, farm manager at Hendred Farm Partnership, Julian Gold, stands on the edge of one of his Oxfordshire fields studying an iPad. The land, sloping away before him, is covered in hundreds of rows of low green shoots of winter wheat stretching away towards distant woodland.

Although the field appears relatively featureless, the tablet computer shows that there is much more to this landscape than first meets the eye. The screen reveals blocks of different soil types, hidden paths for machinery as well as the amounts of fertiliser that have been applied to various parts of the land.

"If we know exactly where we are in the fields, we can map these large fields up into little chunks," says Gold. "It gives us the ability to treat the different areas of soil differently."

Self-driving technology

Gold terms the boundaries between these areas "invisible hedges" and tracks them using a GPS satellite navigation receiver in his tractor cab.

"If you're drilling a crop for instance we can automatically adjust the drill for different soil types within the same field," Gold explains. "As we've already mapped the field out, the box in the tractor cab knows when we're entering a particular soil – whether it's light or clay – and will adjust the rate of drilling automatically."

The satellite navigation signal Gold uses is augmented by a reference signal from a nearby ground station. This provides the farmer with a position accurate to a few centimetres, which also gives him the ability to control where in the fields tractors and machinery can operate.

In the past, tractors and combines on Gold's farm were driven across most of the ground potentially damaging the fragile biology of the soil. Today, they use satellite navigation signals to steer themselves along virtual lanes through the field while pulling implements of a standard width.

"Every time you drive anywhere, you're compacting the soil – a combine, for instance, weighs about 30 tonnes," says Gold. "Now we're only driving on a small amount of the fields, on lanes ten metres apart, there's far less damage to the soil."

This farming technique is known as "controlled traffic". Not only do these invisible lanes keep the soil in much better shape, by not using so much fuel and labour to break up soil that has been compacted, they also save the farm money.

For safety reasons (so, for example, they do not accidentally run anyone over) an operator still needs to sit in the cab but the tractor's steering wheel moves by itself. This means anyone using the technology can focus on what is going on behind the tractor with the implements, or even talk to colleagues on the phone. They no longer have to concentrate on just keeping the tractor moving in a dead straight line.


Gold's farm uses a combine with an extended pipe for unloading grain, to ensure it keeps to the invisible lanes in the field **Credit:** Hendred Farm Partnership

Precision farming

Satellite navigation is not the only way space is helping farmers. Gold uses software developed by Intelligent Precision Farming (IPF), one of several UK companies that supplies farmers with information from Earth observation satellites.

"The satellite providers we use scan the whole of the UK every five and a half days," says Max Dafforn, IPF Technical Marketing Manager. "We use this information to provide farmers with maps showing crop greenness and thickness."

This information, which can be loaded up on smartphones and tablets, enables farmers subscribing to the service to control how much fertiliser and pest control treatments to apply to particular areas. Rather than spraying a whole field, they can target where to apply chemicals.

"What you're trying to do all the time is optimise the use of scarce and expensive resources," says Gold.

"Nitrogen fertiliser is one of the most expensive inputs and environmentally damaging," he says. "If you put too much on a field and the crops can't take it up, it leaches into water courses or gets emitted as a harmful greenhouse gas."

The key to the system is IPF's "online toolbox" – which pulls together all the data from satellites and maps with soil samples taken on the ground and information provided by farmers. This aims to overcome the problem of farmers being overwhelmed with too much data. It also enables IPF to analyse the mass of information the system across the UK generates.


A satellite image of Gold's farm indicating crop growth **Credit:** IPF

"We've got a huge amount of data we can run analysis on," says Dafforn. "We're able to compare 500 farms using different farming systems and analyse the yield benefits for each type of farm." As a result they have been able to help some farmers increase yields by around 6.5%.

IPF recently won the UK section of the European Satellite Navigation Competition for a mobile app, called seeCrop. Designed to allow farmers to upload precise location information on disease, pests and weeds direct from their fields, it should help make treatment of the affected areas even more precise.

A few years ago only a few UK farmers were using space technology, now it is increasingly commonplace on farms large and small. Ultimately, improvements in farming efficiency should help keep food prices down for all of us, as well as reducing the environmental impact of intensive farming.

"If we can produce more from less," says Dafforn, "that has huge benefits for everyone."

Ten years on Titan

John Zarnecki
Professor of space science
Open University

Michele Dougherty
Professor of space physics
Imperial College London

In January 2005, the international Cassini-Huygens mission made history. After a seven-year journey and a two and a half hour descent, ESA's Huygens probe landed on Saturn's largest moon, Titan.

Space:uk talks to two of the senior UK scientists involved, John Zarnecki and Michele Dougherty, to find out what we have learnt about Titan and its neighbouring moon Enceladus:

What was your involvement in the mission?

JZ: I was one of the six Principal Investigators on Huygens. There were six instruments and mine was the surface science package. It was the only one whose prime aim was to make measurements from the surface of Titan.

MD: I am Principal Investigator of Cassini's Magnetometer instrument, which measures magnetic fields.

Where were you when Huygens landed on Titan in January 2005?

JZ: I was at ESOC (ESA's mission control in Darmstadt, Germany). I'll never forget that day. It was incredibly tense. It was literally 15 years of my life on the line and it was possible we'd get nothing at all. The first inkling we got was when one of the big telescopes picked up the carrier signal from Huygens - which meant it was transmitting, it had arrived and was descending under the parachute. It was absolutely fantastic.

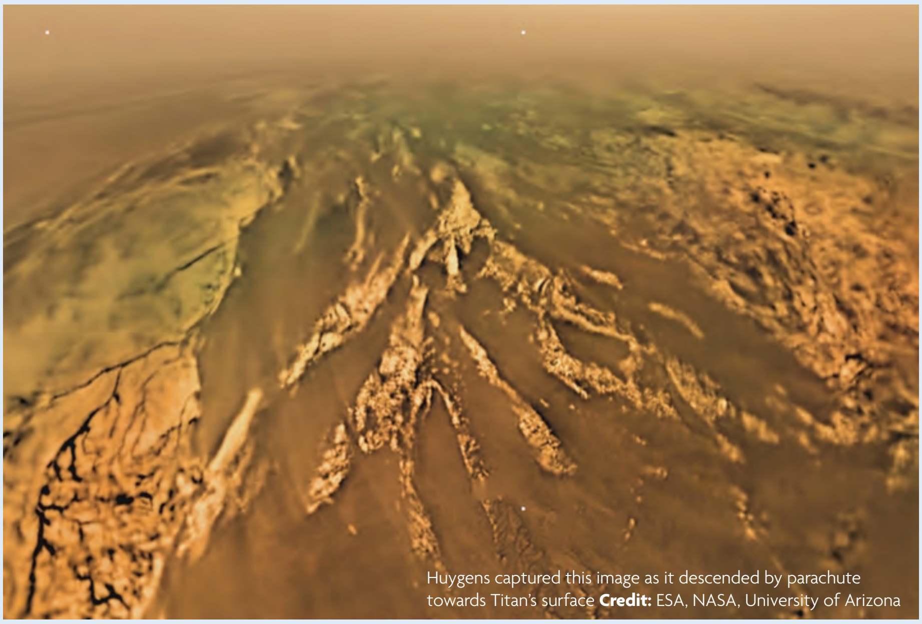
How did you celebrate?

MD: A good bottle of champagne or two were consumed.

JZ: I think if you're at NASA, alcohol on the premises is a sackable offence. Fortunately ESA is more civilised. So the champagne started flowing. It was very emotional and, like many people, I went into a corner and shed a little tear.

The first thing to touch the surface of Titan was made in Britain, what was it?

JZ It was our instrument of course: the penetrometer - one of the nine sensors in the surface science package. We had no clue when we designed it whether we'd land on liquid or land. So we came up with this package of sensors for whatever the landing scenario was and for 15 milliseconds, 15 thousandths of a second, it was the only part of the probe interacting with the surface and in that very short time we were able to work out something about the nature of the stuff we were landing on.



Huygens captured this image as it descended by parachute towards Titan's surface **Credit:** ESA, NASA, University of Arizona

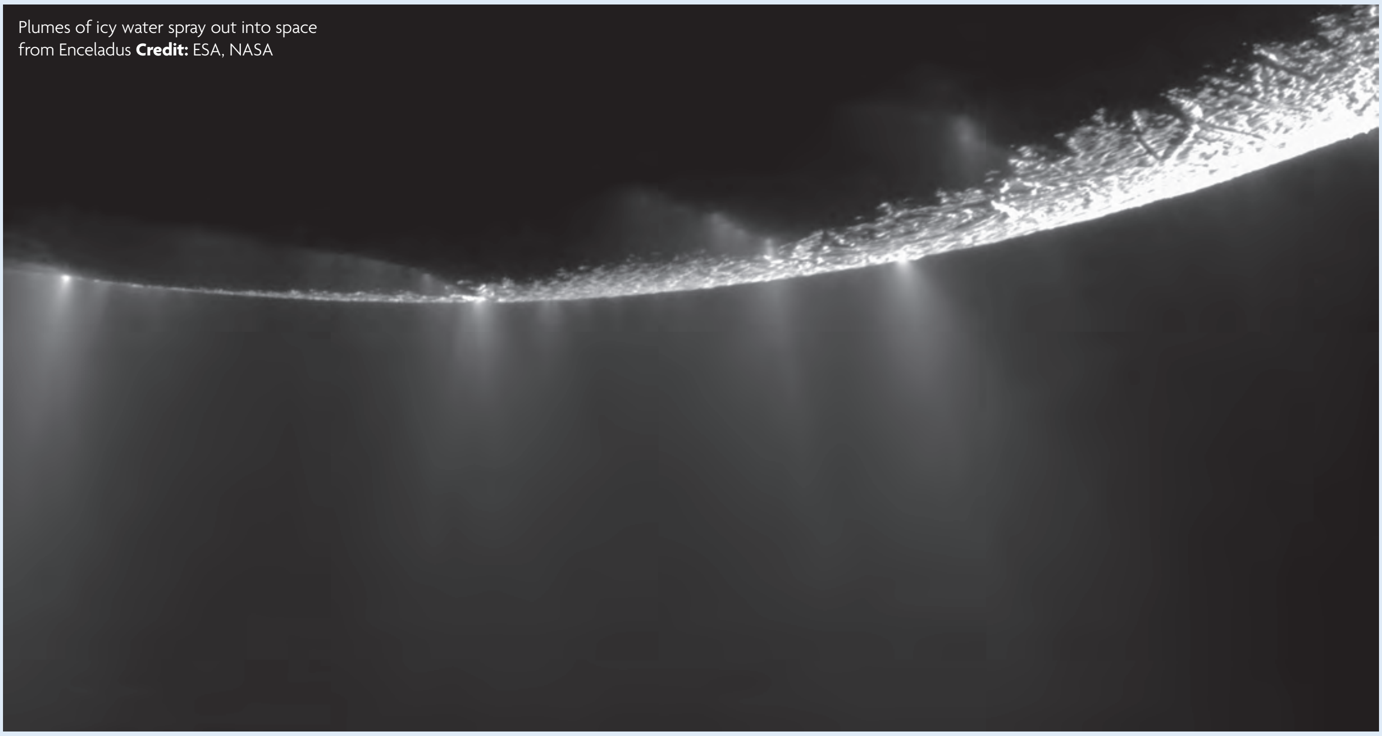
What did the Huygens probe land on?

JZ: We're pretty sure we ended up on a damp dry lakebed.

What did your instruments measure during the descent?

JZ: We got information about the atmosphere. We measured turbulence and the composition of the lower atmosphere, and the local topography around the landing site. We also measured the thermal conductivity and nature of the surface at the impact site.

MD: We took data as the probe was being released from the spacecraft so we could see the rate it was spinning. Our magnetometer instrument is in action for the entire mission. The Cassini spacecraft has flown past Titan about 100 times now so we've got a much better take on what the environment is like and how the background magnetic field of Saturn changes depending on where Titan is in its orbit.


Plumes of icy water spray out into space from Enceladus **Credit:** ESA, NASA

What did this information tell you about Titan?

JZ: It helped to paint the picture of what the place was like at the landing site. What we know now from Cassini, which flies past Titan roughly every 40 days, is that it's quite a varied and incredibly complex place. At the back of our minds we were worried it might be boring and bland but it's got great seas and lakes, rivers, tributaries, hills and small mountains. It's got dune fields – sort of like sand dunes but it's not sand, we're not sure what it is – but about 10-20% of the surface is covered by it. It's possibly got low temperature cryo-volcanoes and it's got weather with clouds and rain. We actually see the sea change shape maybe because it evaporates but the coastline changes. It's a dynamic place.

What is the most important thing you've learnt so far?

JZ: If I had to say one thing it's that Titan is the only other place in the entire Solar System with surface seas.

MD: Saturn's moon Enceladus is the real surprise because it's a very small moon. Its diameter is only 50kms and for a body that small you'd expect that its interior would be dead. When we saw these draped magnetic field lines, which were essentially implying there was an atmosphere of some kind, it was a real surprise. That was when we were able to persuade people to get Cassini to go closer and all the other instruments were able to observe the atmosphere, the plumes of water, the organic material on the surface, the cracks on the surface and the fact that internal heat is leaking out of these cracks. We still don't understand it completely but I think it's the most important discovery that Cassini made – and not just because my data saw it first!

Do you think we will find life on one of Saturn's moons?

MD: I think the best that we can do, at least for the next 30 years or so before another mission goes there, is confirm whether we think the conditions for life to form are there. It's a long slow process. You need heat and at Enceladus, for example, you have a heat source. You need water, which we have at Enceladus. You need organic material and we've got that at Enceladus as well. The fourth thing is you need the conditions to be stable over a period of time long enough for an organism to form and we're not sure about that.

JZ: here's moderately strong evidence that sub-surface oceans might be quite common on icy moons like Europa, Gannymede and Enceledus. So sub-surface water is perhaps not that rare and that offers the opportunity for niches of life in a primitive form to exist. It could be that you drill down, scratch the surface and find life that's sat there quite happily for millions of years.

Have you analysed all your data?

JZ: I'd say around 95%. The probe survived for 72 minutes. Some of that data is hard to interpret so it's still possible we might be able to squeeze something out of it.

MD: No – because we keep getting new data all the time. In some ways Cassini is still a discovery mission and I expect us to continue to learn stuff even 10-15 years after the mission ends in 2017. We've got a really exciting time in front of us. What we're going to do is get inside Saturn's rings, we're going to skim the top of the atmosphere and that's going to allow us to measure the internal planetary magnetic field because we still don't understand it. It's going to be great. I can't wait.

Summer in space

Chris Beard's experiences at ESA's Summer Teacher Workshop opened up a whole range of new teaching opportunities:

In 2012, I joined other teachers from across Europe at the European Space Research and Technology Centre (ESTEC) in the Netherlands to learn more about bringing space into the classroom. Surrounded by space capsules, model rockets and mock-ups of the International Space Station (ISS), sessions ranged from meeting an astronaut and building a radio transmitter, to calculating the wind speed on Venus.

Once I returned to my school, the learning and development did not stop. Not only could I bring resources home to enhance learning for my students, I was also able to develop opportunities through the networking element of the workshop. One of the best examples of this was working with the Human Space Flight Operations education team.

With their help I was able to take a group of students over to ESTEC to use ESA's amazing facilities. Working with scientists and engineers, the students carried out their own microgravity experiments using a drop tower. This once in a lifetime experience has had a lasting effect on staff and students alike. One of the students involved has even chosen to study aerospace engineering.

The following year I was invited back to the workshop as a presenter, to share my knowledge and experience with other teachers. I have also continued to lead and take part in teacher professional development in the UK and have had the pleasure of meeting and working with a large number of inspiring teachers, experts and space ambassadors. All this has had a lasting impact on both me and my students.

With the excitement of the Rosetta mission and Tim Peake's forthcoming flight to the ISS, space exploration is once again proving to be an inspiring, engaging and – more importantly – relevant and current topic for young people. As educators we cannot miss this opportunity to use space as a context for leaning across the curriculum and especially within Science, Technology, Engineering and Mathematics (STEM).

In addition to the ESA Summer Workshop for Teachers, the National Space Academy, National STEM Centre and UK Space Agency run CPD sessions for all teachers in the UK. The majority of these courses are either free, attract funding or are heavily subsidised. They not only allow educators to develop their own practice and professional development, but have a direct impact on students' experiences and outcomes.

The UK European Space Education Resource Office (ESERO) advertises opportunities to attend the ESA Summer Workshop for Teachers. It also provides details of the other CPD courses as well as news stories, links to resources and information about competitions and projects that students can get involved in:

www.esero.org.uk

Chris Beard is the Lead Teacher for STEM at Manchester Communication Academy and is also the Regional Hub Coordinator for the National Space Academy.

Teachers getting to grips with space science at ESTEC **Credit:** ESA

Essex-based e2v designs and manufactures imaging sensors for space missions. These include Rosetta, the Hubble space telescope and the Gaia galaxy-mapping observatory. The company's President of Space Imaging is Marc Saunders:

Marc Saunders

What does e2v do?

We're a specialist technology company, mainly working in the areas of medicine, space and aerospace. Our imaging division – of which space is a part – makes sensors for a whole range of applications. These include scientific cameras and x-ray sensors for dentistry, as well as sensors for spacecraft.

What sort of sensors do you make?

We make large and very sensitive imaging sensors. These convert light into an electrical charge. They are designed to work in very low light conditions. So, for example, with a space telescope like Hubble or ESA's Gaia observatory you are looking at objects that are a long way away and extremely faint. So you need cameras that can turn only a small number of photons into a signal that you can see.

Your sensors have been fitted to a wide range of spacecraft, including ESA's Rosetta comet mission?

We have five different instruments on Rosetta, which means that almost all the images you see from Rosetta come from e2v sensors. These include a navigation camera, the main high-resolution camera and also the spectrometers – used to study what the comet is made of and the chemical composition of any gases emitted. There are also a couple of cameras on the Philae lander itself. Those pictures we saw of the crater wall that the lander ended up against came from one of our cameras.

Are you optimistic for the future of the space sector?

The space business is a significant part of the UK's economy, worth some £11.3 billion. There is now a deep supply chain for space technology in the UK – everyone from camera manufacturers like us, companies developing electronics, software and optics, up to satellite manufacturers. It's a market that's seeing a lot of investment, making the UK the place to develop and build space technologies.

Image top right: Hubble witnesses a star being born, thanks to sensors made in Essex
Credit: ESA, NASA

Bottom image: Fitting the sensors to the Gaia spacecraft. Gaia is producing a 3D map of our galaxy
Credit: e2v, Airbus Defence and Space

European Space Agency

Forty years ago, ten European nations signed a convention to set up the European Space Agency (ESA).

ESA was established in 1975 to bring together European nations to advance space science, applications and technology. The UK was one of the founder members and Britain's Roy Gibson became its first Director General.

ESA was formed from two pioneering European space organisations: the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO). ESRO already had an established track record in building and launching space science missions and ELDO had laid the groundwork for the development of the Ariane series of launchers.

Assembling ESA's first satellite, Cos-B **Credit:** ESA

ESA's first mission, Cos-B, was designed to study gamma-ray sources in our galaxy. It was launched in August 1975 on a two-year mission but remained operational until 1982.

Over the past forty years, ESA has built dozens more missions to explore the Solar System and beyond. It has also developed sophisticated Earth observation, navigation and communications satellite systems.

ESA has its own astronaut corps and works with international partners on missions such as the Hubble Space Telescope and Cassini-Huygens. It has even landed space probes on a moon of Saturn, a comet and Mars.

The UK continues to play a major role in ESA. The Agency's new centre at Harwell near Oxford – the European Centre for Space Applications and Telecommunications – is named in honour of the first Director General, Roy Gibson.

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