

# space:uk

**Growing space: ambitious plan for UK**  
**Counting stars with European satellite**  
**Cornwall looks to deep space**



**UK space  
conference  
success**



**Space station  
views of  
Earth**



**Comet  
mission  
continues**



# :contents

## 01/09 News

Mars site chosen, gravity launch preparations and Earth from the International Space Station

## 10/15 Growing space

Ambitious plans to grow the UK space sector

## 16/19 Star performer

Europe's mission to map the galaxy

## 20/23 Cornwall's deep space mission

Historic Goonhilly ground station looks to the future

## 24 Space in the classroom

Principia projects for students

## 25 Made in the UK

## Pull-out poster: Pluto



**Front cover image** One of the receivers for Europe's new Galileo satellite navigation system – a project with key UK involvement **Credit:** ESA, Arianespace

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## Go for launch

**UK astronaut Tim Peake has completed his training for a mission to the International Space Station.**

The first stage of training began more than five years ago at the European Space Agency's (ESA) centre in Germany, with lessons in orbital mechanics, science, engineering and Russian as well as vital medical and survival training. The next phase – two and a half years of intensive launch preparations, involving travel between Europe, America, Kazakhstan, Japan and Canada – is at an end with the launch scheduled for December.

Although Helen Sharman was the first British astronaut in space, when she flew to the Soviet Mir space station as a research cosmonaut in 1991, Peake is the UK's first ESA astronaut.



Spacewalk training in Houston **Credit:** NASA, Markowitz

“This is a step forward in the fact that the UK Government is now supporting human spaceflight,” said Peake. “What that means is that UK industry, UK education and the UK scientific community can all embrace human spaceflight, and that means taking part in scientific research being conducted not just on board the ISS, but within all the other European Space Agency spaceflight programmes.”

Peake's training has included learning how to run science experiments in ESA's Columbus laboratory, operating a replica of the ISS robotic arm to help dock visiting spacecraft, and preparing for a spacewalk or EVA (Extra Vehicular Activity).

Spacewalk training is performed underwater, at both the ESA Astronaut Training Centre in Cologne and NASA, with life size mockups of space station modules.

### Cool clear head

While Peake will know the ISS inside out even before he gets there, all astronauts must be able to cope with physical and psychological stress as well. In the event of an onboard emergency – such as depressurisation or fire – astronauts must remain calm and take immediate action with a cool clear head. Up in space, 400 km above the Earth, this could be the difference between life and death.

Fortunately, Peake's career as an army helicopter pilot is likely to be a huge asset when it comes to the ability to cope under pressure. “In some ways the training is quite similar to military training,” said the astronaut. “It is quite rigorous but it's also well paced.”

Since he's completed robotic arm training, there is a good chance that Peake might be involved in docking one of the US commercial supply spacecraft vehicles – Dragon from SpaceX or Cygnus from the Orbital Sciences Corporation – during his six-month stay.

The eighth SpaceX cargo resupply mission will help expand the ISS during Peake's mission as it is bringing up the Bigelow Expandable Activity Module (BEAM). This new four metre long expandable module is made of a resilient textile, rather than metal, and will be in space for two years to demonstrate the technology.

It may be the first time in space for Peake but he will fly to the ISS in a Soyuz spacecraft with two experienced companions: NASA astronaut Tim Kopra and Russian cosmonaut Yuri Malenchenko, who has spent a total of almost two years in space during multiple missions.

“Everything is looking good,” said Peake. “Myself and my crewmates are well prepared for this mission.”

## New space centres

**Two major new space facilities have been opened at the UK Space Gateway at Harwell in Oxfordshire.**

Hundreds of representatives from the UK space sector attended the inauguration of a major new ESA facility, the European Centre for Space Applications and Telecommunications (ECSAT) in July. Leading the event were the UK Minister for Universities and Science, Jo Johnson, and the new Director General of the European Space Agency, Johann-Dietrich Wörner. They were joined on a giant screen by British ESA astronaut Tim Peake, speaking from his training at Star City in Russia.

Named after ESA's British first Director General, Roy Gibson, ECSAT's new building will house more than 120 people, including teams working on new applications of space technology.

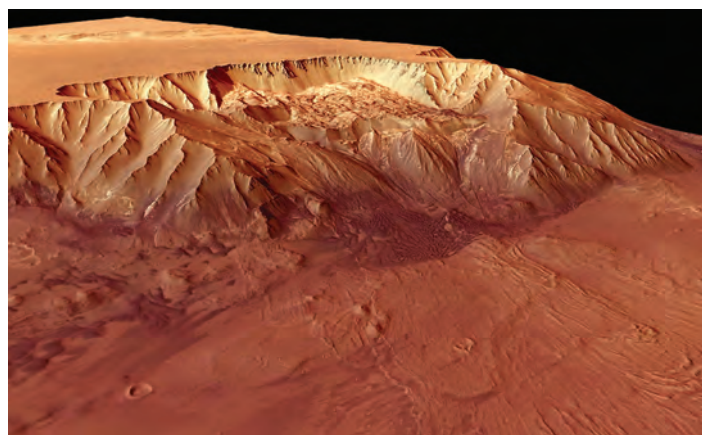
On the same day, RAL Space opened its new £27 million hi-tech test facilities. The R100 building includes 5 m diameter chambers to simulate the space environment. These will be used to test instruments and satellites for missions such as ESA's Solar Orbiter, which will fly closer to the Sun than any previous spacecraft.

"Putting cutting-edge knowledge and innovation and world-class space testing facilities right on the doorstep, the opening of the European Space Agency and R100 facilities at Harwell are a major boost to the UK's space sector," said Jo Johnson, Minister for Universities and Science.



Tim Peake joined the celebrations from Star City near Moscow **Credit:** ESA

## Mars site chosen



This 3D image of a region known as Melas Chasma was obtained by Mars Express – the ExoMars missions will build on the work of this highly successful Mars orbiter **Credit:** ESA, DLR

**The likely future home on Mars for the UK-built ExoMars rover has been identified by an ESA working group of scientists and engineers. The site chosen for the 2018 landing is in a region near the Martian equator known as Oxia Planum.**

ExoMars is a joint venture between ESA and Russia, including an orbiter and rover – the latter due to launch in 2018. Prototype rovers are currently being developed and tested in a simulated Martian landscape at Airbus Defence and Space in Stevenage.

The search for a suitable landing site for the rover began two years ago and was narrowed down to a shortlist of four sites in October 2014. Since then the working group has been assessing the challenges of descent and landing at different locations, balanced against the scientific aims of the mission.

The primary goal of the ExoMars rover is to search for evidence of life on Mars in the past or present. The Oxia Planum region shows strong evidence of once being covered in water – increasing the chances of finding indications of biology.

"Our preliminary analysis shows that Oxia Planum appears to satisfy the strict engineering constraints while also offering some very interesting opportunities to study places where biosignatures might best be preserved," said Jorge Vago, ESA's project scientist on the mission.

The first ExoMars mission, ExoMars 2016, is due for launch in March next year. It includes an orbiter, which will act as a relay for the later flight, as well as a landing demonstration module.

# Ambition on display at UK Space Conference



The UK Space Agency stand at the conference  
Credit: UK Space Agency, Alexander

**More than 1000 delegates attended the 2015 UK Space Conference in Liverpool, showcasing the best of the UK space sector.**

This summer's conference was held at the Convention Centre in Liverpool, on the banks of the river Mersey. Visitors from across the world came to the city for the event, which included sessions on everything from UK space history and the latest advances in space and climate research, to the development of UK spaceports and spaceplanes. A whole floor of the venue was taken up with stands and displays from companies, academic groups and organisations covering all aspects of space exploration with applications.



Cornwall's Goonhilly Ground Station could be used to communicate with Orion. This artist's impression shows the NASA Orion capsule with its ESA service module. Credit: ESA

## Case for space

The conference included the publication of the latest Case for Space report, indicating the UK space sector has trebled in size over the last fifteen years, now employs some 37,000 people and supports an estimated 115,000 jobs in total. An update of the UK Space Innovation and Growth Strategy was also published, reaffirming the intention to grow the value of the UK space industry from £11.8 billion to £40 billion by 2030 (see page 10).

Announcements made at the conference included an ESA agreement with Cornwall's Goonhilly Ground Station to investigate the potential of using the facility to provide communications support to the new Orion spacecraft (see page 20). The event also saw the launch of the Wales Space Strategy. Written in partnership with the Satellite Applications Catapult, this is aimed at growing the country's space sector to £2 billion by 2030.

## Awards

A highlight of the conference was the Gala Dinner, where Britain's first astronaut, Helen Sharman, presented the Sir Arthur Clarke Awards for space achievement. Winners included the Beagle 2 team. New images, revealed earlier this year, showed the British-built space probe on the Martian surface – proving it had successfully landed in 2003 and not broken up in the planet's atmosphere as previously thought. Awards also went to the Rosetta and Philae outreach teams for their work on the historic comet mission.



UK astronaut Helen Sharman speaking at the conference. Credit: UK Space Agency, Alexander

### Broadband from space



UK satellite operator, Inmarsat, celebrated another launch in August. A Proton rocket, on a return to flight mission after a failed launch in May, successfully lifted the communications satellite Inmarsat-5 F3 into orbit from Baikonur Cosmodrome in Kazakhstan.

It is the third satellite in the Global Xpress constellation after launches in 2013 and 2014. Commercial services from the satellites will become globally available at the end of this year – the first worldwide high-speed mobile broadband network from a single operator.

“I’m delighted that we now have three Global Xpress satellites in orbit,” said Rupert Pearce, Inmarsat CEO. “This is a significant milestone for Inmarsat – one that will offer major growth opportunities and promises to change the face of our industry.”

The powerful Proton rocket blasts off from Baikonur **Credit:** Inmarsat

### Power of Three

The new DMC3/TripleSat Constellation of satellites, designed and built by UK company Surrey Satellite Technology Limited (SSTL), has produced its first high-resolution images.

“It’s a real demonstration of technical precision,” said David Parker, Chief Executive of the UK Space Agency. “SSTL’s expertise in small satellites plays a major role in the space sector’s £3.6 billion contribution to the UK economy through exports.”

Launched in July from India, the three identical satellites are all in the same low Earth orbit and can target anywhere on Earth daily. Images from the satellites can be used for security, urban planning, precision farming and agricultural monitoring.



DMC3 captured this image of Sydney airport **Credit:** SSTL

## Quantum leap for satellite tech

**A new UK-developed satellite will be able to receive upgrades in orbit.**

The space industry may be known for its innovation and advanced technology but once a satellite is launched it is usually impossible to change anything. Eutelsat’s new Quantum satellite, however, will be reprogrammable in orbit.

Quantum will be developed by a public-private partnership involving ESA, the UK Space Agency and Airbus Defence and Space. The deal was signed during the inauguration of ESA’s new centre in the UK (see page 2). Eutelsat also signed a contract with Surrey Satellite Technology to build the first example of Quantum, due to be delivered in 2018.

The Quantum project represents a new approach to satellite design and operation, enabling customers to change aspects of the satellite’s performance even when it is in orbit. The general design can be easily tailored to meet a wide range of specific requirements and re-configured to meet changing needs over the spacecraft’s lifetime.

“This is the first of a new generation of satellite that has agility, adaptability, responsiveness and performance at its core,” said Eutelsat’s Chairman and CEO, Michel de Rosen. “It is the culmination of many years of research and evaluation and marks a new age of maturity for the commercial satellite business.”

Quantum will enable operators to change the satellite’s coverage or adjust capacity to meet different requirements for maritime, aeronautical and land-based uses.

“Space is a great British success story,” said Minister for Universities and Science, Jo Johnson. “Our investment in collaborative space science means the UK has the know-how and technical expertise to provide exciting and innovative space solutions that will drive growth and create jobs.”



Artist’s impression of the new Quantum satellite **Credit:** ESA

## Rosetta: thrills and danger at 67P



It's now known that two comets joined together to form 67P's distinctive duck-shape  
Credit: ESA

### The Rosetta team celebrates the first anniversary of landing on comet 67P/Churyumov-Gerasimenko in November and plans a potentially thrilling finale and yet more science.

Since the comet reached perihelion – its closest approach to the Sun – in August, its activity has increased. “We’re seeing up to a thousand kilos per second of material being chucked off the comet,” said ESA’s Rosetta Project Scientist, Matt Taylor.

The comet’s rotation rate has also got faster and the tail is extending to 100,000 km or more. “It’s a very exciting time but it’s also a dangerous time in terms of the point of view of the spacecraft,” said Taylor.

“We had to fly further and further away from the comet because of the activity, because of the interference of dust with our navigation devices. When the activity starts to wane that will enable us to get closer.”

The Rosetta orbiter continues to collect information about the comet although there has been no contact with its lander, Philae, since a short burst of signals between June and early July. Orbiting closer to the comet might allow renewed contact. “If we get closer and we’re able to do a proper contact with it, we’ll be able to command it and then get some more lander science” said Taylor. “Let’s see what happens.”

### Risky manoeuvres

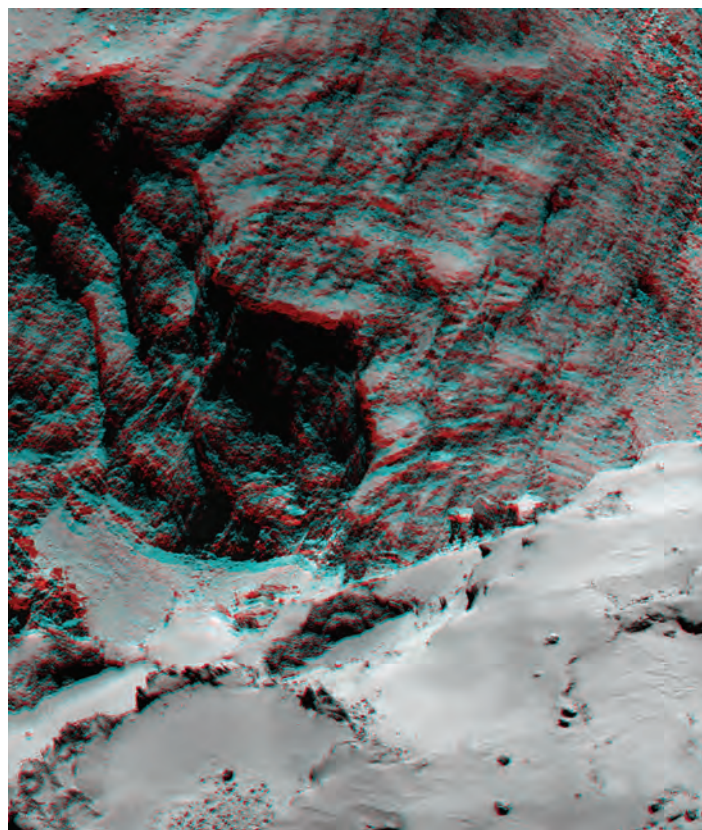
Due to the comet’s unusual shape and the inclination of its rotational axis, the northern hemisphere faces the Sun for five and a half of its six and a half year orbit. The southern hemisphere’s long dark winter ended a few months before perihelion, which means Rosetta can now observe the region with its OSIRIS high-resolution camera.

With the mission extended until September 2016, the team is examining some risky and ambitious manoeuvres. “One of the things we’re looking at doing is actually flying into the tail of the comet,” said Taylor. “We’re discussing whether to do that and how we’d do that.”

The Rosetta mission has been a spectacular success with a number of firsts under its belt: it is the first mission to orbit a comet and the first mission to land on a comet. But the team is not resting on its laurels.

“Our end of mission scenario is to spiral the spacecraft onto the comet,” said Taylor. “It will give us the closest, highest-resolution measurements, as close as we possibly can, but also we can get into the regions where the coma is generated.”

“It’s the first rung in the ladder of how the coma creates itself,” he said. “It’s beautiful that we’ve been able to extend the mission and in some ways it’s poetic that we’re going to put the orbiter on the comet as well – a fitting finale for the entire mission.”



A close-up view of the comet’s surface Credit: ESA

## New space deals

### **UK space technology is being developed to help combat illegal fishing and improve aviation safety.**

Glasgow-based space company Spire UK is working with Singapore's Institute for Infocomm Research to build a satellite system to detect and track illegal fishing activities.

More than three billion people depend on fish as a primary source of protein in many of the areas of the world where overfishing and illegal fishing are most prevalent. The trade poses a threat to ecosystems and coastal economies with estimates suggesting it causes more than \$20 billion of lost revenues, predominantly for developing nations.

The new Glasgow-built nanosatellite system is being designed to track small fishing vessels automatically. The hope is that it could eventually grow into a constellation of 50 small satellites.

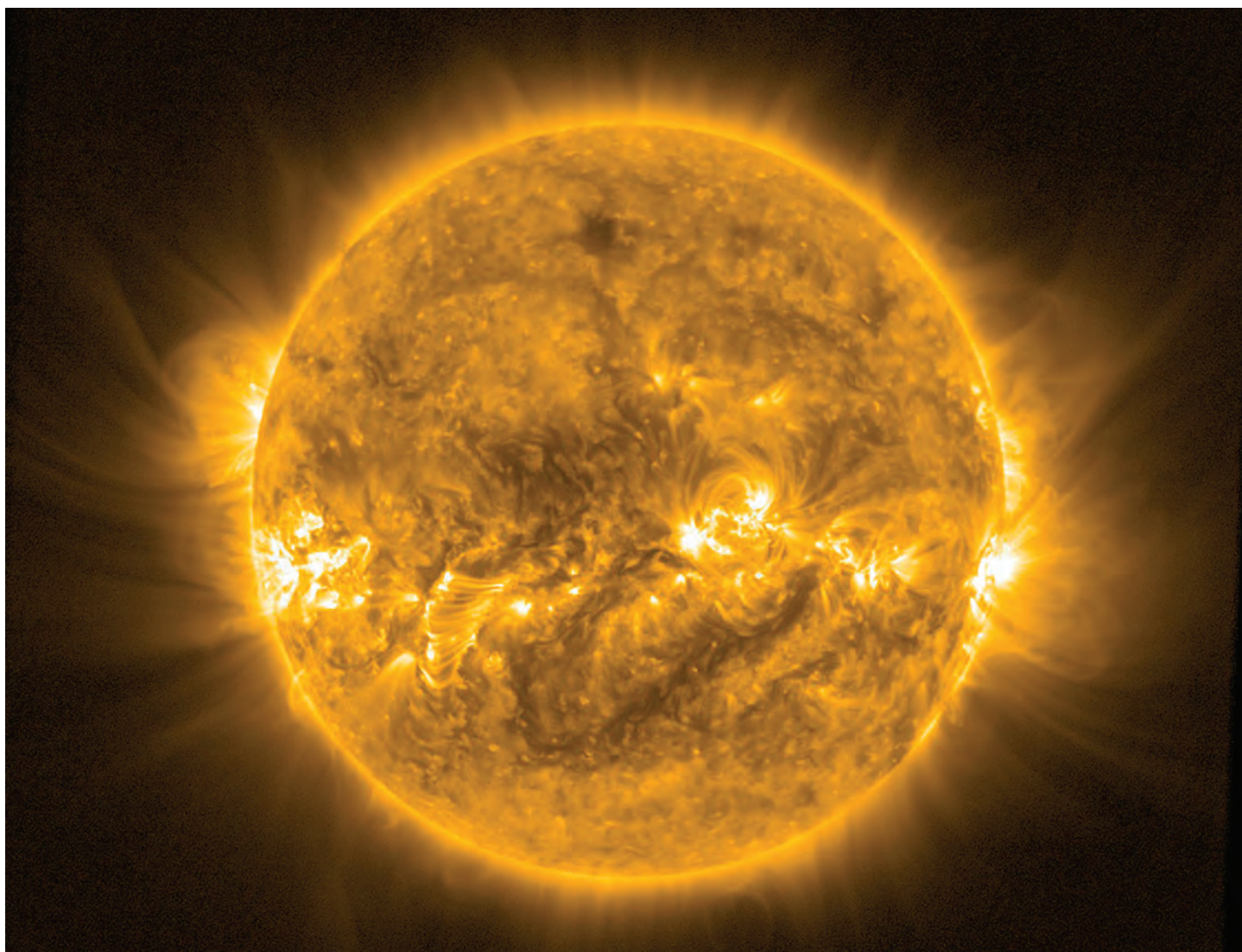
The £1.6 million project, jointly funded by Spire and the UK Space Agency was announced during the Prime Minister's recent visit to Southeast Asia, where a Memorandum of

Understanding was signed with the Indonesian Space Agency to increase collaboration in space.

The UK Space Agency is also working with the South African Space Agency to enhance benefits from space. Both agencies recently agreed to work closer together and review areas of common interest.

"The agreement covers a range of areas where both agencies would benefit from collaboration, including research opportunities around space weather, information sharing in the use of space for applications related to climate change, and satellite data sharing," said UK Government Chief Scientific Adviser, Mark Walport.

UK company Avanti Communications is already involved in a project to develop an enhanced satellite navigation system to improve aviation safety in Africa. At present Africa has 3% of global air traffic but around 20% of the world's air accidents. The new system will have benefits of some £1.2 billion for the African aviation industry, with the potential to save hundreds of lives.



The UK will work with South Africa to study space weather – the effect of solar activity on the Earth. This view of the Sun was captured by ESA's Proba-2 spacecraft **Credit:** ESA



## Go for gravity mission



The LISA Pathfinder science and propulsion modules during final testing in Germany  
Credit: ESA

**LISA Pathfinder has arrived at the European spaceport at Kourou in French Guiana ready for launch. The UK-led ESA mission will test technology that should eventually enable scientists to detect elusive ripples in space-time called gravitational waves.**

These Gravitational waves – predicted by Einstein’s theory of General Relativity but so far undetected – are believed to be caused by the movement of astronomical bodies. As well as providing a further test of relativity, their detection could open the way to a new method of observing the Universe and, in particular, of studying supermassive black holes.

LISA Pathfinder is the first ESA mission with a UK prime contractor since the Giotto comet mission in 1986. Assembled by Airbus Defence and Space, key payload subsystems have been provided by teams from Imperial College London, the University of Glasgow and the University of Birmingham.

Inside the body of LISA Pathfinder two 46 mm gold-platinum alloy cubes, 35 cm apart, will float free and their relative positions will be tracked with a precision unprecedented in space-based instruments. “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 cube and interfering that with another beam,” said Harry Ward of Glasgow’s Institute for Gravitational Research, whose team built the optical instrument. “By watching the interference pattern we can decode the movements of the proof masses.”

The mission will not itself be able to detect gravitational waves but will demonstrate techniques planned for a full-scale detector. Provisionally called eLISA, this is slated for launch around 2034. Employing the same technology as LISA Pathfinder, eLISA will fly its test masses in three satellites arranged in a precise equilateral triangle, 5 million kilometres apart.

## From the Agency

**Summer 2015 saw the return of the UK Space Conference, the launch of our National Strategy for Space Environments and Human Spaceflight and the opening of two new space facilities at the UK Space Gateway in Oxfordshire.**

The inauguration day for ESA’s European Centre for Space Applications and Telecommunications (ECSAT) and RAL Space’s £27 million state of art test facility was also the backdrop for a €180 million contract between ESA and Eutelsat for the first of an innovative class of geostationary communications satellite. The new Quantum satellite will be led and manufactured by Airbus Defence and Space in the UK with a new platform from Surrey Satellite Technology Limited (see page 4).

A week later we were off to Liverpool for the UK Space Conference. With more than 1000 delegates, the 2015 conference was a huge success. It included several key announcements and provided the venue for ESA to sign a contract with Inmarsat in the UK to support the Inmarsat Communications Evolution project, ICE. This public-private partnership gives European industry the opportunity to shape future mobile satellite services on land, at sea and in the air.

On the exploration side, we saw Europe’s billion-star surveyor – Gaia – complete its first year of science observations (see page 16). This is excellent news for the UK, which is a major contributor to the mission.

With British ESA astronaut Tim Peake due to launch to the International Space Station in December, the upcoming months are set to be some of the busiest yet. As Tim embarks on his mission, we want young people across the UK to get involved through our exciting Principia education and outreach activities. More details can be found on our Principia.org.uk website and in a special Principia edition of *space:uk*.



## Earth from the International Space Station

400 kilometres above the Earth, the International Space Station (ISS) orbits the world every 90 minutes. Astronauts living on the ISS take every opportunity to capture pictures of their home planet, revealing the beauty and fragility of the Earth.



ESA astronaut André Kuipers took this picture of London at night



NASA astronaut Terry Virts taking a photo from the ISS Cupola



The Moon seen above the layers of the atmosphere



A glint of sunlight off the Atlantic coast of South America



ESA astronaut Samantha Cristoforetti took this picture of our blue planet protected by its thin atmosphere



ESA astronaut Luca Parmitano selfie, with the Earth and ISS Columbus module reflected in his visor during a spacewalk



An Aurora captured by ESA astronaut Alexander Gerst. Aurora occur when charged particles from the Sun hit Earth's atmosphere

All credits: ESA, NASA



# Growing space

**The UK space sector is worth £11.8 billion and supports more than 115,000 jobs. Richard Hollingham reports on ambitious plans to grow the sector to £40 billion by 2030:**

On a hot July morning at the Harwell campus near Oxford, a group of volunteers is grappling with a cardboard box of flags. The multi-coloured collection represents the member nations of the European Space Agency (ESA). It is up to the team to ensure that the flags fly the right way – a particular challenge with the Union flag.

It is an important day for both ESA and the UK, marking the inauguration of ESA's European Centre for Space Applications and Telecommunications (ECSAT). The new ECSAT building is named after ESA's first Director General, Britton Roy Gibson – a key figure in the development of the agency.

With the flags sorted, more than two hundred representatives from the UK space sector – including the new Director General of ESA, Johann-Dietrich Woerner, UK Minister for Universities and Science, Jo Johnson, and British ESA astronaut Tim Peake (appearing on a giant screen from his training at Star City in Russia) – count down to the formal opening. The volunteers raise the flags in front of the new hi-tech building without a hitch.

continues >



## Rock band

Shortly afterwards, the VIPs gather again to witness the opening of another new space technology building a few hundred metres away: RAL Space's massive new test facility for satellites and space instruments, designed to ensure spacecraft can survive being blasted into space.

It is a big day for the UK space industry and the significance is not lost on Chief Executive of the UK Space Agency, David Parker. "It's remarkable for those of us who've been in the business for 25 years now," says Parker. "We've gone from being an underground rock band to rock stars."

"We've got tremendous investment happening, both from ESA and nationally," says Parker. "We've got the recognition of how important space is – not just exploring space with missions to Mars and Tim Peake's mission to the space station, but the practical uses of space. We're seeing both of these

growing together, side by side, and it's symbolised by what's happening here at Harwell."

## Catapult

As well as the new ESA centre and STFC's space facilities, the Harwell campus includes among its many buildings the massive futuristic doughnut of the Diamond Light Source and the Satellite Applications Catapult. "This site brings together the world of space and the rest of the world of science and technology," says Parker. "Our vision is to join up important science, new technology and the world of business."

The Satellite Applications Catapult was set up as a result of the Space Innovation and Growth Strategy (IGS) report, first published in 2010. "We have been a key catalyst in many areas," says Joanna Hart from the Catapult. "Because we're not part of government or industry directly, we've been able to do many different things."

The Catapult can point to any number of successes, from using satellites to help deliver more efficient council services in Milton Keynes to tackling illegal fishing in remote areas of the world. "The Catapult can be a trusted friend to help people understand what satellites can do," explains Hart.

Five years on, much of what was recommended in the first IGS report can be ticked off the space to-do list. As well as the development of the Catapult – part of the UK Space Gateway at Harwell – the UK Space Agency has been set up and the Space Leadership Council established.

**"The UK's investment in ESA shows the world that it's serious about space"**

Joanne Wheeler  
Satellite Finance Network



The new RAL Space test facilities at Harwell Credit: STFC

uto



# Pluto

Pluto was the ninth planet in the Solar System until its status was downgraded by the International Astronomical Union to 'dwarf planet' in 2006. Although Pluto is smaller than our Moon it is the largest of the dwarf planets, with a diameter of 2370 km.

Discovered in 1930, no mission had visited Pluto until 2015. Even the Hubble Space Telescope has trouble seeing the planet's surface in detail, so our knowledge of features has been limited.

Astonishing images and measurements from NASA's New Horizons mission have shown that a third of the planet is water ice, with frozen plains, mountain ranges and icy peaks up to 1.5 kms high. Pluto's temperature is  $-230^{\circ}\text{C}$  with an atmosphere of methane, nitrogen and carbon dioxide.

The planet's orbit takes it between 4.4 and 7.3 billion km from the Sun. This means that, for 20 years of its 248 year orbit, Pluto is closer to the Sun than Neptune.

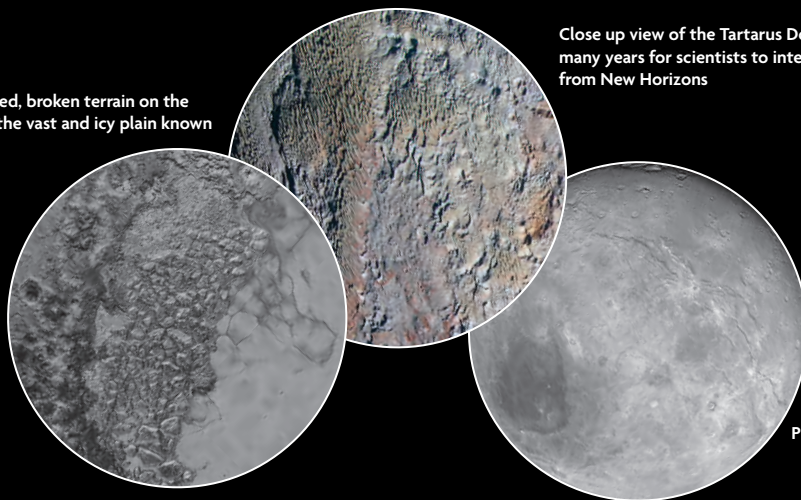
## Pluto's moons

In 1978 Pluto's apparent solitude in the outer Solar System was broken with the discovery of its moon, Charon. Two smaller moons – Nix and Hydra – were observed in 2005 followed by Kerberos in 2011 and Styx in 2012.

Icy Charon is the largest and innermost moon with a dark north polar region, heavily cratered areas, mountains and sunken terrain. It is approximately half Pluto's size but one eighth of its mass.

Charon and Pluto orbit a common centre of gravity and are tidally locked, keeping the same face towards each other as they move. This makes Charon and Pluto more like a double planet, or binary, system.

A large region of jumbled, broken terrain on the northwestern edge of the vast and icy plain known as Sputnik Planum



Close up view of the Tartarus Dorsa mountains – it will take many years for scientists to interpret all the images and data from New Horizons

Pluto's largest moon, Charon

## New Horizons

Our knowledge of Pluto has been transformed by NASA's New Horizons mission.

Launched in January 2006, the spacecraft made its closest approach to Pluto on July 14 2015 during its six-month flyby. The images it has returned of the dwarf planet and its moons are astonishing, allowing us to see Pluto in detail for the first time.

Pluto is no longer an indistinct grey blob. It has mountains, rippling landscapes, dunes of ice particles and surface features resembling snakeskin.

The mission will help us understand how icy dwarf planets, like Pluto and those in the Kuiper Belt, have evolved over time. The spacecraft is equipped with seven onboard instruments, including the Venetia Burney dust counter – built and operated by students.



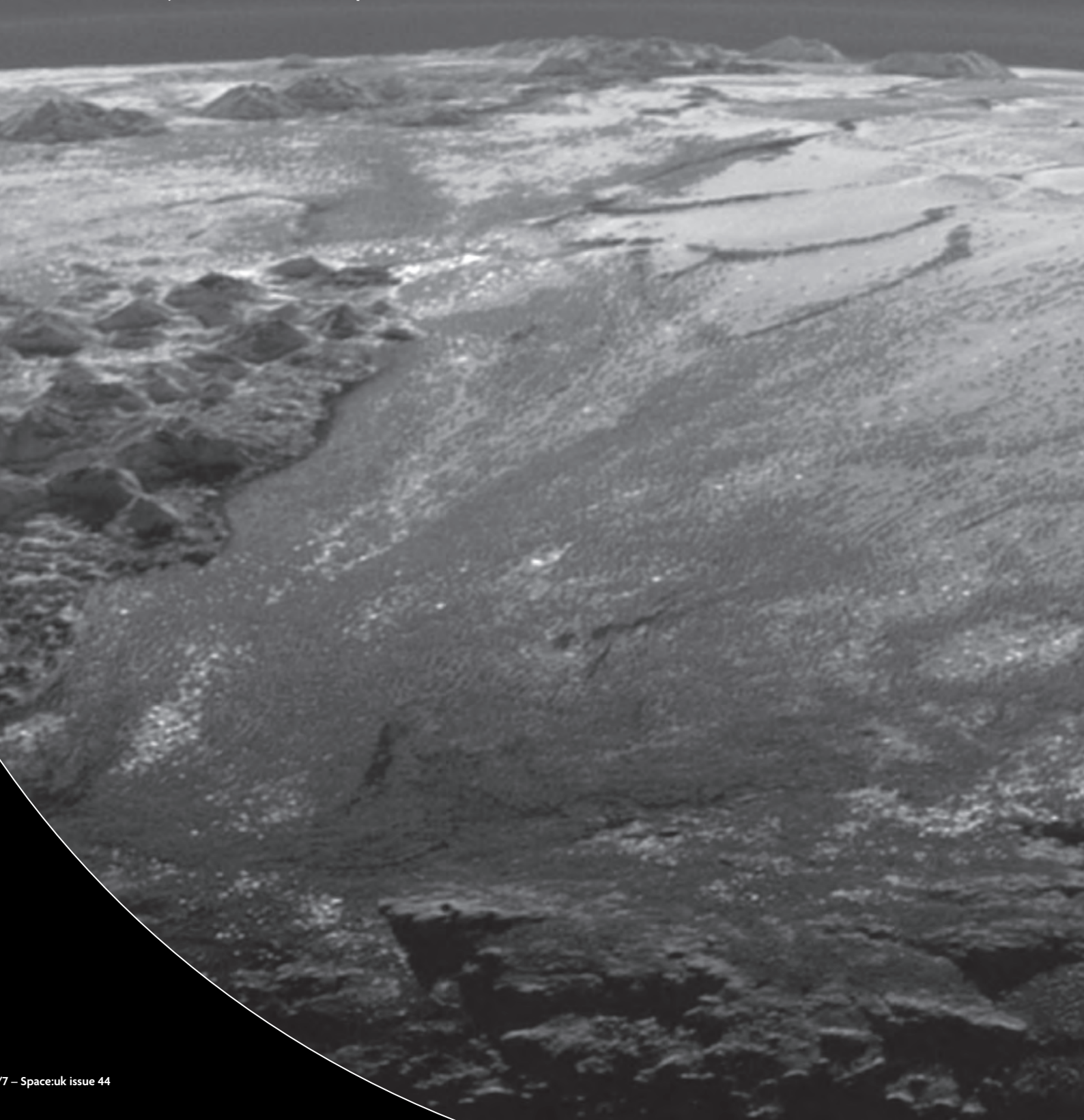


### **Pluto: into darkness**

Pluto was discovered by an American astronomer in 1930 and named by an English schoolgirl after the Roman god of the underworld. Not, as rumoured, after a cartoon canine who also made his appearance that year. Disney's dog Pluto was named after the planet.

Clyde Tombaugh was working at the Lowell Observatory in Arizona when he identified Pluto. He died in 1997, nine years before it was downgraded to a dwarf planet. A few months after this demotion, the New Horizons mission carried some of Tombaugh's ashes into space.

Pluto's known moons – Charon, Styx, Nix, Kerberos and Hydra – continue the classics theme. Charon was the man who ferried dead souls across the River Styx to the Underworld, guarded by a multi-headed dog Kerberos. Nix was the Greek goddess of darkness and Hydra the nine-headed serpent that battled Hercules.



# Plu

**After decades hidden from view in the darkest reaches of the Solar System, Pluto is enjoying the limelight as we discover more about this surprising dwarf planet.**



The colours have been enhanced in this view of Pluto captured by NASA's New Horizons spacecraft



## Mars rover

The UK's contributions to ESA have also risen in that time – from £220 million per year in 2010 to £300 million in 2015. It is no coincidence that this concentrated effort in developing and investing in the space industry tallies with a significant increase in the turnover of the sector. The recently published Case for Space 2015 report shows that the UK space industry has been growing by an average of 8.6% year-on-year since the beginning of the decade.

Today's headline figure for this £11.8 billion industry includes everything from

the construction of a Mars rover and hi-tech communications satellites, to the provision of satellite navigation and TV services. The projections are that, with continued investment, the UK space sector will continue to grow.

“The clear message that space is not spending money but investing to build the economy is well understood,” says Parker. “We’ve got to show we’re spending the money wisely with the right investments.”

The latest updated IGS report was published in the summer, reiterating the goal to grow the UK space sector

to £40 billion by 2030. This would give the UK 10% of the predicted global space market. The UK currently captures around 7%.

**“We’ve gone from being an underground rock band to rock stars”**

David Parker  
UK Space Agency

## Ambition

It is an ambitious target. In fact the word ambition is written throughout the latest IGS report, as if through a stick of rock. And it is not as if other nations are standing still – they too are trying to grow this potentially lucrative sector of the economy.

“It’s hugely ambitious,” admits Joanne Wheeler, Partner at Bird and Bird – a London-based international law firm specialising in technology and communications with a particular focus on space. “To achieve that target the Government and industry need to come together to concentrate not just on small businesses but to help the larger companies grow and encourage non-UK companies to the UK.”

Wheeler is a founding member and Co-Chair of the Satellite Finance Network (SFN), set up as a result of another recommendation of the first IGS report. SFN aims to bring together companies and potential sources of finance for growth. “We try to remove some of the



perceived risks of the space sector in the eyes of the finance community,” says Wheeler. “We aim to show investors that this is an industry they use on a daily basis without realising it – and one with potentially good returns.”

## Down to Earth

Satellites provide us with everything from TV services and international phone calls to weather forecasts and navigation systems. The timing signals from navigation satellites are even used to accurately time-stamp financial transactions and keep data moving around the Internet.

“Applications of space technology are a rich growth area,” says Wheeler. “A lot of what we do is to bring the space industry down to Earth.”

“The SFN has also been influential in changing some of the regulations to bring the UK in line with other spacefaring nations,” says Wheeler, “and that’s in the interest of all space companies.”

The revised regulations, so far, relate to satellite insurance and liability. Most new satellites are insured to cover launch failure and failure in orbit. Insurance premiums can add tens of millions of pounds to the cost of launching a satellite. Recent changes introduced by the Government include capping the amount of liability on companies for damage caused by a satellite and removing insurance premium tax for insuring spacecraft.



The launch of Europe’s latest Galileo navigation satellites. Services using these satellites are a potentially lucrative growth area **Credit:** ESA, Arianespace

## Skilled workforce

Many of these measures bring the UK into line with other nations but are unlikely to achieve the £40 billion growth target alone. Wheeler is keen to entice foreign companies to set up in Britain. “The UK’s investment in ESA shows the world that it’s serious about space,” she says. “There is a Government drive to encourage companies to come to and grow in the UK, employ here, partner with other companies or universities and potentially put their headquarters here.”

The other priority – in fact the only certain way of achieving the £40 billion figure – is to grow exports. This is an area the Satellite Applications Catapult

is already focussed on, putting together ‘roadmaps’ to exploit new markets at home and abroad. “Exports are a key area in reaching the growth targets,” says Hart.

“We’ve got six markets where there has been active work and there are four more areas under development,” she says. “If we get the right momentum, they could create significant markets for the UK.”

With a British ESA astronaut about to fly to the International Space Station, a Mars rover under construction in Hertfordshire and a wide range of hi-tech missions and space applications under development, there has never been a more exciting time to be

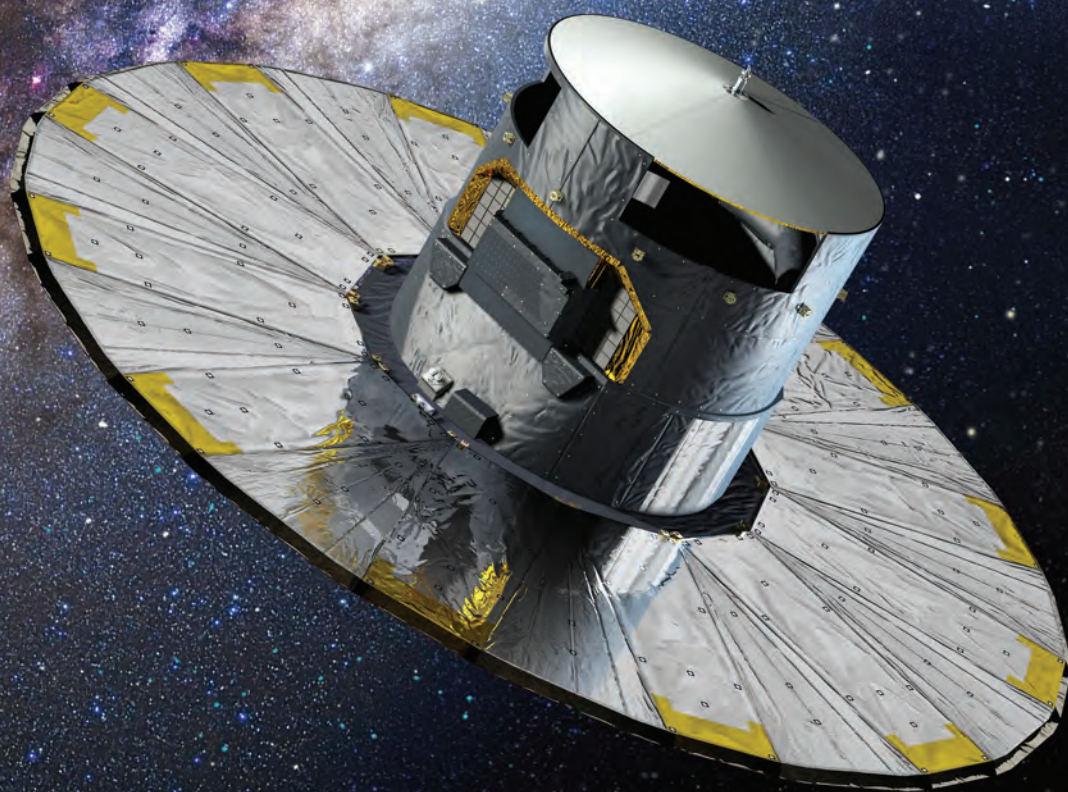
involved in the UK space sector. But behind the headlines of rovers, astronauts and daring missions to distant worlds, there is money to be made. And that benefits everyone in the UK.

“We have a really strong skilled workforce, we can make things, we have a good engineering base,” says Wheeler. “If we can capitalise on this and grow these companies, everyone will benefit.”

But she cautions that achieving a £40 billion industry should not be taken for granted. “It is very ambitious and, potentially, too ambitious,” she says. “But if the Government remains focused on this industry we’ve got a good chance.”



British astronaut Tim Peake during his Soyuz training **Credit:** ESA



# Star performer

**The UK plays a major role in the star mapping Gaia mission – the ESA space telescope making a census of the stars. Sue Nelson reports on the challenge of producing the first 3D map of our galaxy:**

**“The satellite itself is running beautifully and the data is delightful”**

Gerry Gilmore  
Cambridge University's Institute of Astronomy

If you are lucky enough to see the Milky Way in the night sky, pick a section and try counting the stars. It is a formidable task for the naked eye but ESA's Gaia mission can see and pinpoint each star's position with extraordinary precision.

Launched in December 2013 from ESA's spaceport in French Guiana, Gaia recently celebrated its first year in full survey mode. By July 2016 it will have

produced both the first-ever high-resolution catalogue of the whole sky – more than a billion stars – and a 3D map of the brightest two million stars in its sights.

“The first thing we'll give to the world will be our little patch of the Milky Way,” says Gerry Gilmore, Gaia's UK Principal Investigator from Cambridge University's Institute of Astronomy.

# :star performer

## Top hat

Gaia does not look like an ordinary spacecraft. It resembles a metallic top hat with a skirt-like sunshield. This is half the size of a tennis court and is designed to keep the spacecraft's payload of instruments in the shade. These instruments perform measurements of position, brightness and the spectrum of light.

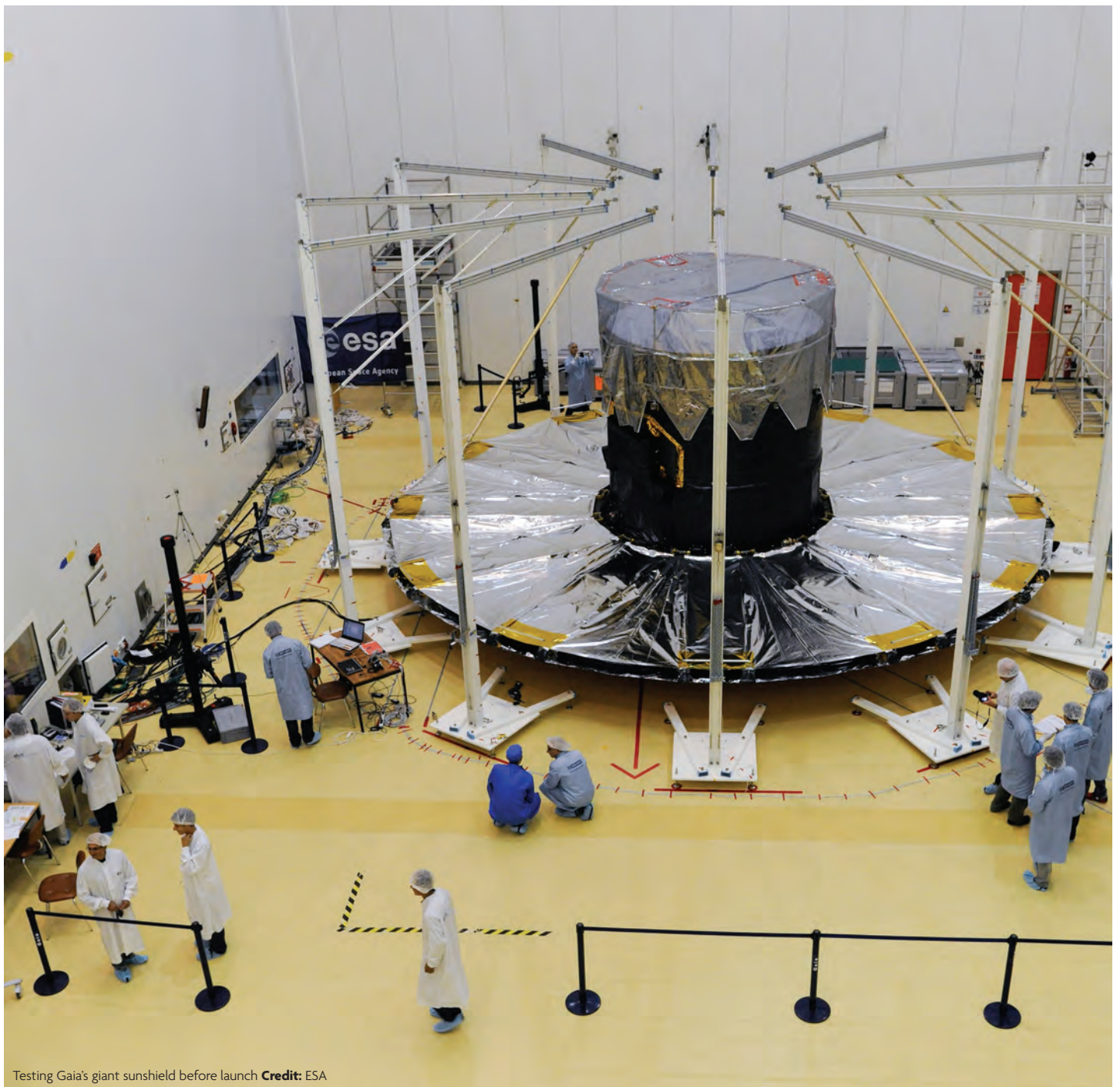
"It's unique compared to most space missions in that all of the spacecraft's payload was made by industry, including major contributions in the UK," says

Gilmore, who is a member of the original team that proposed the mission. "It's a big success for UK industry and UK science and engineering – something we can be very proud of."

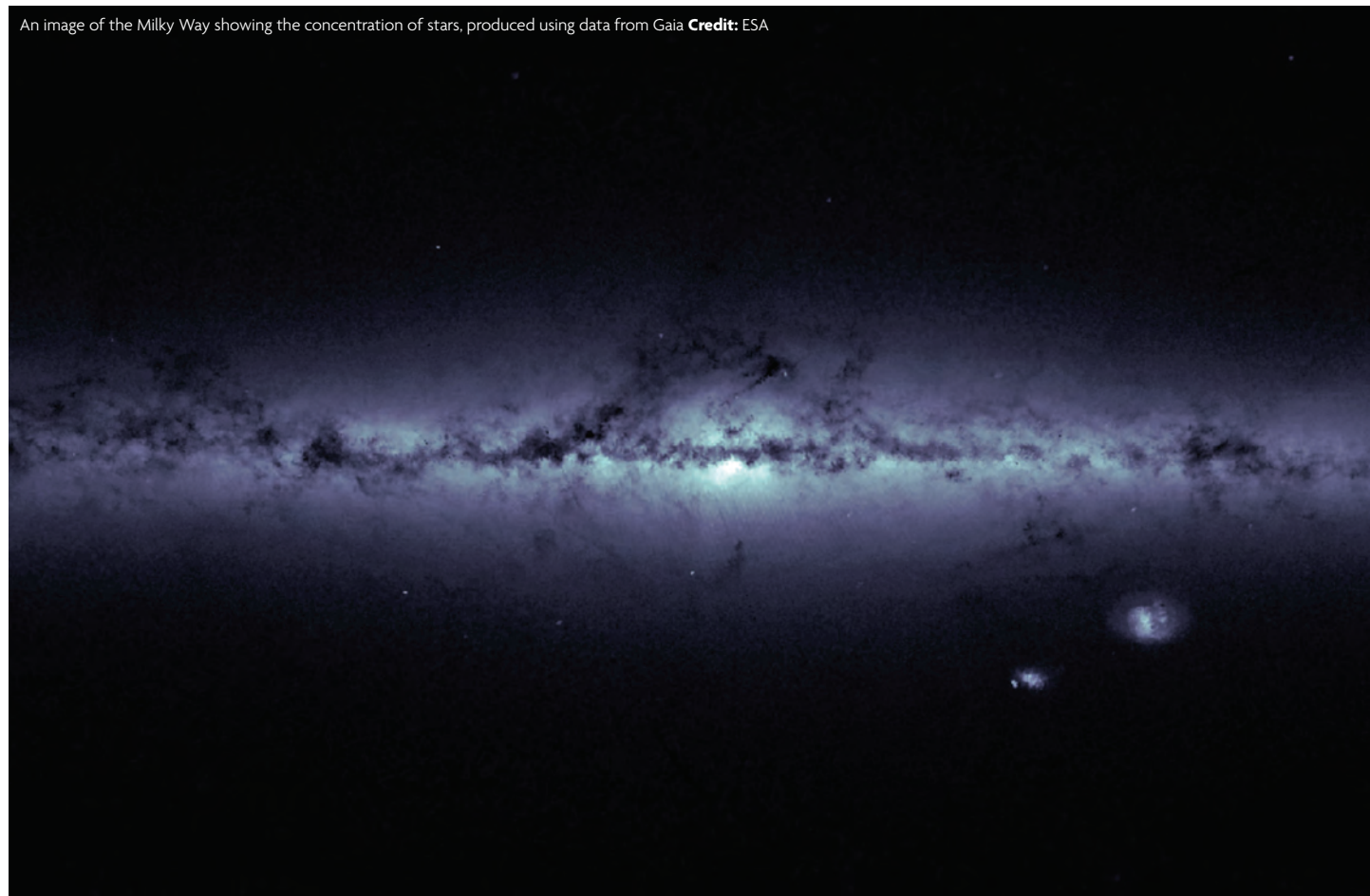
The spacecraft, whose electrical service module was designed and built by Airbus Defence and Space in Stevenage, permanently faces away from the Sun at the L2 Lagrange point. This position, 1.5 million kilometres from Earth, allows uninterrupted observations free from any eclipses. However, in order to stay at the L2 point, Gaia must make small changes to its position every month.

Gaia will observe each star or astronomical object about 70 times, providing a record of the source's brightness and position over time. With more than a billion stars to catalogue, the amount of data will be mindbogglingly big. Five centres across Europe are processing the information and the Cambridge Institute of Astronomy houses one of them: the Cambridge Gaia Photometric Data Processing Centre.

[continues >](#)



Testing Gaia's giant sunshield before launch **Credit:** ESA



An image of the Milky Way showing the concentration of stars, produced using data from Gaia **Credit:** ESA

## Delightful data

“The satellite itself is running beautifully and the data is delightful. We’re producing outstandingly good results,” says Gilmore.

The amount of data was always going to be huge but the mission’s success is adding to the challenge.

“We will actually be able to measure stars we can see with our eyes but, in addition,

the e2v camera on board is so sensitive and is working so well that it’s been possible to extend the survey,” Gilmore says.

“Instead of doing one billion stars we’re now going to do one and a half billion,” he says. “It’s 50% more than we were going to do but that’s relatively straightforward. The challenge is in the complexity of handling the image data from the spacecraft.”

Nigel Hambly, from the University of Edinburgh, knows all about this complexity. He is part of a team that contributes to the software that processes all the information from the spacecraft. This arrives in the form of a stream of numbers from the onboard camera. It is the equivalent, I suggest to him, of a technological clean up.

“You could think of it in that way,” says Hambly diplomatically. “It’s basically calibrating the data into something that’s useful scientifically.”



Working on Gaia’s CCD sensors at e2v **Credit:** e2v



# :star performer

## Intense

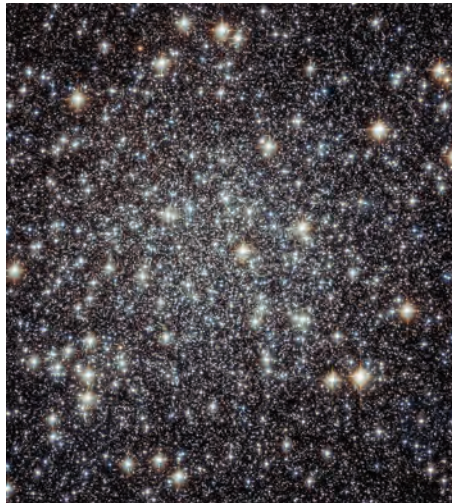
The software is also working well. “The initial scientific results are looking extremely promising and everybody’s excited about them. In some small part,” Hambly says, “that’s due to the software that we’ve provided.”

So far, during its full science observations, Gaia has recorded 272 billion position measurements, 54 billion brightness or photometric data points and 5.4 billion spectra.

“The past twelve months have been very intense,” says Timo Prusti, Gaia project scientist at ESA. “But we are getting to grips with the data, and are looking forward to the next four years of nominal operations.”

As with all software projects, there is always low level maintenance and bug fixing along the way. “But what’s more important with Gaia is that we expect the instrument characteristics to evolve,” Hambly says. “Over the years the detectors get damaged by the harsh radiation environment of deep space and that changes the calibration.”

Gaia will map more than one billion stars **Credit:** ESA, NASA



There have been a few surprises since launch but all have been resolved. Water was leaking onto the spacecraft’s mirrors and condensing but the onboard heaters sorted that out.

Also, fibres on the outer edge of the sunshield allowed some scattered light through. Fortunately it will only affect high-resolution observations of the faintest stars. “But there will still be 50 million or so spectra from Gaia,” says Gilmore, “which is spectacular compared to the one million acquired in the entire history of astronomy on the ground.”

UK space scientists have been involved in all aspects of the mission, from engineering work on the spacecraft’s propulsion, electronics and electrical system, to designing Gaia’s crucial sensors.

While Gaia has been scanning the cosmos and measuring the motions of stars, it has also detected a number of other astronomical objects including asteroids. In August 2014, it also spotted its first supernova.

Gaia’s main legacy, however, will be surveying and cataloguing the chemical elements, speeds, ages, masses and orbits of more than one billion stars. Information that will help determine how our galaxy has evolved. This greater understanding will come as a result, in no small part, of the work of dozens of scientists and engineers from the UK.

### Gaia fact file:

**Launched:** December 2013

**Mission lifetime:** 5 years

**Instruments:** Two identical telescopes, a blue and red photometer and a radial velocity spectrometer

**Sunshield:** The 10.5m wide sunshield consists of 12 rectangular panels and 12 triangular sections. There are solar panels on the underside of the skirt to generate electricity to power the spacecraft

**Operations:** The European Space Operations Centre in Germany controls the spacecraft using ground stations in Spain and Australia. The European Space Astronomy Centre in France conducts the science operations

**Name check:** In Greek mythology Gaia was the goddess who created both the Universe and our Earth, as well as knowledge and understanding

**History:** Hipparcos was the first mission to chart the stars. Launched in 1989, the ESA spacecraft produced a primary catalogue of around 118,000 stars and a secondary catalogue containing over two million stars. This data is widely used by astronomers

The spectacular nighttime launch of Gaia in December 2013 **Credit:** Arianespace



# Cornwall's deep space mission



Goonhilly is surrounded by beautiful countryside  
**Credit:** Boffin Media

**“We have some of the best engineers in the world in the UK and we have this fantastic space industry as well”**

Ian Jones  
Goonhilly Earth Station

## **The historic Goonhilly Satellite Earth Station in Cornwall is building on its illustrious past to support future missions to the Moon, Mars and beyond. Sue Nelson takes a tour of the site:**

Imagine a collection of 1960s buildings with a control tower resembling Thunderbirds' secret International Rescue base on Tracy Island. Instead of sea, surround it with rolling Cornish countryside and a selection of white antennas, some of which are visible for miles. This is the wonderfully retro Goonhilly Satellite Earth Station. It is a blast from the past in both looks and name but, despite earning its place in history, Goonhilly has its sights set firmly on the future as the UK's first deep space network.

One storey high with tinted windows to reduce reflections, the control tower provides an impressive vantage point for a large portion of the 65 hectare site. “This was the first building,” says Ian Jones, CEO of Goonhilly Earth Station Limited. He points at a large 1100 tonne parabolic dish in the distance. “And that’s Goonhilly 1 or Arthur,” he says, “built to pick up the very first transatlantic pictures from Telstar and controlled from here in 1962.”

# :cornwall's deep space mission

## King Arthur

Although each antenna is numbered, local King Arthur legends play a part across the site. The Goonhilly 3 antenna is nicknamed Guinevere while Goonhilly 6 is Merlin. Arthur and Guinevere are currently being converted into radio science dishes.

In total there are 40 antennas on site, ranging in size up to 32 metres in diameter. These dishes are either working, awaiting an upgrade or ready for construction. Jones recently bought several from the BBC Television Centre building in London. The dissected panels lie stacked in a warehouse ready to be put back together again.

“There are currently ten antennas in use,” says Jones. “We are transmitting data services for customers, controlling satellites, doing telemetry tracking control and there are monitoring activities going on as well – so a wide range of commercial satellite communications,” he says. “One of our newest antennas, which we’re hosting on behalf of Planet Labs, is tracking their low Earth orbiting Dove satellites.”

Some of the largest dishes date back to the dawn of the space age  
Credit: Boffin Media



## Remote location

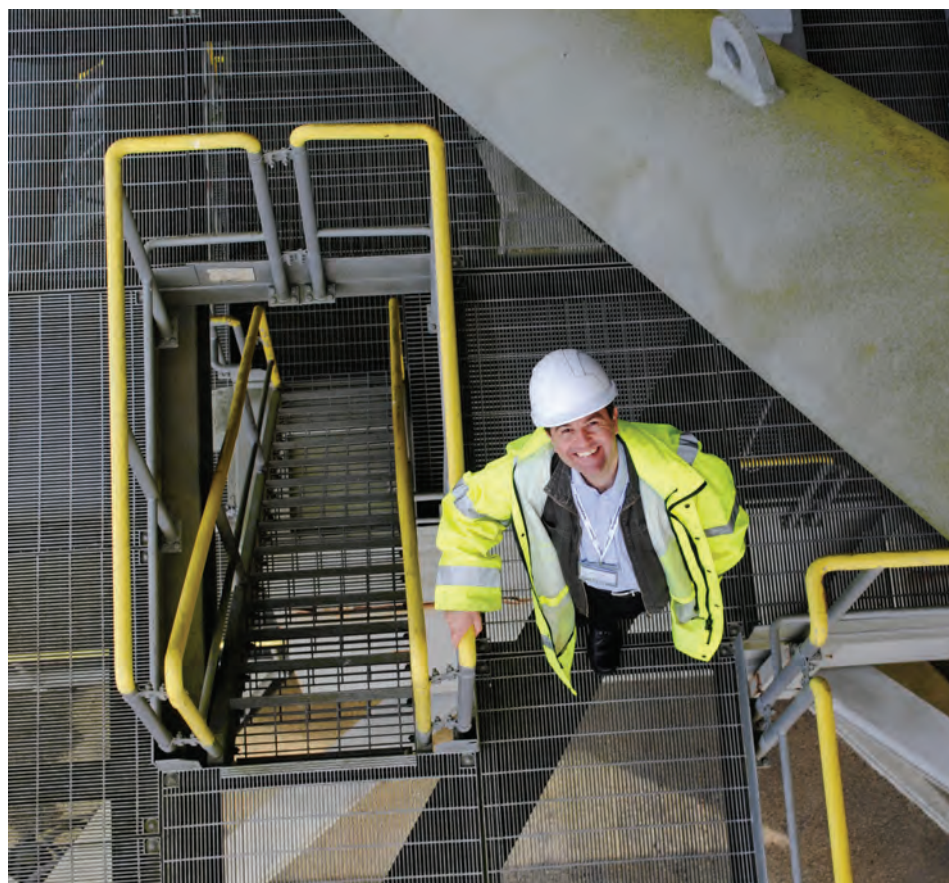
The control tower is now a viewing platform. The real control room is in another building, fully refurbished with computers and several large screens. “This is where all the signals from around the site come in and we can monitor them,” says Jones. “Twenty years ago it

would have been filled with racks and control panels. Now it’s possible to control somewhere like Goonhilly from a laptop.”

One of the wall screens shows a projection of the Earth with two coloured tracks. “The blue one is Strand-1, a cubesat built by Surrey Space Centre,” says Goonhilly’s chief scientist Matthew Cosby. “The yellow one is the International Space Station,” he says. “We’re tracking the space station with one of the antennas, preparing for Tim Peake’s flight when he comes over in December.”

Goonhilly’s remote location on the Lizard Peninsula works in its favour for Peake’s Principia mission. “Our latitude is 50 degrees north,” explains Jones, “the same latitude as the inclination angle of the space station which means the station comes right overhead.”

The position is also ideal for geostationary satellites, in orbit high above the Earth, and has a considerable reach. “We can use satellites to see all of South America, across to the mid-west of North America, all of the Atlantic, all of Europe, all of Africa, all of the Middle East, all of the Indian Ocean and all the way across to Perth in Australia,” says Jones. “So we can see pretty much the entire population of the world from Goonhilly.”



Matthew Cosby on a walkway beneath the Merlin antennae Credit: Boffin Media

# :cornwall's deep space mission

## Launch party

Peake's mission has prompted a launch party for local schools and astronomers. "We believe we'll be the first people to see the ISS come over the horizon as Tim's spacecraft docks at about 4.30pm," says Cosby. Goonhilly will also be part of the mission's Amateur Radio on the International Space Station (ARISS) experiment with schools, using another newly-installed 3.8 m dish. Owned by the Satellite Applications Catapult, this will provide back-up for the audio and video downlink.

On the control room screen, ESA and NASA's deep space networks are marked at different locations across the globe. These ground stations are designed to communicate with spacecraft beyond the Earth. Jones is developing another deep space network at Goonhilly.

"There hasn't been a private company that has entered the market for deep space communications," Jones says. "We believe we can do it extremely well, as good as all of the space agencies, with really good value for money and there is a market out there."

A 12-month mission, for example, often has a far longer working lifetime during which a spacecraft's instruments continue to gather science. "So having spent all those billions on getting the spacecraft to Mars," argues Jones, "why not spend a little bit more money on some additional facilities on the ground to receive that scientific data?"

Money is also needed to continue to modernise Goonhilly's 1960s buildings, which were originally built and operated by the Post Office before the site was transferred to BT in 1984. BT was going

to knock the antennas down to build a windfarm until Jones – an entrepreneur and engineer – stepped in to save this British icon.

His company began leasing the antennas in 2011 and put them to use, with an agreement to buy the site in the future. So far GES Limited has received £3.8 million in private equity finance and a £2 million regional growth award. Business is expanding. The company turned over more than £1 million in the first year since buying the site. "The growth rate now and the level of interest from space companies wanting to place contracts at Goonhilly is phenomenal" says Jones.

## Golf ball

I am driven around the site, past a white 'golf ball' – a 5 m antenna in a protective windshield (radome) – stopping at different antennas along the way: the 6.1 m Goonhilly 40 and the 30m Goonhilly 3. None of antennas were transmitting when Jones took over, so each working dish has been brought back into service.

The biggest, Goonhilly 6 (Merlin) at 32 m across, towers above us – not least because it stands on top of a building so you have to climb several flights of stairs just to reach the plinth. Wearing yellow visibility jackets, heads encased in hard hats, we continue upwards behind the dish itself.

A refurbishment will allow Merlin to track geostationary as well as low Earth orbit satellites and the dish frequencies are to be expanded for scientific spacecraft. There will also be opportunities, not just to educate people about UK space through tourism, but for highly skilled scientists and engineers.

"With the advent of private companies going to the Moon, and ultimately SpaceX wanting to go to Mars, they're all going to need ground stations," says Jones. "We can offer those services to them. We have some of the best engineers in the world in the UK and we have this fantastic space industry as well."



An engineer working on one of the 40 dishes **Credit:** Boffin Media

# :cornwall's deep space mission

The dishes are intricately engineered **Credit:** Boffin Media



## Visitor centre

“We’re already working with SES, Inmarsat and Eutelsat,” says Jones. “They’re three of the four biggest satellite operators in the world. We also have contracts with business customers who need Internet or TV uplink services.” Recently Goonhilly installed a fibre connecting it to Jodrell Bank via the high-speed academic Janet network.

The potential, like the site, is huge. Jones and Cosby escort me inside one building with 2000 square metres of floor space, air conditioning, a suspended floor and back up power. “If we were to lose electrical power from the grid,” says Cosby, “we could survive here for four months.”

Jones is visibly proud. “A fantastic data centre opportunity,” he says, his voice

echoing around the building. “Or clean rooms for producing satellites. There is also a visitor centre which, when open in 2017, will be able to show people what we do and inspire the next generation of scientists and engineers.”

Other sections are already in use. There is a conference hall, offices and a corridor decorated with screen prints produced through a collaboration with Falmouth University’s Fine Arts department.

As a space scientist, Cosby concentrates on the site’s scientific potential. “Goonhilly 6 will be used for supporting science missions, such as deep space probes around Mars or around Mercury,” he says. “So we could be supporting ExoMars or BepiColombo if needed. If ESA require additional capacity then we’ll switch Goonhilly 6 into receiving that data.”

“Currently we are looking at modifying the antenna to receive Orion, NASA’s manned spacecraft, so when it goes around the Moon hopefully we’ll be able to support that in a few years time,” Cosby says. “Once we’ve renovated all the equipment, we’ll be able to track all the spacecraft around Mars.”



Goonhilly 1 was built to receive pictures from the world’s first TV satellite, Telstar **Credit:** BT

# Principia projects for students



**UK ESA astronaut Tim Peake is due to be launched from Russia's Baikonur cosmodrome in Kazakhstan in**

**December on a five-month mission to the International Space Station (ISS).**

The new Principia website brings together information and links about all the fantastic education activities, public events and other opportunities that will be available for you to become involved in the mission.

The site also showcases the best of the wonderful images and videos that will be produced during the flight – not only those from the ISS but also from schools across the UK.

A special edition of *space:uk* has been produced to mark the occasion, which is available from the UK Space Agency. This also contains details of all the education activities planned around the mission.

## Astro Challenge

The Astro Science Challenge is an interactive space adventure free to all UK schools, home educators and families. Children aged 7-11 will work to become space agents as they take part in missions created in partnership with leading science organisations.

Run by Unlimited Space Agency, the project runs for seven weeks from 19 October and leads up to Tim's launch. Children will be inspired in Science, Maths and English through online film, story and classroom activities, with free lesson plans provided for teachers.

## Mission X

Teachers (any Key Stage) can register to be part of Mission X 2016 to train alongside astronaut Tim Peake by registering on the international website: [trainlikeanastronaut.org](http://trainlikeanastronaut.org)

You will need to use the code: CHARLIE2016 in order to register. Registration closes 10 December 2015. The team will then explain the support that can be expected from the UK Space

Agency and give you ideas on how to deliver Mission X in your school. Please invite other local schools to take part – the more schools in a locality, the more opportunities there are to organise teacher training and other special events.

## Odysseus II

This fun-based educational contest focusing on space science is up and running. Young people all over Europe can register to take part in a competition that combines scientific learning with hands-on experience. Aimed at learners between the ages of 7 and 22, the contest is designed to engage young people with a spirit of discovery and an interest in science.

Odysseus II challenges students to push the boundaries of their knowledge by discovering answers to fundamental questions on topics ranging from satellites and space probes, to astrobiology and interplanetary travel.

[www.odysseus-contest.eu/explorers](http://www.odysseus-contest.eu/explorers)



Schools across the country – including Sandringham School in St Albans – are getting involved in Tim Peake's mission **Credit:** Sandringham school

## Magna Parva is a design, manufacturing and test facility in Leicester making components and structures in space – be it for missions to Mars or satellites orbiting the Earth. Director Andy Bowyer celebrates the company's tenth anniversary with *space:uk*



**Andy Bowyer**

### What does Magna Parva produce for the space industry?

We provide a mechanical engineering service to the space industry – from design to delivering flight hardware of components and structures. Recent projects we have worked on include ESA's mission to Mercury, BepiColombo, and Mars mission ExoMars.

We supplied the optics structure for BepiColombo's MIXS instrument for the University of Leicester and housings to contain the mission electronics. For ExoMars we're providing environmental housings, base plates and structures either for the instruments, computers or the spacecraft itself.

### How much of your work is for ESA?

About 95% of our work is for space and for ESA, working on technology readiness programmes. It took us six months to win our first ESA contract. Nine and a half years later we're still working on projects that haven't flown yet. But that's the nature of space. What it does is challenge the engineer to deal with complex problems. But when we develop a new technology we also look for terrestrial applications and if they start to disrupt our space work we spin those out.

Image top right: Magna Parva is a specialist in precision engineering  
**Credit:** Magna Parva

Bottom image: Magna Parva is making components for Europe's forthcoming mission to Mercury  
**Credit:** ESA



### Give us an example?

Back in 2006 we started working on ultrasonic planetary tools for exploring Mars and looked at using the technology in conventional manufacturing. One of the areas involved working with can-making companies to improve the beverage can process – making it cheaper and using less material. We span that out into Magna Parva Packaging and sold half the company to a global can-making company, Rexam. It's now a successful business.

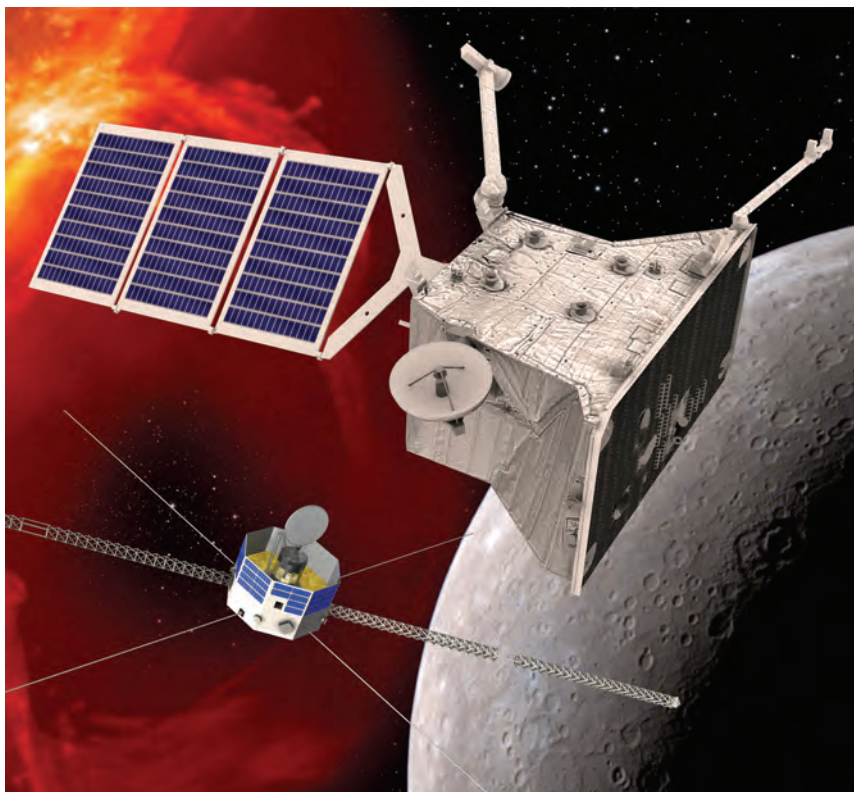
### Which technologies excite you?

One of our funded key technologies this year is using sound to pump fuel within fuel tanks in microgravity. When a fuel tank goes into microgravity the fuel coalesces into blobs so it isn't where you need it, which is by the thruster. The spacecraft either has to move or carry baffles and pumps - which are heavy and take up space where you could have fuel. Imagine an ultrasound transducer that, rather like looking for a baby in a body, would measure where and how much fuel is in the tank. By increasing the power to the transducer you can use sound waves to move the fuel where you want. We call it an acoustic propulsion management device.

### What sort of people do you need?

It's mechanical engineers on the whole but they come from a range of backgrounds: astrophysics, materials science, aerospace and automotive engineering.

We also helped create the Higher Apprenticeship in Space Engineering scheme with the National Space Centre, Loughborough College and The University of Leicester and have two people going through to a foundation degree. So there are more vocational routes. During careers talks we highlight that we also need marketers, accountants and web people. There are other ways to be involved in space.



## SSTL



Putting the finishing touches to one of SSTL's latest DMC-3 satellites **Credit:** SSTL

### **Thinking big about small satellites has paid off for Surrey Satellite Technology Limited as it celebrates 30 years in the space industry.**

SSTL is an independent British company within the Airbus Defence and Space Group providing small satellites, payloads and space training for clients around the world.

SSTL was formed as a spin-out company from the University of Surrey in 1985 to transfer its small satellite engineering research into a commercial enterprise. Since then more than 40 SSTL satellites have launched from eight different sites around the world. Six national space agencies have been formed with the launch of a SSTL small satellite as a country's first mission.

Based at the Surrey Research Park in Guildford, SSTL's 500 staff assembles satellites and space hardware in clean rooms and laboratories. The company can build and launch satellites for Earth observation and imaging, navigation and telecommunications, scientific research, military and defence, or for technology demonstration by testing an instrument in space.

SSTL's founder, Sir Martin Sweeting, was a PhD student at the University of Surrey when his team designed, manufactured and – with the help of NASA – launched experimental small satellite UoSAT-1 in 1981. The 72 kg satellite was the first microsatellite with an in-orbit re-programmable computer and outlived its three-year lifespan by more than five years.

The company quickly found a niche for small satellites, stimulated a new global industry and expanded. It put the UK's first nanosatellite in orbit, was the first company to use butane as a space propellant and built the first momentum wheel to guide a landing craft to the surface of a comet. This component helped stabilise Rosetta's Philae lander as it made its descent to comet 67P in November 2014.

SSTL currently has more than 20 spacecraft being manufactured or awaiting launch. It is also constructing 22 payloads for Europe's new satellite navigation system, Galileo.

