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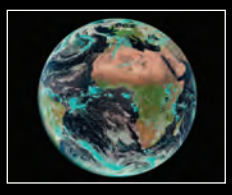

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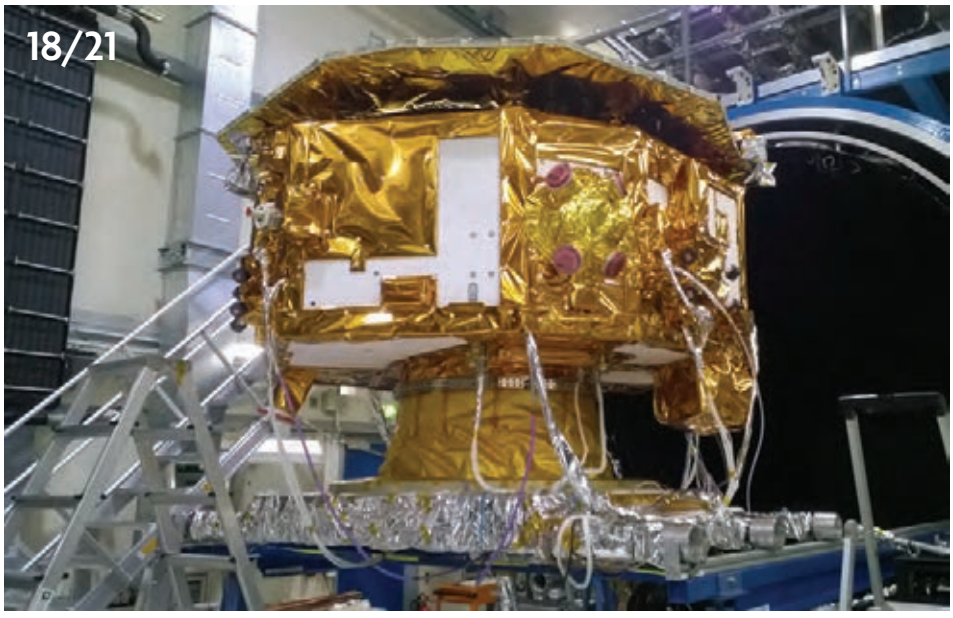

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Front cover image An Aurora over the British Antarctic Survey's Halley research station **Credit:** BAS

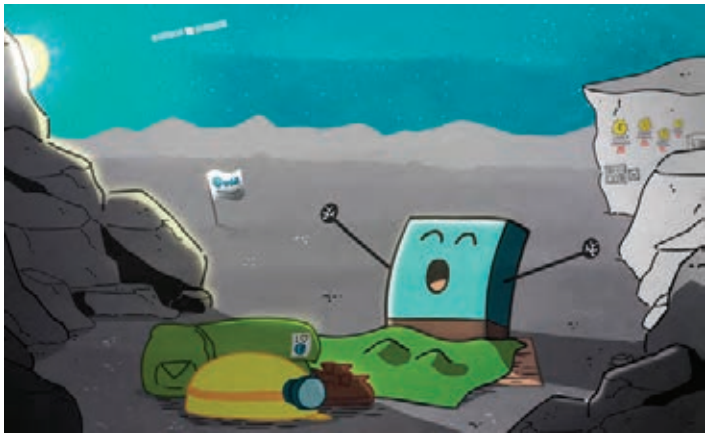
Rosetta's lander wakes for science

In June, seven months after going into hibernation, Rosetta's Philae lander made headlines once again after waking up and sending back a short signal from the surface of comet 67P/Churuymov Gerasimenko.

"It's great to have Philae pipe up that it is alive and well," Rosetta's Project Scientist, Matt Taylor, told *space:uk*.

Rosetta, which launched in 2004, became the first space mission to orbit a comet and then, in November 2014, to land on a comet. The landing was an extraordinary success despite Philae making a breathtaking series of unexpected bounces before finally settling and sending back the first images from the surface of a comet.

Philae performed 57 hours of science before going into hibernation as planned. However, its final resting place was not in the middle of a chosen plain but in a shady area with limited access to sunlight. As a result, the hibernation was longer than planned.



Philae has woken from hibernation to send back more data from comet 67P **Credit:** ESA

Back to work

The comet is approaching its closest distance to the Sun, perihelion, in August and the lander has begun to receive more and more solar energy, enabling it to begin its wakeup. The first signal received by the orbiter was only 85 seconds long, the second even shorter. Since then signal windows have lasted for several minutes.

"We are working hard to maximise our communication opportunities," said Taylor, "to try and turn these fleeting contacts into some solid conversation chunks, which will allow us to uplink science operations commands and get Philae back to work."

UK scientists and industry are involved in multiple aspects of the European Space Agency (ESA) mission, including the UK-led Ptolemy instrument. "Members of the Ptolemy Team are delighted with the news that Philae has re-established communication," said Ian Wright, Ptolemy's Principal Investigator and professor of planetary sciences at the Open University.

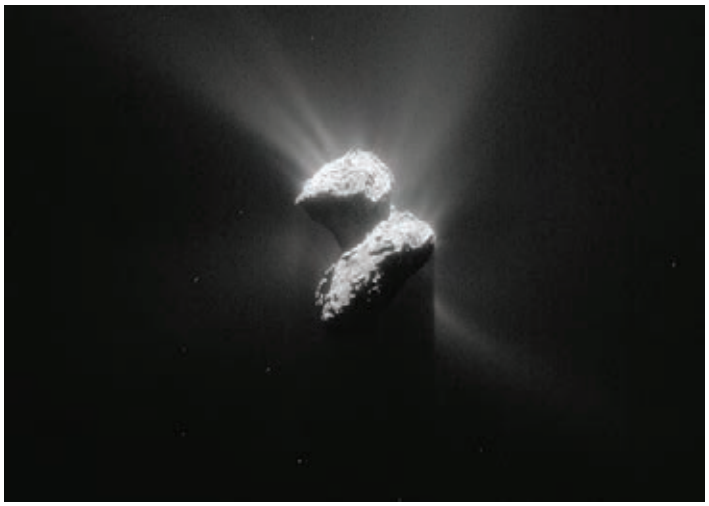
Philae's selfie showing one of the lander's legs, taken shortly after touchdown on the comet **Credit:** ESA

"There is still a way to go in order to achieve a completely stable signal, but we are now poised to execute some of the operations that we have been planning over the last six months," said Wright. "It is incredible to think that we are on the verge of conducting investigations that are way beyond anything we could have hoped for at the time the mission was designed."

Rosetta has performed unprecedented close orbits of the comet, some closer than 10km from the surface, before orbiting further away as the comet's activity increases. The orbiter will now be manoeuvred closer to the comet to try and establish a longer connection. But it must stay out of harm's way from the jets of dust and gas streaming away from the comet.

ESA has extended the Rosetta mission until the end of September 2016. "The next months are very exciting for the orbiter," said Taylor. "We can look forward to lots of cometary activity. This will be both challenging from an operational perspective and rewarding from a science perspective, as we experience the comet at its most active."

For more on comet 67P see our pull-out poster



The duck-shaped comet is becoming more active as it nears the Sun **Credit:** ESA

Destination Mercury

A key instrument for Europe's first mission to Mercury has been completed by a team at the University of Leicester.

The Mercury Imaging X-ray Spectrometer (MIXS) has been integrated into the European Space Agency's (ESA) BepiColombo spacecraft, which is due for launch in 2017. The instrument – built in the UK, funded by the UK Space Agency and led by the University of Leicester's Space Research Centre – will identify chemical elements in the planet's surface by measuring fluorescent X-rays.

"The team has worked incredibly hard over many years to design and build such a complex instrument," said Emma Bunce, MIXS Principal Investigator and professor of planetary plasma physics at the university.

"It has been a very challenging project from a technical point of view," she added, "as the instrument needs to survive extreme temperatures at the orbit of Mercury, which is perilously close to the Sun."

Mercury's harsh environment means MIXS will endure temperatures of up to 350°C while gathering data using specialised X-ray optics. Scientists will use information collected by the instrument to better understand how Mercury formed. It will provide an insight into the evolution of the Solar System and increase our understanding of how planetary surfaces evolve and change over time.

Deliberately crashing

BepiColombo will study Mercury's composition, geophysics, magnetosphere and atmosphere. It will be only the third mission to Mercury after NASA's Mariner 10 probe in the 1970s and its more recent MESSENGER spacecraft, which ended its 11-year mission in April by deliberately crashing into the planet's surface.

"NASA's MESSENGER mission showed us that Mercury is a misfit planet," said MIXS Co-Investigator David Rothery, a professor of planetary geosciences at the Open University who also leads ESA's Mercury Surface and Composition Working Group.

BepiColombo is heading for Mercury in 2017. This image of the planet was captured by NASA's recent MESSENGER mission **Credit:** NASA

The Japanese-built Mercury Magnetospheric Orbiter recently arrived at ESA's facilities in the Netherlands **Credit:** ESA

"There's so much about it that we didn't expect and that we don't understand," he said. "MIXS is one of the instruments for BepiColombo that will help us sort things out."

As well as delivering the MIXS instrument, the UK has built much of the BepiColombo spacecraft at Airbus Defence and Space in Stevenage. UK companies also hold contracts for several other components of the mission.

There are three sections to BepiColombo – the Mercury Transfer Module, which is designed to get the spacecraft to the planet and two orbiters: the Japanese Mercury Magnetospheric Orbiter and the larger European Mercury Planetary Orbiter.

When it reaches Mercury in 2024, the ESA orbiter's 11 scientific instruments, including MIXS, will study the planet from a low orbit.

"The MIXS instrument for BepiColombo is an excellent example of the novel technology that is being designed and built in the UK for international space missions," said David Parker, Chief Executive of the UK Space Agency.

"The UK's considerable skill in new technology development is not only allowing us to explore our solar system," said Parker, "but is securing valuable contracts for UK industry while often creating products that can also be applied to other industries."

The night launch of Sentinel-2A Credit: ESA

Sentinel environment satellite launched

The second satellite in Europe's Copernicus Earth monitoring programme has been successfully launched. Sentinel-2A blasted off on a Vega rocket from the European spaceport in French Guiana on 23 June.

The satellite will be used to take pictures of the Earth in visible and infrared. As well as mapping the growth of cities, destruction of forests and the aftermath of disasters, the spacecraft will monitor food crops to help improve global food security.

The fleet of Sentinel satellites is being built by ESA, with investment from the UK Space Agency. UK involvement in the European Union's Copernicus programme is through the Department for Environment, Food and Rural Affairs.

"The launch of Sentinel-2A brings us another step closer to a new era in Earth observation," said Chief Executive of the UK Space Agency, David Parker.

Copernicus will eventually supply an unprecedented quality and range of environmental data to European governments, agencies and businesses.

The UK Space Agency and the Satellite Applications Catapult are funding a world-class data facility to provide full access to Earth observation data from the programme.

"The unique constellation of Sentinel satellites is set to live up to its name by watching over our planet and providing us with the vital data we need to solve the climate and environmental problems facing mankind," said Parker.

Several of the satellites involve UK industrial and academic teams, with the Sentinel 5 Precursor (S5P) satellite being built by Airbus Defence and Space in the UK.

Work is also progressing on the Sentinel 3 satellite. This will carry a sophisticated new instrument – the Sea and Land Surface Temperature Radiometer – which will be used to improve understanding of how the Earth's climate is changing.

The completed instrument has recently undergone a comprehensive series of tests at RAL Space in Oxfordshire before being shipped to France for installation in Sentinel 3.

"We are very much looking forward to obtaining data from the first Sentinel 3 mission," said Chris Merchant of the UK's National Centre for Earth Observation. "Because of the instrument's design and calibration, the sea surface temperature measurements we will derive from its images should be very trustworthy."

Debris agreement

A new agreement has been signed between five European countries to improve monitoring and tracking of space objects and detect their uncontrolled re-entry into the Earth's atmosphere.

The Earth is surrounded by a cloud of space junk **Credit:** ESA

There are an estimated 30,000 pieces of space debris surrounding the Earth. This 'space junk' includes failed satellites, fragments from redundant spacecraft and other space systems that can severely damage and even destroy orbiting satellites.

The UK Space Agency has long supported efforts to monitor the space environment and the Space Surveillance and Tracking Consortium Agreement – signed by France, Germany, Italy, Spain and the UK – is aimed at improving the tracking of this debris. It will also support satellite operators to help avoid collisions in orbit.

Space: in business

New initiatives to help grow the UK's £11.3 billion space sector have been announced by the UK Space Agency.

The Agency has signed an agreement with the broadcast regulator, OFCOM, which will see the two organisations work more closely together. With increasing demands on the radio spectrum – the basis for radio and wireless communications such as Wi-Fi or mobile broadband – the aim is to ensure that the space industry's needs are fully addressed.

The Government has also scrapped insurance premium tax for spacecraft operators. This will save money for any company insuring a satellite for launch, orbit or re-entry and brings the space industry in line with commercial aviation and shipping.

Printing spacecraft

The curved design of the bracket would be almost impossible to manufacture using conventional techniques
Credit: Airbus Defence and Space

UK-built satellites will soon benefit from components manufactured using 3D printing. The first printed aluminium component will be used on Airbus Defence and Space's Eurostar E3000 communications satellites as a result of a two-year research and development programme funded through Innovate UK and the UK Space Agency.

The printed part – a structural bracket for mounting antennas on the satellites – was manufactured for Airbus by 3T RPD Limited in Newbury.

Arctic station

UK satellite manufacturer and operator Surrey Satellite Technology Limited (SSTL) has installed a new ground station in the Arctic. The Svalbard transmitter and receiver will keep in contact SSTL's polar-orbiting satellites every 90 minutes as they pass over the North Pole.

The ground station has been fitted in Kongsberg Satellite Services' facilities in Svalbard and a high-speed data link has also been installed between the remote Arctic island and SSTL.

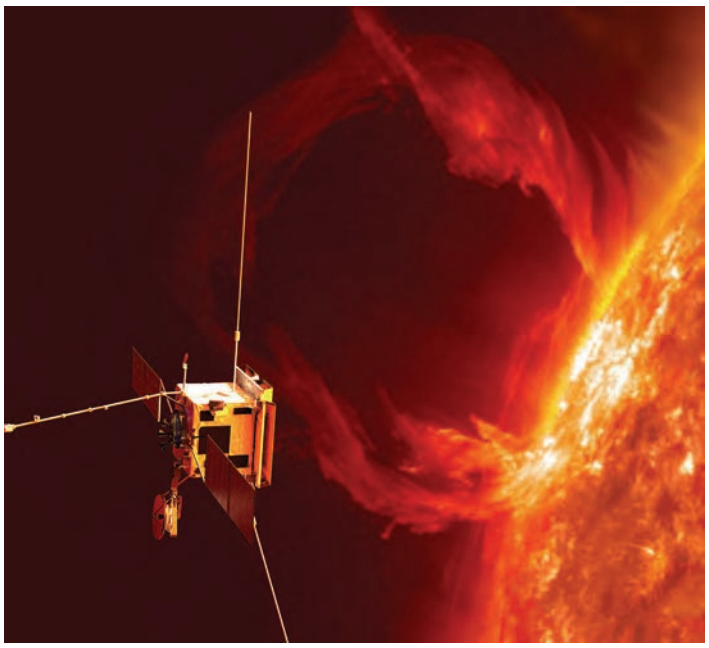
As well as the ground station, SSTL has completed a new Spacecraft Operations Centre at its headquarters in Guildford, Surrey. This control hub contains the infrastructure to track, command and control the company's growing fleet of orbiting satellites around the clock.

More than 20 spacecraft are currently being built by SSTL including a new Synthetic Aperture Radar (SAR) satellite, NovaSAR. This satellite – backed by £21 million from the UK Space Agency – will be used to capture images of the Earth day and night, in all weather conditions, and is useful for a wide range of applications. These include maritime surveillance of drug-trafficking and oil spills, environmental monitoring as well as tracking deforestation and flooding.

SSTL, which specialises in small satellites, has recently signed a contract with Canadian company UrtheCast, to build key systems for a constellation of 16 Earth observation satellites. UrtheCast already has strong connections with the UK space industry and currently operates HD cameras on the International Space Station. These were built in the UK by RAL-Space in Oxfordshire.

SSTL's new ground station is close to the North Pole in Svalbard
Credit: Kongsberg Satellite Services AS

Here comes the Sun



Artist's impression of Solar Orbiter **Credit:** ESA

A full-scale version of the Solar Orbiter spacecraft, built in the UK by Airbus Defence and Space, is on its way back to Stevenage after successfully completing three months of mechanical testing in Germany.

The Solar Orbiter's Structural and Thermal Model (STM) is used for important pre-flight testing of the spacecraft. It is virtually identical to the real thing, apart from replica components inside, and has the same size and weight. The mechanical tests ensure that the final spacecraft can survive the impact of noise and vibrations during launch in 2018.

"STM is a dummy spacecraft. It's got all the mass, mechanical and thermal properties but it doesn't work," said Ralph Cordey from Airbus Defence and Space.

By passing the mechanical tests, the spacecraft is an important step closer towards full construction of this joint ESA and NASA mission to study the Sun.

"This spacecraft has almost served its purpose at this stage and, now that we've tested that its results correlate against the computer predictions, we can get on with the business of building the real spacecraft," said Cordey. "The next stage will be to start the construction of the flight model."

The STM will return to Germany later this year for thermal testing but Airbus can start developing component parts for the final spacecraft. "The schedule from now until launch is building, final assembly and testing," Cordey explained.

"The spacecraft's individual instruments are being developed and assembled across Europe and the US," he said. "Over time they will make their way to Stevenage to be integrated into the spacecraft."

Protective skin

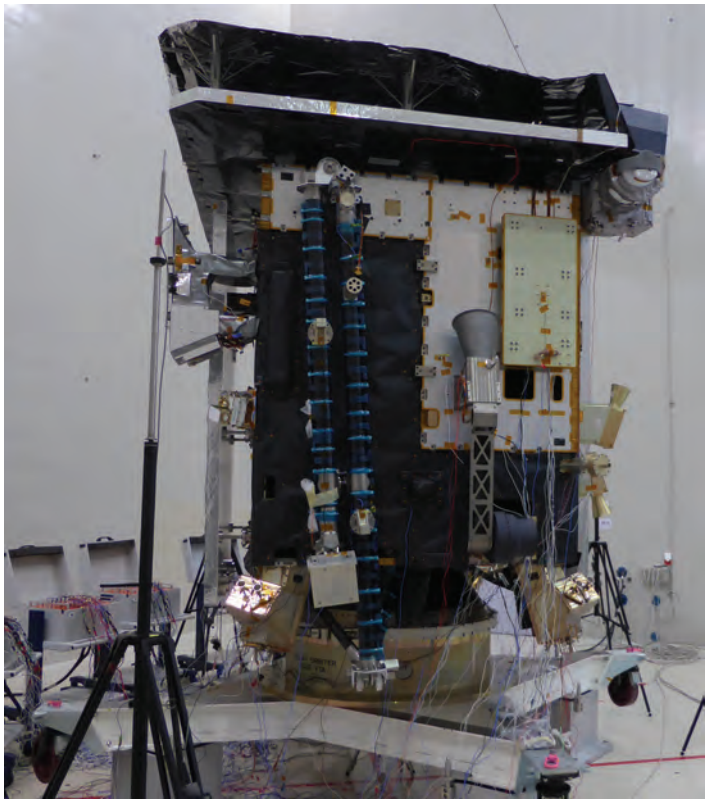
Thermal testing will be crucial as Solar Orbiter will fly closer to the Sun than any previous spacecraft. At its nearest approach, the light from the Sun will be thirteen times more intense than for satellites orbiting the Earth.

Solar Orbiter must survive the thermal radiation and also protect its instruments, allowing them to observe the nuclear reactor at the centre of our galaxy.

The design includes a heatshield made from several layers of titanium and coated by a specially developed protective skin as well as new high temperature solar array technology. Slightly oversized, the heatshield will ensure that parts of the spacecraft remain in the shade, while other regions heat up to around 600 degrees Celsius.

UK teams, funded by the UK Space Agency, are involved in four of the mission's ten instruments. Two of these are led by the UK: the magnetometer (Imperial College London) and the Solar Wind Plasma Analyser (University College London's Mullard Space Science Laboratory). Both these instruments are located on the spacecraft's two-metre long boom.

The Sun's energy supports life on our planet but its coronal mass ejections – violent eruptions of charged particles from the surface at speeds of between 500 and 2000 kilometres per second – also have the capacity to disrupt satellites and crash computers, power grids and communications. Understanding the Sun's behaviour is therefore vital to life on Earth.



The Solar Orbiter STM in the test chamber **Credit:** Airbus Defence and Space

Rocket (salad) science

The UK Space Agency has teamed up with the Royal Horticultural Society to give half a million children the chance to carry out their own space biology experiment.

Rocket Science will involve flying 2kg of rocket salad seeds to the International Space Station (ISS) as part of British ESA astronaut Tim Peake's six-month Principia mission. After several months on board, orbiting the planet at 27,000 kilometres per hour, the seeds will be returned to Earth and sent to thousands of UK schools together with a batch of seeds of the same cultivar that have stayed on Earth.

During the summer term of 2016, pupils will grow and compare the seeds. The results of the nationwide citizen science experiment will then be analysed to discover whether space travel has had an effect on the seed's growth.

"During my six-month tour, I'll be conducting a number of experiments on the International Space Station," said Peake. "I hope that Rocket Science will inspire the next generation to think scientifically, and to consider the fulfilling careers in Science, Technology, Engineering and Maths."

The Rocket Science project was launched at this year's Chelsea Flower Show, with an exhibition featuring a prototype Mars Rover. Interactive displays took visitors – including Her Majesty the Queen – through the past, present and future of plants in space. The exhibition highlighted the important role scientists play in helping plants to thrive in inhospitable conditions, how space exploration helps solve problems on Earth and the plants astronauts will need to survive long-term missions.

The Queen is shown a prototype Mars rover **Credit:** RHS, Bethany Clarke

"Britain's space industry is going from strength to strength," said the Minister for Universities and Science, Jo Johnson. "For this to continue it's right we inspire the next generation of scientists and engineers. Rocket Science is doing just that by giving thousands of schoolchildren the opportunity to play a part in Tim's mission, while learning new skills in a fun and unique way."

See page 24 for more on Rocket Science and other education projects

One of the displays in the Rocket Science exhibition
Credit: RHS Campaign for School Gardening

What effect does gravity have on plant growth?
Credit: RHS Campaign for School Gardening

Agency update

From new international partnerships to a whole raft of activity around Tim Peake's flight to the ISS, 2015 is shaping up to be a very productive and busy year for the UK Space Agency.

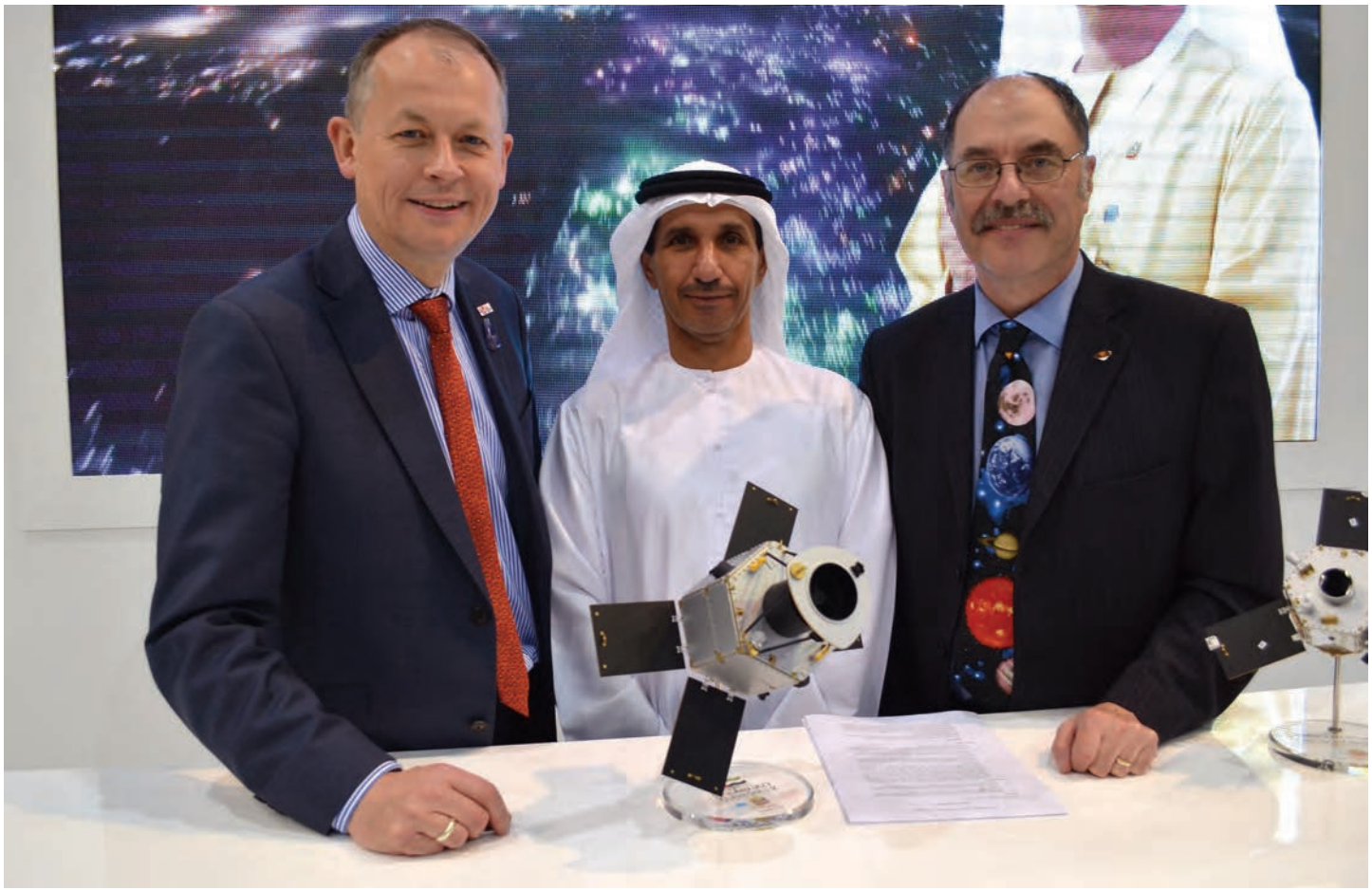
Following the UK general election in May, Jo Johnson MP was appointed Minister for Universities and Science with responsibility for the space portfolio. His first visit in his new post was to the Agency's stand at RHS Chelsea, where he learned how the Agency is using Tim Peake's Principia mission to engage schools around the country to think about science and engineering (read more about the Agency's stand at Chelsea opposite).

The UK Space Agency has also continued to work internationally. Chief Executive of the Agency, David Parker, delivered a keynote address at the launch of the new United Arab Emirates Space Agency. He also witnessed a deal for sharing satellite data between UK company Deimos and the Dubai government as part of the Agency's International Space Partnership Programme (see page 10). The agreement will provide regular information on changes in land use – including tracking infrastructure, vegetation and urban development.

The UK also recently became part of a Space Surveillance and Tracking Consortium. This has been set up to do more to monitor and track space objects as well as detect their uncontrolled re-entry into Earth's atmosphere. With France, Germany, Italy and Spain, the UK signed an Agreement at the International Paris Air Show to help protect European space infrastructure, facilities and services. These are essential for the safety and security of national infrastructures and economies.

Minister for Universities and Science Jo Johnson on the Rocket Science stand at RHS Chelsea **Credit:** RHS

The five countries are contributing use of their infrastructure to provide a service to monitor and track space objects and debris. They will also provide support for spacecraft operators and users with a service for collision avoidance, create surveys for fragmentation detection and monitor uncontrolled re-entry of space objects into the Earth's atmosphere.



David Parker CEO of the UK Space Agency, Dr Mohammad Al Ahbabi, Director-General of UAE Space Agency and Philip Davies CEO of Deimos UK **Credit:** UK Space Agency

Training for space

With his mission to the International Space Station (ISS) currently slated for December 2015, British ESA astronaut Tim Peake has entered a period of intensive training at centres in the United States, Russia and Germany. Peake is due to spend six months on the ISS carrying out scientific experiments and taking part in a wide range of educational projects.

Suited up for a training session on the space station airlock at the Johnson Space Center in Houston **Credit:** ESA

ESA astronauts do most of their training in Houston, Cologne in Germany and at Star City near Moscow. This shows Peake by one of the Russian Soyuz spacecraft simulators in Star City
Credit: ESA

The official crew photo for Peake's mission showing the astronaut with Soyuz crewmates Yuri Malenchenko and NASA astronaut Tim Kopra. Before their own mission, the team will serve as the back-up crew for a flight to the ISS **Credit:** Roscosmos, GCTC

Another day, another space outfit. Here, the crew are practicing fire drills in the cramped corridors of the Russian segment of the ISS in Star City
Credit: Roscosmos

Couches in the Soyuz are moulded to the bodies of individual astronauts. Here, Peake is being lowered into a mould containing liquid plastic. Once it sets, it will be used to build his spacecraft seat **Credit:** ESA

Peake will fly in a Russian Soyuz spacecraft, a design that first launched more than forty years ago. This picture shows the Soyuz that recently returned ESA astronaut Samantha Cristoforetti and her two crewmates safely to Earth **Credit:** ESA

Space for everyone

IPSP includes a project to improve aviation safety in Africa
Credit: ESA

A major new UK Space Agency initiative aims to tap into the hi-tech skills of British business to bring the benefits of space to emerging economies. Richard Hollingham reports:

Without satellites the world would be very different. Take, for instance, the applications we use everyday on the average smartphone: Map apps use navigation satellites, weather apps are increasingly reliable thanks to data from weather satellites; apps that enable us to watch live TV from the other side of the world or make international phone calls rely on communication satellites.

Even the internet would struggle without space technology – the timing signals that keep all the billions of packets of data moving around the globe originate from satellites. Space technology is also employed to monitor crops, trace pollution, track disasters and investigate our planet's changing climate.

"We're looking to work with emerging economies to open up markets early for UK companies"

Ray Fielding
UK Space Agency

Long lasting

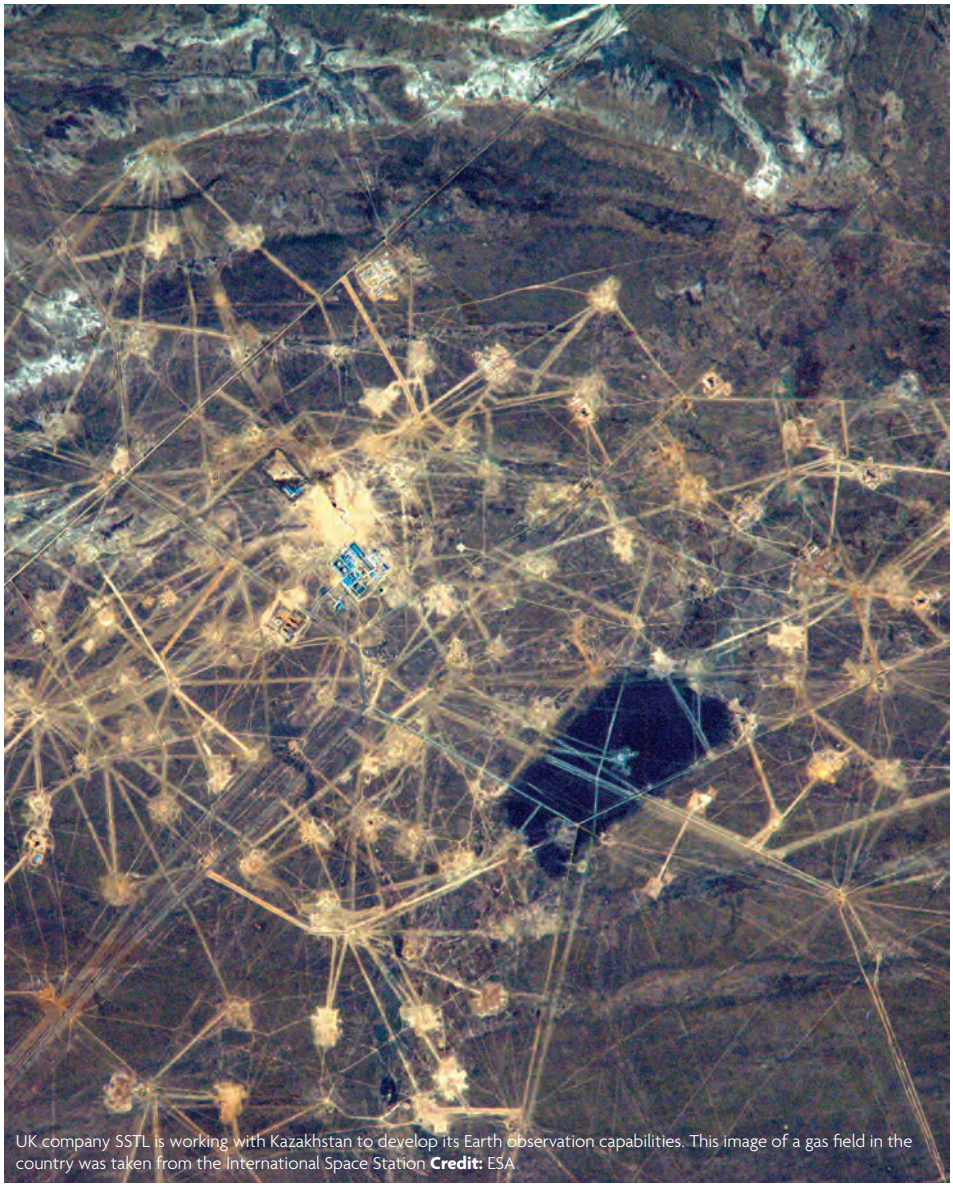
We take this space infrastructure for granted but it is crucial for our modern lives, our society and economy. However, in many parts of the world these benefits of space technology are not available. This is why the UK Space Agency has launched the new International Partnerships in Space Programme (IPSP).

"We're trying to do a couple of things," says Ray Fielding, Head of the IPSP at the space agency. "First is to establish some long lasting partnerships to bring the benefits of space to emerging economies and, second, we want to open up new doors for UK industry to help develop export opportunities."

The two-year, £32 million programme is funding twenty new projects with international partners in Asia, Africa, South America and China. These include using satellites to help improve teaching in rural schools, reduce air accidents in Africa and save lives by improving disaster response.

"The projects will bring a range of services to people that may be denied to them at the moment, such as better education and improved health information," says Fielding. "We also hope they will help improve scientific and engineering skills in the partner nations."

The idea is that these projects benefit both the partner country and the UK. "We've identified benefits for the UK in excess of £100 million," says Fielding. "These will either be indirect societal returns to the UK or direct benefits to UK industry."



UK company SSTL is working with Kazakhstan to develop its Earth observation capabilities. This image of a gas field in the country was taken from the International Space Station **Credit:** ESA

International space partnerships

The UK Space Agency has awarded contracts to twenty projects to develop satellite technology in emerging economies. These include:

iKnowledge
Avanti Communications will deliver an ICT infrastructure and e-learning programme for teachers across Tanzania. The project will equip up to 250 schools in rural and underserved areas with ICT infrastructure and broadband internet via satellite.

SBAS Africa
Working with governments in Africa, Avanti Communications will be helping to improve aviation safety by setting up and demonstrating new satellite-based flight safety systems.

Outernet Partnership for International Development
Clyde Space and US partner Outernet are developing a telecommunications service delivered via a constellation of low-cost cubesat satellites. This will be used to provide a wide range of data, broadcast and information services to people in remote and isolated regions of the world.

I-Sat Connection
UK-based satellite communications company Inmarsat is working with Kenya's Equity Bank Group and Kenya and Mobile Alliance for Maternal Action to provide a range of new digital services in Africa. These include providing maternal and child health services to rural communities in remote locations.

Oceania Pacific Recovery and Protection in Disaster (RAPID)
UK lead supplier Stevenson Astrosat will work with a range of international partners to provide satellite images and communications to governments and emergency workers in the aftermath of disasters.

Enabling Kazakhstan's Earth Observation Capability
Surrey Satellite Technology Limited (SSTL) is working with Ghalam LLP in Kazakhstan to develop the mission operations system for Earth observation satellites. Information from these satellites will be used for a wide range of applications in Kazakhstan such as land use monitoring and agriculture.

Collaborative development of radiometer components for meteorological instruments
This project, involving Teratech Components Limited, is a partnership with the Xi'an Insitute of Space Radio Technology in China to develop instrumentation for a new generation of weather forecasting and disaster management satellites.

continues >

Free services

One of the more unusual projects being funded by the IPSP involves a partnership between Glasgow-based satellite manufacturer Clyde Space and American company Outernet to develop a satellite telecommunications network.

Traditional telecommunications satellites are large, sophisticated and expensive spacecraft that sit high above the Earth in geostationary orbits. The Outernet system, on the other hand, will use a network of cubesats – tiny low-cost units just 10cm cubed – in low Earth orbit to provide a range of broadcast and other communications services to people all over the world.

"It's a really interesting project," says Clyde Space CEO Craig Clark. "This is a great example of how one kilogram satellites can be used to provide data to remote or isolated areas of the world."

The Outernet service will provide users with a range of reliable information and entertainment services – from news reports and TV shows to a cross section of websites, including weather alert sites and reference sources such as Wikipedia.

People who sign up to the service will require only a small solar-powered receiver, not much bigger than a USB stick, to download the content. Although there will also be paid subscriber services, most of it will be free.

"It's not free internet," says Clark. "It's download only, giving people free content from space with these receivers collecting data from the satellites all through the day."

The Outernet service will start with a constellation of three satellites to demonstrate the concept. "Then we plan to move to 20 satellites," says Clark. "Ultimately we'll mass produce 200 of these small spacecraft in orbit – so if one drops out, they'll be another just around the corner."

To avoid space debris, each satellite will have a lifetime of three years before its orbit decays and it burns up in the atmosphere. This means that every year the constellation will be refreshed with new satellites, fitted with the latest technology.

"For Clyde Space, not only is this a great project to work on," says Clark, "the investment from Outernet and the UK Space Agency is giving us the opportunity to expand our facilities, so we can produce 100s of satellites at a time."

"We've identified benefits for the UK in excess of £100 million"

Ray Fielding, UK Space Agency

Satellite broadband in use at the Buguruni School for Deaf Children in Tanzania **Credit:** Avanti Communications

ımov-Gerasimenko

5,000 kilometres per hour, Comet 67P is gradually revealing its mysteries to ency's Rosetta mission.

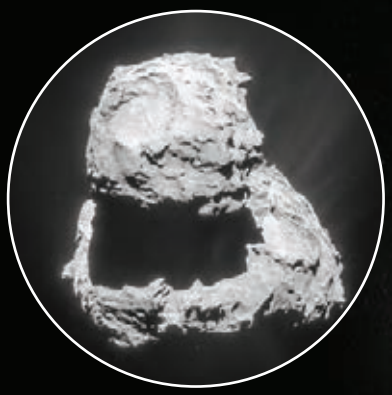
UK SPACE AGENCY

Mission to a comet

In August 2015 comet 67P/Churyumov-Gerasimenko will reach its closest distance to the Sun. Several tails of dust, ice and gas will extend into space and, as surface activity increases, the comet may even break into the two distinct parts that form its unusual duck-like shape.

Named after the two astronomers who discovered it in 1969, the comet could either be one solid piece of icy rock or two chunks of material that fused together during the formation of the Solar System.

The surface of the comet ranges from flat terrain to brittle cracks, circular depressions and rock-like boulders and cliffs. It also contains organic molecules – chemical compounds built around chains of carbon and hydrogen. Organic compounds form the basic building blocks of life on Earth.

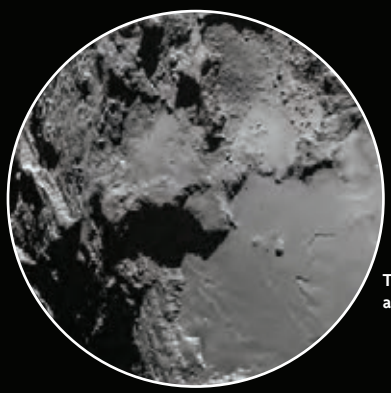


The Rosetta Mission

The European Space Agency's Rosetta spacecraft launched in 2004 and, after a ten-year journey, it arrived at comet 67P in 2014. It became the first mission to orbit a comet and also the first to land on a comet and send images back from the surface. Its mission has now been extended to December 2016.

The Rosetta orbiter's long-term presence alongside the comet – sometimes flying less than 10 kilometres away – has allowed its 11 scientific instruments to study 67P in unprecedented detail.

Airbus Defence and Space in Stevenage built key sections of the spacecraft and scientists from seven UK universities are working on instruments. UK industry produced elements of the onboard software, supplied imaging devices and the lithium-ion batteries for both the orbiter and the lander.



The comet's surface seen during a close-approach in February 2015

Produced by RCUK's Internal Service Provider on sustainable forestry paper, July 2015. www.gov.uk/government/organisations/uk-space-agency Issue 43

Philae image of Rosetta after the lander's separation

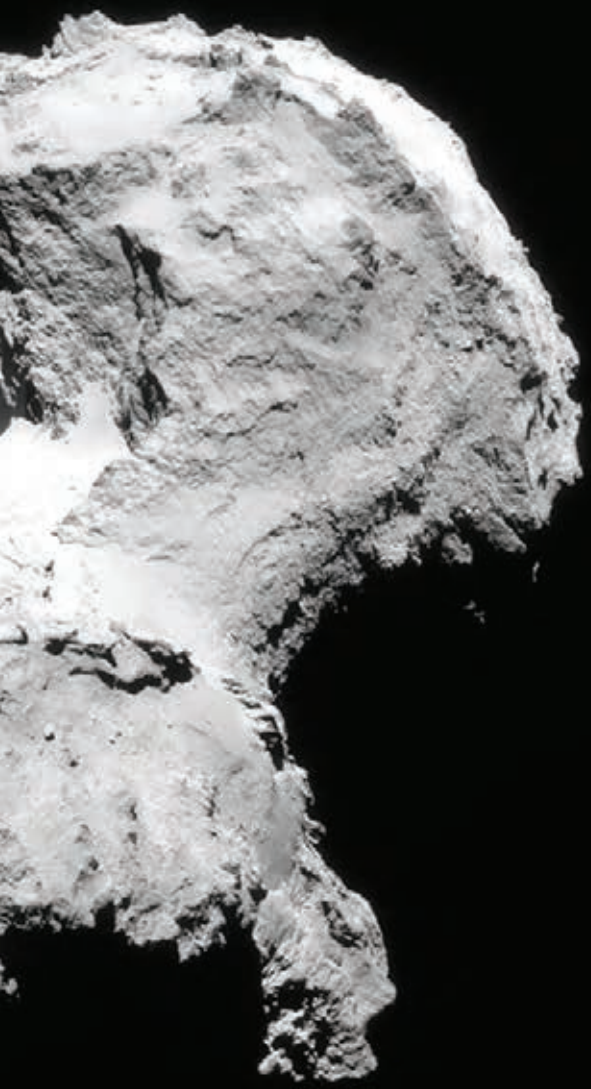
The Philae lander

Rosetta's Philae lander made history on 11 November 2014 when, after a seven-hour descent, it landed on the surface of the comet. It then bounced twice before settling in an unexpected area that was partly in shadow.

Philae performed almost 57 hours of science before entering its planned hibernation. Seven months later, it sent back the first of a new series of signals.

Now that different parts of the comet are receiving more sunlight, it is hoped that Philae will gain enough energy to allow its instruments to perform even more science.

UK scientists work on many of the instruments but one of them, Ptolemy, is entirely UK-led and was built and designed at the Open University in Milton Keynes. The size of a shoebox and weighing less than 5kg, Ptolemy uses gas chromatography and mass spectrometry to investigate the comet.



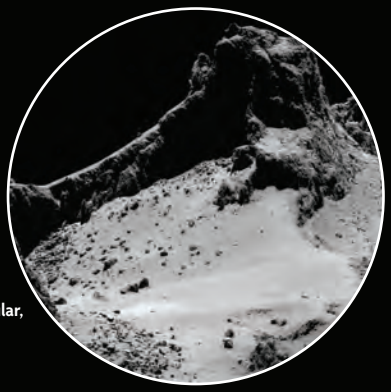
Cometary science

The comet's dark and dusty surface is, at -70°C, unexpectedly warm. It is four kilometres wide at its largest point, has a mass of some 10 billion tonnes and takes six years to orbit the Sun.

Measurements of the comet's mass and volume shows that it is unexpectedly porous and that water vapour is streaming away from the surface. The water, however, is not the same type as that on Earth, suggesting a weaker connection between comets and our planet's water than previously thought.

Gases detected from the comet include carbon monoxide, methane, ammonia, methanol and carbon dioxide. Rosetta has also made the first ever finding of molecular nitrogen on a comet.

During the next few months Rosetta will examine the gas and dust vented from the surface – the birth of the coma – to see how it develops as the comet nears the Sun.

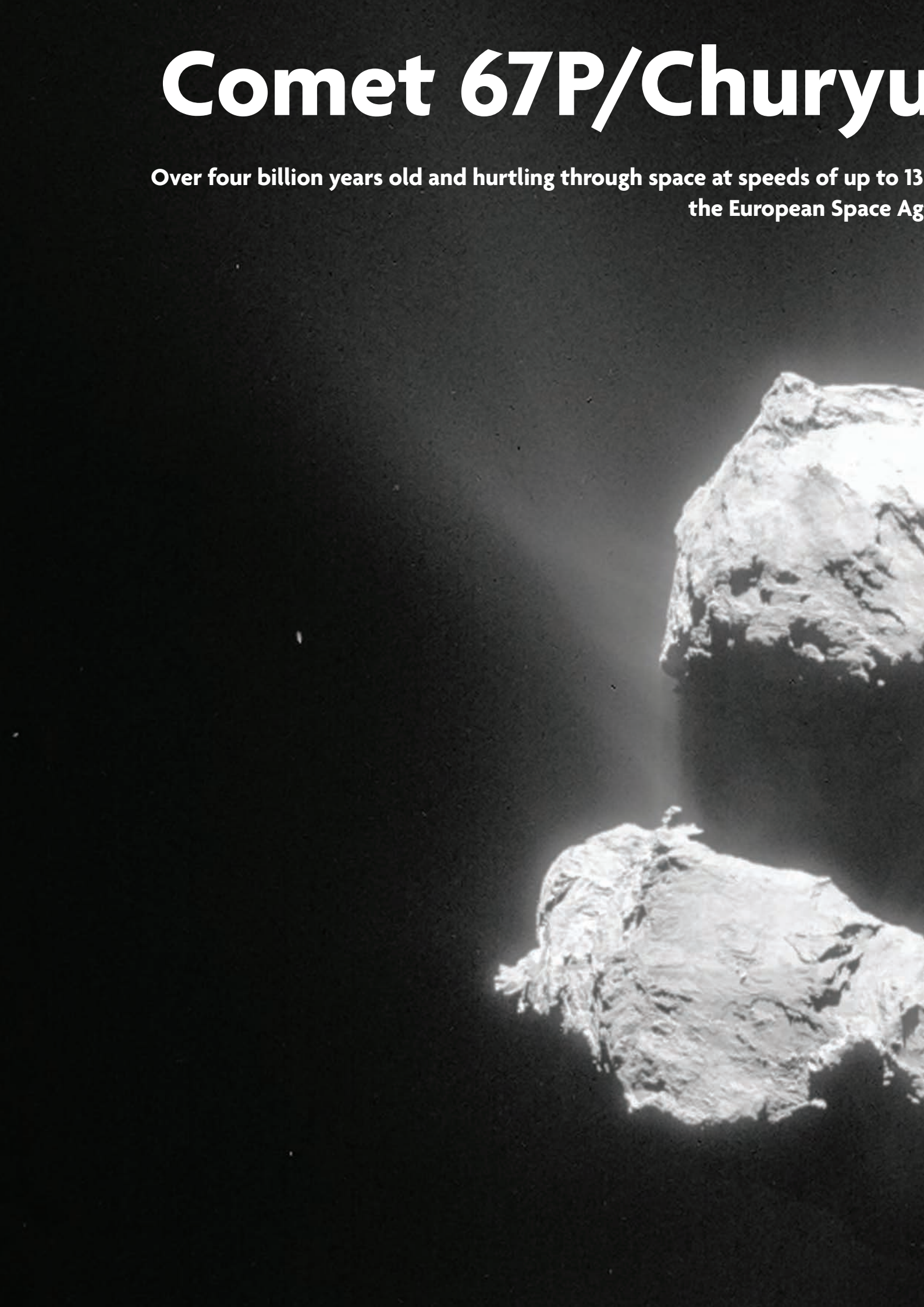


Close-up revealing the irregular, rocky surface of the comet

UK SPACE AGENCY

Comet 67P/Churyu

Over four billion years old and hurtling through space at speeds of up to 13
the European Space Ag



Flight safety

Another application being funded through the IPSP is aimed at cutting the number of aircraft crashes in Africa. "Africa has just 3% of global air traffic and yet air accidents in Africa account for around 20% of the worldwide total," says Graham Peters from ApTec, part of Avanti Communications.

Avanti has expanded rapidly over the past ten years to provide a wide range of communications and satellite services from space. The satellite operator will lead the development of an enhanced satellite navigation system, known as a Satellite-Based Augmentation System (SBAS). With SBAS-Africa, Avanti will work in partnership with government agencies in South Africa, Ghana and Madagascar.

"SBAS-Africa will use technologies developed in Europe derived from EGNOS – the European Geostationary Navigation Overlay Service – to make flying safer," explains Peters. "The system works by transmitting signals from a geostationary satellite containing information on the reliability and accuracy of GPS."

The launch of Avanti's Hylas 1, one of the company's broadband satellites **Credit:** Arianespace

Studies suggest that such a system will have benefits of some £1.2 billion for the African aviation industry. More importantly, it also has the potential to save hundreds of lives.

"The first step will involve demonstrating the potential performance of SBAS systems in various African airspace sectors," says Peters. "There is also significant interest in the services in markets outside aviation, such as agriculture."

Clyde Space's Ukube-1. The outernet satellites will be a third the size **Credit:** Archibald Photography

Grow exports

One of the priorities for the UK Space Agency is to support the space sector to grow its export business. The IPSP will, it hopes, open the door to a range of new opportunities in emerging markets.

"We're looking to work with emerging economies to open up markets early for UK companies," says Fielding, who describes the programme as a "win-win undertaking."

"We're hoping these projects not only generate new and sustainable partnerships between UK businesses and emerging nations but have lasting benefits on the ground," he says. "When our funding comes to an end we want the projects to continue."

The BAS Halley research station in the icy depths of the Antarctic winter **Credit:** BAS

Antarctic Astronauts

Space agencies are teaming up with Antarctic researchers to study the challenges of long duration spaceflight. Sarah Cruddas reports:

It is the most extreme environment on the planet. Temperatures can reach as low as minus 55°C. Winter consists of months of near-total darkness and the closest neighbour can be the International Space Station when it passes above.

Those overwintering in Antarctic research stations are as isolated as astronauts and the conditions they face are almost as extreme. The startling similarities between life in the two environments is the basis of a new scientific study – a partnership between the British Antarctic Survey (BAS) and ESA aimed at better understanding how humans can survive the isolation and extreme conditions of future long-duration space missions to the Moon or Mars.

Completely alone

In the middle of winter, there are no flights in or out for researchers living in the BAS Halley research station on the Brunt Ice Shelf or, 3000 kilometres away, French-Italian Concordia base on the Antarctic Plateau in East Antarctica. Both stations look like something out of an imagined Mars mission – futuristic and metallic with labs, sleeping quarters, a kitchen and even a gym.

At this time of year only 12 people live on each station – teams made up of doctors, scientists, engineers and a chef. Although they are not floating around in microgravity, the confinement, stresses and social situation for those in the Antarctic environment are very similar to the physiological and psychological stresses affecting astronauts.

"This really is the most isolated place on Earth," says Andrew Kuh from the UK Space Agency, which contributes to the ESA human spaceflight programme. "Studies in the Antarctic provide us with a really good analogue for future planetary missions."

Being on these research stations can feel like living on another world. "We've even had video links from the International Space Station," explains Beth Healey, the doctor leading ESA medical research at the Concordia base. "It was a strange feeling when the last plane left."

While studies into the effect of this unique environment have been carried out at Concordia for the last decade, this is the first time BAS has been involved. With teams at two research stations now being studied, this potentially doubles the amount of data that can be gathered.

"For all intents and purposes, those on Halley and Concordia are the closest explorers we have to being on another world"
Beth Healey, ESA

continues >

Lower oxygen

One significant difference between the two stations is altitude. BAS's Halley base is at sea level but Concordia sits at 3200 meters. Because of atmospheric conditions in the Antarctic, this is the equivalent of living at a height of 3800m on the equator or nearly three times the height of Ben Nevis. Higher altitude also means less oxygen.

"The difference between both stations is so important," says Nathalie Pattyn, the medical doctor at Halley Research Station on secondment from Vrije University in Brussels. "It means you can study in more detail the effect of different factors, the idea is to measure what causes the disturbances – is it lack of oxygen or isolation and the lack of light?"

Knowing what effect this reduced oxygen, or permissive hypoxia, has on people compared to those at the lower level research station, could have a huge impact on the design of future spacecraft and habitats. Being able to survive with lower oxygen levels also has an interesting engineering pay-off for spaceflight.

"This means a pressure reduction on the hull of the spacecraft, as the pressure is not as intense," explains Pattyn. It is a factor already used in commercial aviation, with planes pressurised to a height of 1800m instead of sea level.

Another study is investigating whether the ability to perform skills degrades and whether this is influenced by isolation and confinement or hypoxia. "Maintaining skills is a known issue in the planning of long duration spaceflight," says Pattyn. "How do you know that a skilled pilot will still be skilled after eight months of non-activity?"

In order to understand this, the Antarctic teams have been trained on a spacecraft simulator and then divided into frequent and infrequent training groups, to analyse how their performance changes during the winter. At Concordia, Healey is taking blood samples to measure people's adaption to altitude.

Concordia in the moonlight **Credit:** ESA,IPEV,PNRA

Mental health

The Antarctic over-winterers are now more than halfway through their isolation. Other studies underway involve using video diaries to better understand mental health issues. Developed with the Russian space program, analysis of voice patterns can be correlated with psychological strains or declines in performance.

"The crew complete regular questionnaires and I make monthly clinical observations," says Healey. "Prior to arriving, immediately on return and then six months later we have also taken functional MRI scans of brain activity and structure."

The video diaries are made weekly and analysed through a computer algorithm. The hope is that the knowledge gained will enable scientists to develop computer technology to detect possible psychological issues. It could mean preventing an astronaut performing a task, which they may not be mentally capable of doing, or providing support for any mental health issues that arise.

Beth Healey outside in summer – in this image she even looks like an astronaut **Credit:** ESA,IPEV,PNRA


Concordia beneath a spectacular aurora **Credit:** ESA,IPEV,PNRA

Continuous darkness

The four months of continuous darkness could have an effect on the eyes. "We are investigating the potential changes to eye accommodations under the influence of either constant illumination, or constant darkness," explains Pattyn.

Darkness can also be bad for a good night's sleep. "Sleep complaints remain among the most common issues with regard to health and wellbeing in extreme environments," says Pattyn.

The results of this joint scientific programme will, according to ESA Science Co-ordinator Jennifer Ngo-Anh, "provide us with important data, experience and knowledge to prepare for future long-duration human missions to the Moon, Mars and beyond."

And it is not just future space explorers who could benefit from these studies. Understanding how the human body reacts at these extremes can have huge benefits for all aspects of medicine and psychology for us here on Earth.

"There are so many added values to this," explains Pattyn. "This is a natural lab, which allows us to study conditions we wouldn't be able to recreate in our traditional research environments. We can measure things we would never be able to."

Of course taking part in these studies is not always easy for those who live in the research stations. "You have your good days and you have bad," says Healey, "but it's an amazing experience".

Pattyn describes the experience as a contrast between the extraordinary other world you can see out the window and the mundane, being locked up with 11 other people, "but you never get bored," she adds.

These are emotions that one day, at a date we cannot yet know, humans will experience on another planet. "We see astronomical phenomenon, changing lights, changing temperatures," says Healey. "For all intents and purposes, those on Halley and Concordia are the closest explorers we have to being on another world."


Beth Healey at work in the Concordia lab
Credit: L. Moggio, ESA, IPEV, PNRA

Antarctic diary

As ESA research MD, writes Beth Healey, I am responsible for implementing the research protocols selected by ESA on the crew (and myself!). In addition I perform fortnightly tests on the water from our grey water recycling machine, lead the medical rescue team and assist the clinical doctor in case of emergency.

The crew come to my lab every week (different pairs each day), they also come on additional days for the experiments requiring set intervals. I set up equipment, take samples (from blood to snow!), initialise devices, carefully store samples and download or upload data from devices to send back to Europe.

Perhaps the most challenging aspect of my job is motivating the crew to continue to participate in the studies conducted here. All the crew have busy schedules so it can be tough for them to find time to participate in the ESA experiments. However, I have been very fortunate with our overwinter crew and we have enjoyed extremely good participation levels this year.

Once a week I send a weekly report to ESA and the scientists leading the experiment, commenting on participation levels and any problems we may have encountered during the week.

In my spare time I like to go to the gym, practice photography, learn languages, watch films and cook with Luca the chef.

Artist's impression of LISA Pathfinder – the science module will separate from its propulsion module before beginning operations **Credit:** ESA

LISA's adventure in space and time

As the LISA Pathfinder spacecraft undergoes final tests before its October launch, Sue Nelson meets some of the team working on this challenging UK-led mission:

All journeys begin with one small step but the step LISA Pathfinder is about to take is anything but small, and could change the way we observe the Universe.

LISA Pathfinder will carry two small gold and platinum alloy cubes into space to test the technology needed to detect gravitational waves. These are ripples in space and time, predicted by Albert Einstein almost a hundred years ago.

Violent astronomical events – such as colliding black holes or exploding stars – are thought to cause gravitational waves. These waves spread out across the cosmos, much like if you dropped a stone into a pond to see waves spreading across the water. However, despite the fact gravitational waves almost certainly exist, they have so far proved impossible to observe.

A joint ESA and NASA mission, LISA Pathfinder is a technology demonstrator. It may not be able to detect gravitational waves itself, but will be able to see if the detection technology that can find them works.

"It's a unique mission, quite different even to a normal science mission"

Vicki Lonnon
Airbus, Defence and Space

LISA's adventure in space and time

Pushing boundaries

Once in space, LISA Pathfinder's two 46 mm metal cubes, or test masses, will be contained in gravitational freefall 35 cms apart. Highly advanced precision instruments on board the spacecraft must be able to show that these test masses float completely freely.

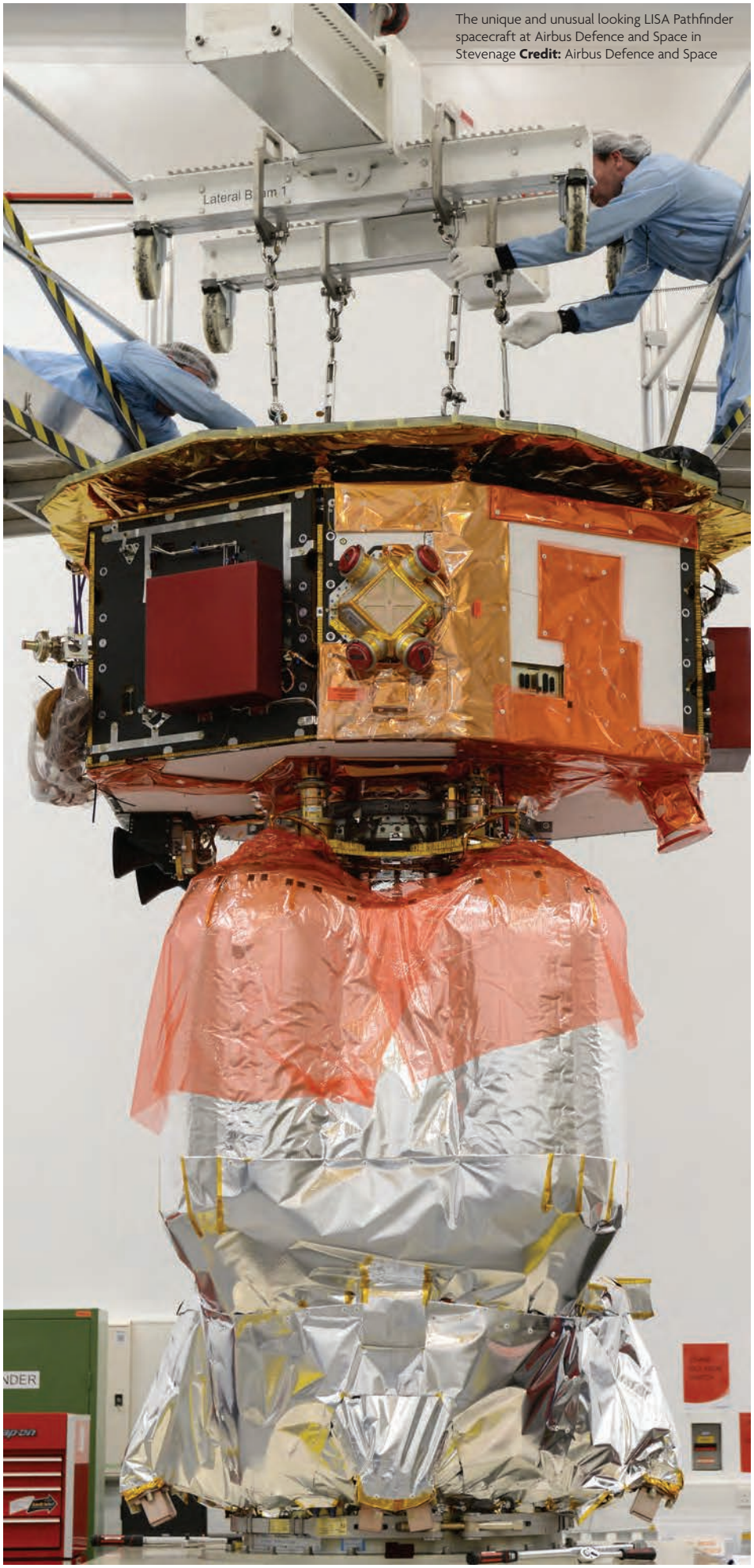
In the follow up LISA mission, which will launch after 2030, its two test masses will be in separate space capsules five million kilometres apart. Scientists need to be sure that any changes in the masses' relative movement over that distance are only as a result of gravitational waves and not from systems on the spacecraft or the gravity of the Sun or planets.

"We are pushing the boundaries everywhere of what can be measured," says LISA Pathfinder project scientist Paul McNamara, a Brit based at ESA's European Space Research and Technology Centre in the Netherlands.

"LISA Pathfinder is a physics lab in space," says McNamara. "What we need to demonstrate is that we can take one of these cubes, locate it inside a spacecraft and control all the sources of noise, temperature, magnetic field and so on, and control them to a level where we can't see any of that noise whatsoever."

"I'm absolutely confident the mission will be a success"

Harry Ward
Institute for Gravitational Research



The unique and unusual looking LISA Pathfinder spacecraft at Airbus Defence and Space in Stevenage **Credit:** Airbus Defence and Space

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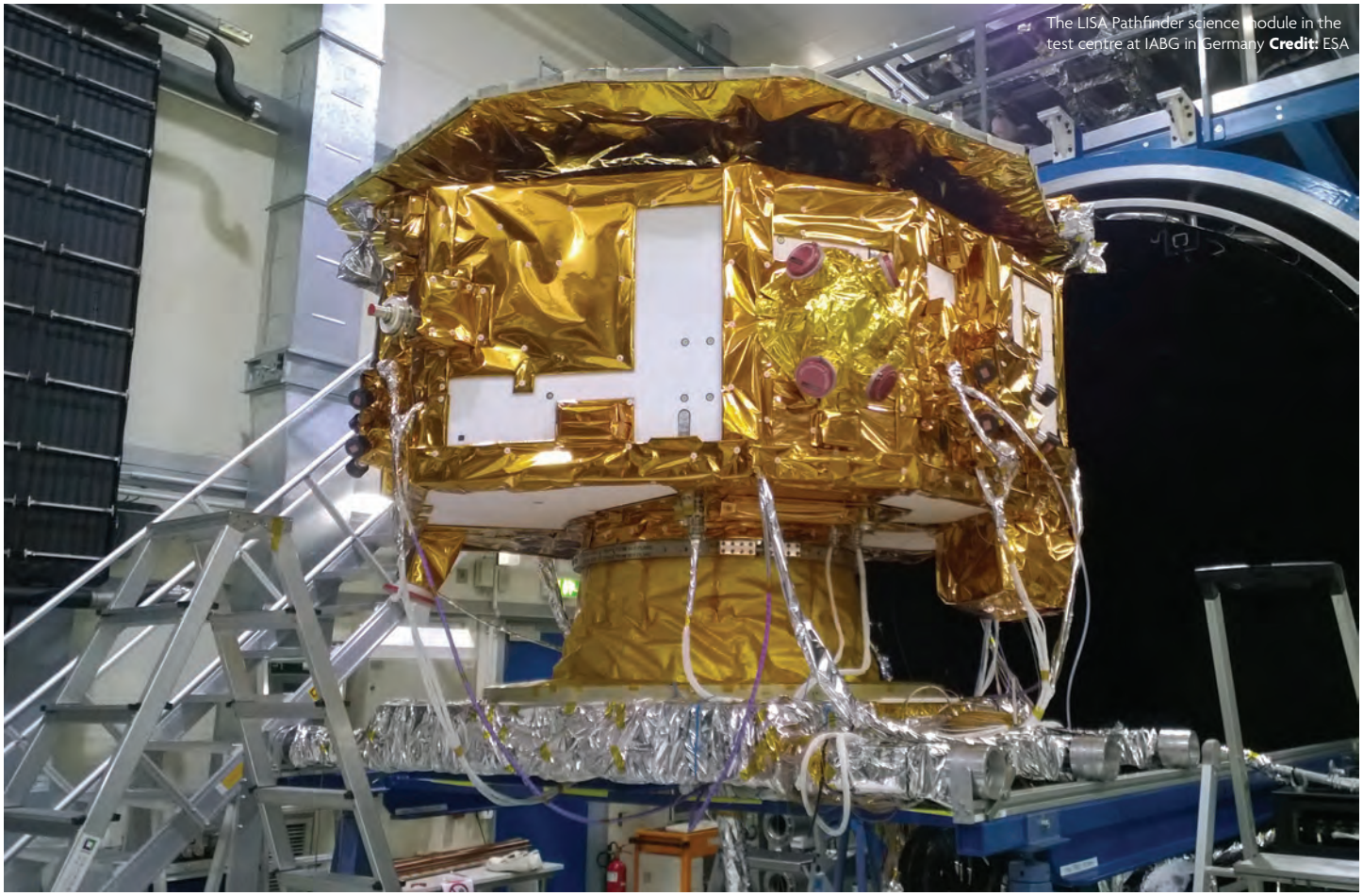
LISA's adventure in space and time



The LISA Pathfinder science module in the test centre at IABG in Germany **Credit:** ESA

British led

This ambitious mission is the first to be entirely led by UK industry since Giotto, which successfully flew past Halley's comet in 1986. Imperial College London, the University of Glasgow and the University of Birmingham are each providing instruments for LISA Pathfinder. These will be the most advanced of their kind ever flown in space.

There are several reasons why we need to find gravitational waves. "First to study our current theory of gravity – General Relativity – in ways that cannot be done using other types of observation," says Timothy Sumner, from Imperial College London. "This will allow the direct study of gravitational waves themselves but also we could map out, in exquisite detail, black holes, providing a definite proof of their existence."

Gravitational waves permeate the Universe – the LISA missions are designed to detect them **Credit:** NASA, ESA

Gravitational waves would also enable astronomers and space scientists to study the Universe in a completely different way to that done by conventional telescopes. "This will be akin to 'listening' to the Universe," says Sumner, "and will give information which is both complementary to other telescopes and, in some cases, totally new."

Imperial College London has built the spacecraft's Charge Management Device (CMD), which will control the amount of charge on the free-floating test masses. "The charge steadily builds up due to the action of cosmic rays and energetic solar particles," explains Sumner, "and the CMD is then used to neutralise the charge."

LISA's adventure in space and time

Unique mission

Sumner describes the mission as "a significant challenge" and LISA Pathfinder as "an unusual satellite for ESA both in terms of its scientific payload and the construction. It has required a much tighter cooperation than usual between industry and academia to realise."

Vicki Lonnon, from Airbus, Defence and Space, agrees. The spacecraft was built in the company's Stevenage facilities and she is the quality assurance engineer for the LISA Pathfinder project. "It's a unique mission," she says, "quite different even to a normal science mission."

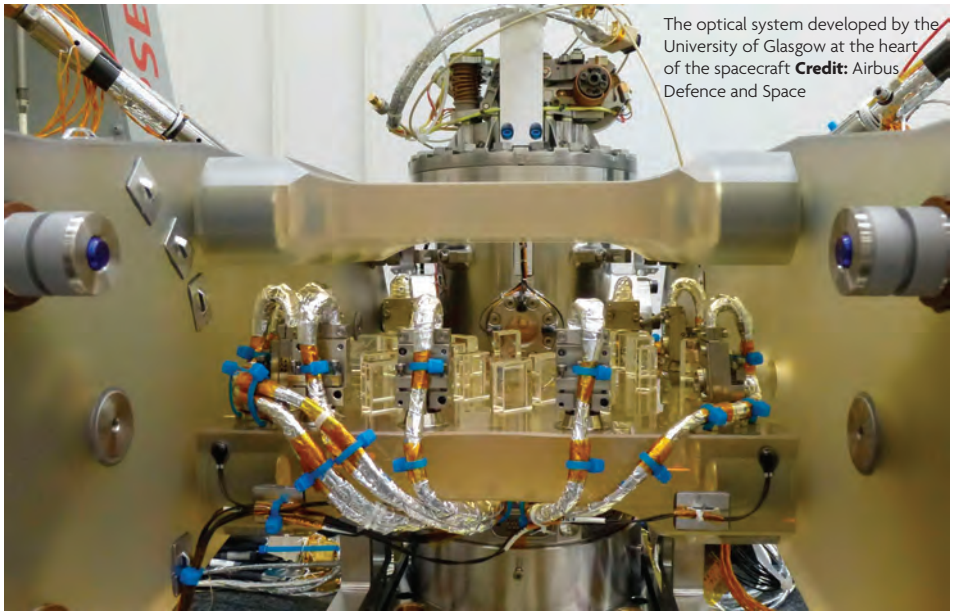
Lonnon is currently with LISA Pathfinder near Munich in Germany, where it is undergoing final tests. The spacecraft has already been inside a giant vacuum chamber for thermal testing at temperatures as low as minus 140°C.

"We try to simulate the coldness of space," says Lonnon. "Then we power the spacecraft and run it through a series of tests to ensure the spacecraft will operate and respond as expected."

LISA Pathfinder consists of two parts. The top section contains the scientific instruments and the larger bottom half is a propulsion module. This is because the spacecraft has to reach the L1 Lagrange point, a point in space where gravitational forces effectively cancel each other out.

LISA Pathfinder will be launched initially into a temporary parking orbit before the propulsion module kicks in to direct it towards its final destination, 1.5 million kilometres from Earth.

The spacecraft has already undergone tests to check its mass properties – such as the centre of gravity and moments of inertia – and the results are fed back into its design to ensure everything will work as planned. Over the summer the payload will be integrated into the spacecraft, with an acoustic noise test planned for July. "We simulate the conditions inside the launcher fairing during the launch and blast it with high frequency sound in a noise chamber," Lonnon explains.



The optical system developed by the University of Glasgow at the heart of the spacecraft **Credit:** Airbus Defence and Space

Optical heart

What goes into the payload is key to LISA Pathfinder. "We've built the optical heart," says Harry Ward, from the University of Glasgow's Institute for Gravitational Research. "It's the optical system that performs the sensitive measurements inherent to the mission."

The Glasgow team's laser interferometer will measure the motion between the two freely floating metal cubes. "The measurement has to be made at the level of a millionth of a millionth of a metre and that's done by laser interferometry – essentially reflecting a laser beam off the moving proof mass and interfering that with another beam," says Ward.

"By watching the interference pattern we can decode the movements of the proof masses," he says. "The challenge has been twofold: to build it with the required precision and to make it dimensionally stable - so we had to develop a new way of attaching all the optical components in place."

As glue is difficult to control and doesn't always survive the stresses of spaceflight, the team at Glasgow had to consider something different. "We used a technique we'd been using in the lab to bond glassy materials together and we extended that to allow us to bond things with very high accuracy of positioning, says Ward. "That bonding technique has really been the key to getting the stability of the optical system and all its components."

The other key UK payload element is the electronic component that detects the interferometer signals and calculates the movements of the test masses. This phase measurement system has been provided by the University of Birmingham.

Other UK industrial teams have also played a significant role in the mission. "SCISYS were involved in the Lisa Pathfinder mission from the very start, designing and implementing the on-board computer software that controls the spacecraft and its payloads," says Roger Ward, Technology Manager in the Space Division at SCISYS UK Limited. "The whole SCISYS team will be delighted to see our work launched."

Now it is almost ready to go. "We've done everything we can," says Harry Ward. "The payload has surpassed all our expectations and all of the testing we've done on the ground has demonstrated a performance better than we could hope for."

"We're optimistic," he adds. "Now it's almost in the lap of the gods in the sense that when the rocket is fired we have to keep our fingers crossed that it does the right thing and goes to the right place. Assuming that happens, I'm absolutely confident the mission will be a success."

Near Earth Objects

Credit: Flamsteed Astronomy Society/Mike Meynell

Richard Crowther
Chief Engineer, UK Space Agency

The first Asteroid Day was held on 30 June, raising awareness of why out planet needs protecting from Near Earth Objects.

We asked UK Space Agency Chief Engineer Richard Crowther to explain why we should be concerned about an asteroid hitting the Earth:

Why does the Earth need protection?
We've seen evidence of how asteroids and comets can change the way life has evolved on Earth. We're now in a position that if one of these Near Earth Objects (NEOs) came towards us, we could have the technology to divert one and avoid the collision.

How big are these NEOs?
The search surveys up until now have been looking for objects down to one kilometre in size, and we've identified around 90% of these and tracked their orbits. But while looking for larger objects we've seen a big population of smaller objects - down to 100 metres in size - and the more we look, the more of them we find. Currently over 12,000 have been identified and we expect to find tens of thousands more.

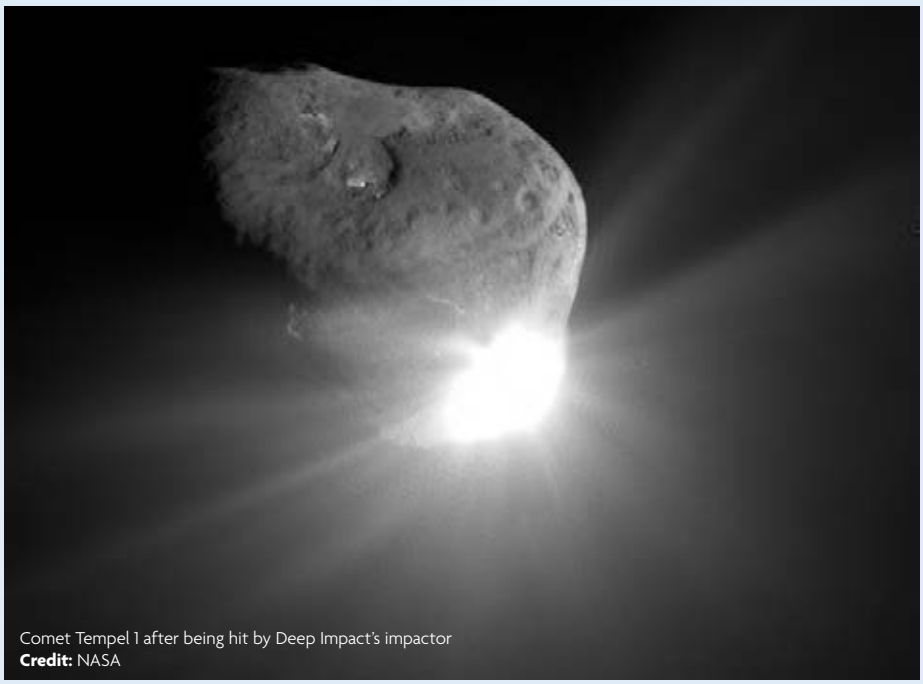
What damage could a 100 metre wide asteroid cause?
These have the potential to cause devastation locally but it depends where the asteroid falls and also what it's made from. So in addition to looking at size, we need to determine the object's composition. If it's a 100m metallic asteroid, we would expect it to survive entry through the atmosphere and that would cause a large crater in addition to a blast wave.

The reason so many people were hurt during the 2013 Chelyabinsk meteor incident in Russia was because, as light travels faster than sound, people came to the windows when there was a flash of light. When the later blast wave came, it broke the windows and caused injuries.

What technologies could deflect asteroids?
To avoid a collision between the Earth and an asteroid all we have to do is arrive at the intersection point of our orbits in space at a different time to the asteroid. We can't change the path of the Earth in space but we can potentially modify the trajectory of an asteroid by using a kinetic impactor - which imparts a change of momentum – or a gravity tractor – which exploits the mutual gravitational attraction of the asteroid to the 'tractor' probe.

So a gravity tractor is basically a probe that you fly close to an object to change its path.
If you flew a probe close to an asteroid then the asteroid would exert a gravitational pull on the probe and pull it towards it. If the probe then thrusts away from the asteroid, it doesn't make any physical contact but that gravitational attraction between the two will be enough to slightly change the orbit of the asteroid.

A gravity tractor is designed so that its thrust doesn't impinge on the body that it's trying to pull away - that's important - and it also has to have a continuous thrust to have any useful effect over a long period of time.



Comet Tempel 1 after being hit by Deep Impact's impactor
Credit: NASA

An asteroid hitting the Earth could be very bad news indeed
Credit: ESA

And the impactor is just something that smashes into a NEO?
Yes - you just hit it like the NASA Deep Impact mission did to comet Tempel 1 in 2005. These impactors have a mass, which you fire towards the object. A change in energy and momentum causes a change in trajectory.

Is the gravity tractor more controllable?
Yes, although we're anticipating there will be a phased approach. First you send a probe to determine the compositional structure of the asteroid and that would help you decide what system to use. A kinetic impactor could try to deflect it and then, if you're trying to fine-tune the resulting trajectory, you could use a gravity tractor as well.

In exceptional cases people are proposing nuclear detonation ahead of the object. But it depends on the size, and also the composition of the asteroid, because some of the larger objects are believed not to be solid lumps of material. They tend to be aggregrations - so called rubble piles. There appears to be a loose gravitational attraction that keeps these objects together and so if you were to try to blast them out of the way, it has been suggested that the blast would cause the pieces to disperse and then coalesce again along the same trajectory towards the Earth.

What is the UK doing about potential NEOs?
On the science side we're involved through the research councils in supporting some of the telescopes that have contributed to search campaigns. Recently the UK joined the Space Mission Planning Advisory Group.

This involves NASA, ESA, the UK Space Agency and other agencies and is looking at what technologies and missions are needed to be able to deflect different types of asteroids – such as a gravity tractor or a kinetic impactor - and who would do what, and when. This group also supports the International Asteroid Warning Network, which identifies and tracks new objects.

Have you ever seen a meteor?
I've seen shooting stars but nothing big. But the great thing about security, dashboard and video cameras is that we can capture these objects coming in.

In 1972 when an asteroid appeared over Lake Teton, in the United States, this very large object just clipped the top of the atmosphere. But if that had hit the Earth it would have caused regional devastation. So these objects are out there but hopefully, when they come to us, we'll be ready and we will have the technology and missions to deflect them.

Learn with an astronaut

Britain's first European Space Agency astronaut, Tim Peake, will begin his six-month Principia mission to the International Space Station (ISS) later this year. This is a unique opportunity to use space as an inspiring context for learning in the classroom.

The UK Space Agency, together with a large array of partners, is putting together a comprehensive education and outreach programme that spans a broad range of subjects and age ranges. A selection of these programmes is presented here, with more projects and resources planned to be announced over the coming months.

Primary School Project
The UK Space Education Office's (ESERO-UK) Tim Peake Primary Project will work with 1000 primary schools, delivering a range of free space activities to help primary students engage with science, numeracy and literacy.

These activities will be delivered in schools with the help of Space Ambassadors and will include professional development for teachers available locally and, where possible, delivered via INSET training. Schools can apply now via the ESERO-UK website.

Schools Grant Scheme
ESERO-UK has funding from the UK Space Agency, to offer grants of £1000 to both primary and secondary schools. Schools can use the funds for innovative projects to celebrate Tim's mission. Projects will be creative, have a lasting impact and can cover a wide range of subjects, including STEM, art, design, drama, food, and music. Schools can apply now and must submit their proposals to ESERO-UK by Wednesday 22 July 2015.

Rocket Science
The UK Space Agency is partnering with the Royal Horticultural Society in an innovative educational project that will give around half a million UK children the chance to become space biologists.

As part of Tim's mission, 2kg of rocket seeds are being sent to the ISS and returned to Earth so that thousands of UK schools can grow and compare these seeds with ones that have stayed on our planet.

Participating schools will each receive two packets of 100 seeds to grow and compare, and a collection of fun and inspiring curriculum-linked teaching resources and posters, tailored to primary and secondary pupils (Key Stages 1 and 2 or Key Stages 3, 4 and 5).

Sample education resources are available on the ESERO-UK site, and you can register your interest in receiving seeds at: **www.rhs.org.uk/schoolgardening**

Space Shows
Twenty of the nation's top science and discovery centres will be running an inspirational and exciting hands-on programme of space activities and experiments for children, schools and families across the UK. These will be launched during the autumn and will run during Tim's mission.

Zero Robotics
The Zero Robotics tournament turns the ISS into a gaming arena for secondary school pupils. The competition challenges youngsters to control volleyball-sized satellites through a virtual field mined with obstacles. The tournament is not only about writing code - participants must solve problems, apply their maths and physics knowledge and work in teams to achieve success.

The 2015/16 competition will begin in September, with the finals taking place during Tim's mission. Details on the competition, how to register and supporting resources will be available on the ESERO-UK website.

The Astro Science Challenge
The Astro Science Challenge is an interactive, space science adventure for children aged 7-11 to be run by Unlimited Theatre in November to December 2015. The adventure will consist of six missions, each with a new science-based challenge for the students to complete. Schools can register their interest at: **www.astrosciencechallenge.com**

The Great British Space Dinner
Students are invited to design a menu for astronauts to eat in orbit. As part of the process they will learn about healthy eating and the importance of exercise for both astronauts and people on Earth. The Great British Space Dinner educational resources for primary and secondary schools are available at: **www.esero.org.uk/timpeake**

Further information, and resources for all the projects listed below can found at:
www.esero.org.uk/timpeake

Sign up for the Principia newsletter:
www.gov.uk/ukspaceagency

Find out about Tim and follow his amazing journey at:
www.twitter.com/astro_timpeake

www.facebook.com/ESATimPeake

Printech Circuit Laboratories produces specialist circuitry and circuit boards for the space industry. Nick Potts is the company's Managing Director:

Nick Potts

What does Printech make?

We employ around 35 people in Essex, manufacturing electronic circuitry. We started out making printed circuit boards but today we hand-craft bespoke circuit based components for a wide range of specialist applications. These include flexible and rigid circuitry for spacecraft and circuits for Formula 1 racing cars.

What sort of space missions do you work on?

We've been working in the space sector for more than 25 years. Our circuit boards are on dozens of spacecraft, ranging from commercial communications satellites such as Inmarsat 4, to space science missions for ESA and NASA. One of the latest missions is Gaia – a European mission that is producing a detailed three-dimensional map of our galaxy. We have also recently started to work on developing new antennas for Cubesats.

How are you expanding the business?

Around half our business is exports and we're actively trying to get far more international business and expand our client base. There is lots of research and development involved in every project but the key is to be adaptable.

Are you optimistic for the growth of the UK space sector?

There's definitely great potential. Space companies need to talk to each other more to look for new markets. But Cubesats, in particular, provide tremendous opportunities for growth and innovation.

Image top right: Working on a circuit board in the clean room at Printech
Credit: Printech

Bottom image: Missions include ESA's Gaia spacecraft, seen here during testing in 2013
Credit: ESA

UK SPACE
AGENCY

The UK Space Agency is at the heart of UK efforts to explore and benefit from space – one of the fastest growing, innovative and most productive sectors of the UK economy.

An executive agency of the Department for Business, Innovation and Skills, the UK Space Agency is responsible for the UK's civil space programme and its future strategy. Set up in 2010, it aims to provide a clear, single voice for UK space ambitions in technology, science and applications.

The UK space sector is worth 11.3 billion, supports more than 34,000 jobs and is growing at an average rate of 7.2%. Working with industry, academia and partners in Government, the UK Space Agency plans for the UK to capture 10% of the global market for space by 2030.

The UK is already a world leader in many areas of space research, business and innovation.

The UK builds and operates some of the world's largest communications satellites, sophisticated navigation and Earth observation satellites and is developing a new generation of compact spacecraft.

British scientists and engineers are involved in missions to study the Earth, explore other planets in the Solar System and investigate the cosmos beyond.

The UK is a world leader in providing communications, broadband and television services from satellites. UK companies and researchers are also developing new ways of using satellite data for a wide range of applications including navigation, weather and climate research, food security, health and education.

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