Spring 2013 Issue 37

space:uk

Feeling the heat: UK scientists staring at the Sun

Inside Britain's new space city

Archaeology from space

Plus:
Understanding the Universe, first phone in orbit, celebrating 80 years of space and asteroids pull-out poster

UK SPACE AGENCY

Contents

Front cover image: An eruption of plasma from the Sun's north pole
Credit: Hinode, JAXA

Follow us:

twitter @spacegovuk
flickr spacegovuk
YouTube spacegovuk

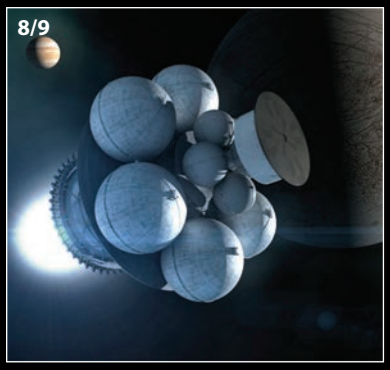
From the editor

As a science journalist, I have grown used to describing satellites as being the size of a washing machine, car or even double-decker bus. As space technology has advanced, satellites have tended to get larger but, in recent years, that has begun to change. The UK has led the way in the development of micro and nano satellites and is now moving into building CubeSats. Based on cubes just 10cm across, these provide a relatively low-cost way of getting into space.

Just as more and more features can be squeezed into phones, the same is true of spacecraft. Now, for the first time, the two technologies have come together. The UK's STRaND-1 nanosatellite is being operated by a smartphone. This first phone in space is no stunt. Loaded with powerful apps, the satellite will be used to conduct science experiments and – by proving that mass-produced consumer electronics can be used in a satellite – it could radically reduce the cost of space technology.

Big satellites will still get built but the rise of the small satellite is opening up space to many more people – with developing countries, universities and even schools having a stake in space technology. Space is no longer solely the preserve of the big space agencies or companies. And that is incredibly exciting.

Richard Hollingham
Editor



Credit: Adrian Mann, www.bisbos.com

Credit: ESA

Credit: ESA

Credit: Bournemouth University

The UK Space Agency is an executive agency of the Department for Business, Innovation and Skills

space:uk is written and edited for the UK Space Agency by Boffin Media
www.boffinmedia.co.uk

space:uk is designed and produced by RCUK's internal service provider
www.jrs.ac.uk

And there was light…

The European Space Agency's (ESA) Planck mission has produced a new map of the oldest light in the Universe.

The map shows the afterglow left behind 380,000 years after the Big Bang – the explosion that is thought to have brought the Universe into existence. At this point in time there were no planets or stars, simply a hot dense state of protons, electrons and photons (light particles).

When protons and electrons combined to form hydrogen atoms, the light was set free and stretched across the cosmos to microwave wavelengths as the Universe expanded. This afterglow of light, imprinted in the sky, is called the Cosmic Microwave Background (CMB) radiation and can be seen at microwave frequencies at a temperature of 2.7 degrees above absolute zero.

The map is the result of the initial 15 months' worth of data from the Planck space telescope. Its colours show temperature differences – small deviations from this average background temperature – where blue is cooler and red is warmer. These variations are thought to reflect differences in density of matter and this cold dense matter formed the seeds for what became stars and galaxies.

The data indicates that there is slightly more matter in the Universe and slightly less dark energy – which is thought to be accelerating the expansion of the cosmos. The findings also test the theory of inflation, the brief period of accelerated expansion after the Big Bang. While Planck's findings do much to confirm the Big Bang theory, there were unexpected anomalies that challenge some of the fundamental principles of cosmology.

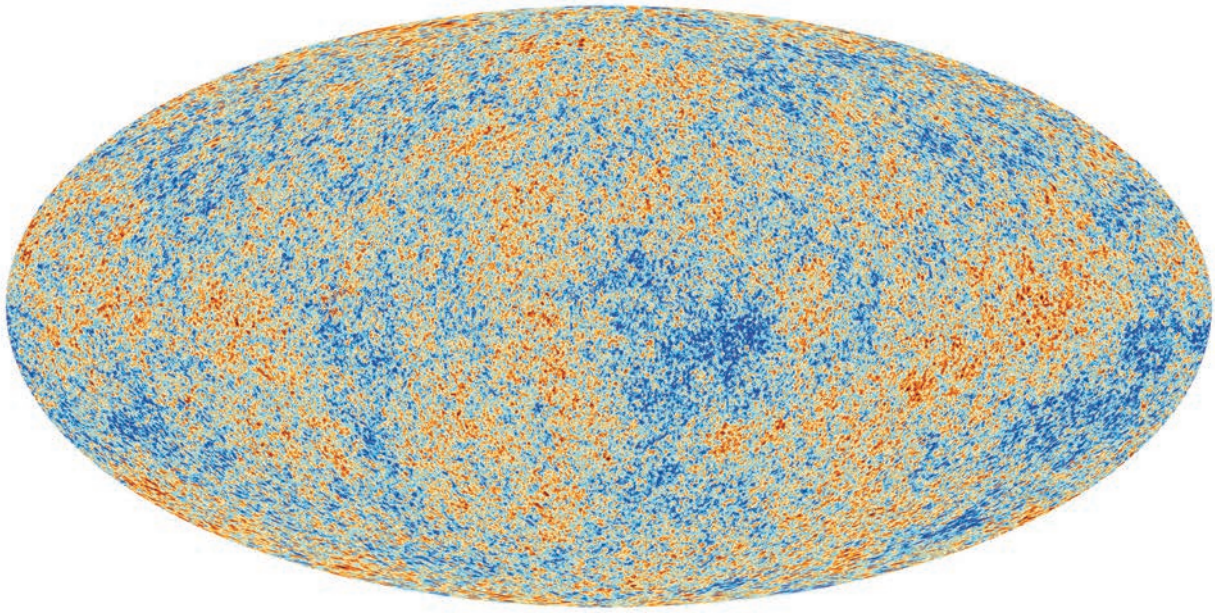
"Okay, the Universe is odd," said George Efstathiou from the University of Cambridge, speaking at the press announcement in Paris. A lead scientist on the mission, he admitted that, for inflationary theorists "it's a little bit unusual" but not so unusual that the theory should be abandoned.

"The CMB temperature fluctuations detected by Planck confirm once more that the relatively simple picture provided by the standard model of cosmology is an amazingly good description of the Universe," he said.

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

"We're immensely proud to be playing a key role in this amazing discovery," said Chris Castelli, Acting Director of Science, Technology and Exploration at the UK Space Agency. "Planck is helping us to place the vital pieces of a jigsaw that could give us a full picture of the evolution of our universe, rewriting the textbooks along the way."

Launched in May 2009, Planck was designed to measure fluctuations in cosmic background radiation with greater resolution than ever before. Its aim is to determine the composition of the Universe and also its evolution. These are the first cosmological results from the telescope. Data from Planck has also aged the Universe at 13.82 billion years, making it around 80 million years older than previously thought.



The cosmic microwave background radiation map, courtesy of Planck, showing temperature variations of the oldest light in the Universe **Credit:** ESA

Welcome to a new issue of *space:uk*!

I'm Dave Parker, the new Chief Executive of the UK Space Agency. I thought I would give Emma a break for this issue to introduce myself, and give you a short insight into where I see the Agency heading over the next year.

Having been part of the Agency for the last three years as its Director for Technology, Science and Exploration, I think I'm allowed to say that we had a momentous 2012, capped by a huge success at the ESA Ministerial in Naples in November.

Over the next year we will be working with ESA and our European partners to deliver our contribution, leading programmes where the UK has a strategic interest. We've made the step change in investment in 2012 and now we will start to deliver on our commitments.

So far we've had a busy 2013. In addition to all of the scoping work that we're doing with ESA to set the boundaries for our new investment, we've been setting the tone for the future.

The Big Bang Fair in March was a huge success. With 65,000 enthusiastic kids over four days, we had a great chance to get them excited about space and the opportunities our industry can offer for rewarding careers. Our stand was run in partnership with the Natural Environment Resource Council and highlighted the great science that we're enabling with our investments in Earth observation technology.

A big bang at this year's Big Bang **Credit:** UK Space Agency

A knitted ExoMars rover at the Big Bang Fair – the real one will be built in the UK…but not from wool **Credit:** UK Space Agency

David Willetts also launched a new Higher Apprenticeship scheme to train school leavers to work in the space sector. He met a group of existing apprentices, toured facilities at Harwell and chatted with RAL-Space staff. He also chaired a round table with STFC, ESA, local businesses and council staff to discuss how to create a bigger impact from all the science and technology in the Oxford area.

Discussions continue on the expansion of the ESA facility at Harwell, which you'll find highlighted in this issue. Magali Vaissiere, ESA's Director of Telecommunications, does a great job of showing how the story will unfold in the UK, why they recognise the benefits of the growing UK space sector and what the year ahead will tell us about the future.

I think it is a great sign of how far Britain's space sector has come in such a short time. And we have a monumental task ahead of us in the next twenty years to achieve the Innovation and Growth Strategy's targets.

From the creation of the Agency in 2010 to the successes of last year, we've set an impressive pace for collaboration and growth. With the strong backing from the Government, an ambitious industry and world-class scientific community, I believe we can achieve whatever we set out to do.

This is an exciting time for the UK space sector. So keep reading *space:uk*, connecting with us on the web and on social media to get the latest on what we're doing in the Agency and around the sector.

Smartphone in space

A UK team has launched the first smartphone into orbit. The Android phone on board STRaND-1 will be used for scientific experiments, to take pictures of the Earth and even to prove if anyone can hear you scream in space.

Measuring just 10cm by 30cm and weighing 4kg, STRaND-1 was built by engineers at the University of Surrey and Surrey Satellite Technology Limited (SSTL) and is the UK's first CubeSat mission. The team also included undergraduates at the university and SSTL trainees, with many working on the project in their spare time.

The spacecraft was launched from India alongside SSTL's fortieth satellite, Sapphire, and there was great excitement when the first signals were received from STRaND-1 at the ground station in Guildford. "The feeling was absolutely fantastic," exclaimed Chris Bridges, lecturer at the University of Surrey's Surrey Space Centre (SSC) and one of the project leaders. "The team here was elated and very, very excited to hear the first signals come down. It's been a really great experience for everyone."

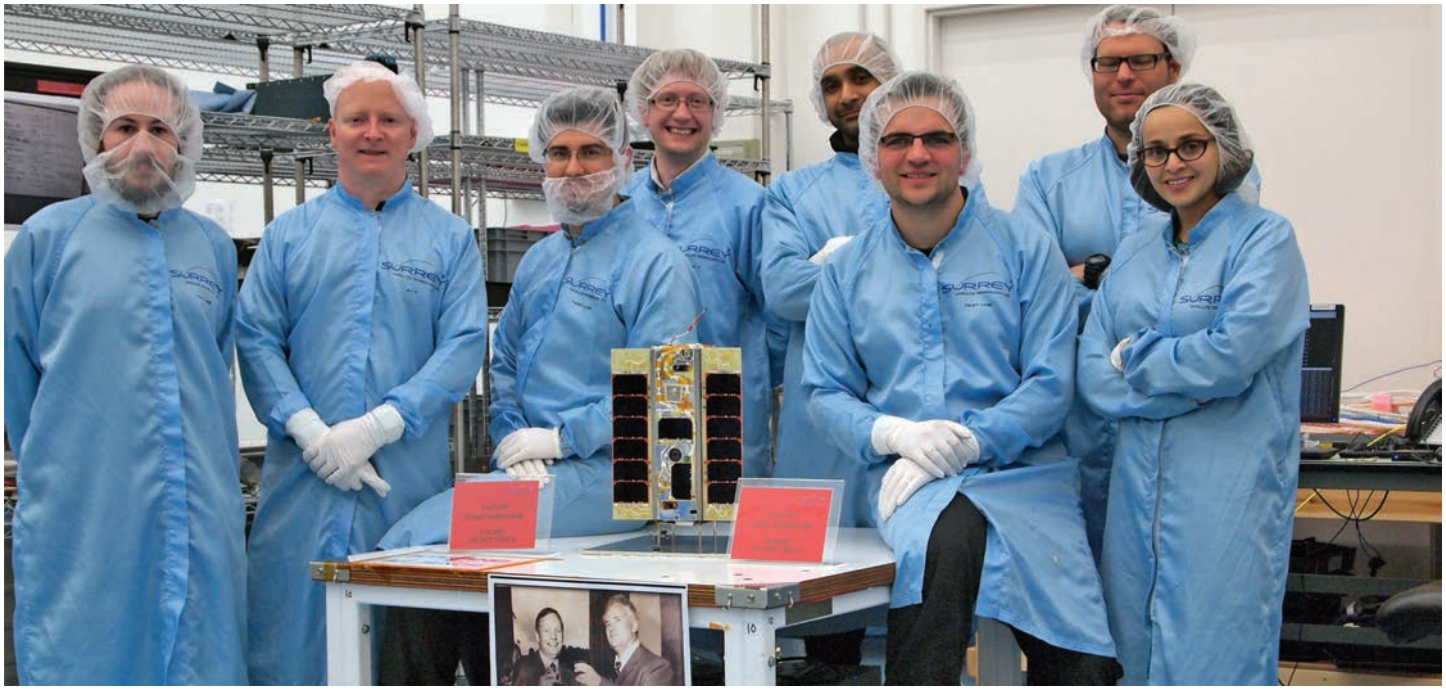
The serious purpose underlying the STRaND-1 mission is to see how well consumer electronics cope with the harsh space environment and whether this technology could be used for future missions. Early data from the satellite has confirmed that all critical systems on board are working well and, at the time of publication, the team was preparing to test the specially designed apps loaded into the phone. These apps include iTesa, which employs the phone's in-built magnetometer (used for its compass) to take measurements of the Earth's magnetic field. "That one will be really interesting to see if the phone can live up to the same standards, the same reliability and the same resolution as components we typically use for CubeSats," said Bridges, "or maybe it can even out-perform them."

Warp speed

Another app displays satellite telemetry on the phone's screen. This is being viewed by an additional camera on-board, with the images transmitted back to Earth. In the meantime, the phone's camera is being used to take panoramic views of the planet. The satellite also features a number of other new technologies and even Star Trek inspired engines. This WARP DRiVE (Water Alcohol Resistojet Propulsion system) will help the satellite perform orbital manoeuvres.

Students at the University of Cambridge have designed the app that has received the most interest. The Scream in Space app tests the tagline from the 1979 sci-fi film Alien, that "in space no-one can hear you scream." Videos of screams have been recorded on the phone and the idea is to see whether these can be picked up by the device's microphone. Screams loaded onto the satellite include an ear-splitting video submitted by year 6 pupils from Chudleigh Church of England Community Primary School in Devon.

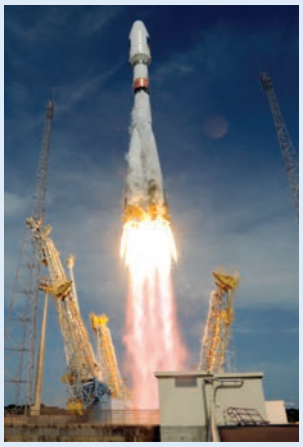
"STRaND-1 has been an excellent project linking academia with industry and taking space engineering research through to a real mission," said Craig Underwood from SSC. "It's another major space success for the UK."



Members of the happy STRaND-1 team with their satellite **Credit:** University of Surrey

Galileo works

Tests of Europe's new Galileo satellite navigation system have proved that it works. For the first time, engineers have been able to use the four Galileo satellites currently in orbit to determine a position on the ground. Because of their orbits, with these four In-Orbit Validation (IOV) satellites it is only possible to test the full system for around two hours daily but as more satellites are launched, and extra ground stations come online, this frequency will increase.



The launch of the second pair of IOV satellites **Credit:** ESA, Arianespace

The first Galileo services are expected to start by the end of 2014, with the full constellation of 30 satellites in orbit by 2018. The payloads for the IOV satellites – containing the crucial navigation equipment – were built in the UK by Astrium and UK company SSTL is building the navigation payloads for the next 22 satellites.

Spaceport UK

Should the UK have its own spaceport, launch vehicles or spacecraft? These are the questions being considered during a six-month economic study to examine whether there is a viable case for a UK launch infrastructure. The research, funded in a partnership between industry and the UK Space Agency, will consider whether there is a business case for developing a UK launch vehicle and the viability of a British spaceport.

Test for giant satellite

One of the world's largest communications satellites, Alphasat, has completed its vital thermal vacuum testing, designed to simulate the conditions it will have to survive in space. Alphasat is being built by Astrium, working in partnership with ESA and UK satellite operator Inmarsat, and is the first satellite to use Alphabus. This new technology is designed to make the satellite more powerful, versatile and cheaper for users than previous telecoms satellites. Weighing more than 6.5 tonnes, Alphasat is due for launch later this year.

Alphasat outside the testing chamber **Credit:** Astrium, D Eskenazi

Mars plans agreed

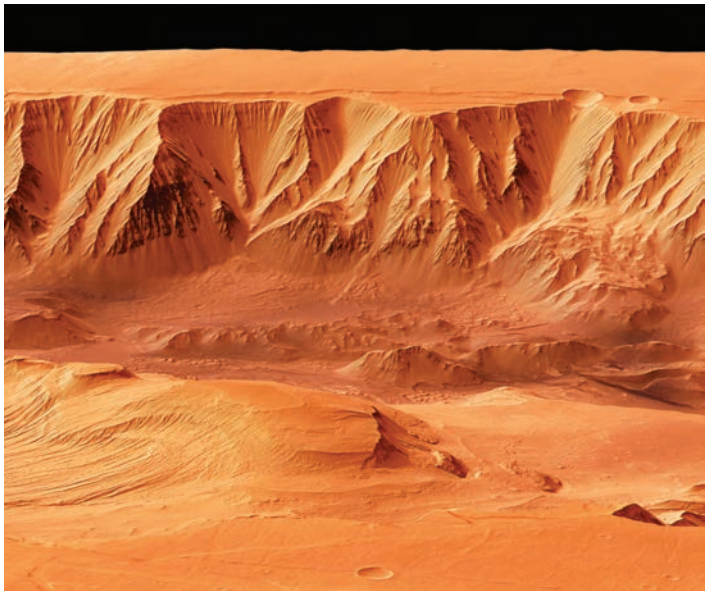
A formal agreement has been signed between ESA and the Russian space agency, Roscosmos, for the future exploration of Mars. The deal paves the way for the continued development of ExoMars, a two-stage mission to search for signs of life. The UK is the second largest contributor (behind Italy) to the ExoMars project, which will involve launches to Mars in 2016 and 2018.

The 2016 mission will include an orbiter, which will investigate the Martian atmosphere for signs of methane and other gases that might have been produced from biological or geological processes on the planet's surface. The spacecraft will also release a small lander, designed primarily to test landing systems for future missions.

In 2018, the ExoMars rover will be launched. This will study the planet's geology and search for evidence of past and present life. It will be the first Mars rover capable of drilling up to 2m into the Martian soil to collect and analyse samples. The rover will be built in Britain by Astrium and its high-resolution camera will also be led by the UK.

Scientific instruments for both missions will be provided by ESA member states and Russia, with NASA also assisting the programme. Russia will provide the launches for both missions.

The ExoMars project has faced a series of delays and challenges but this new agreement puts the ambitious project back on track. "It confirms again that projects of such tremendous scale have to be implemented through international cooperation," said the Head of Roscosmos, Vladimir Popovkin.



Europe's Mars Express has already captured remarkable images like this one of a Martian valley **Credit:** ESA

Arctic ice loss

Scientists using the European CryoSat mission to investigate the Earth's ice cover have discovered a major loss of sea ice in the Arctic over the past ten years. The research, led by University College London, has also confirmed – for the first time – that this decline in sea ice has been accompanied by a substantial fall in ice volume. Measurements from CryoSat compared to data from the earlier ICEsat satellite show that, between 2003 and 2012, the volume of Arctic sea ice has declined by 36% during autumn and 9% during winter.

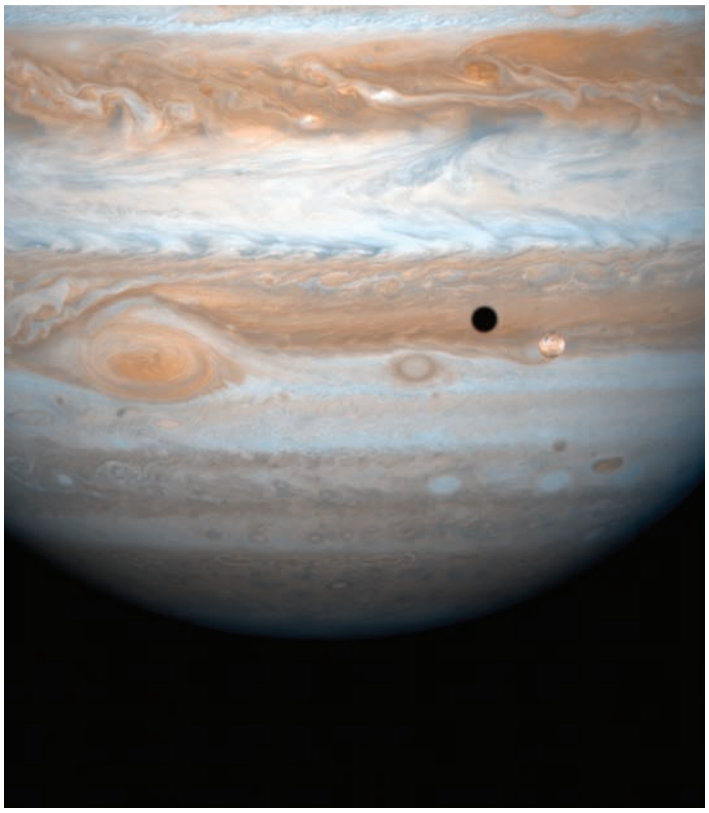
"Thick sea ice has disappeared from a region to the north of Greenland, the Canadian Archipelago and to the northwest of Svalbard," said Katharine Giles, co-author of the study.

Ice plays a major role in our climate system and loss of sea ice could affect ocean currents and how much of the Sun's heat is reflected back into space. To understand the impact of global warming it is therefore vital to work out how much ice there is on our planet and monitor any changes.

Launched in 2010, CryoSat uses twin radars to build up a 3D image of floating sea ice and the polar ice sheets. Results from the mission are checked against ground and airborne measurements. "Other satellites have already shown drops in the area covered by Arctic sea ice as the climate has warmed," explained Tommaso Parrinello, CryoSat Mission Manger, "but CryoSat allows scientists to estimate the volume of sea ice, a much more accurate indicator of the changes taking place in the Arctic."

Artist's impression of CryoSat in orbit **Credit:** ESA

JUICE to Jupiter



Io casts its shadow on Jupiter **Credit:** NASA

An instrument led by a UK team has been selected for Europe's JUICE mission to Jupiter. JUICE, which stands for JUpiter ICy moons Explorer, is due for launch in 2022. The mission will explore the gas giant planet and its moons of Io, Ganymede, Callisto and Europa.

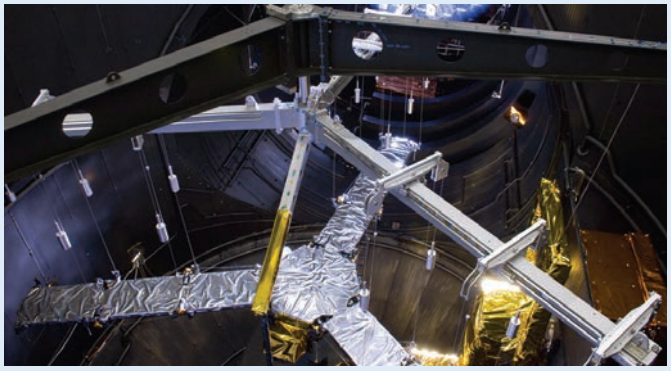
The UK-led magnetometer instrument selected for the mission will study the magnetic fields of the gas giant and its moons to gain an understanding of their internal structure. It will operate alongside ten other instruments, cameras and ground-penetrating radar. Together, they are designed to make the most detailed study of the Jovian system yet undertaken.

UK involvement in the mission is funded by the UK Space Agency and Britain is also leading the science team. "JUICE is an excellent example of the type of big national missions that UK scientists continue to win key involvement in," said the UK Space Agency's Acting Director of Science, Chris Castelli.

Ganymede, Callisto and Europa are thought to harbour water oceans beneath their icy surfaces and JUICE will investigate the icy moons environment to understand if they have the potential to support life. The spacecraft will fly past the most heavily cratered object in the Solar System, Callisto, 12 times and will be the first probe to measure the thickness of Europa's icy crust.

SMOS success

ESA's Soil Moisture and Ocean Salinity satellite (SMOS) has provided new insights into the Gulf Stream – the crucial ocean current that keeps Western Europe (relatively) warm. Salinity observations from SMOS have enabled scientists to track what happens when warm water from the south meets cold water from the Arctic. This is being used to build up a more accurate picture of ocean circulation. Data from the satellite is also helping efforts to monitor sea-ice extent and thickness, complementing the work of CryoSat.



The star-shaped SMOS satellite being tested prior to its 2009 launch **Credit:** ESA

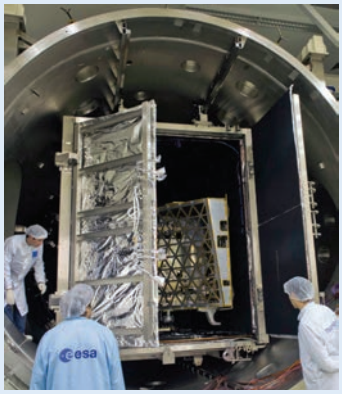
Space and climate

A new strategy has been unveiled to develop the UK's success in providing climate data and services. Prepared by a group made up of representatives from industry and Government, the report highlights future commercial opportunities for using satellite data for services such as weather prediction, climate modelling and carbon measurement.

Baking Bepi

The largest section of the joint European and Japanese BepiColombo mission to Mercury has been baked in a giant oven for 23 days. The procedure is designed to remove any contaminants that might cause damage in space. This bake-out of the spacecraft's Mercury Planetary Orbiter (MPO) section took place at ESA's technical facility, ESTEC, in the Netherlands.

BepiColombo will be only the third spacecraft to visit the closest planet to the Sun in the history of space exploration and is being built to endure temperatures up to 350°C. Due for launch in 2015, the spacecraft consists of three sections, the MPO, the Mercury Magnetospheric Orbiter and the Mercury Transfer Module. In the UK, Astrium is the co-prime contractor for the electrical and chemical propulsion systems and the structure of all modules. QinetiQ is building the engine for the Transfer Module and SEA has a major role in developing key spacecraft components.



Closing the oven doors on BepiColombo at ESTEC **Credit:** ESA

Cool space

ESA's Herschel space observatory – the largest and most powerful infrared telescope ever launched – is nearing the end of its mission. After four years in space, its supply of liquid helium is now exhausted.

The spacecraft's 2000 litres of liquid helium cooled its instruments close to absolute zero. They could then study star formation in our galaxy and other, more distant star-forming galaxies at previously unexplored infrared and sub-millimetre wavelengths.

By investigating cool regions of cosmic gas and dust, Herschel provided new insights into the origin and evolution of stars and galaxies. Mission highlights include observing the birth of stars, detecting cold water vapour around a young star for the first time, finding oxygen molecules in space, an asteroid belt around the star Vega and a belt of comets surrounding a nearby planetary system.

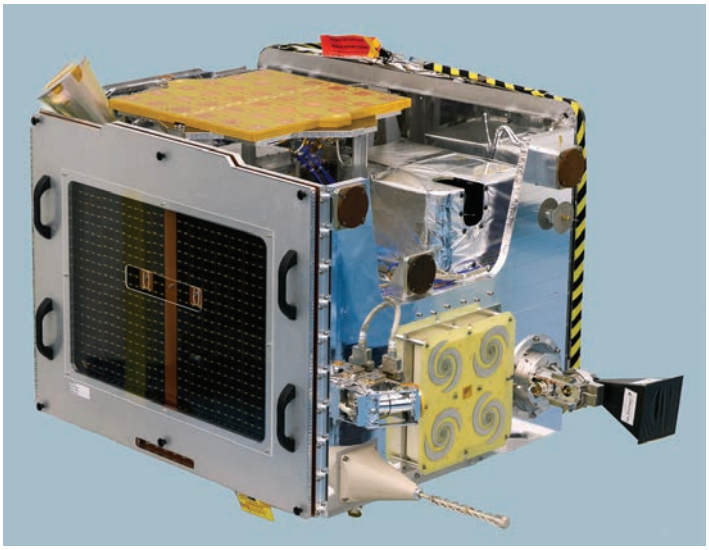
Images from the UK-led SPIRE (Spectral and Photometric Imaging REceiver), one of three instruments on board Herschel, also discovered hundreds of thousands of distant star-forming galaxies, allowing astronomers to study the evolution and development of galaxies over cosmic time.

"It was a sad day when Herschel ran out of helium," said SPIRE Principal Investigator Matt Griffin of Cardiff University, "but we're pleased that it lasted a bit longer than its planned lifetime - even more so that it has exceeded all our scientific expectations."

The spacecraft will be placed in a long-term stable parking orbit around the Sun in May. Here on Earth, Herschel's data will ensure that the science will continue for many years.

Herschel's cryostat vacuum flask was filled with 2000 litres of liquid Helium **Credit:** ESA

New ideas satellite



A small satellite crammed with instruments **Credit:** SSTL

A low-cost UK satellite designed to test new space technologies will be launched later this year. TechDemoSat-1 will carry eight experimental commercial payloads to prove their capabilities in space.

Part-funded by the Technology Strategy Board (TSB) and South East England Development Board, TechDemoSat-1 is being built by small satellite experts Surrey Satellite Technology Limited and will be launched on a Soyuz rocket from the Baikonur Cosmodrome in Kazakhstan. It will be the first satellite to be operated from the new Satellite Applications Catapult Centre at Harwell (see page 10).

"This hugely exciting and anticipated development will provide true space flight heritage to a number of new ideas and companies," said TSB Head of Space, Tim Just. "Once in orbit, TechDemoSat-1 will be able to test several new satellite based products from UK businesses, breaking one of the key barriers to innovation in the space sector by reducing risk in demonstrating new space-based technologies."

One of the instruments on the satellite, a new style cosmic ray detector, was developed by the Langton Star Centre, part of a sixth form college in Kent. Other payloads include a device to demonstrate how GPS signals could be used to measure the roughness of the oceans. The satellite is also fitted with a 'de-orbit sail', which will move the satellite out of orbit to burn up quickly in the Earth's atmosphere at the end of its life.

Work in space

The first ever Higher Apprenticeship in Space Engineering has been launched by Loughborough College and the National Space Academy. The pioneering programme is designed to provide work-based and degree level training to prepare students for careers in UK space companies.

"Space is big business for the UK and can offer our young people interesting and fruitful careers," said Chief Executive of the UK Space Agency, David Parker. "Programmes like this will help us to nurture the next generation of scientists and engineers, equipping them with the skills and knowledge needed to boost both our growing space sector and the whole economy."

The UK space industry currently employs some 30,000 people and contributes over £9 billion to the economy. The Government's aim is to help triple the sector's value to £30 billion in less than 20 years.

"One of the major potential hurdles that could stifle the space sector's growth is a lack of high-level technical entrants," said Anu Ojha, Director of the National Space Academy Programme. "These Higher Apprenticeships will tackle this issue head on, strengthening the industry through academically rigorous, sector-specific two year programmes."

The new apprenticeship scheme starts in September 2013 and involves education providers, including Loughborough College, the National Space Academy and the University of Leicester, working alongside the space industry companies employing the trainees.

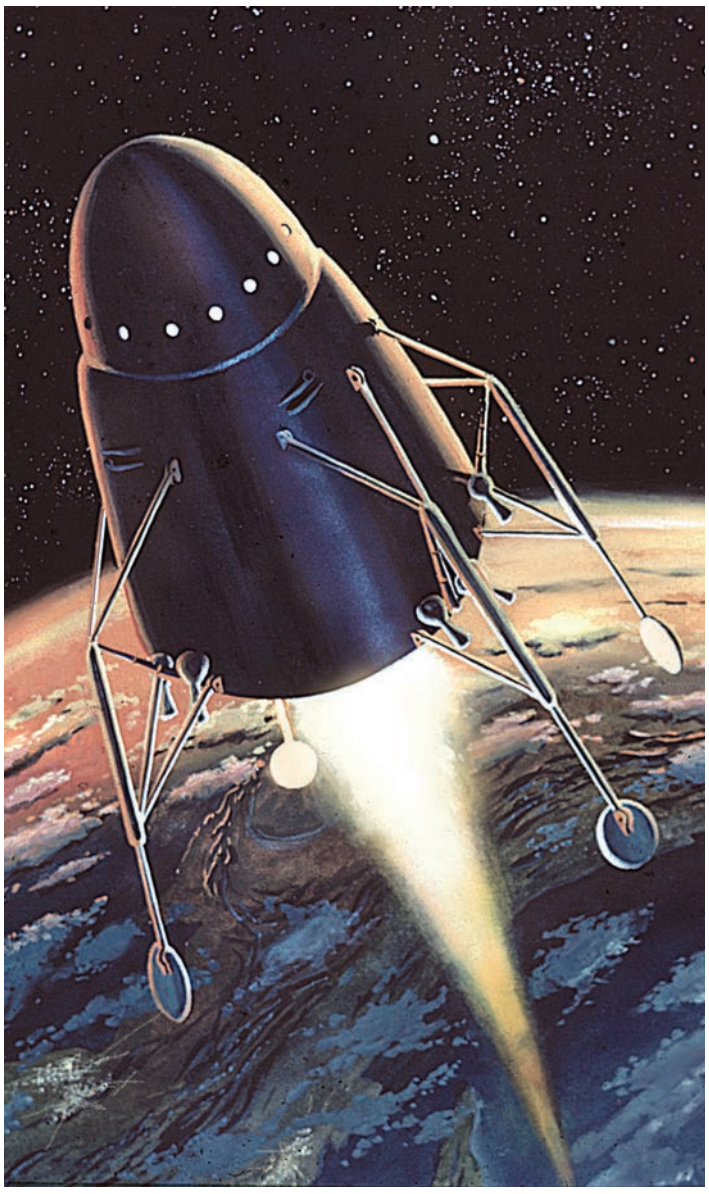
The new apprenticeships will prepare students for engineering careers in the space industry **Credit:** UK Space Agency

80 years of space

In 1933, long before the first spacecraft, a group of enthusiasts got together to devise a mission to the Moon. Eighty years on, the British Interplanetary Society's (BIS) motto 'from imagination to reality' still holds true.

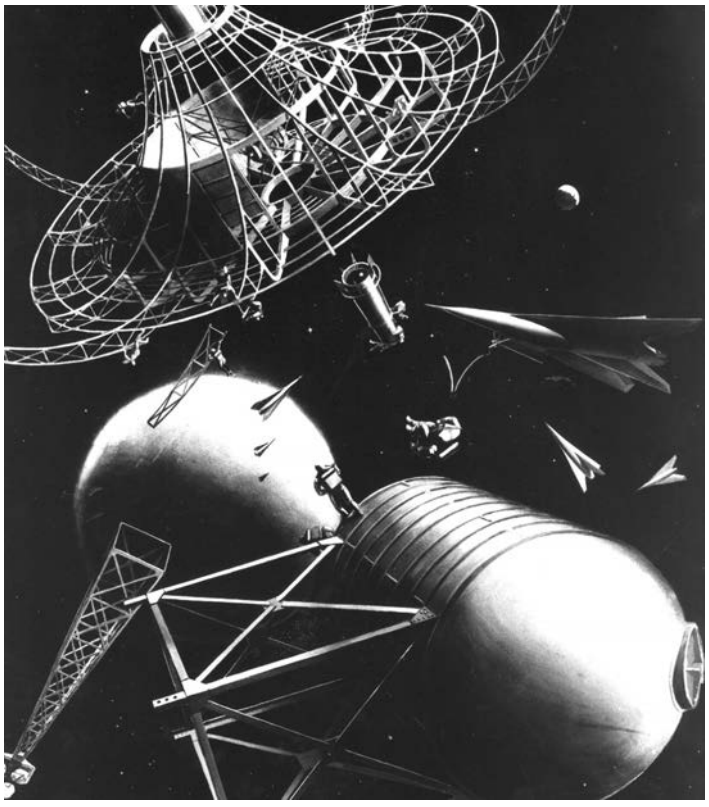
This organisation of space enthusiasts, scientists, artists, science fiction writers and engineers continues to develop daring concepts and designs for humanity's future in space. These visionaries coined the phrase 'satellite', decades before the first one was launched, and their early rocket designs were remarkably similar to those used by NASA to take men to the Moon.

Today, members of BIS are working on satellites, a design for an interstellar spaceship and a UK-built spaceplane. Here are some of the concepts the society's talented artists and designers have worked on over the years:

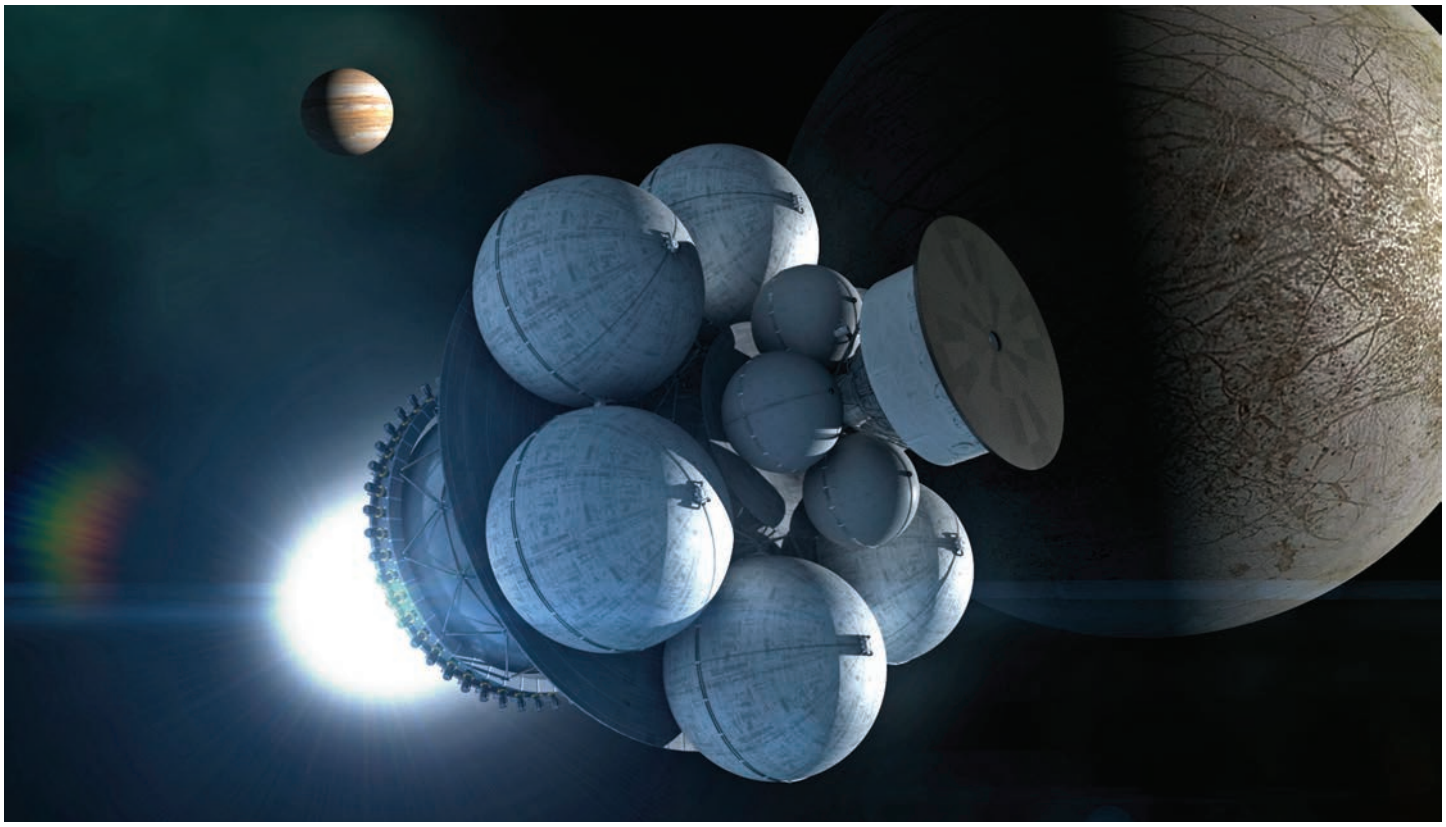


1955 concept drawing by space artist David A Hardy of a lunar lander
Credit: David A Hardy, www.astroart.org

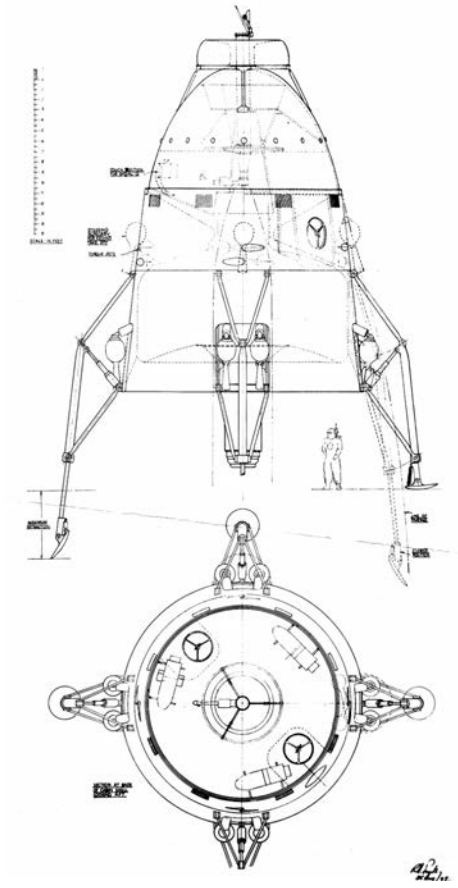
BIS had designed a space suit long before NASA **Credit:** BIS



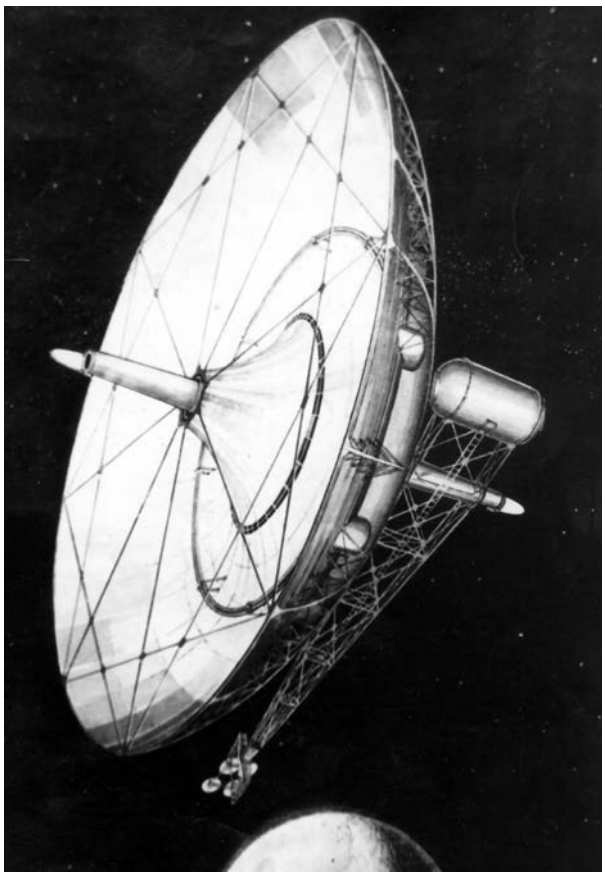
A 1950s design showing a space station being assembled in orbit
Credit: RA Smith, BIS



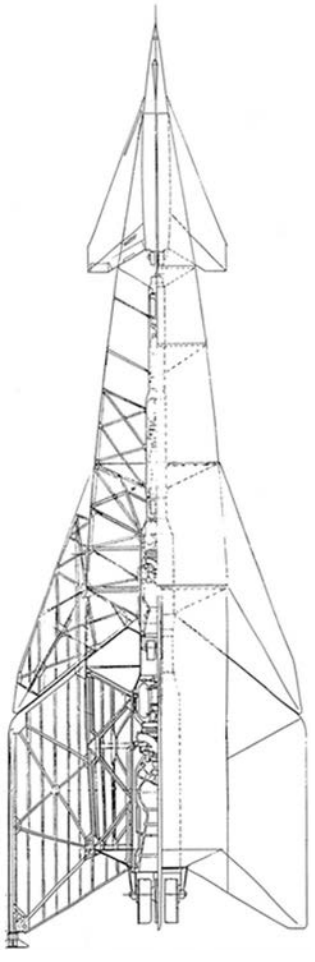
Adrian Mann's painting of the Daedalus starship, a concept now being developed further by BIS **Credit:** Adrian Mann, www.bisbos.com



Engineering drawings of a 1950s design for a massive lunar lander **Credit:** BIS



A detailed 1950s plan for a space station. Sadly, nothing this ambitious has ever been built **Credit:** BIS



A multi-stage rocket to take astronauts into space. These BIS designs were often years ahead of their time **Credit:** BIS

Image above: The Harwell campus
Credit: STFC

Space City UK

In the rolling hills of the Oxfordshire countryside, a major global centre for space technology is taking shape. Richard Hollingham visits Harwell near Oxford, where space scientists are rubbing shoulders with entrepreneurs:

Mark Evans, the founder of Radius Health, hopes to do for hospital x-rays what LCD screens have done for TV. "Your TV used to be big, bulky, a vacuum tube, it used to take two people to move it and there used to be a TV repair man," says Evans. "Now it's an LCD and you carry one around in your pocket. We're going to go through that same journey with the clinical x-ray machine."

X-ray machines require an x-ray source and some sort of detector to capture the final image. Today's machines still generate x-rays using technology invented more than 100 years ago, with a process involving passing a high current between two electrodes in a sealed glass tube. The machines are bulky and are usually fixed in position in a special room. Evans intends to replace these with a much smaller solid-state device – equivalent to the replacement, in the 1950s and '60s, of electronic valves with transistors. "We see a vision where x-ray machines are transformed using space technology."

The space technology he is using was developed for spacecraft propulsion systems. "These generate electrons in controlled and focussed beams, which can be converted to x-rays," Evans explains.

Space technology is also being used for the detectors. "In an x-ray telescope you have x-ray optics. So we're taking these two technologies, bundling them together in a very different form but still it's space technology at the heart." The final machine will be only a little bigger than a laptop and Radius Health plans to have a full working model later this year.

Image bottom left: Mark Evans with a component from his new x-ray machine
Credit: STFC

Image top right: X-ray telescopes can probe the far reaches of the Universe; now the technology is being adapted for use in hospitals
Credit: ESA

New venture

UK space engineers at the Science and Technology Facilities Council's RAL-Space at Harwell developed much of the underlying technology for Evans' revolutionary x-ray machine and the company is now a tenant of the European Space Agency's (ESA) Business Incubation Centre (BIC). This new centre is just across the road from the RAL-Space laboratories and also shares the site with the Satellite Applications Catapult centre, which – as the name suggests – is aimed at developing new satellite applications.

The Harwell Science and Innovation Campus is also home to the vast silver doughnut of the Diamond synchrotron, offices for the National Centre for Earth Observation and a major new data centre to handle the vast amount of information generated by scientific satellites. On top of that there are dozens of small companies at Harwell developing space technology for innovative new products and services. You can see why, at a recent conference, Minister for Universities and Science David Willetts described Harwell as becoming a "space city."

Following agreement at the Ministerial Council meeting in November, the UK – through the UK Space Agency – is now the third largest funder of ESA. This has already brought with it increased investment from the Agency into the UK and ESA is now gearing up for a major expansion of its Harwell facilities. It will shortly move the heart of its satellite communications programme to the site, significantly raising the number of ESA staff working in the UK.

"We see the possibilities for these companies around us at Harwell to find partners somewhere else in Europe"
Magali Vaissiere
ESA

continues >

Space City UK
continued

Top image: The Hylas-1 satellite, operated by UK-company Avanti, was developed under ESA's ARTES programme
Credit: ESA

Bottom Image: Unloading a Galileo navigation satellite from its transport aircraft. Navigation is a major area of growth for the UK space industry
Credit: ESA

"This is a new venture for ESA, the first case where an ESA centre is embedded in something bigger," says Magali Vaissiere, ESA's Director of Telecommunications and Integrated Applications. Vaissiere is responsible for ESA's Advanced Research in Telecommunications Systems (ARTES) programme and oversees the development of new satellite communications technologies and applications.

The UK is already a world leader in satellite communications, which provide everything from TV and broadband internet to global phone services for the remotest parts of the world. Britain is the highest contributor within ESA to ARTES, so it makes sense for parts of the satellite communications sections of ESA to be re-located to Harwell. But, says Vaissiere, there are other advantages: "We are going to look at partnering with the people around us – such as the Catapult and RAL-Space – to take advantage of the fact that we are in a campus."

Dirty word

This exchange of knowledge between ESA and other organisations at Harwell is designed to work both ways. "We see the possibilities for these companies around us at Harwell to find partners somewhere else in Europe – we can be in between the rest of Europe and the people here," says Vaissiere. Ultimately, she says, this should benefit all of us. "I think what is more and more important is to generate benefits for the citizens of Europe but also generate growth for the economy, which is already an important area we are pursuing."

A recent study suggested that the UK space industry is worth some £9 billion to the UK economy and is growing at a rate of seven percent a year. The Government recently identified space as a key sector for investment

A close up image of the Lutetia asteroid captured by ESA's Rosetta spacecraft **Credit:** ESA

UK SPACE AGENCY

Astounding

Millions of asteroids orbit the Sun and they come in many odd shapes and sizes. Although m have trajectories that pass close to the Earth and are tracked in case they pose a threat. Seve

Space rocks

Asteroids are the rocky remnants left over from the formation of the planets in the Solar System some 4.5 billion years ago. The astronomer William Herschel first used the word asteroid – Greek for star-like – to describe these celestial objects. They range in size from large asteroids such as Ceres, which is 952 kilometres across, to many others that are only a few metres in diameter. Some of the larger asteroids are also known as minor or 'dwarf' planets.

At least nine out of ten asteroids are concentrated in the doughnut-shaped asteroid belt, 180 million kilometres wide, found between the orbits of Mars and Jupiter. However, some asteroids may have ended up as moons. There is a theory that the rocky Martian moons of Phobos and Deimos were asteroids that got captured by the planet's gravitational field.

Some asteroids may contain significant amounts of valuable metals such as platinum and several companies propose mining asteroids for their mineral wealth.

Printed by RCUK's Internal Service Provider on sustainable forestry paper, April 2013. www.bis.gov.uk/ukspaceagency Issue 37

Artist's impression of asteroids passing the Earth **Credit:** ESA

g asteroids

ost of these space rocks are found in the asteroid belt, between Mars and Jupiter, some eral space probes have visited asteroids and there are even plans for a human mission.

Impact Earth

In February 2013, asteroid DA14 came within just 27,700 km of our planet – between the Earth and the orbit of geostationary satellites. Although space agencies do not know of any asteroids that are on a direct collision course with the Earth, NASA estimates that there are 1,300 potentially hazardous rocks out there in the Solar System.

Dangerous space rocks are known as Near Earth Objects (NEOs) and telescopes on Earth are used to track NEOs to spot any large objects heading our way. We know that asteroids have hit the Earth in the past and one event, around 65 million years ago, may have been responsible for a sudden change in climate and the mass extinction of dinosaurs.

The Earth is regularly bombarded by much smaller lumps of material and even rocks just a few metres across – called meteoroids – can do serious damage. When these meteoroids burn up in the Earth's atmosphere they are termed meteors and we see them as shooting stars. If they reach the surface, they are called meteorites.

In a weird cosmic coincidence, on the same day that asteroid DA14 passed harmlessly by, almost 1000 people in Russia were injured as a result of the shockwave from a meteor entering the Earth's atmosphere. This was a timely reminder we need to take the potential threat from NEOs seriously.

Asteroid missions

As well as assessing possible threats, studies of asteroids will give us a better idea of what the early Solar System was like and the processes that enabled its formation.

The first spacecraft to observe an asteroid close-up was NASA's Galileo mission in the early 1990s. This was followed by the Near Earth Asteroid Rendezvous (NEAR) mission, which made the first ever landing on an asteroid in 2001.

In 2008, ESA's Rosetta spacecraft passed close to asteroid Steins and, two years later, asteroid Lutetia on its way to its final destination comet 67-P/Churyumov-Gerasimenko. Data obtained from the Lutetia fly-past suggests the asteroid is 3.6 billion years old and an ancient artifact from the early Solar System.

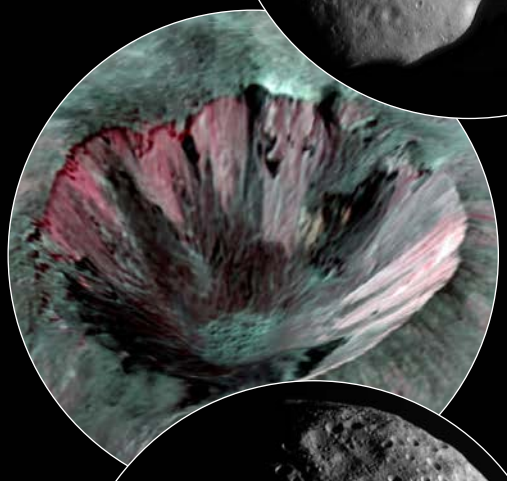
The Dawn spacecraft recently orbited asteroid Vesta for more than a year and is now on its way to the dwarf planet Ceres, where it is due to arrive in early 2015.

NASA currently has plans for a human expedition to an asteroid and UK astronaut Tim Peake recently took part in a simulated asteroid mission. This involved a team of astronauts living and working, for 12 days, in an undersea habitat off the Florida coast.

Asteroids

Asteroids are lumps of rock, smaller than planets, which orbit the Sun. These space rocks range in size from a few metres to several hundred kilometres across. There are many millions of asteroids throughout the Solar System but most are found in the asteroid belt.

Asteroid Eros
Credit: NASA



Close up view of a crater on the giant Vesta asteroid
Credit: NASA

Asteroid Vesta is almost spherical
Credit: NASA

UK SPACE AGENCY

to help generate long-term economic growth. The aim is that projects developed at centres like Harwell will ultimately bring benefits to the UK taxpayer.

Perhaps Harwell's greatest advantage is that the people developing the science and technology are in the same place as the organisations funding the work, as well as the entrepreneurs turning some of those ideas into new products. Paul Vernon, who runs ESA's Business Incubation Centre, has found that attitudes have changed considerably in the eleven years he's worked at Harwell.

"Commercialisation was quite a dirty word," he says. "I was a bit of a strange beast, wondering around the corridors in a suit watching scientists dive into their offices to avoid me." From this unpromising start, he went on to help set up almost twenty spin-out companies. "We've gone on to set up a business development team to get industry to come in and use our expertise and since then we've set up business incubation facilities."

The Satellite Applications Catapult centre is the latest facility to be located at Harwell, where it will merge with the International Space Innovation Centre, a project which involves many of the UK's major space companies. If all this seems a little confusing, the underlying point is that everything's coming together in what Vernon terms, "a critical mass." There are regular meetings between everyone involved, including the UK Space Agency, ESA and RAL Space. "We've all understood the fact that having everything co-located makes it all stronger," says Vernon.

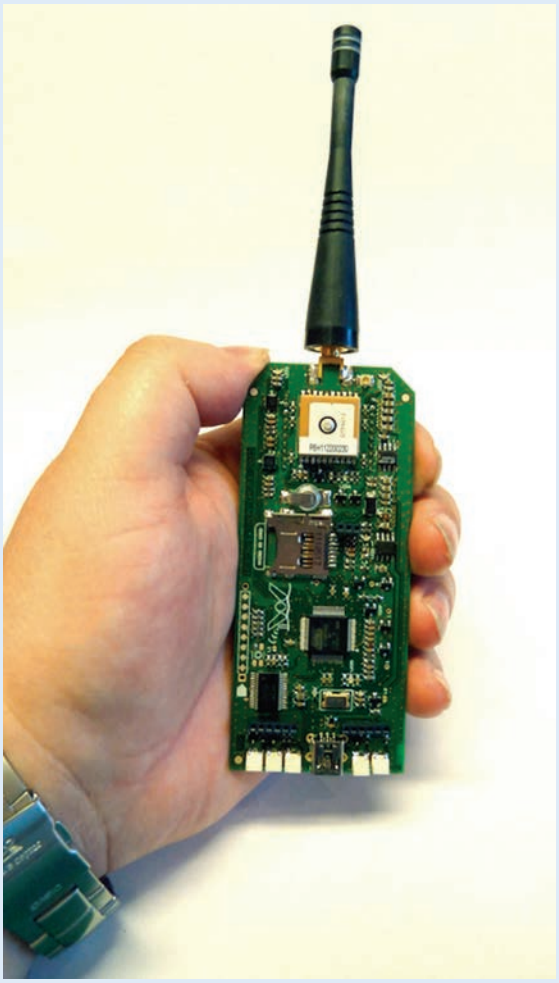
Search at sea

When it comes to applications from space technology, one of the major growth areas is satellite navigation. You can find a good example in an office just along the corridor from Vernon where Christine Edwards and Peter Hall, Directors of Sci-Tech (POB) Limited, have been developing Diver Tracker. The device is designed so that crew on a boat can easily find people returning from a dive.

"It's filling a gap in the market," says Hall. "We had some market research done and we found there was a definite need for something to track people on the surface. This has happened to me, I got lost from the guy I was diving with and I couldn't see the boat either. The sea was calm, and they found me in ten minutes, but it's not much fun to be separated." In rough seas, it could be fatal.

Diver Tracker consists of individual waterproof handsets resembling mobile phones, which are attached to the divers' equipment. There is also a base station on the boat with a small LCD screen. The handsets have satellite navigation receivers fitted with a chip that uses the European EGNOS system. This gives a much higher degree of accuracy (see *space:uk* issue 36 for a feature on EGNOS). Once on the surface the devices on the divers transmit their position to the base station, where it's displayed on the screen, and the divers can be located and recovered from the water. The device will be tested at sea in the next few months and Hall hopes to get the product to market later this year.

Diver Tracker is another example of how space technology is being applied to a new area, an area that was never even considered when satellite navigation was first developed. Likewise, when x-ray telescopes were being built for spacecraft, the priority was to explore the cosmos rather than improve medical care. It is further proof that investment in space technology produces a wide range of benefits here on Earth. And that is what the partnership of space organisations, agencies and businesses at this "space city" of Harwell is all about.



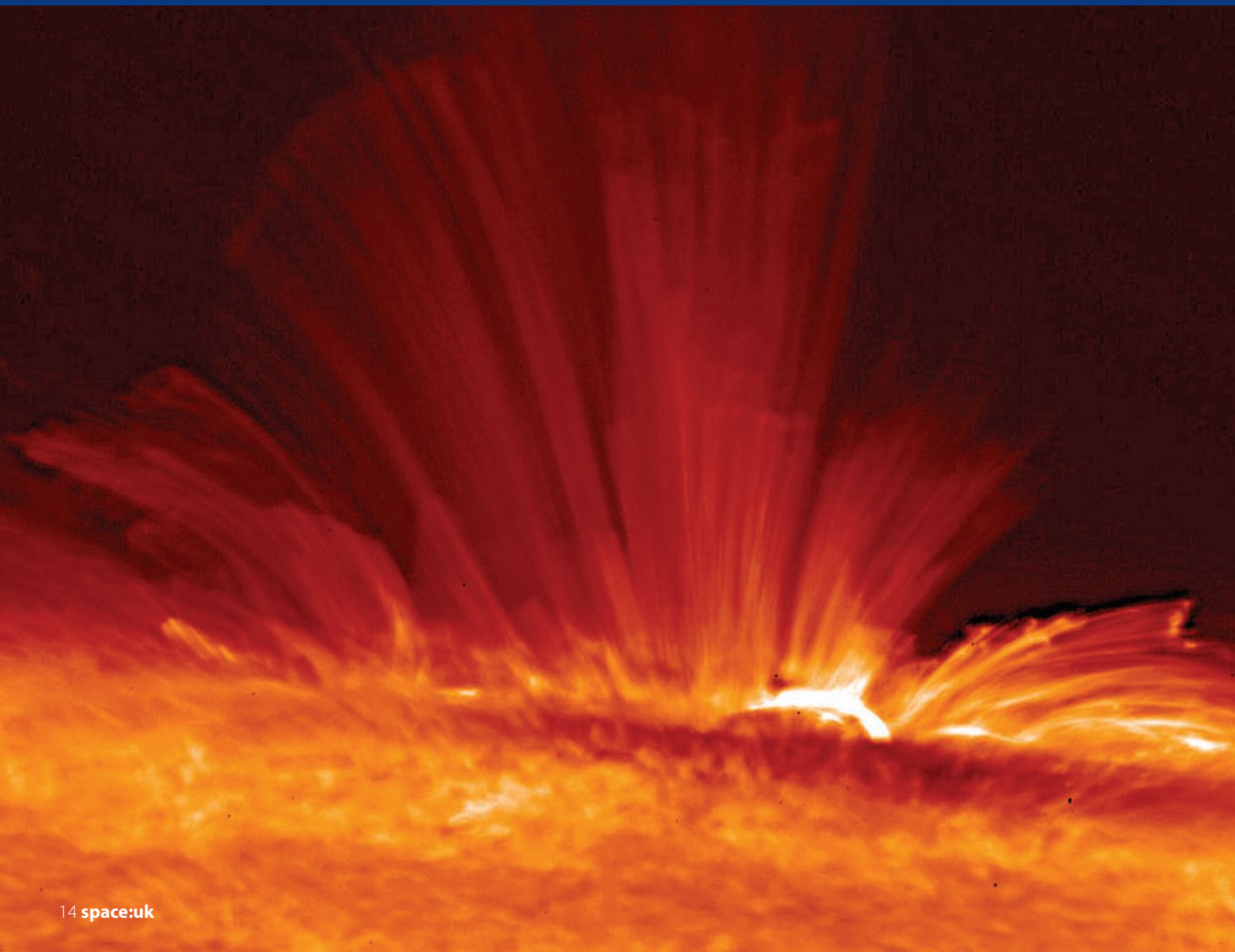
Bottom Image: The Diver Tracker device without its case
Credit: Sci-Tech (POB)

"I was a bit of a strange beast, wondering around the corridors in a suit watching scientists dive into their offices to avoid me"

Paul Vernon
ESA

Feeling the heat

As the Sun gets more explosive, the importance of studying our nearest star has never been greater. Violet Berlin reports on a new spacecraft that will get closer to the Sun than ever before:



This Hinode image of the solar chromosphere reveals the structure of the Sun's magnetic field as plasma rises from a sunspot
Credit: JAXA

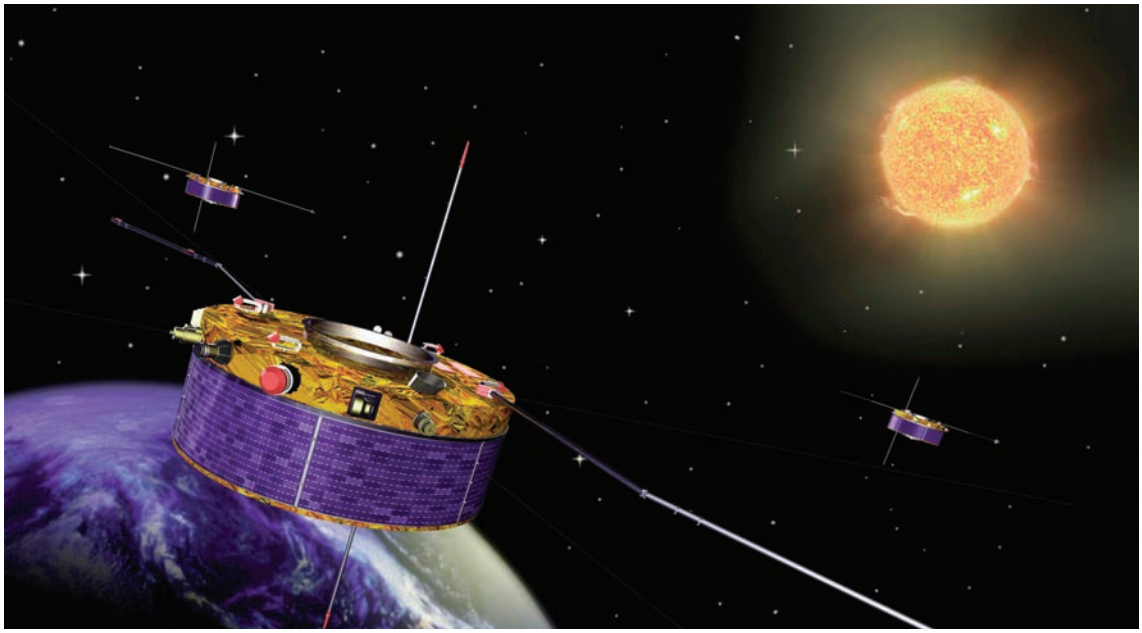


Image opposite: The Cluster constellation is measuring interaction between the solar wind and the magnetic bubble surrounding the Earth, known as the magnetosphere
Credit: ESA

This year could turn out to be an exciting one for solar physicist Lucie Green of University College London's Mullard Space Science Laboratory. The Sun is due to reach the apex of its natural cycle, although we will not know for sure that it has reached this solar maximum until after the event. It all comes down to the tally of dark blotches on the star's surface.

"In the 1800s it was realised that the number of sunspots follows a cycle," says Green. "The number rises over roughly 11 years, solar maximum is the time the sunspot number peaks. Instruments on scientific spacecraft show us that as numbers of sunspots increase, so do explosions in the Sun's atmosphere, known as solar flares."

As well as counting sunspots and monitoring the solar flares, these scientific instruments can also track the vast, violent clouds of charged particles that burst from the Sun called Coronal Mass Ejections (CMEs). These hurtle outwards at speeds of between 500 and 2000 kilometres per second, bombarding anything in their path, including the Earth.

Blast from the past

It was during a solar maximum more than 150 years ago that a CME left the Sun and travelled the 150 million kilometres to Earth, causing the largest geomagnetic storm ever recorded.

The signs of that solar super storm were first spotted on 1 September 1859 by astronomer Richard Carrington. He was observing sunspots from his home observatory in Surrey, using a brass telescope to project an image of the Sun onto a painted glass screen, when he reported that "two patches of intensely bright and white light broke out. My first impression was that by some chance a ray of light had penetrated a hole in the screen."

Carrington had, in fact, spotted a solar flare. Unknown to him, the flare was accompanied by a very fast CME and this bubble of super-heated, electrically charged gas – or plasma – was heading straight for Earth.

"The Carrington event was interesting from two perspectives," says Green. "It was the first time a solar flare was observed on the Sun and, very shortly afterwards, the Earth's magnetic field had a very strong response so it was the first time that we had some observations that suggested that the Sun affected the Earth."

"Strong response" is no understatement. To the Victorians, the beginning of September 1859 must have looked like the apocalypse. Skies shone blood red, cities from London to Bombay lit up with stunning aurora. The world's press, abuzz with the news, was hampered by a communications blackout — electrical surges passed along telegraph wires disabling the system and shocking operators. Sparks flew from the equipment and it was reported that telegraph papers burst into flames. In the aftermath, scientists came to understand that the Sun bathes our planet in more than just heat and light.

"The Sun's hot atmosphere continuously expands into the solar system," explains Green. "This outflow is called the solar wind. Earth is sitting in the solar wind, immersed in the atmosphere of the Sun. This means energy that ultimately starts at the Sun flows out as solar wind to Earth and interacts with our planet's magnetic field."

"When it comes to solar science, the UK is in a leading position"
Ralph Cordey

continues >

Feeling the heat
continued

Top image: The Sun as seen by the Hinode satellite
Credit: JAXA

Bottom image: The STEREO spacecraft captures an eruption on the Sun's surface
Credit: NASA

"In the 1800s it was realised that the number of sunspots follows a cycle"
Lucie Green
Mullard Space Science Laboratory

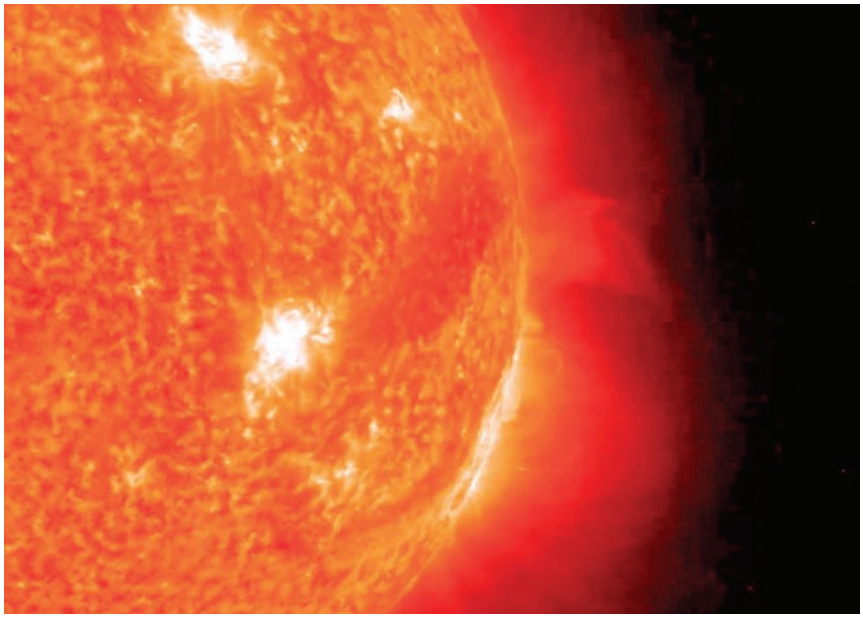
CMEs represent a sudden enhancement in the solar wind and a very large increase in the energy that flows from Sun to Earth, hence the strong storms that can follow.

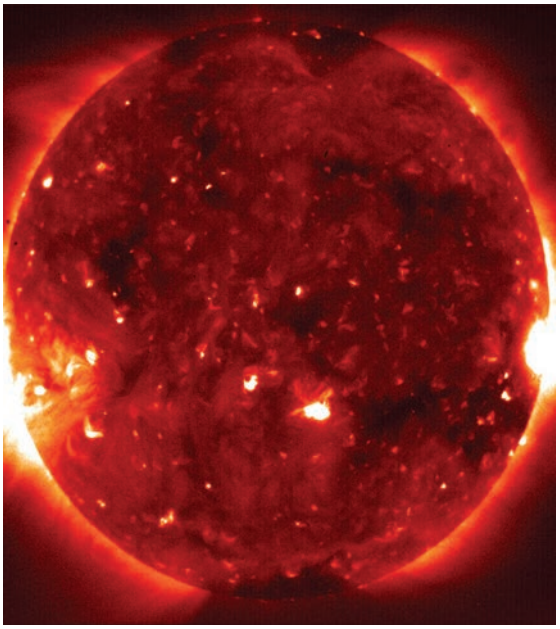
Although the Carrington event of 1859 affected telegraph communications, that is nothing compared to what a similar event would do today. A recent report from the UK's Royal Academy of Engineering stated that a solar superstorm could degrade the performance of the electricity grid and affect satellites, GPS systems, aviation and possibly communications systems such as mobiles and the Internet. Although the study went on to say that the UK was reasonably well prepared to deal with such a threat, the potential disruption is such that it is more important than ever to investigate what the Sun has in store for us.

Missions to the Sun

No-one can yet predict when another solar storm will occur but, far beyond Carrington's brass and glass, this year's solar maximum will be measured, imaged and analysed by instruments being carried on several international spacecraft. And in 2017 the most ambitious solar mission yet, Solar Orbiter, will be launched pushing the knowledge of our parent star further by getting closer than ever before.

Solar Orbiter's journey to the Sun starts at Astrium UK's base at Stevenage in Hertfordshire. "There's a team sitting in the building above me who are dedicated day and night to the development of Solar Orbiter," says Ralph Cordey, who is working with ESA to shape the mission.





"We're coordinating the entire development and will be putting the spacecraft together in our clean rooms here."

UK science and the Sun

Solar Orbiter takes its place alongside a range of missions with UK involvement that are all designed to understand how the Sun creates and influences the environment around it, including the Earth.

- STEREO – Two identical spacecraft which look at the Sun from different angles. This allows them to create 3D images, mapping the evolution of the clouds of charged particles spat out from the Sun during CMEs.
- Cluster – Four identical spacecraft orbit Earth in a tetrahedral formation. This means they can accurately measure the affect of the Sun's activity on near-Earth space, and map how this region changes over time.
- Hinode – Instruments on this Japanese-led mission include the first large space-bourne optical telescope dedicated to solar observation. The purpose is to study the magnetic fields that lead to explosive events on the Sun.
- SOHO (Solar & Heliospheric Observatory) – A satellite that stares continuously at the Sun with different instruments in different wavelengths. As an unexpected benefit, it has also turned out to be history's biggest comet detector!

The UK's considerable contribution to this European mission is funded by the UK Space Agency and science instruments for the spacecraft are the responsibility of universities and institutions in the UK and around Europe. But designing technology to survive so close to a star will be tough.

"Solar Orbiter will get closer to the Sun than any other spacecraft, to inside the orbit of Mercury," Cordey explains. "It will experience 13 times the heat and light flux from the Sun than we get on Earth. Science instruments will peer through special holes cut in the heat shield, protected by baffles."

One side of the spacecraft will heat to about 600 degrees Celsius, whilst the other side will be in shadow. According to Cordey, this means protecting the instruments is not just about heat management. "It is crucial that the spacecraft must never wobble or turn so its unprotected parts face the sun"

At its closest approach, Solar Orbiter will almost match the same rotation speed as the star itself. "This means it can follow a feature on the Sun's surface for a long time," says Cordey. "The orbital plane will also allow it to look towards the poles of the Sun — the only spacecraft to do this since Ulysses back in 1990, only this time from much closer."

The design stages of Solar Orbiter are close to completion. The next phase is to start building equipment and creating structural and thermal models in a computer.

"That's followed by constructing actual models – a spacecraft that looks like the real thing, ready for testing in ESA's large solar simulator, a big container that can shine a simulated Sun, only much hotter."

Once the spacecraft is in position, the heart of the mission is to study the 'solar dynamo' — the evolution of the Sun's magnetic field that leads to all the bangs, pops and whistles of solar activity. It will take close-up pictures of our star and measure particles and magnetic fields in plasma whooshing by.

Solar physicists long for the data it will supply. Says Green, "It will be really fantastic to hover over the Sun's surface. At the moment, we watch a region and it rotates out of our view, but from the Solar Orbiter's position at the Sun's poles, we can follow an active region for several days."

Solar Orbiter

As well as being designed and built in the UK, three key instruments on Solar Orbiter are being developed here too:

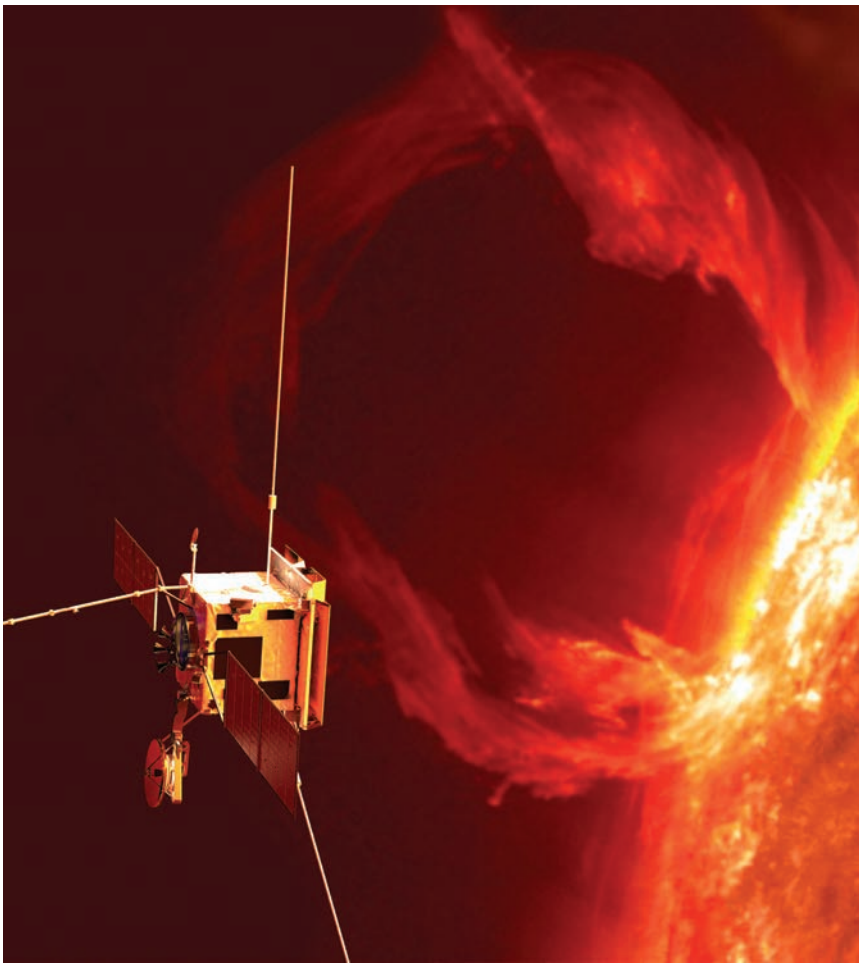
- Magnetometer – specialised for measuring magnetic fields around the space craft (Imperial College)
- Solar wind analyzer – for measuring particles as they flow around the space craft. (Mullard Space Science Lab at UCL)
- Spectral imaging device – basically, a telescope which is imaging and taking measurements of the solar disk and the corona around it. (Rutherford Appleton Lab)

Together with other solar missions the UK is involved in, Solar Orbiter will increase our understanding of the connection between Sun and Earth. After all, the more we know, the better we can prepare for extreme events.

"When it comes to solar science, the UK is in a leading position", confirms Ralph Cordey. "We're doing it because the Sun is so important as an influence on our lives and will be even more important in influencing the infrastructure we rely on in the future."

Image below: Artist's impression of Solar Orbiter
Credit: ESA

"Solar Orbiter will get closer to the Sun than any other spacecraft "
Ralph Cordey



Space for Archaeology

Image above: A Bournemouth University student using GPS to record a Neolithic house near Stonehenge
Credit: Bournemouth University

Space is giving archaeologists a unique perspective on historic sites. As Sue Nelson discovers:

The incredible success of the Indiana Jones films caused some people to believe that archaeologists spend most of their time on their hands and knees digging with a trowel for a lost ark or temple (preferably of doom). The trowel is still a vital piece of equipment but many archaeologists are taking a much greater overview of interesting sites with a somewhat larger and more technologically advanced tool: a satellite.

"In Libya I've been able to look at coastal sites by satellite because I can quickly identify the places we need to target and then go and survey them," says archaeologist Katia Schörle from the University of Oxford. "That's how I've discovered very important Roman villas. Before, you would not have been able to simply walk across that landscape because these are huge areas."

Pictures from satellites provide a superb overview of the Earth for the expert eye. They can detect features such as buried walls, roads, buildings and rivers due to changes in the landscape – either through visible light satellite images or those in infrared – and all on a global scale. "Generally we have formal data that we know from ancient texts and historical documentation where some places might be," says Schörle, "but satellite data allows us to identify places in the landscape that would be of interest. It's completely transformed the way that we can look at landscape."

The use of satellites has been particularly useful for rural archaeology. "Our understanding of how agriculture works has been radically transformed," states Schörle. "We can move from an understanding of urban spaces and landscapes in the city to a much closer understanding of what life would be like for people living outside the city."

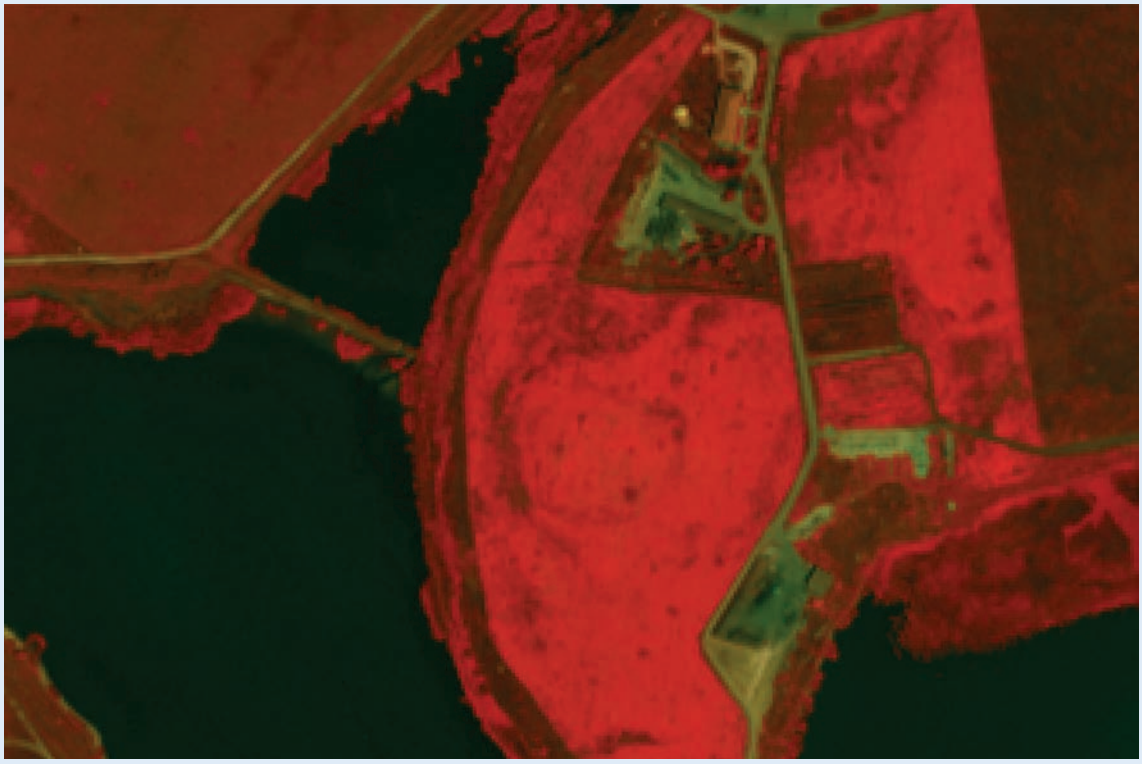
Spy satellites

Ioana Oltean, from the University of Exeter, has been using satellite imagery since 1998. Most recently her paper in Antiquity, one of largest journals in archaeology, described how new and archived images from satellites and aerial photography helped increase the number of known Greco-Roman burial mounds, or barrows, in Romania, where the Danube meets the Black Sea.

"There were literally thousands and thousands of them littered across the landscape," says Oltean, "and the satellite imagery helped us make the first quantitative study. A lot of these monuments are flattened now and are not visible on the ground. It's better to see them from above and they become visible under specific conditions."

Oltean used images from several sources including the GeoEye and QuickBird commercial Earth observation satellites. But she also studied pictures taken in the 1960s by CORONA spy satellites. These, once top-secret, satellites were used by the Americans to detect missile launch sites and other areas of strategic interest in the Soviet Union, and its allied countries, during the Cold War.

Image below: A QuickBird satellite image of a buried Iron Age settlement in southeast Romania
Credit: University of Exeter



"Satellite imagery is absolutely crucial to our understanding of regional patterns"
Katia Schörle
Archaeologist

continues >

Space for Archaeology
continued

Top image: An overview of the Stonehenge landscape, with archaeological features superimposed, viewed in Google Earth. The Stonehenge circle itself is in the bottom left-hand corner
Credit: Google Earth, Bournemouth University

Studying Stonehenge

Archaeologists use satellites for more than just images, however. "Satellites are fundamentally important to archaeologists as we rely heavily on GPS (Global Positioning Satellite) technology," says Kate Welham from Bournemouth University. "Everything from locating where our trenches should be - to plotting in where we found that Neoltithic bone or flint - we do all of that predominantly using GPS."

Welham uses GPS on many projects, including those at World Heritage Sites on Rapa Nui (at Easter Island), Songo Mnara in Tanzania and at Stonehenge in England. The Stonehenge Riverside Project began in 2003 and has resulted in a re-interpretation of how Neolithic people lived around the monument. The project has led to the discovery of a new prehistoric village and, in 2009, the excavation of a new stone circle – Bluestonehenge - by the river Avon.

"The Stonehenge excavations were some of the largest that were taking place in Europe at that time," says Welham. "Over five years we dug more than 60 trenches and had up to 150 people at any one time out and about. Without satellite technology, managing where we were and what was being recorded would have been virtually impossible."

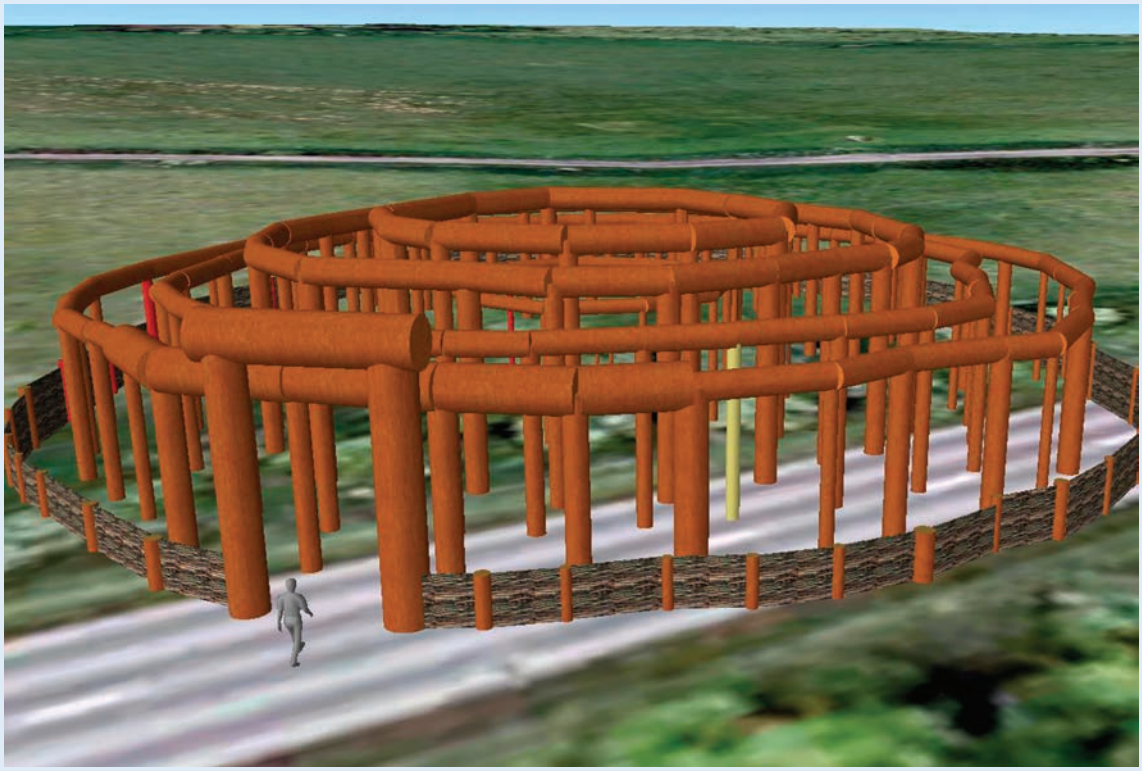
Before GPS technology was easily available to archaeologists, Welham and her team relied heavily on traditional mapping. "We would go into the field and measure ourselves in from fixed points like fences and other landmarks and then correlate all our data back to Ordnance Survey maps," she says. "But now, with the widespread availability of satellite technology, it's revolutionised what we do."

This approach has also led to Bournemouth University working with Google to produce Google Under-the-Earth: Seeing Beneath Stonehenge. "Because we recorded everything with GPS technology, we could locate that accurately within Google Earth and allow any user to zoom in on the landscape," Welham explains. "And it wouldn't have been possible for us to have done that without the advances in the use of satellite technology within archaeology."

It has also allowed people to engage with her work. "Stonehenge is not just situated in isolation, it's part of the landscape," says Welham, "and within that landscape there are lots of other important monuments and activities that relate to the stones themselves. So the point behind both projects was to try to understand and research what's going on in the landscape and the relationship between monuments and places but also to engage people, whoever they might be and from whatever part of the world, in understanding more about the site."

It has certainly worked. So far they have had over 10,000 downloads from more than 30 different countries.

"The uptake of Earth observation data by archaeologists is a fantastic example of what can happen when data is made easily and freely available"
Ruth Boumphrey
UK Space Agency



Top image: Google Earth view of a reconstruction of the Southern Circle – an important monument in the Stonehenge landscape. It is positioned under a modern road **Credit:** Google Earth, Bournemouth University

Bottom image: The launch of the latest Landsat. These hi-tech satellites are able to give a unique perspective on the past **Credit:** United Launch Alliance

Endless opportunities

For Schörle too, there have been enormous benefits to applying space technology to her work. "Satellite imagery is absolutely crucial to our understanding of regional patterns," she says. "You could very quickly identify where you would have military strategic points, where there are fortification walls to even where farms are tending to develop and therefore how the landscape was being used."

"In my own work," says Schörle, "we previously thought that the city of Leptis Magna on the north coast of Libya was relatively isolated. Looking along the coast we can now say it was a highly occupied landscape and I've been able to prove that every single bay was occupied by a building or private villa. That's the sort of change that satellite imagery does to your understanding."

"The uptake of Earth observation data by archaeologists is a fantastic example of what can happen when data is made easily and freely available," says Ruth Boumphrey, head of Earth observation at the UK Space Agency. "Innovative and creative people will take a free data resource and use it in ways which were never conceived when the missions were being designed."

Most UK archaeologists are currently using US satellite data as it's often free or inexpensive. "US Landsat managers have learnt this lesson and have seen an exponential take up of their data by making it free to use," says Boumphrey. "Our hope is that EU Sentinel data will also be free and easily accessible, which will inspire people to use it in creative, unforeseen ways, just like these archaeologists."

The opportunities, it appears, are endless. "Now satellite imagery is becoming more accessible," says Oltean, "there's basically no excuse not to use it. "But once a satellite has located something, there is no substitute for fieldwork on the ground. Even using today's space technology, Indiana Jones would still need a trowel.

"Satellites are fundamentally important to archaeologists as we rely heavily on GPS"

Kate Welham
Bournemouth University

education & careers

Ask the experts

With questions on black holes, life on Mars and bases on the Moon, students at Oldham Hulme Grammar Schools in Oldham have really put our experts to the test. We even had to track down an astronaut:

Sophie Allan
National Space Centre, Leicester

What happens when you get too close to a black hole?

To answer this we first need to think about what a black hole is. A black hole is effectively the small, super dense remains of a very large star that has ended its life in a spectacular explosion called a supernova. The outer layers of the star get blown out into space but the core begins to collapse in on itself. If there is enough mass it will continue to get smaller and denser until it has such a strong gravitational pull that even light itself cannot escape and it becomes black.

Having such strong gravity means that, if you got too close, you would get pulled in towards it. However, you would not simply fall towards the core in a nice human shaped lump. In fact, assuming you are traveling feet first, the difference in gravitational pull between your feet and your head would be so great that your whole body would feel a massive tidal force. Your feet would accelerate towards the black hole faster than your head and your whole body would get stretched out into a spaghetti-like strip. We actually call this effect spaghettification.

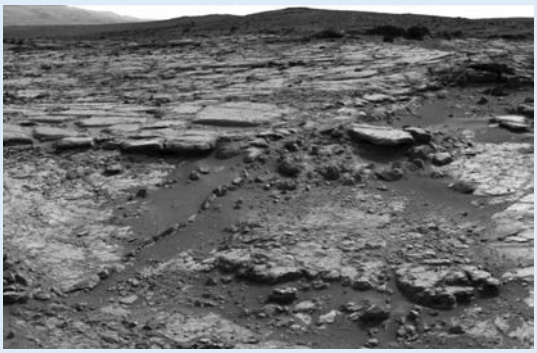
But there is another problem. Material being pulled into a black hole gains so much energy as it speeds up that it gets hot, so hot that it begins to give off high energy x-rays. And x-rays are not good for humans. Even if you survive all that, you could never go fast enough to escape. Even light, the fastest thing in the Universe, is too slow to escape a black hole.

Scientists predict that there are black holes at the centre of galaxies **Credit:** ESA, NASA

Was there ever life on Mars?

The reason that we think Mars may have developed life of its own is that it seems to have an environment quite like that of Earth, or at least it did billions of years ago. The surface of Mars is now very dry and cold but we know that the planet was once a warmer, wetter world. It had rivers and lakes of liquid water gushing across its surface and a thicker atmosphere. It would also have had organic molecules – the chemical building blocks of all life on Earth – raining down onto its primordial surface from meteorites and comets, in just the same way they did onto the Earth.

There are plenty of energy sources for life on Mars, including sunlight to grow by and nutrients in the rocks. So it seems as though Mars ticks all the right boxes for habitability but was Mars ever Earth-like enough for life to get started? Well, we don't know yet, but we are trying hard to find out. NASA's latest Mars rover, Curiosity, is now driving across the landscape using a whole suite of instruments to try to find out what the ancient environment was like. Then, in 2018, the European Space Agency will launch its own rover, called ExoMars, specifically to look for signs of life by drilling underground.



Could life once have lived here? **Credit:** NASA

Lewis Dartnell
Centre for Planetary Sciences
University College London

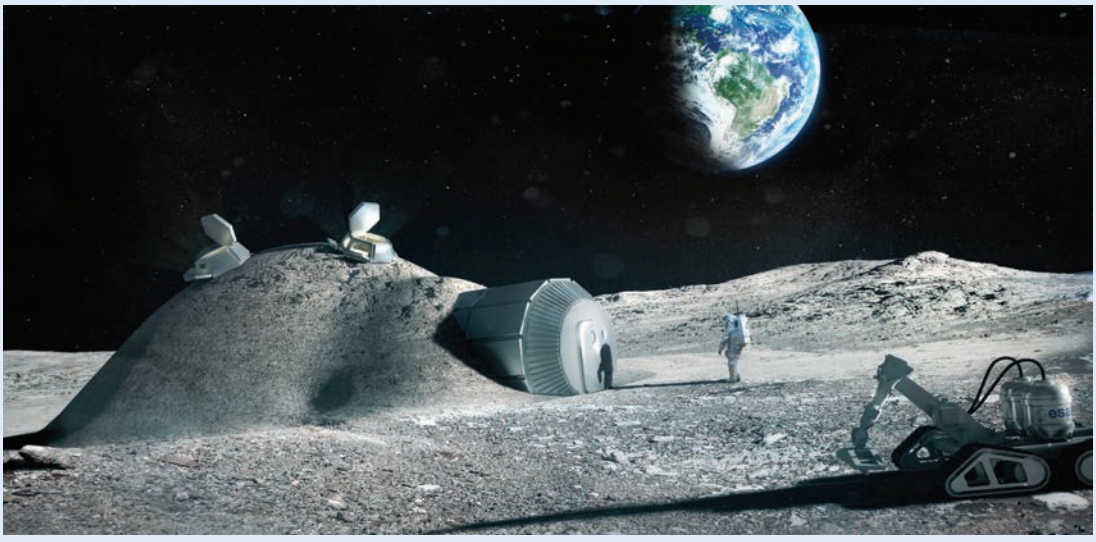
Do scientists think colonising the Moon is viable?

If we had a moonbase it would be for scientific reasons. I do not see any commercial value in going back to the Moon. The Moon is not a good place to launch from to go to Mars; it is just not in the right position to do that.

I can see two reasons to go back to the Moon. One is to build a space station that we could train Mars astronauts for six months in and the other is to put an observatory on the backside of the Moon. Those would be valuable things but we do not know if the money that it would cost to do that is reasonable because I do not think anyone has ever figured it out.

To me the Moon is not as important as utilising the International Space Station. I feel that the space station should be like a gas station, where you could build a spacecraft and fill it with fuel a little at a time. Then you could do all sorts of wonderful things from Earth orbit. It would be a lot easier to get to places [like Mars] than it is from the Earth's surface.

The editor adds: I put this question to Al Worden during his recent visit to the UK. We also asked several UK engineers and scientists for their opinion but none of them were convinced of the need for a moonbase. You can hear an interview with Worden in the April edition of the Space Boffins podcast. Search for 'Naked Scientists Space Boffins' to find it.)



Even an astronaut who has visited the Moon does not think a moonbase like this will ever be built **Credit:** ESA

Al Worden
Command Module Pilot, Apollo 15

education & careers

Teaching resources

Meet the team:

Allan Clements
ESERO-UK Manager

Tom Lyons
ESERO-UK Teacher Fellow

Alice Coates
STEM Project Officer

ESERO-UK promotes space in the UK and the use of space to enhance and support STEM teaching and learning. It has been established at the National STEM Centre through funding from ESA and the Department for Education.

ESERO-UK has developed a collection of resources in the National STEM Centre eLibrary that brings together materials from ESA, and other providers, to promote space exploration and help teachers and lecturers to use space as an engaging context for teaching and learning in STEM subjects.

This collection has recently been expanded to include resources developed by schools in the Leading Space Education Programme (LSEP). This is a Science and Technology Facilities Council (STFC) funded project with the aims of developing good practice in using space for STEM education and then disseminating that practice across the sector. Thirty specialist colleges have been supported to develop practice, work with local secondary and primary schools and the local community.

A project publication and video give examples of the impact on standards that can be achieved.

The resources in this collection have been written by teachers from some of the Leading Space schools and span a variety of activities that have been used in the classroom. These include:

- A whole Year 8 scheme of work themed around space
- A space day for the whole school
- The chemistry of rockets and combustion
- Using space apps in the classroom

You can access the resources in the ESERO-UK collection at: **stem.org.uk/cx3nf**

In addition to its resource collections, ESERO-UK has established a network of space ambassadors across the UK to actively support partners from the space education sector in their work with schools and colleges. Further information is available from the ESERO-UK website: **www.esero.org.uk**

On the website you will also find a dedicated teacher support section where you can search for space activities, space centres, observatories or CPD days taking place in your area.

image opposite: LUCID, the Langton Ultimate Cosmic ray Intensity Detector, on display at the Royal Society summer exhibition in 2012. This instrument has been developed by students at the Simon Langton Grammar School in Kent and will be launched into space on the TechDemoSat-1 satellite later this year (see page 7)
Credit: STFC

Made in the UK

Serco plays an important behind-the-scenes role in the space industry, including at the European spaceport in French Guiana. Serco's Europe Space Business Director, Jim Cater, reveals all to *space:uk:*

Jim Cater
Europe Space Business Director

What does Serco do?

We're predominantly a services company. We tend not to make things but operate them, maintain them and take the pain away from the customer. Serco is a UK company in the FTSE 100 and has done very well exporting its services. We now operate in over 30 countries around the world.

The part of Serco that I work for is European Agencies, so we provide IT and administrative support to international agencies within Europe – such as CERN, the European Parliament and European Space Agency (ESA).

Is space a new venture for Serco?

No, we've been in space for 35-40 years now – it's a long heritage. In Space, we have about 500 people working in the UK, about 500 in America working on satellite operations and in Europe wherever ESA is, that's where we are. We're looking forward to working with ESA at Harwell in Oxfordshire.

In 2012 Serco started a five-year contract to provide corporate IT support to Europe's Spaceport in French Guiana, what does this involve?

We supply the IT support to more than 1,000 users and administrative staff on site. If anyone has a problem with their PC, they come to us. There's no connection between us and someone pressing the launch button. But for someone to get to pressing the launch button they will have had to come through us at some point.

What is your background?

I was a helicopter engineer and transformed into operating things that flew a little higher. I left school at 16, joined the Royal Navy, did an engineering apprenticeship, an engineering degree and then went into this business. I've been in the space industry now for about 30 years and have done everything from writing procedures for Skynet 4 satellites to supporting the development of the Columbus module on the International Space Station. It's a very interesting industry, it's taken me to many countries and I've enjoyed every minute of it.

Image opposite: Serco provides support services at the European spaceport in French Guiana
Credit: ESA, Arianespace

SPACE PIONEERS

Hewitt-Schmidt Camera

The preserved Hewitt-Schmidt camera **Credit:** Observatory Science Centre, Herstmonceux

How do you take a photo of a satellite in space? This was the challenge facing British space pioneer Joseph Hewitt, the designer of the Hewitt-Schmidt camera.

This remarkable piece of equipment, now on display at the Observatory Science Centre at Herstmonceux in East Sussex, was deployed in the early 1960s to observe satellites in orbit. In operation until 1990, it was one of the largest cameras of its type in the world and had powerful optics allowing it to see faint and distant satellites. The giant camera's wide field of view also enabled the long arc of a satellite's trajectory to be recorded. Hewitt employed a special lens, which made the camera a world leader in accurately tracking satellite positions.

Information obtained from the camera's satellite observations helped determine the density, velocity, and temperature of the upper atmosphere, as well as the shape of the Earth and the structure of its gravitational field. At the dawn of the space age, this work proved critical to understanding the space environment and how it affected satellites orbiting our planet.

Today, the UK continues to use radar and special cameras to monitor space and track satellites, space debris and even asteroids. Facilities include RAF Fylingdales in North Yorkshire and the Starbrook system, operated by Space Insight Limited on behalf of the UK Space Agency.

Produced by RCUK's internal service provider on sustainable forestry paper
April 2013. UK Space Agency www.bis.gov.uk/ukspaceagency