Summer 2012 Issue 35

space:uk

Special issue: *50 years of the UK in space*

From Ariel-1 to Solar Orbiter:
celebrating half a century of space science

Fried by the bomb:
the full story of Ariel-1's demise

space:uk 1962:
pull-out supplement

Plus:
UK astronaut's underwater challenge, scientists plan for mission to Jupiter, innovation in space and postcards from Saturn

UK SPACE AGENCY

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50 YEARS UK IN SPACE

Front cover image: Enceladus hangs below Saturn's rings while Titan lurks in the background. A new image captured by the Cassini spacecraft
Credit: ESA, NASA

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From the editor

I've been spending a lot of time with old documents over the past few months. It's quite a thrill to leaf through Government archives with 'Secret' written in big letters across the front. And it's only now, 50 years after Ariel-1's historic flight, that the full details of the satellite's untimely demise can be revealed. We tell the story on page 16.

The science and engineering that went into Ariel-1 sowed the seeds of the UK space industry. Now worth some £7.5 billion and still growing. Today, the UK's expertise in building spacecraft is being employed for missions to the Sun, Mercury, Venus, Mars and Saturn, as well as the many satellites that study the Earth. The UK also builds some of the world's most sophisticated communications and navigation satellites. You can read more about these missions throughout *space:uk*.

We've also included a special supplement, imagining what a 1962 issue of this magazine would have been like. It was great fun to put together but made me realise that although space was exciting then, it's just as exciting now.

Richard Hollingham
Editor


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Credit: NASA


Credit: ESA
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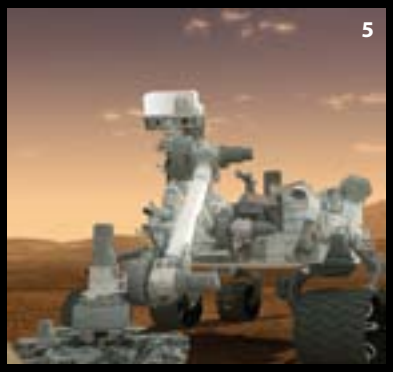
Credit: NASA


Credit: NASA
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UK to build Sun mission

A spacecraft designed to get closer to the Sun than ever before, is to be built in Britain. Astrium UK has been selected by the European Space Agency (ESA) as the prime contractor for the Solar Orbiter mission, which will make a detailed study of our nearest star and its influence on the Earth.

The €300 million contract was signed on the anniversary of the launch of the UK's first satellite, Ariel-1, as part of the celebrations for the 50th anniversary of the UK in space. One of the world's first scientific satellites, Ariel-1 was also designed to study the Sun and its influence on the Earth.

"The prime contract for this mission is the biggest ever signed between the ESA science programme and a UK company," said Chief Executive of the UK Space Agency, David Williams. "Solar Orbiter represents an important stage of the UK's ambition for growth and innovation and it's a testament to the skills and expertise of UK industry that we win such major contracts."

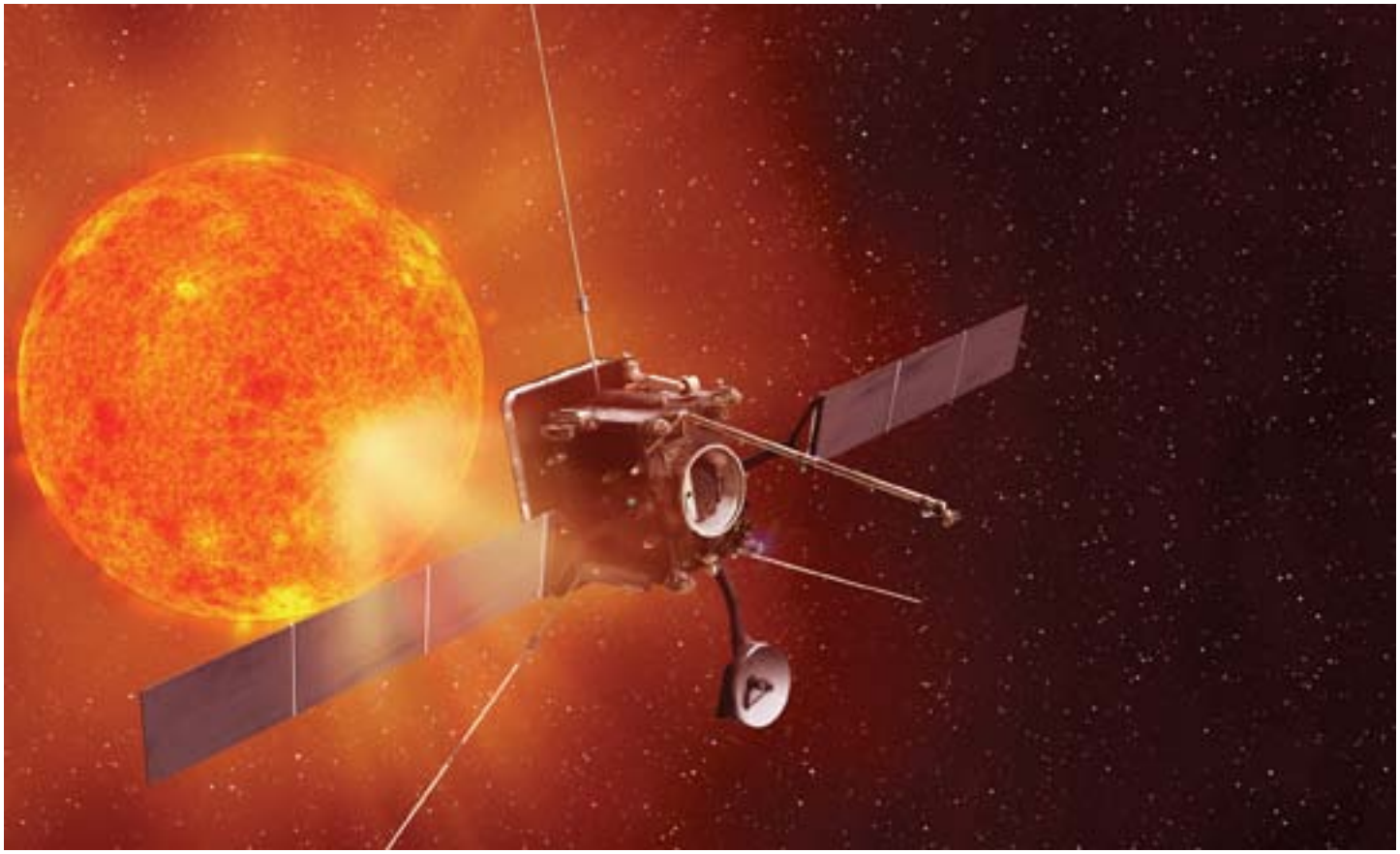
Solar Orbiter will orbit the Sun in an elliptical orbit where it will capture detailed images of the star and study the solar wind – the stream of charged particles the Sun ejects out into space. These particles interact with the Earth's magnetic shield – known as the magnetosphere – and produce spectacular auroral displays. Occasionally the Sun releases bursts of matter, along with high-energy particles. These Coronal Mass Ejections cause surges of electrical activity around the Earth, damaging satellites in orbit and even bringing down power grids.

Due for launch in 2017, this mission is extremely challenging. As well as enduring temperatures higher than 500 degrees, Solar Orbiter will have to cope with powerful bursts of energy and eruptions of high energy particles from the Sun's surface. As a result, the spacecraft will need to be equipped with a specially designed heat shield and a new type of solar array.

"I am delighted that Astrium has won Solar Orbiter," said Head of Astrium UK, Colin Paynter. "This contract builds on our unrivalled heritage in solar missions which includes the SOHO satellite, which is still operational after 17 years and providing valuable data for solar scientists around the world."

The UK Space Agency has also announced a planned £11.5 million investment to be shared between British institutions for the development of four of the mission's instruments.

Read more about Solar Orbiter and the legacy of Ariel-1 on page 10.



Artist's image of Solar Orbiter **Credit:** Astrium

Welcome to the summer edition of *space:uk*, writes Emma Lord, Director of Policy and Operations for the UK Space Agency.

I introduced the last issue by commenting on the busy year we were expecting and that has certainly proved to be the case so far.

On 26 April we celebrated the anniversary of 50 years of the UK in space when guests at a London conference came together to recall the first UK designed and operated satellite ever launched, Ariel-1. The Secretary of State, Vince Cable, attended the event as well as a number of UK space pioneers and people who work in today's space sector. I wonder who would have predicted in those early days how the sector in the UK would grow and how many people it would employ by the 21st century. The last study of the industry showed almost 25,000 are employed directly in the space sector with a further 80,000 jobs supported by space. I hope that by the next issue of *space:uk* we will be able to update these figures with new data.

And talking of today's space sector workers, what of tomorrow's? Well some of them came together in London at an international event to celebrate the closing of Mission X: Train Like An Astronaut. Mission X is designed by NASA to encourage school students, between 8 and 12 years old, to be more physically active. It uses astronaut training to teach how good food and exercise play an important role in human performance in space and on the Earth. The UK is one of 16 nations to have signed up to the challenge by organising Mission X educational programmes. There are likely to be even more next year.

I had a personal first in May when I visited a local primary school as part of a prize for our design a Christmas card competition, which we ran last year. This is the first time I have been offered up as a prize and, as always, it was a pleasure to meet so many young and enthusiastic children and teachers who all listened intently to our talk and asked a number

Credit: Swindon Advertiser

Emma Lord,
UK Space Agency Director of Policy and Operations

Two delegates take on ESA astronaut, Paulo Nespoli, during the Mission X event in April
Credit: UK Space Agency

of challenging questions. If this is the calibre of the next generation of scientists, mathematicians and engineers then I think we can say the UK heritage of developing world-leading technology is in safe hands. The real delight was in meeting Angel-Lee Richardson, the winner of the competition. She is not only a first class artist but a very modest and generous girl who was only too pleased to share the limelight of local media interest with her classmates.

As I will continue to mention, the ESA Ministerial meeting takes place at the end of 2012. This large project involves colleagues across the Agency working with industry, academia, and government colleagues to prepare the UK position. We are also spending an increasing amount of time working with European colleagues at the ESA headquarters in Paris as nations from the 19 member states come together to build the space priorities for the coming years. I wish that it were as glamorous as it sounds but in the current economic climate the meetings involve difficult decisions and long working days. Working with European partners is always interesting though and keeping my rather rusty French going offers yet another element to a very varied job.

You can keep up to date with the latest news and events on our website or through social media such as Facebook and Twitter. And don't forget the new blog for a more personal view from inside the Agency.

www.bis.gov.uk/ukspaceagency

UK first for NASA

UK space scientists and engineers have delivered the first completed instrument for Hubble's successor, the James Webb Space Telescope. The Mid InfraRed Instrument (MIRI) took more than 200 people to build and has resulted in a camera so sensitive it would be able to see a candle on one of Jupiter's moons.

MIRI was shipped in May to NASA's Goddard Space Flight Center, where it will be put together with the three other instruments and the telescope itself.

David Willetts, Minister for Universities and Science, was at the handover ceremony between ESA and NASA at the Institute of Engineering and Technology in London.

"MIRI is the impressive result of more than ten years of work, led by Britain in partnership with Europe," said Willetts. "With world-leading space research facilities at the Rutherford Appleton Laboratory, a host of excellent universities and strategic direction from the UK Space Agency, the UK is clearly well placed to contribute to major global missions."

"It is wonderful to be the first to achieve this major milestone," said Gillian Wright, the European Principal Investigator for MIRI based at STFC's Astronomy Technology Centre in Edinburgh. "We can now look forward to significant scientific discoveries when it is launched in 2018."

MIRI complete and ready to go **Credit:** RAL Space

Bright ideas rewarded

Funding to investigate 'green' spacecraft propellants has been won by a group including Reaction Engines Limited, the company behind the Skylon spaceplane
Credit: Reaction Engines Limited

Concepts to develop environmentally friendly propellants for future spacecraft and new high performance materials for satellites have been rewarded with funding from the UK Space Agency. Other winners in the National Space Technology Programme's (NSTP) latest competition include the developers of a new type of spacecraft thruster and a team designing highly sensitive detectors to observe the Earth from space.

The NSTP was set up to help maintain the success and growth rate of the UK space industry by investigating technologies that could be used in future space missions. So far, since its launch in 2011, the scheme has helped 50 hi-tech space projects. The ten products selected in this latest competition all showed potential to meet future operational, commercial or scientific objectives in the global space economy.

"The call for submissions for the NSTP has unearthed a range of marketable, innovative ideas which will hone the UK's space technology capabilities," said Director for Technology, Science and Exploration at the UK Space Agency, David Parker. "It is fantastic for us to be able to invest in technical developments that will have an economic impact into the future."

CryoSat: new results

Europe's ice mission, CryoSat, has been used to produce the first detailed map showing the thickness of Arctic ice over an entire winter. The mission, which is led by a UK science team, is using radar to build up a picture of the world's ice cover and how it is changing. Every year, the Arctic Ocean experiences the seasonal formation and melting of vast amounts of floating ice. However, there is strong evidence that – as a result of climate change – the area in the Arctic covered by ice is shrinking.

Artist's image of CryoSat **Credit:** ESA

Japan agreement

The UK and Japan have signed an agreement to work closely on future space missions. The deal commits the two countries to cooperate on space research and identify potential commercial opportunities. One of the key areas for collaboration is on Earth observation technology, such as the UK's Disaster Monitoring Constellation. These satellites provided vital data to assist with rescue efforts and damage assessment in the aftermath of the 2011 Japan earthquake and tsunami.

CubeSat takes shape

Two of the five experiments being carried on the UK Space Agency's first CubeSat, UKube-1, mission have been successfully tested at Clyde Space in Glasgow, where the satellite is being put together. CubeSats are smaller and much cheaper to build than traditional satellites, with the basic CubeSat unit just 10cm across on each side. UKube-1 is the size of three of these units stuck together. Final construction and testing of all the component parts is expected to take place over the summer.

The entire satellite is only 30cm long **Credit:** Clyde Space

Jupiter's frozen moons

The Jupiter Icy Moons Explorer (JUICE) is to become the first European-led mission to the outer solar system. The spacecraft, which will launch in 2022 and arrive eight years later in 2030, will also be the first to orbit an icy moon.

The ESA Science Programmme Committee gave JUICE the go-ahead at a meeting in Paris in May. JUICE will explore the gas giant Jupiter and its three largest moons Europa, Ganymede and Callisto, as well as fly past the moon Io.

"It's a fabulous mission," said Professor Andrew Coates from University College London's Mullard Space Science Laboratory. "The key jewel in this mission is going to the icy satellites and to be able to compare Europa, Ganymede and Callisto and look at Io. These four Galilean satellites are all unique in their own way."

Coates helped draw up the plans for the mission and is now leading an international consortium to put together a suite of instruments to fly on board the spacecraft. Several universities and institutes in the UK and across Europe are now in the process of proposing experiments to study Jupiter and its moons in unprecedented detail.

Europa, Ganymede and Callisto are all thought to have oceans beneath their surface and may even harbour the conditions for life. Examining the Jovian system will also help scientists better understand planet formation and how the Solar System works. "We will be working out in detail how the formation of those moons happened and also looking at the habitability there," said Coates. "I'm really excited about it!"

JUICE will visit, from left to right, the icy moons Europa, Ganymede and Callisto **Credit:** NASA

Money for Mars science

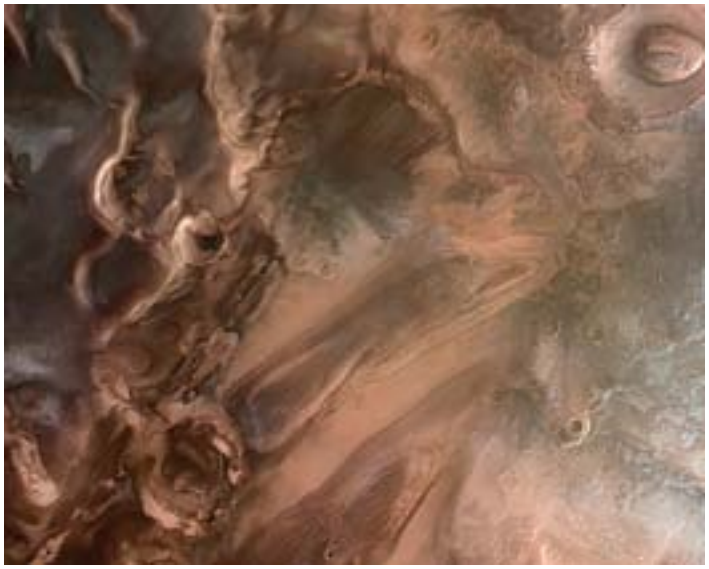
The UK Space Agency has awarded £2 million to scientists to examine the atmosphere, geology, chemistry and habitability of Mars as well as the possibility of past and present life on the red planet.

The UK's expertise in planetary science is internationally recognised. As a result, the standard of research being funded is not only high but also extremely diverse, reflecting the range of scientific disciplines associated with space science. The money is being shared between nine successful bids from the Universities of Leicester, Kent and Edinburgh, University College London, Imperial College London and the Open University.

Two of the awards will have an immediate benefit, helping UK scientists as NASA's Mars Science Laboratory (MSL) prepares to land its Curiosity rover on the Martian surface in August. Sanjeev Gupta, from Imperial College London, is participating in this mission and his work will analyse the evolution of the Martian surface.

UK-funded research on Martian meteorites has also resulted in NASA selecting John Bridges, from Leicester University, and Simon Kelly, from the Open University in Milton Keynes, as MSL scientists. Their funding will allow them to study the interaction between water and rock on Mars.

"This will allow us to participate in what is, in my view, the most important and exciting robotic landing mission ever attempted to date," said Bridges. "MSL has the potential to reveal whether Mars was ever habitable for microbial life and determine if there were standing bodies of water for long periods of time."



This recently released image from Europe's Mars Express mission shows ice in the southern polar region of Mars. One of the winning bids will study the potential of these polar regions to support life **Credit:** ESA

The Curiosity rover will start exploring Mars in August **Credit:** NASA

MSL isn't the only spacecraft within the planetary neighbourhood. Mars Express, Europe's first mission to Mars involving a number of UK scientists, recently celebrated its eighth anniversary in space. The orbiter sent back superb images of ice at the planet's southern polar region. One of the award winners, Axel Hagermann of the Open University, will use his funding to study the Martian poles and the potential of these regions to support life.

The search for life elsewhere in the Universe is one of mankind's key questions and astrobiologist Lewis Dartnell, from the University of Leicester, was another of the successful bidders.

"I'm absolutely delighted with this award," said Dartnell, who will examine the planet using a technique called Raman spectroscopy. "Raman is particularly exciting as it can spot signs of extreme life in the most hostile environments on Earth – and has lots of other applications, like detecting drugs – but has not yet been deployed on a planetary mission."

The funding will enhance ESA's existing Aurora and science programmes within the UK and continue the innovation and growth of the UK's space industry. "The UK should be proud to have such a dynamic research community," said the UK Space Agency's David Parker. "We are delighted to support researchers at the forefront of exploring the red planet."

Galileo checks out

The first two satellites in Europe's new satellite navigation system, Galileo, have passed all their performance tests in orbit. The heart of the satellites – the navigation payloads – were developed and built by Astrium in the UK. The next two satellites in this In Orbit Validation (IOV) phase are due for launch later this year. Meanwhile, Surrey Satellite Technology Limited has delivered the first payload for the fourteen remaining satellites in the Galileo constellation. When it's complete, Galileo will be the most accurate civilian satellite navigation system in the world and will be completely compatible with the American GPS and Russian GLONASS systems.

This picture, taken in May, shows the fourth Galileo IOV satellite during testing in Rome **Credit:** ESA

Rainforest deal

A UK-built satellite is being used to help combat illegal logging in the Amazon rainforest. A contract has been signed between DMC International Imaging Limited and Brazil's National Institute for Space Research to monitor forest clearance as it happens. The UK-DMC2 satellite will take pictures of the entire Amazon basin every two weeks, so that the authorities are alerted as soon as possible after logging is detected.

When galaxies collide

Our galaxy, the Milky Way, is on course to collide with its neighbour the Andromeda galaxy. But don't panic just yet because it won't happen for another four billion years. The discovery was made by studying data and images from the international Hubble Space Telescope. According to the research, it is likely the Sun will be flung into a new region of our galaxy but our Earth and solar system are in no danger of being destroyed.

Artist's impression of the night sky just before the galactic collision **Credit:** NASA

Underwater astronaut

Tim Peake (left) with fellow aquanaut Steve Squyres **Credit:** NASA

British ESA astronaut Tim Peake has been taking part in a mission to an asteroid…beneath the waves. Peake's mission was undertaken in June as part of NASA's Extreme Environment Mission Operations programme (NEEMO) and involved spending two weeks living in a special underwater habitat, Aquarius, off the Florida coast.

These underwater expeditions are designed to give astronauts a realistic simulation of what life will be like on a real long duration space mission. Participants live in cramped quarters, conduct experiments and go on excursions to simulate space walks.

NASA is currently planning to send a manned spacecraft to an asteroid in the 2020s and this particular mission – NEEMO 16 – included using small submarines as exploration vehicles and even a time delay between the underwater base and mission control on the surface.

During the mission the 'aquanauts' posted a daily blog of their activities. In one of the entries Peake wrote that it was an "an incredible experience." Describing two floodlit submersibles appearing out of the gloom, he said: "It really wasn't that hard to remind ourselves that we were simulating an asteroid mission...the special effects have so far been worthy of an award!"

The crew of NEEMO 16, Tim Peake is on the far left **Credit:** NASA

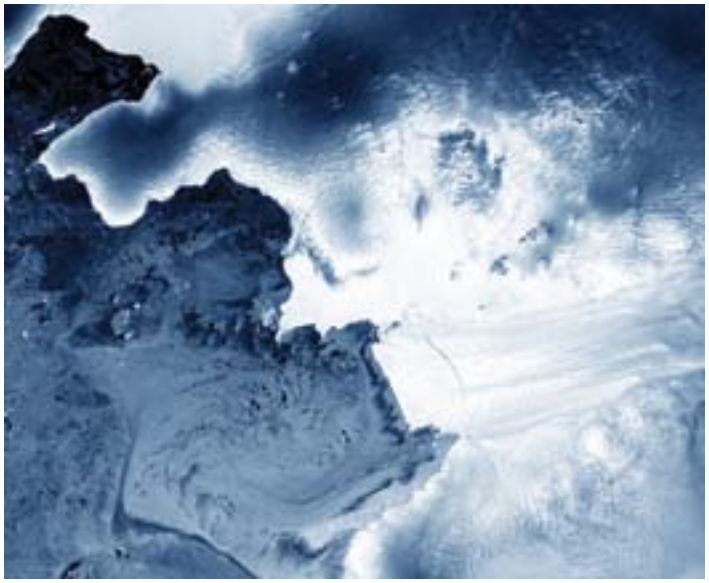
Fond farewell to Envisat

ESA has declared the Envisat mission officially at an end after losing contact with the environmental satellite in April, only a few days after it celebrated ten years of successfully monitoring our planet. Envisat, the largest Earth observation satellite ever built, was expected to continue operating into 2014 and had already lasted more than twice its original five-year lifetime. Despite concerted efforts to re-establish contact with the satellite, the operations team has concluded that nothing further can be done.

During its service, Envisat circled the globe more than 50,000 times with its ten instruments helping us keep a check on the health of our planet by monitoring the oceans, the ice caps, the land and the atmosphere. The data acquired has proved essential in enabling scientists to understand the long-term changes happening to the Earth.

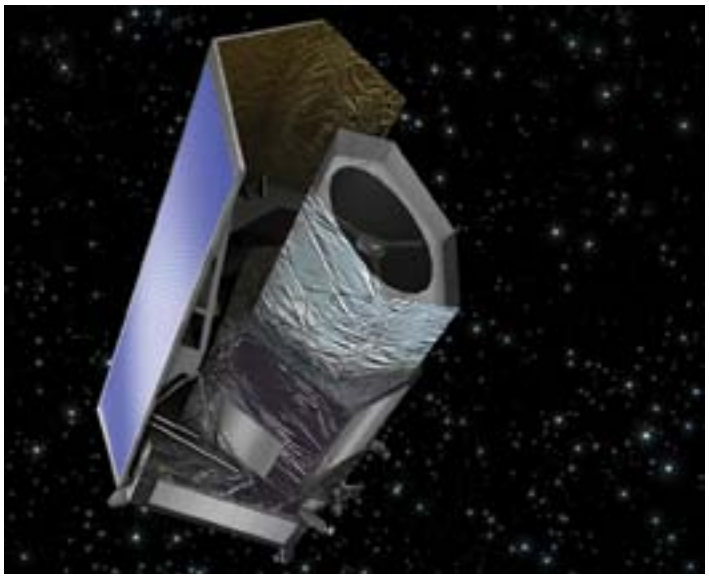
Several UK research teams are involved in collecting and analysing results from Envisat, with more than 1,200 scientific projects from all over Europe. UK companies and institutions have also played leading roles in the manufacture of the satellite, supplying the platform and developing two key instruments: the Advanced Along-Track Scanning Radiometer and the Advanced Synthetic Aperture Radar.

"Envisat was unique with all its instruments on one platform," said Maria Adams, Head of Earth Observation Missions and Technology at the UK Space Agency. "Over the last ten years, it has provided a wealth of essential and continuous long-term quality data which have contributed to the better understanding of Earth's complex processes, such as climate change."



One of the last images obtained by Envisat reveals a crack across Pine Island Glacier in West Antarctica **Credit:** ESA

Missing matter mission



Artist's impression of Euclid **Credit:** ESA

Scientists working on a new mission to investigate the fundamental mysteries of the Universe have been granted £8.5 million by the UK Space Agency. The Euclid mission will study dark energy and dark matter and UK science teams are at the forefront of this ESA project.

Normal matter – the stuff we're made of – only makes up around 5% of our Universe. Most of the Universe is therefore considered to be 'missing' until scientists can find out what makes up the remaining 95%. According to theoretical physicists, dark energy – which would explain why the Universe is expanding at an accelerating rate – could account for the missing 70%. Invisible dark matter would account for the remaining 25%.

Euclid will use a telescope to study dark matter and dark energy with great precision, tracing its distribution throughout the Universe. The UK Space Agency grant will support the development of the mission's two key instruments and University College London's Mullard Space Science Laboratory and the Open University will lead the research groups.

"This is a huge mission," said David Parker, Director of Technology, Science and Exploration at the UK Space Agency. "At the heart of the mission is one of the billion pound questions of physics and the UK Space Agency is proud to be funding the teams that are working to unlock some of the great mysteries of the Universe."

Euclid received final approval in June and the Space Agency is also providing funding to the consortium of UK institutions coordinating the vast amount of data that the mission is expected to generate.

Postcards from Saturn

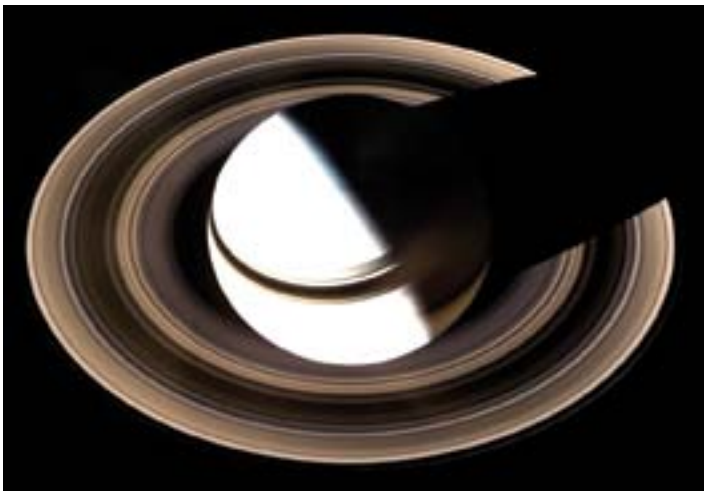
The international Cassini-Huygens mission arrived in orbit around Saturn in July 2004. Since then it has made an extensive study of the ringed planet and its moons.

In January 2005, the Huygens probe landed on Titan – the first part to touch the surface of this alien world was made in the UK.

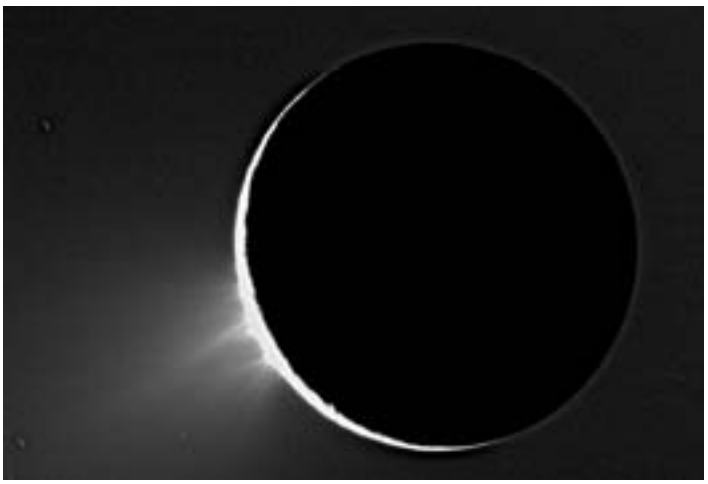
During its eight years in orbit, Cassini-Huygens has made remarkable discoveries and captured some incredible images.

Here are just a few of them:

(All credits: ESA, NASA)

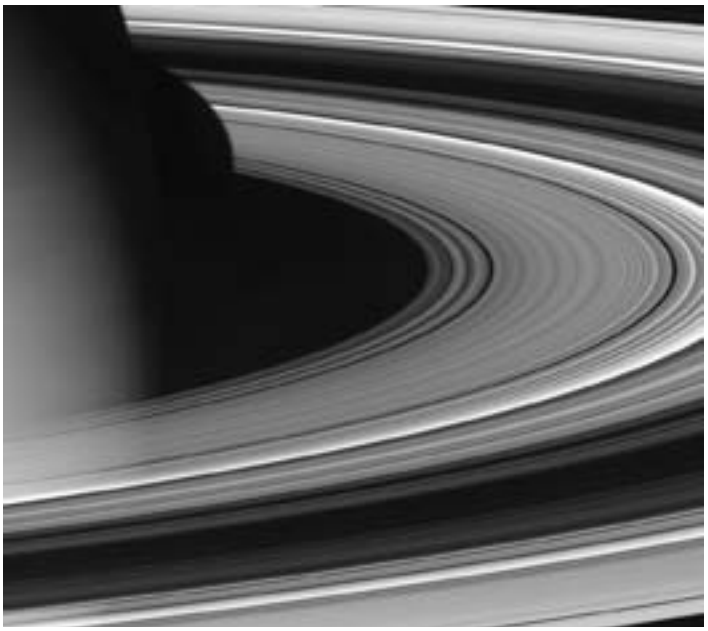


Saturn's rings in all their splendour

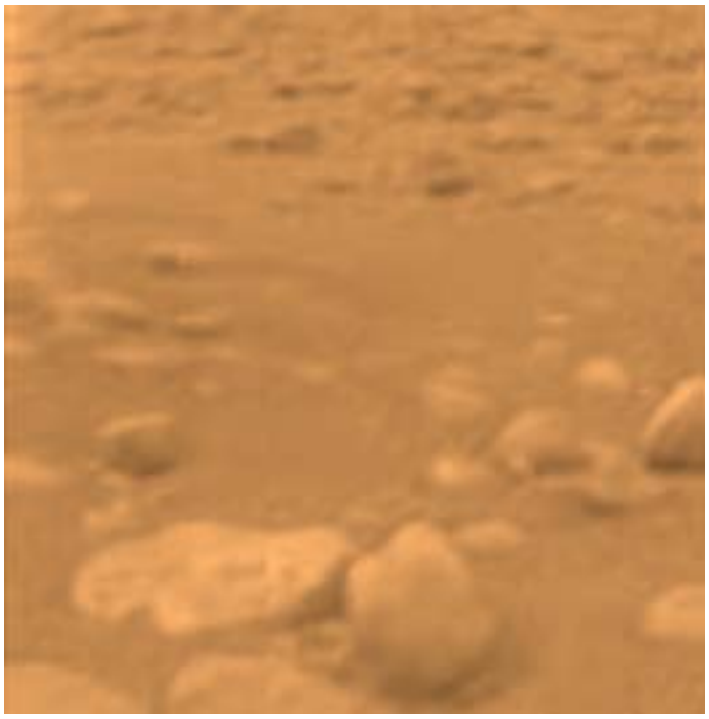


Saturn's icy moon Enceladus expels around 250kg of water every second through a collection of jets at its south polar region

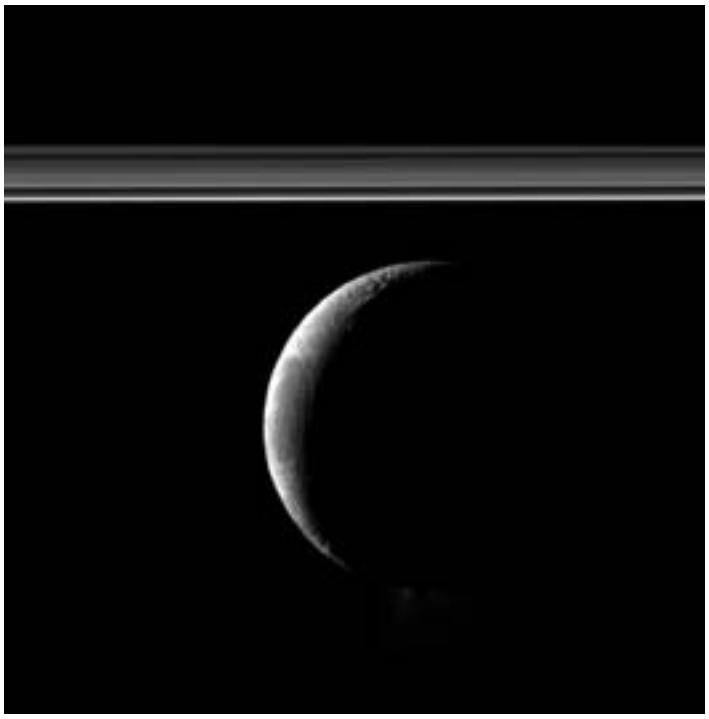
The moon Mimas seen against the blue backdrop of Saturn's northern latitudes. These 'true' colours are exactly how Cassini saw them



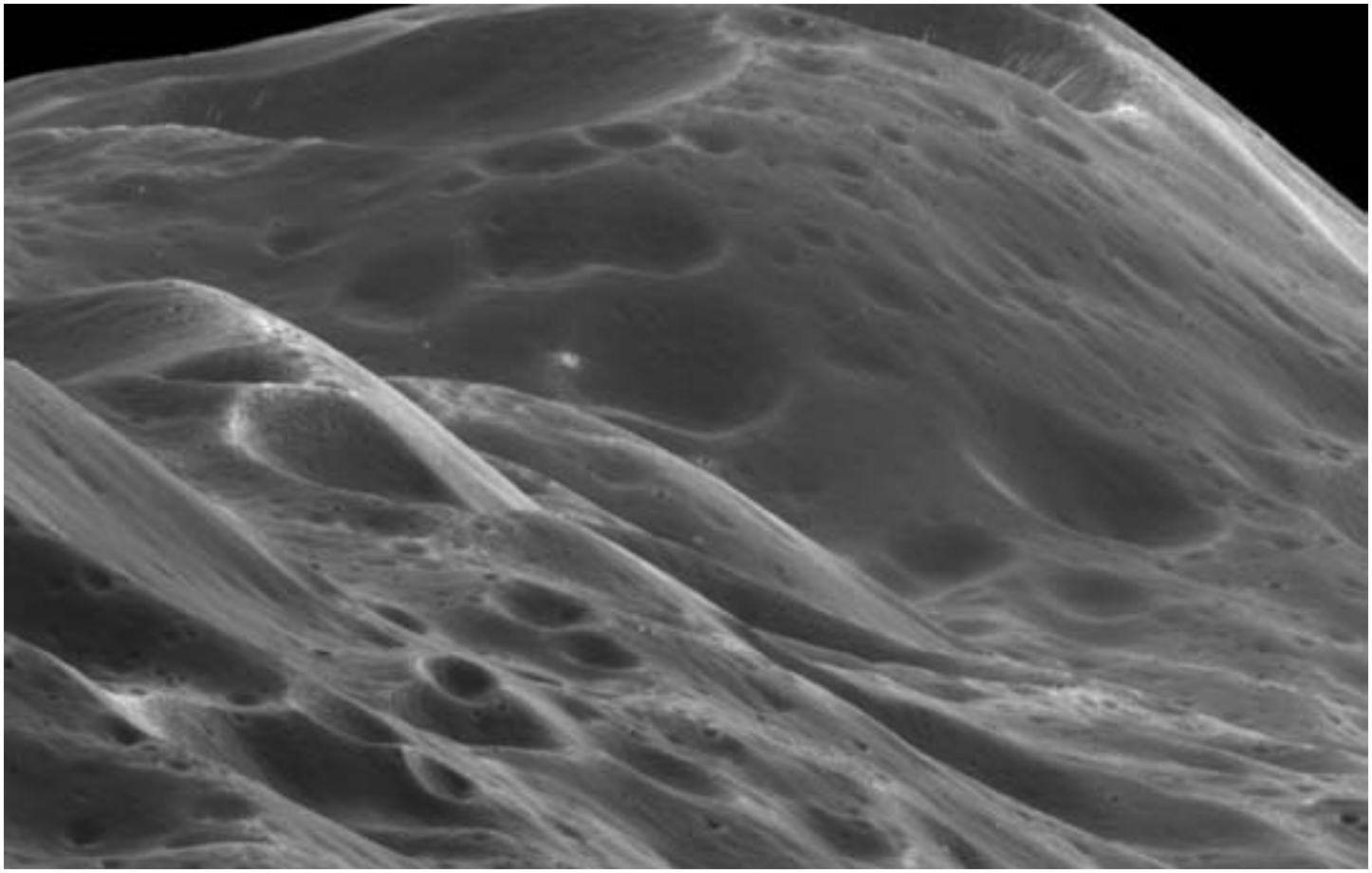
Looking down on Saturn's rings



The first colour view of Titan's surface sent back by the Huygens probe. The moon is smothered in a thick atmosphere and there is evidence of methane rain, erosion, stream-like drainage channels and dry lakebeds



In this image Enceladus can be seen beneath Saturn's rings. If you look very closely you might even see the plumes of water



Mountainous terrain reaches about 10km in height along the equatorial ridge of Saturn's moon Iapetus

50 years in space

Image above: View from the International Space Station of the UK and Ireland at night
Credit: ESA

From Ariel-1 to Solar Orbiter: what do two space science missions fifty years apart have in common? As Richard Hollingham discovers, the UK space industry owes a lot to its pioneers:

"It's hot for goodness sake!" exclaims Astrium UK's head of space science, Ralph Cordey, as he outlines the challenges facing Europe's latest mission to the Sun. "It's going to a place where it'll be as if there are 13 suns in the sky."

Due for launch in 2017, Solar Orbiter will fly closer to the Sun than Mercury. In fact the spacecraft will fly closer to our nearest star than any previous mission, to monitor its surface and study the particles it spews out into the Solar System.

"This is a unique mission," says Cordey, and a mission that requires a unique design. "We're going to use a specially designed heat shield, so it will be 500 degrees on the front surface and the equivalent of room temperature on the back." This will protect the instruments and electronics. Solar Orbiter will also need to be built with special solar cells, designed to cope with the intense sunlight.

The €300 million deal to build this complex spacecraft was awarded to Astrium UK in April. It's the biggest ever contract signed between the ESA science programme and a UK company, and came exactly half a century after the launch of the UK's first satellite, Ariel-1. Solar Orbiter will incorporate technology developed for ESA's Mercury mission, BepiColombo, which is currently taking shape in the company's Stevenage factory. But it will also build on the long legacy of UK successes in space science and engineering that started fifty years ago.

Solar science

Named after the 'sprite' in Shakespeare's 'Tempest' – a legendary or magical creature that could appear at will – Ariel-1 was not only the world's first international satellite but the world's first solar mission. Built by NASA, the satellite flew six UK experiments designed to investigate the interaction between the Sun and the Earth. Instruments on board made measurements of solar radiation and studied the ionosphere – the band of charged particles surrounding the Earth in the upper atmosphere.

Four of the experiments were built by University College London (UCL) and led by Harrie Massey, a key figure in the development of the UK's space science expertise. As a result of the mission, UCL established the Mullard Space Science Laboratory. Today scientists from the lab are working on Solar Orbiter.

The Chief Executive of the UK Space Agency, David Williams, says we owe a debt of gratitude to the UK's first space scientists. "The UK entered the space age with a space science project and we have remained at the forefront of space research and exploration," he tells *space:uk*. "From this small satellite on the edge of our atmosphere, we've had space missions that have gone further from the Earth and seen further into the universe than many believed possible."

These missions have included Giotto, the spectacular mission to rendezvous with a comet, Hubble, the space telescope that's transformed

Image below: A star is born – Hubble image of star formation in the Cygnus (swan) constellation
Credit: ESA, NASA

"It's going to a place where it'll be as if there are 13 suns in the sky"
Ralph Cordey, Astrium UK

continues >

50 years in space
continued

Image top right: An image of a solar flare captured by ESA's Soho spacecraft
Credit: ESA

Image bottom right: Martin Sweeting (right) and his team with UoSAT-1
Credit: SSTL

Giotto

In 1985, the UK-built Giotto spacecraft was launched as Europe's first deep space mission. Giotto was designed to help solve the mysteries of comets by passing as close as possible to the nucleus of Halley's Comet. It did this on 13 March 1986, sending back unprecedented images and data. By studying its composition, Giotto confirmed Halley as a primitive remnant of the Solar System and billions of years old. It also detected complex molecules locked in Halley's ice that could have provided the chemical building blocks of life on Earth. Remarkably, Giotto survived the encounter with Halley, allowing it to rendezvous with a second comet, Grigg-Skjellerup, in 1992.

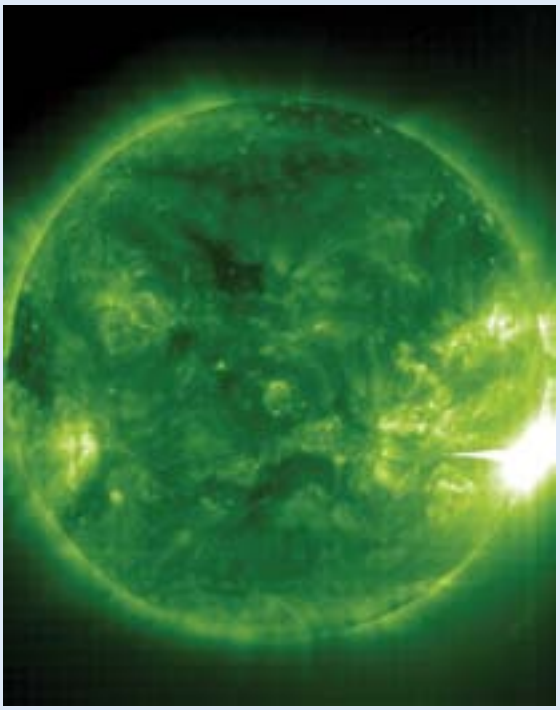
The nucleus of Halley's Comet as seen by Giotto **Credit**: ESA

our understanding of the universe and Cassini-Huygens, the remarkable international mission to Saturn. But as well as space science expertise, Ariel-1 kick-started an entire industry: making and using satellites.

"Capability has expanded from space science," says Williams, "to providing Earth observation data – especially for weather forecasting – as well as communications, broadcasting and broadband services that are revolutionising the way we lead our lives."

Small satellites

The first satellite to be built entirely in the UK was Ariel-3. Designed by 'space department' at the Royal Aircraft Establishment and manufactured by the British Aircraft Corporation, Ariel-3 was launched from the United States in 1967. This scientific mission built on the work of its predecessors, with experiments to investigate the ionosphere. By the mid 1970s, the UK's commercial satellite industry was firmly established – building bigger and more powerful satellites. But they were also getting more complex and expensive.



In 1979, a group of engineers at the University of Surrey, led by Martin Sweeting, decided they could do space a lot cheaper. But they still turned to the teams that had built the Ariel satellites for guidance. "The people and experience in the Royal Aircraft Establishment and at British Aerospace in Stevenage [now Astrium UK] were the people I went to for advice and to use their test facilities," Sweeting recalls. "They also donated some components that we were able to use to get underway."

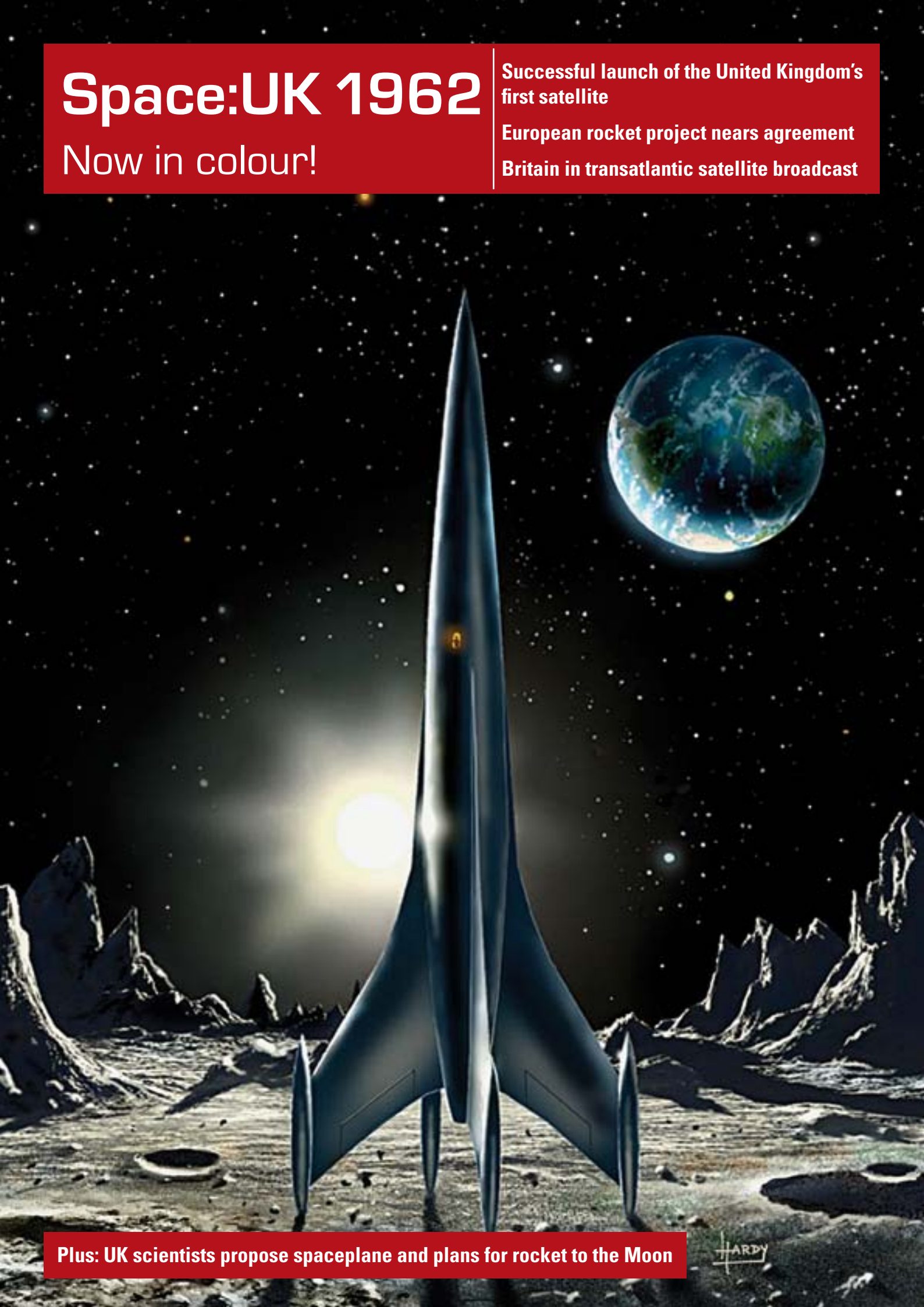
Space:UK 1962

Now in colour!

Successful launch of the United Kingdom's first satellite

European rocket project nears agreement

Britain in transatlantic satellite broadcast



Plus: UK scientists propose spaceplane and plans for rocket to the Moon

Cover image: Artist's impression of a future Moon rocket **Credit:** David A Hardy

FROM THE EDITOR:

It was only five years ago that the first man-made satellite, Sputnik, was launched into orbit. Now, the UK has become the third country able to call itself a space-faring nation. This is truly an exciting time and allows us to speculate as to what the future may hold.

Ariel has proved that Britain has the expertise to build world-class scientific instruments. It is likely that this collaboration with America will continue and we understand that engineers at the Royal Aircraft Establishment are developing an all-British satellite. Whilst many people were saddened by the cancellation of the Blue Streak missile programme, we also welcome the news that it will form the basis of a European launcher. How long before a British-built rocket puts a British satellite into space? Maybe even a British astronaut!

The first pictures from the Telstar satellite suggest that this technology has great potential for beaming historic events around the world. Perhaps in the years to come, football fans in other countries will be able to watch our great British teams; or maybe TV series, such as Coronation Street, will be transmitted live to American audiences! In the far future, we could all have our own satellite dishes to receive pictures from around the world.

1962 is certainly an exciting time for the UK in space!

The Bell X-1, the first plane to break the sound barrier. Could aeroplanes be the future of spaceflight? **Credit:** NASA

SPACE PLANE PROPOSED BY UK ENGINEERS

Engineers at UK company Bristol Siddeley Engines are proposing the development of an 'air-breathing' launcher. The system would allow for larger satellites to be carried at considerably lower cost than conventional rockets. Early designs seen by *space:uk* show a delta-winged aircraft with rockets mounted on the back. In a submission to the British Interplanetary Society's journal 'Spaceflight', the designers said that it represented a 'revolutionary advance in space technology.'

TELEVISION FROM SPACE!

For the first time in history, television pictures have been 'beamed' by satellite across the Atlantic Ocean. The broadcast from the United States in July was relayed by the Telstar satellite and received at the Post Office's Goonhilly Earth station in Cornwall. The first pictures were transmitted live on BBC television.

During a broadcast, the BBC showed the engineers busy behind their consoles at Goonhilly as the first pictures came in. BBC commentator, Raymond Baxter, said the images and sound were "as clear as a bell." The historic broadcast included a tuning signal and a speech from an official of the American Telephone and Telegraph company.

Telstar was built by a team at Bell Telephone Laboratories in the United States. The satellite circles the Earth approximately every two and a half hours, allowing for twenty minutes of transatlantic communication during each orbit.

The historic launch of Ariel **Credit:** NASA

SUCCESSFUL LAUNCH OF ARIEL

British scientists and engineers have been celebrating after the first international satellite, Ariel, was successfully lofted into orbit on 26 April aboard a Delta rocket from Cape Canaveral in Florida. The launch of Ariel represents a major milestone, making the United Kingdom only the world's third space-faring nation.

The satellite carries six scientific experiments, which have been designed and built by British space scientists. They include instruments to measure solar radiation and solar flares, investigate cosmic rays and study the density and temperature of charged particles in the upper atmosphere. Four of the experiments were conceived by University College London, led by the British space pioneer Professor Harrie Massey.

Ariel was constructed in the United States and is the first satellite to be launched under an American programme that offers launches for scientific undertakings by allied nations. The mission illustrates the potential of international cooperation in space. Officials at Cape Canaveral report that the satellite is operating well and is expected to send back data to Earth for several years.

Image opposite: David A Hardy's impression of what a future launch site at Woomera might look like **Credit:** David A Hardy

PLANS FOR EUROPEAN ROCKET PROGRAMME

Final agreement is being sought for the creation of a European Launcher Development Organisation. A recent meeting, jointly organised by the governments of the United Kingdom and France, proposed an initial programme of work for the development of a three-stage rocket. The system will use Britain's Blue Streak missile for the first propulsion stage, a French rocket for the second stage and the third stage will be developed by West Germany. The first firing of the new European launch system is planned for 1965 at the Australian rocket testing range at Woomera. In a statement to the press, the Minister of Aviation, Mr Peter Thorneycroft stated that: "This is probably the biggest technological effort any group of nations has attempted in history. The Blue Streak missiles were manufactured by De Havilland in Hatfield and Stevenage as part of the UK's nuclear deterrence programme but the project was cancelled in 1960.

A Blue Streak missile being tested at the Spadeadam Rocket Establishment near Carlisle Credit: War Office

International news

SECOND US ASTRONAUT IN ORBIT

America's second astronaut to orbit the planet, Scott Carpenter, has returned to Earth after an eventful mission. His flight in Aurora 7 lasted for 4 hours 54 minutes during which time he navigated the spacecraft through three revolutions of the Earth, reaching a maximum altitude of 164 miles. During the mission Carpenter carried out a series of experiments, which included seeing how liquids behaved in weightlessness. He also carried out tests on the Mercury capsule's performance in preparation for longer duration missions.

The launch of Aurora 7 with astronaut Scott Carpenter on board. Any Moon rocket will have to be much larger than this to escape Earth's gravitational field **Credit:** NASA

Scott Carpenter in his space suit **Credit:** NASA

ROCKET TO THE MOON

The National Aeronautics and Space Administration (NASA) has approved the development of a massive rocket to enable America to land men on the Moon. The design calls for the development of a three stage booster to place an 'Apollo' spacecraft in orbit. This would join with a second spacecraft and be 're-launched' from orbit.

DOUBLE SOVIET SUCCESS

Two cosmonauts came just miles from each other in orbit during the flights of the Soviet Union's latest missions. The spacecraft Vostok 3 and Vostok 4 were launched a day apart, making them the first simultaneous spaceflights. According to a communiqué from the Soviet news agency, TASS, at one point in the joint mission the two craft were just three miles apart and the cosmonauts were able to talk to each other over a radio link.

Fast forward

Sadly, there was no real space:uk in 1962 but everything we have written is based in fact.

The optimistic tone of these pages reflects the excitement of space exploration at the time. By 1962 the 'space race' between the United States and Soviet Union was well underway. The year also saw the world come terrifyingly close to nuclear conflict with the Cuban Missile Crisis.

So how did our stories turn out?

Only a few months after its launch, Ariel 1 was severely damaged by a high altitude US nuclear test. Nevertheless, the satellite helped establish the highly successful UK space sector and laid the foundations for international cooperation in space.

The Telstar satellite captured the public's imagination – there was even a hit record made about it (Telstar by the Tornados). The satellite was also damaged by the US nuclear test but nevertheless established the potential of satellite broadcasting. Technology, that today, we take for granted.

The European Launcher Development Organisation was indeed established. Although it illustrated the potential of European space projects, the programme itself suffered a series of setbacks. The Blue Streak section of the launcher proved powerful and reliable but the other two stages failed to perform and the programme was abandoned without a single successful launch. However, the expertise and experience did feed into the development of Europe's highly successful Ariane launcher.

The idea of spaceplanes was a running theme in 1950s and 60s science fiction. The US military continued to develop high altitude aircraft and in the 1970s NASA built the Shuttle. Today, the British Skylon is under development - which could finally make air-breathing spaceplanes a reality.

***We are extremely grateful to artist David A Hardy for allowing us to use some of his stunning images. His website is:* www.astroart.org**

© Crown Copyright. URN 12/69B1

Ariel-3

The curious-looking Ariel-3 was designed to investigate the space environment. It carried five experiments, including instruments to study the ionosphere – the electrically charged area of the Earth's upper atmosphere – and measure the oxygen found at high altitude. The project involved scientists from the universities of Sheffield and Birmingham as well as Jodrell Bank and the Met Office.

An American Scout rocket launched Ariel-3 on 5 May 1967 and two days later it sent back its first useful data. The satellite performed well for the first five months of operation until the tape recorder began to malfunction. The instruments continued to gather data for a further two years until Ariel-3 was switched off in September 1969. It broke up in the atmosphere in December 1970.

Artist's impression of the Ariel 3 satellite in orbit **Credit:** David A Hardy

"for the first satellites, we went down to B&Q at the weekend to buy the bits to make our cleanroom"

Martin Sweeting, University of Surrey

"There was no money," he says. "If you wanted to do something then you had to use your imagination…for the first satellites, we went down to B&Q at the weekend to buy the bits to make our cleanroom!"

But their persistence paid off and, in 1981, the University of Surrey launched its first satellite, UoSAT-1. Four years later the University spun-out a company, Surrey Satellite Technology Limited (SSTL). Now the world's leading small satellite company, it employs some 500 people with Martin Sweeting as its Executive Chairman. SSTL has built and launched 36 satellites, including the Disaster Monitoring Constellation – a pioneering international satellite project. The company is currently building the payloads for Europe's new satellite navigation system, Galileo.

Sweeting now divides his time between the University and the company he helped to create. "We kept the university link very closely," he explains, "because we realized that we need people thinking up crazy new ideas like we did in the 70s and 80s."

And perhaps it's those 'crazy' ideas, more than anything, that go to the heart of the UK's success in space. British space scientists and engineers may not have had the biggest budgets, but they've never been short of ambition.

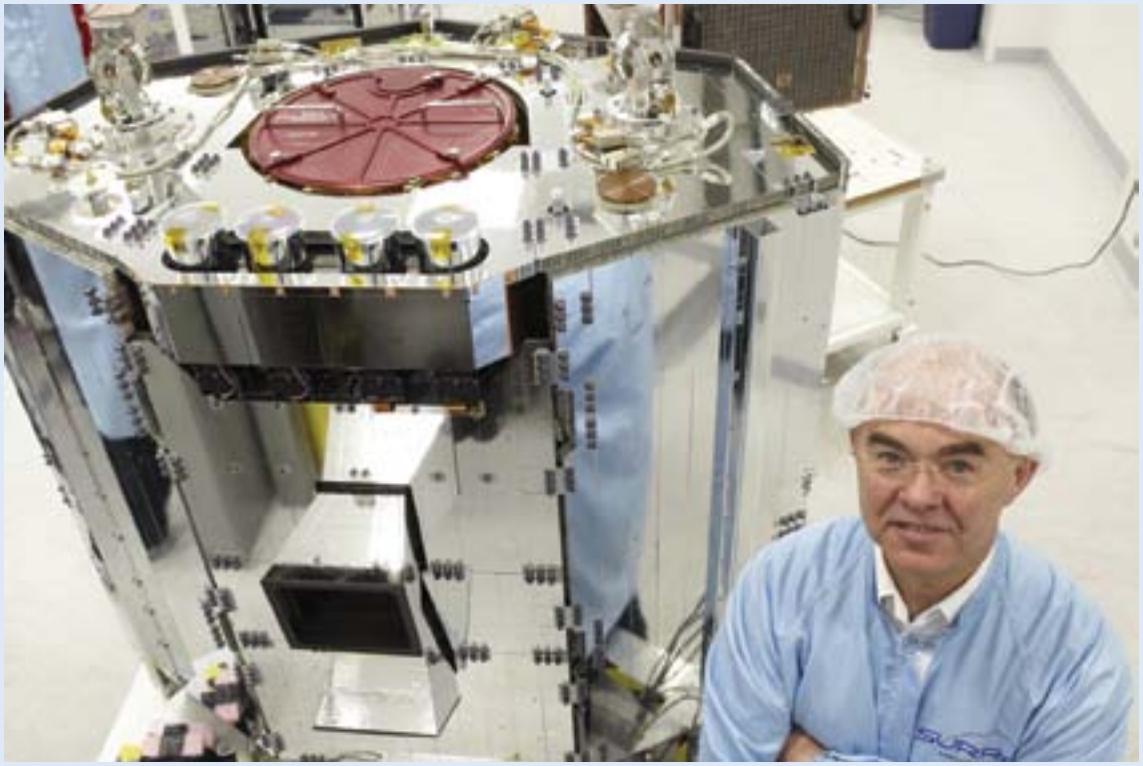
Can-do attitude

"The UK has more of a can-do attitude than many of our counterparts in space," says Sweeting's colleague, Chris Bridges from Surrey Space Centre (SSC) at the University of Surrey. "Looking at those missions – the whole of British innovation – has an edge that other designs and systems don't necessarily have. When you look at a British system, there's always something that's unique and quite clever about it. Hopefully, we're still replicating that today."

A case in point is perhaps the two STRaND (Surrey Training, Research and Nanosatellite Demonstrator) satellites, currently under development by both SSC and SSTL. The first, now nearing completion, is powered by a smartphone, the second will employ

continues >

50 years in space
continued

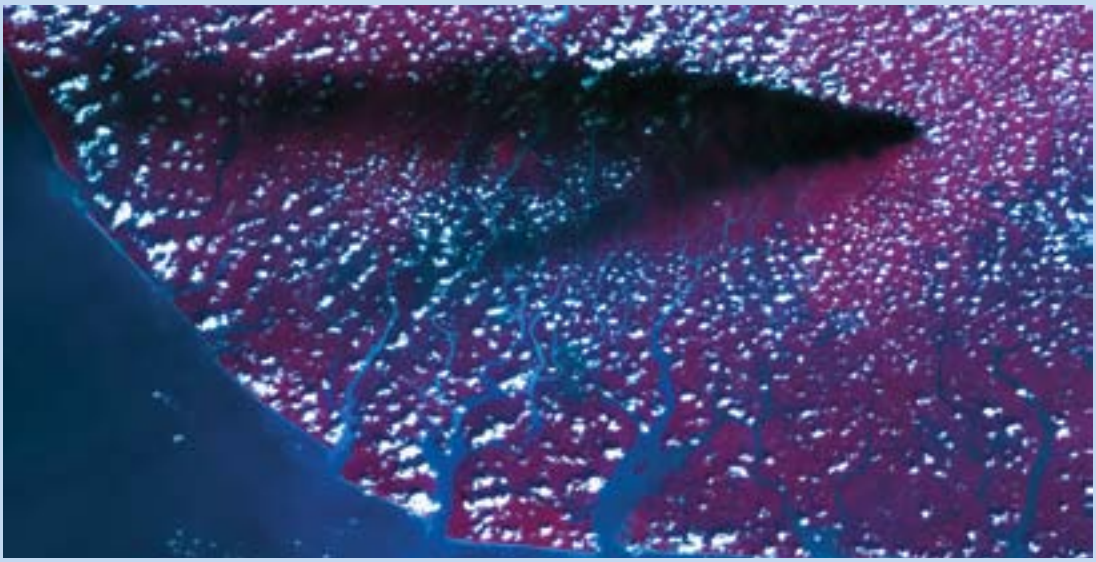


Top image: Martin Sweeting with NigeriaSat-2
Credit: SSTL

Disaster Monitoring Constellation

The Disaster Monitoring Constellation (DMC) is a network of satellites designed to provide detailed images of any part of the world in times of need. The data is used to produce maps and information to assist relief efforts and ultimately to save lives. The satellites have been placed in a constellation that allows daily imaging of any given point on the globe. Images from the DMC have been used following floods in the UK, Hurricane Katrina in the United States and earthquakes in Iran, Kashmir and South America.

Built by SSTL, the current constellation is owned by the UK (UK DMC-2), China (Beijing-1), Spain (Deimos-1) and Nigeria (NigeriaSat-2 and NigerSat-X). For most of the time the satellites are deployed by their owner nations to monitor such things as land use, water supply or agriculture. However, the DMC operates within the International Charter: Space and Major Disasters and when disaster strikes, the charter can be activated by the UN or national agencies to pull together information from a whole range of satellites.



A pall of smoke spreads across the Niger delta in this image captured by the DMC **Credit:** DMCii

"We owe a debt of gratitude to the UK's first space scientists"
David Williams, Chief Executive, UK Space Agency

identical twin 30 cm long satellites and utilise components from the XBOX Kinect games controller to allow the satellites to join-up in space. Like space building blocks.

"It may seem far-fetched, but our low cost nanosatellites could dock to build large and sophisticated modular structures such as space telescopes. Unlike today's big space missions, these could be reconfigured as mission objectives change, and upgraded in-orbit with the latest available technologies."

For Sweeting, it's ideas like this that give the UK an edge on competitors. "Industry has to focus its attention on operational missions – customers come along, they want to buy a satellite to do a job of work reliably. So, having university groups that are unconstrained, and when they are good ideas, we can inject them into the industry product line and that gives us innovation in the UK."

So how about the future? The UK has a space industry worth some £7.5 billion. It is currently involved in current and future space science missions to Mercury, Venus, Mars, Saturn, Jupiter and the Rosetta mission to land on a comet. UK scientists are leading experiments on space observatories studying the Sun, the galaxy and answering fundamental questions about the universe. Satellites made in the UK provide global communications and navigation services and Earth observation missions, like Cryosat, are led from the UK. That, and the fact that satellite

Image top right: Solar Orbiter will employ technology developed for ESA's Mercury mission, BepiColombo
Credit: ESA

Image below: The launch of Giove-A. Built by SSTL, this was the first test satellite for Europe's new satellite navigation system, Galileo. The company is now building the payloads for the final system
Credit: ESA

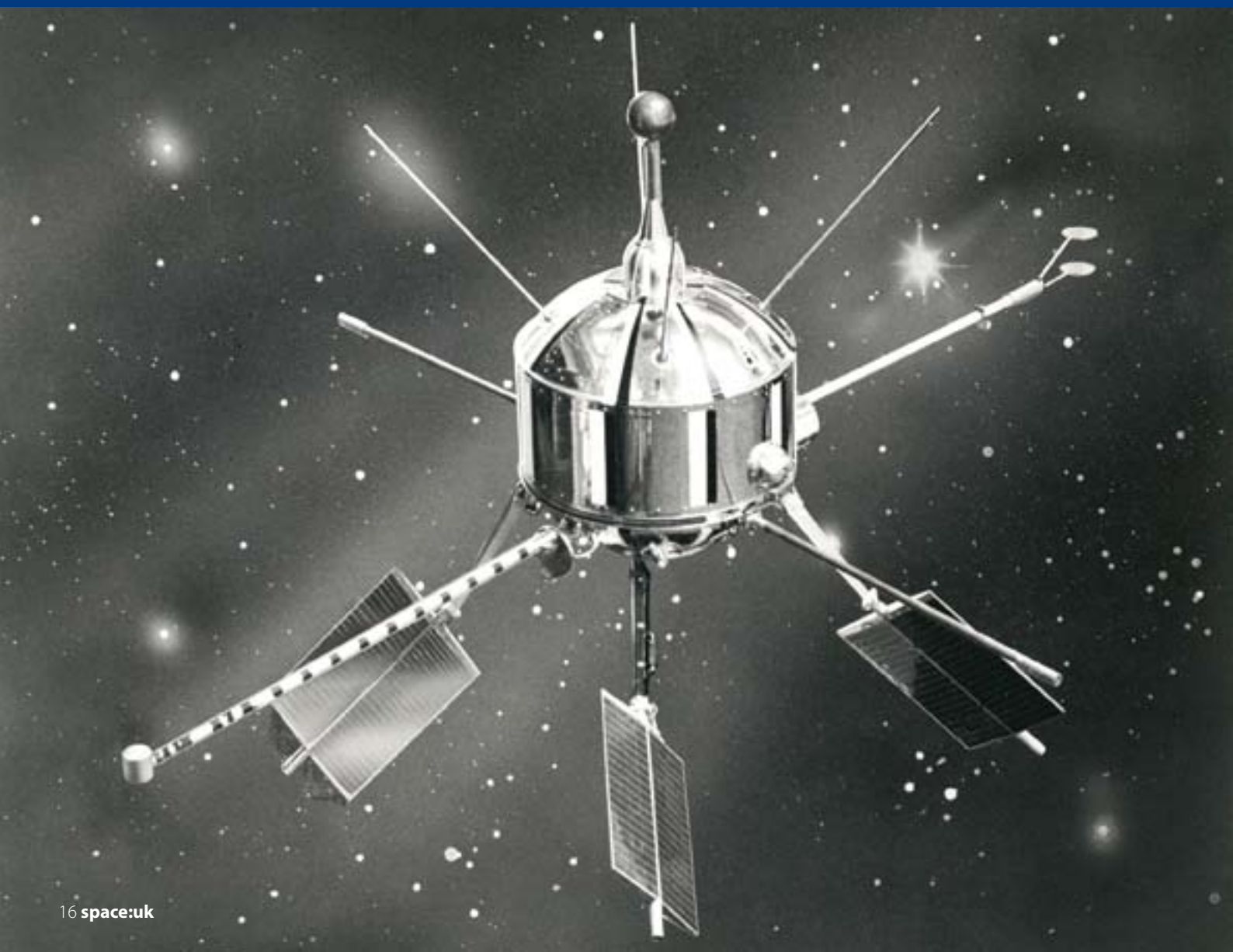
manufacture in the UK encompasses everything from Solar Orbiter to STRaND, gives David Williams from the UK Space Agency grounds for optimism.

"I think we have a remarkable road ahead," he says. "We've set out a number of major goals for the UK space sector, including taking 10% of the global space market by 2030. UK businesses and institutions are currently involved in some of the most advanced and innovative space projects being developed anywhere in the world."

And all of that, says Williams, can be traced back to a small satellite, launched fifty years ago. "I expect that, in fifty years time, we will have many more great stories to tell!"

Ariel-1: the secret history

Recently declassified papers have revealed detailed discussions between Britain and the United States over the accidental destruction of Ariel-1 – the UK's first scientific satellite. Sue Nelson reports on this fascinating insight into the beginnings of the UK's space industry:



Artist's impression of the Ariel-1 satellite
Credit: NASA


OFFICE OF THE MINISTER FOR SCIENCE

SECRET

Anglo-American Satellite

The yellowing Office of the Minister for Science paper is stamped SECRET in red capital letters. It is the cover page of file number 92/6/04, entitled Anglo-American Satellite, and contains the communication, confusion and eventual clarification of what happened to the world's first international satellite.

The file contains numerous confidential minutes, telegrams and correspondence between the British and American governments from 13 July to 7 December 1962 about the loss of Ariel-1. Everything is there: from Prime Minister Harold Macmillan's typewritten letters and handwritten corrections to the wonderfully funny and florid prose of the then Science Minister, Lord Hailsham.

For lovers of history and space, it is a genuine delight. After all, it's not every day that a global super power unintentionally destroys a satellite from its own national space agency and one of its allies.

Launched from Cape Canaveral on 26 April 1962, Ariel-1 made history. It was a welcome success after the United States was beaten by the Soviet Union with the world's first artificial satellite, Sputnik, five years earlier.

"The shock [of Sputnik], particularly in America, was intense," says Doug Millard, curator for space at London's Science Museum. "The Eisenhower administration made clear that they wanted to help their allies launch space experiments on their satellites and Ariel-1 was the first example of an international collaboration, in this case between the US and the UK. So this was all part of the Cold War and the space race."

NASA provided the rocket and the satellite structure for Ariel-1. The UK supplied six scientific instruments that were designed to examine the relationship between the ionosphere, solar and cosmic rays. Leicester University's newly formed space research group, together with University College London, built one of them: a solar X-ray monitor.

"Everything went well from launch for several weeks and we were getting very interesting data," says Leicester University's emeritus professor of space science, Ken Pounds, who was in his twenties at the time. "We showed how the X-ray flux from the Sun changed dramatically when there was a solar flare. That was cutting edge science at the time and was a kick off to solar weather, which is now a mini industry."

But then everything changed. "Suddenly without any warning our X-ray count rate went off the scale. Everything went wild," recalls Pounds. "We knew there was something strange going on but our initial suspicion was that our detector was suffering from electrical breakdown."

The cause of the problems was on a scale no one could have imagined – it was as a result of a massive nuclear explosion.

Radiation cloud

On 9 July, as Ariel-1 was orbiting above New Zealand, the US Air Force detonated a high altitude nuclear test on the other side of the planet. The test, part of project Starfish, briefly created a new radiation belt around the Earth and for a short period of time no one – not even NASA – knew it had taken place.

"It seems incredible now that they carried out atmospheric nuclear tests," says the UK Space Agency's David Parker, "but the huge cloud of radiation and particles created was spread all around the Earth and affected quite a few spacecraft, including Ariel-1. Basically it degraded Ariel-1's ability to generate its electric power from its solar generators, so it began to behave badly and eventually died."

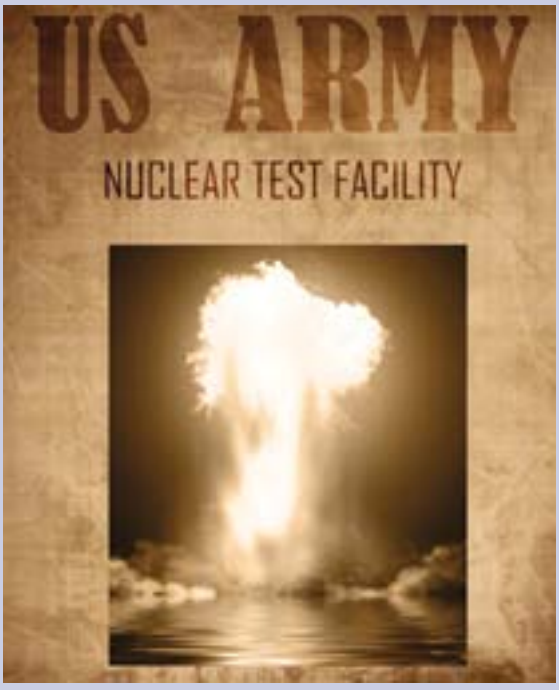


Image top left: The cover of the previously secret Ariel documents
Credit: HM Government

Image bottom right: Atmospheric nuclear tests were carried out until 1963
Credit: Fotolio

Image below: Memo from Prime Minister Harold Macmillan
Credit: HM Government

continues >

Ariel-1: the secret history
continued

Image top right: Ken Pounds, who worked on instruments for Ariel-1
Credit: University of Leicester

"The other instruments were also experiencing unusual readings," says Pounds. "We discovered after just a few days that there something strange going on because there were these mysterious communications from the other side of the Atlantic. There was a call that came through to the UK site from NASA asking rather enigmatically 'have you seen anything strange lately?' "

"It wasn't an immediate discovery that the Starfish tests had caused the problems with Ariel-1," says Parker. "The official papers start off suggesting otherwise. So it was only over a period of time, as problems got worse with the satellite, that the Americans realised that this is what had happened and that there was an explanation for this and problems with several other spacecraft."

The UK Space Agency and the Science Museum organised the recent 50 Years of the UK in Space conference in April. "What I didn't know until that meeting," says Pounds, "was that NASA wasn't aware either that this bomb was going to be let off. In fact they launched the Telstar communication satellite the day after Starfish had occurred, into a dreadful environment and they did that quite innocently not realising what the US Air Force had been up to. So it was kept secret not just from us but from rest of America and NASA in particular."

"Even though Ariel-1 was short lived, I think it has a significant place in the history of space science"
Ken Pounds

Wounded satellite

The newly released documents reveal a great deal of to-ing and fro-ing over the cost of losing Ariel-1. As NASA had spent $2 million compared with the UK's £200,000, America carried the brunt of the financial burden.

The documents also reveal the delicate negotiations required about the lack of internal communications in America about a nuclear test, at a time when there was widespread fear about the four minute warning of an imminent nuclear attack.

"You will have seen from the telegram we have just sent you about Ariel, that the Americans did not consult us before announcing that their high altitude nuclear experiment last month put Ariel out of action," reads one of the confidential missives sent from the Foreign Office on 21 August to the British Embassy. "It is not merely the case that they did not consult us about the announcement; they had not even told us that they had come to this conclusion themselves…"

"It is clear," the communiqué continues, "that they have now come to the conclusion that their own experiments were responsible for the damage to Ariel, and we think it is really rather remiss of them not to have told us of their conclusions before announcing them to the world… Would you please have a word with the Americans about this, more in sorrow than in anger, and seek some explanation of this surprising lapse on their part."

The matter soon came to the public's attention but even that was not straightforward, as the US Air Force put out a press release explaining what had happened without permission from NASA or the British Government. This put a number of noses out of joint on both sides of the Atlantic.

But it is the personalities that really come to life during the correspondence. Both Parker and Millard particularly enjoyed the tone and style of Science Minister Lord Hailsham. "The language used was wonderfully Shakespearean," says Millard, who has set up a temporary exhibition dedicated to Ariel-1 at the Science Museum.

"Thank you for your minute of 3rd September on Ariel unfortunately damaged by Caliban as he girdled the earth," writes Lord Hailsham to Prime Minister Macmillan on 10 September 1962. "We have got a great deal out of him during his life (short, but neither nasty nor brutish), in the shape of a large number of data, not yet fully analysed but said to be important."

Top image: Ariel-1 was launched in the same year as NASA's first manned orbital flight. John Glenn is seen here getting into the capsule that will take him around the Earth
Credit: NASA

Image below: Aurora seen from the International Space Station. Like Ariel-1, Solar Orbiter will be used to study the interaction between the Sun and the Earth
Credit: ESA

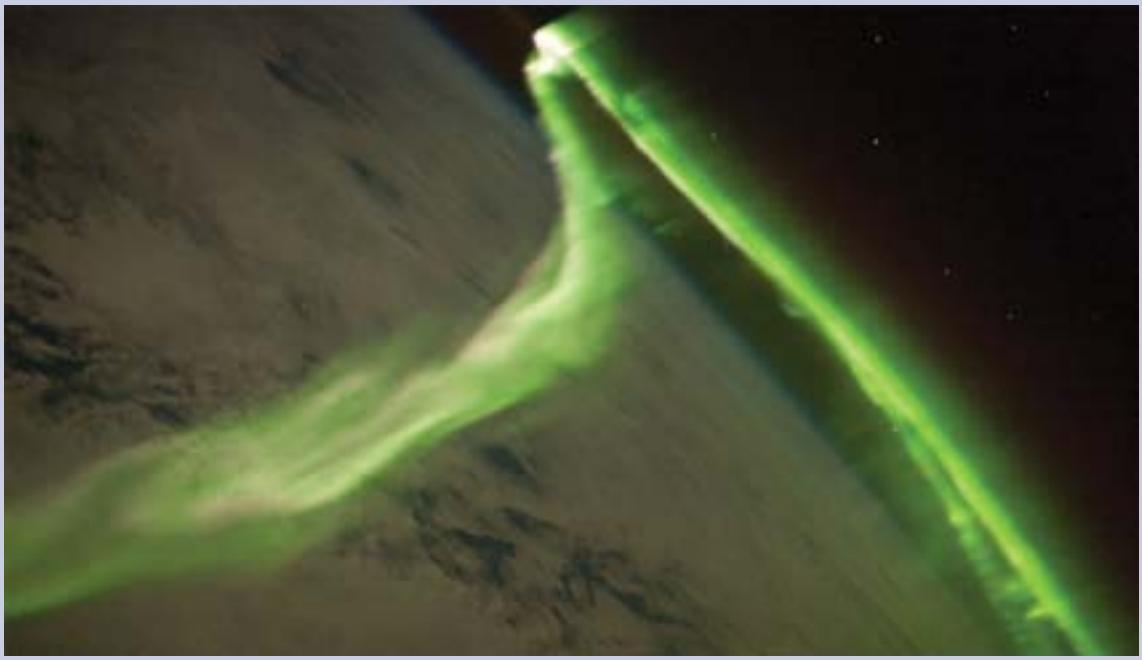
"Although badly wounded in his solar paddles (the organ which recharges his ability to speak) he is not quite dead. He still utters intermittently – sometimes intelligibly – and is listened to by our monitors with respect."

"Even though Ariel-1 was short lived, I think it has a significant place in the history of space science," says Pounds. "First of all it was the first international satellite and the fact that a competitive cutting edge science payload was put together in less than two years on an international project was a remarkable achievement. You couldn't imagine it happening nowadays."

"Scientifically, the impact was obviously limited by the fact that we only had a few weeks of good data. Nevertheless I think it did trigger some important areas of science for the UK. It was the first solar space mission that the UK was involved in. It was important for kicking off a number of areas of space science and it gave a great boost for space science for universities in the UK."

Parker agrees and is also full of praise for Lord Hailsham and his colleagues battling for UK space science under difficult conditions. "It's a good testament to those people, the foresight and that we carried on and built Ariel-2 and Ariel-3," says Parker. "Our entire space programme now builds on foundations that were established back then."

You can hear more about the previously secret documents in the May edition of the space boffins podcast: audioboo.fm/spaceboffins



education & careers

Ask the experts

Questions this time come from Year 8 students at Marlborough Science Academy in St. Albans:

Sophie Allan
National Space Centre, Leicester

How far could Tiger Woods hit a golf ball on the Moon?

The Apollo 14 mission saw humanity's first lunar golfing activities. Commander Alan Shepard, teeing off one handed due to the lack of flexibility in his suit, used a six-iron head attached to a lunar sample scoop handle. This enabled him to hit the ball "for miles and miles". In actuality it flew around 200 metres, accompanied by a joke from mission control "That looked like a slice to me, Al."

So how far could Tiger Woods, unencumbered by a bulky space suit, hit the ball? Tiger can drive the ball with an average speed of 200 kilometres per hour. His longest drive in a tournament is 425 yards, or 388.6 metres. At all times, the surface gravity of the Earth pulls the ball downwards as it travels and it follows a curved path until impact with the ground. And, of course, air resistance plays a major limiting role in the distance that his golf ball can travel.

However, the Moon has considerably less mass and therefore about 1/6 the surface gravity of the Earth. A soaring golf ball on the Moon has six times less gravity pulling it down and should travel six times further than it would on Earth.

This still neglects the effect of air resistance. With no atmosphere to provide friction with the ball, if we assume that Tiger could hit the ball at a perfect 45° angle and with 1/6 the surface gravity of Earth, that same drive would go nearly two kilometres.

And as for Alan Shepard…while he may not have the best swing in the world, he still has the best swing on the Moon!

Alan Shepard plants the US flag on the Moon. There are no still images of him playing golf but NASA's recording of the live TV transmission can be seen on YouTube **Credit:** NASA

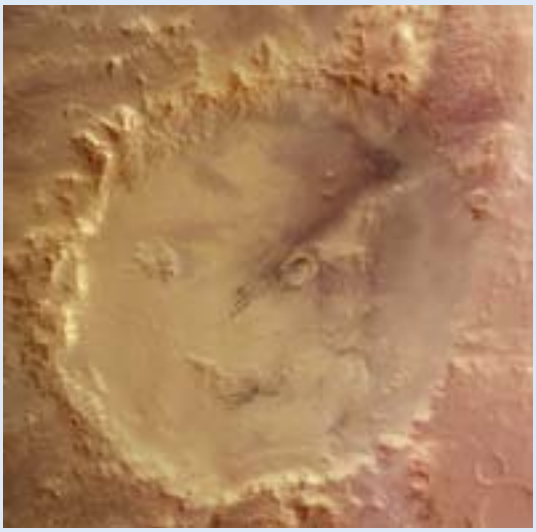
Why are the planets different colours?

Becky Parker
Director, Langton Star Centre, Kent

Why is anything the colour it is? It's all to do with absorption and reflection of light. A white top in hot weather will reflect sunlight, whereas a blue one will absorb all colours of the spectrum except blue - which it reflects. That's why it appears blue. Under red light it will appear black because there is no blue light to reflect.

So when we think about the planets, their colour is to do with what their atmosphere is or – if there is very little atmosphere – the rocky surface below.

Mars, the red planet, is covered with rusty rocks and these give Mars its red/orange colour. For Mercury we see the rocky surface of grey and no cloud cover. This is different to Venus, which gets its lightish yellow colour from clouds of sulphuric acid and carbon dioxide.



Mars gets its colour from its rusty rocks **Credit:** ESA

A true colour image of Jupiter taken by the Cassini spacecraft. Jupiter's moon, Europa, is casting the shadow on the planet **Credit:** ESA, NASA

With the four gas giants – Jupiter, Saturn, Uranus and Neptune – their colour is from the clouds in their atmospheres. For Jupiter, white bands are from clouds of ammonia and the orange from ammonium hydrosulphide clouds. Saturn has a pale yellow colour with hints of orange. Its outer atmosphere is mostly molecular hydrogen and helium with clouds of ammonia crystals. Uranus is a bluish green from the methane clouds. You may have seen a bright green picture from the fly past of Voyager 2 but that colour was artificial. Neptune has icy bright blue methane clouds that move around the planet at speeds of more than 1100km/h.

So what of the Earth, the blue planet as seen from outer space? Sunlight is scattered by small particles in the atmosphere to give us blue sky. Apollo 17 astronauts famously described the Earth as a blue glass marble.

When astronauts use the toilets in the International Space Station, where does the urine and faeces go?

Jeff Hoffman
former NASA astronaut and now lecturer at the University of Leicester

Urine goes into the water recycling system. Believe it or not, after sufficient processing, the water in the urine is drinkable!

Faeces are stored in bags inside the commode. After use, there is a small outlet to the vacuum of space, so the liquid content evaporates. When the bag is full, it is put in the trash.

When a Progress, ATV or HTV supply vehicle visits the space station, after all the supplies are unloaded, the vehicle is filled with trash, including the vacuum-dried faeces. The supply ship is then deorbited and burns up in the atmosphere.

Changing the urine tank on the International Space Station – all in a day's work for a busy astronaut **Credit:** ESA, NASA

education & careers

Teaching resources

Top image: The ESERO library at the National STEM Centre
Credit: ESERO

Meet the team:

Allan Clements
ESERO-UK manager

Tom Lyons
ESERO-UK Teacher Fellow

Alice Coates
STEM Project officer, National STEM centre

The National STEM Centre in York hosts the UK space education (ESERO-UK) office. It also houses the largest open collection of resources for teachers of science, design and technology, engineering and mathematics (STEM) in the UK. Alongside contemporary resource materials we have a growing archive collection, showcasing several decades of curriculum development.

Resources for use with early years to post-16 students are freely available as physical and eLibrary collections. The eLibrary currently contains over 4,300 teaching resources for STEM subjects, of which over 200 have a space theme.

These materials include:

- Print, multimedia, interactive and practical teaching materials
- Digitised archive resources drawn from recent decades
- Research publications with bearing on classroom practice
- Cross-curricular resources to aid innovative STEM teaching approaches
- The ESERO-UK collection of space education resources

New services

Playback Schools is a new service from the National STEM Centre and gives free access to the 3,500 videos produced by Teachers TV. These popular resources allow teachers to 'step inside' real classrooms to share good practice and ideas.

To foster colleagues' work with the resource collections, a free online community is available to support the development of collaborative projects. Community functions include options for teachers and technicians to collate links to resources from the eLibrary (or elsewhere on the web) and share their own materials and ideas.

The ESERO-UK team has produced lists of resources that use space as a context to enrich the teaching and learning of STEM subjects. These include a list of several exciting video resources and a list of resources for use by teachers in primary schools. This contains the 'Is there anyone out there?' resource featured in the spring edition of *space:uk*.

To access these lists, register on the National STEM Centre website and search 'all lists'. You can also try the quick search terms: 'Eggnaut' for the primary list and 'Light Show' for the Playback Schools list.

Alongside the library, the centre's accommodation includes meeting rooms, events facilities, overnight accommodation and hot-desk space for colleagues from STEM partner organisations. The Centre is also an ideal venue for schools and colleges to hold departmental away-days, cross-curricular planning events and whole-school STEM training.

For further information, to access the eLibrary and to register with the National STEM Centre visit **www.nationalstemcentre.org.uk**

Made in the UK

UK space research laboratory *RAL Space* also celebrates its 50th anniversary this year. *RAL Space* is part of the STFC Rutherford Appleton Laboratory in Oxfordshire and *space:uk* met its Director Richard Holdaway:

Richard Holdaway
Director, *RAL Space*

How long have you worked at RAL?

A very long time! I started on Ariel-5 in 1974 and have worked on many projects over the years, first as an engineer, then as a project manager and finally as Director of this fantastic organisation.

What goes on at *RAL Space*?

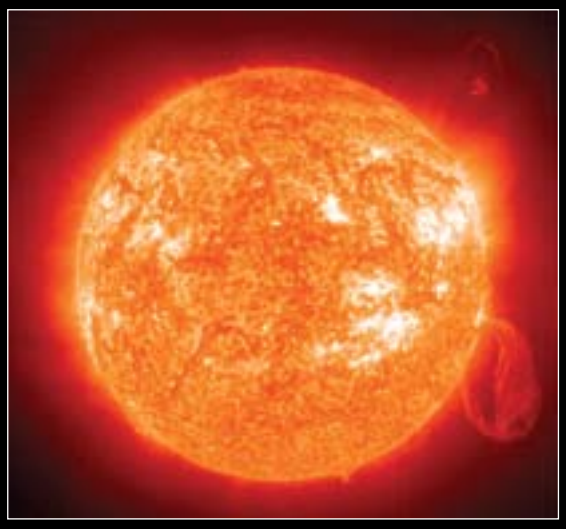
RAL Space undertakes space research, develops space instruments, operates space facilities and data archives and supports the wider space community both nationally and internationally. We have also spun-out five technology companies in recent years and have undertaken a large portfolio of outreach programmes.

What do you consider is *RAL Space's* speciality?

One of the science areas that we have been most noted for over the years is Solar Physics, and our scientists have helped lead a number of ground-breaking missions such as SOHO, STEREO and the Solar Dynamics Observatory (SDO).

On the current SDO spacecraft, *RAL Space* built the primary part of the four cameras that produce the amazing photos of the Sun at temperatures between 50,000 degrees and 2 million degrees.

On a wider front, *RAL Space* is involved in Earth observation space science missions, leading the world on the development and science of sea surface temperature and its importance to weather forecasting.



What has been the greatest change within UK space science over the last 50 years?

Given that the UK space community is generally regarded as 'punching above its weight', probably the greatest change has been securing the money to be involved in so many missions, and to make such an impact scientifically.

In more recent times the economic and societal impact has been a major factor too. This is an argument that the Treasury seems to have accepted as a result of the hard work of the UK Space Agency and its partners in industry and academia.

RAL Space has contributed to 200 space instruments, what missions are you working on now?

We are currently involved in over 30 upcoming missions. These include ESA's new Solar Orbiter programme, ESA's Sentinel-3 mission and providing two privately funded cameras for Urthecast on the International Space Station.

What do you consider *RAL Space's* greatest achievements?

Almost everything we do is in partnership with industry and university groups. So, much of our success is down to our ability to support (and lead where appropriate) those other groups in the community. Often we are able to bring uniquely innovative technologies to these projects, but before even that happens we can provide the initial twinkle of an idea that eventually leads to a new mission.

Image top left: Richard Holdaway, Director *RAL Space*
Credit: RAL Space

Image bottom left: An image of the Sun taken by the Solar Dynamics Observatory
Credit: NASA

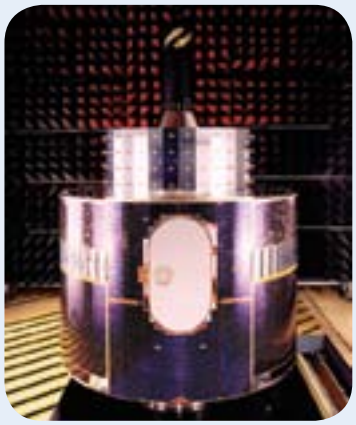
Image top right: The camera for the UK's TopSat satellite under test in a cleanroom at *RAL Space*
Credit: RAL Space

The UK in space: some of the

Launch of Ariel-1, the first satellite with UK instruments on board

European Space Agency (ESA) established, with the UK as a founder member

British Prospero satellite launched on a British Black Arrow launch vehicle



Launch of Meteosat-1, Europe's first weather satellite

1962

1972

1982

First all-British satellite, Ariel-3, is successfully launched

Launch of Ariel-5, designed to monitor X-ray sources in space such as pulsars

UK-built Giotto spacecraft intercepts Halley's Comet

50 YEARS UK IN SPACE

Picture credits: ESA, NASA, DMCii, ISRO, UK Space Agency

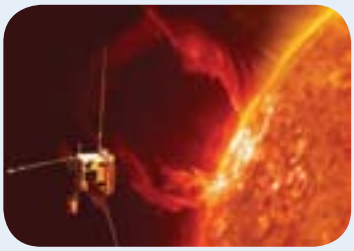
key missions from fifty years

International Hubble Space Telescope launched

Launch of world's largest Earth observation spacecraft, Envisat

Launch of the Herschel Space Observatory and Planck Surveyor satellites

Launch of first UK-built Disaster Monitoring Constellation satellite



UK company Astrium selected as the prime contractor for ESA's Solar Orbiter mission

Launch of international SOHO spacecraft on a mission to investigate the Sun

1992

2002

2012

Britain's first astronaut, Helen Sharman from Sheffield, blasted into orbit

Mars Express arrives at the red planet and releases the Beagle 2 probe but the signal from the lander is lost

First signals received from the UK-built fully operational Galileo satellites

Launch of Cassini-Huygens spacecraft to Saturn

Launch of Giove-A, the first satellite in the Galileo global positioning system

Huygens probe lands on Saturn's moon, Titan

SPACE PIONEERS

Telstar

Credit: BT Heritage

Launched 50 years ago in July 1962, the Telstar communications satellite captured the world's imagination. The satellite enabled the first high-quality live television pictures to be broadcast across the Atlantic from Maine in the United States to Goonhilly Downs in Cornwall.

Telstar was built by US phone company AT&T and launched by NASA on a Delta rocket from Cape Canaveral. Only around one metre across, the satellite was covered in solar panels and equipped with a valve amplifier. Orbiting the Earth once every 158 minutes, it was designed to receive and transmit signals – making it the world's first 'active' communications satellite.

The Post Office satellite communications station at Goonhilly was a key part of the network of ground stations built for the experimental transmissions. The station used a British-designed dish-shaped aerial – this 26 metre wide parabolic dish was the first of its type.

Live TV pictures were first received at Goonhilly on 11 July 1962 and broadcast on the BBC. Reaction to the event was spectacular and a major news story around the world. 'Telstar' by the Tornados became the bestselling record in the UK that year and was the first British hit to reach the top of the charts in America.

Although the satellite only operated successfully for a few months, the project was considered a major technical success. Telstar proved the potential of satellites to transform global communications. Fifty years on – with satellite dishes bolted to the sides of our houses and the ability to call anywhere in the world – we take this technology for granted, but it can all be traced back to Telstar.

Produced by RCUK's internal service provider on sustainable forestry paper
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