UK SPACE AGENCY

Issue #49

SPACE UK

MYSTERIOUS MERCURY

IN THIS ISSUE:

Contents

Cornwall Calling

Cornwall could soon be communicating with the Moon and Mars, following the announcement that the world's first commercial deep space communication base will be at the Goonhilly Earth Station.

An £8.4 million investment will see a two-year upgrade of the Goonhilly-6 antenna so it can communicate with future robotic and crewed missions to the Moon and Mars. The Cornwall and Isles of Scilly Local Enterprise Partnership's Growth Deal and the European Space Agency (ESA) – which the UK Space Agency contributes to – funded the contract, which will allow Goonhilly to support ESA's worldwide network of spacecraft monitoring ground stations.

"The UK Space Agency has played a vital role in supporting this partnership," said Science Minister Sam Gyimah, "and will continue to work alongside industry, local leaders and international partners to grow the UK's share of the global space market."

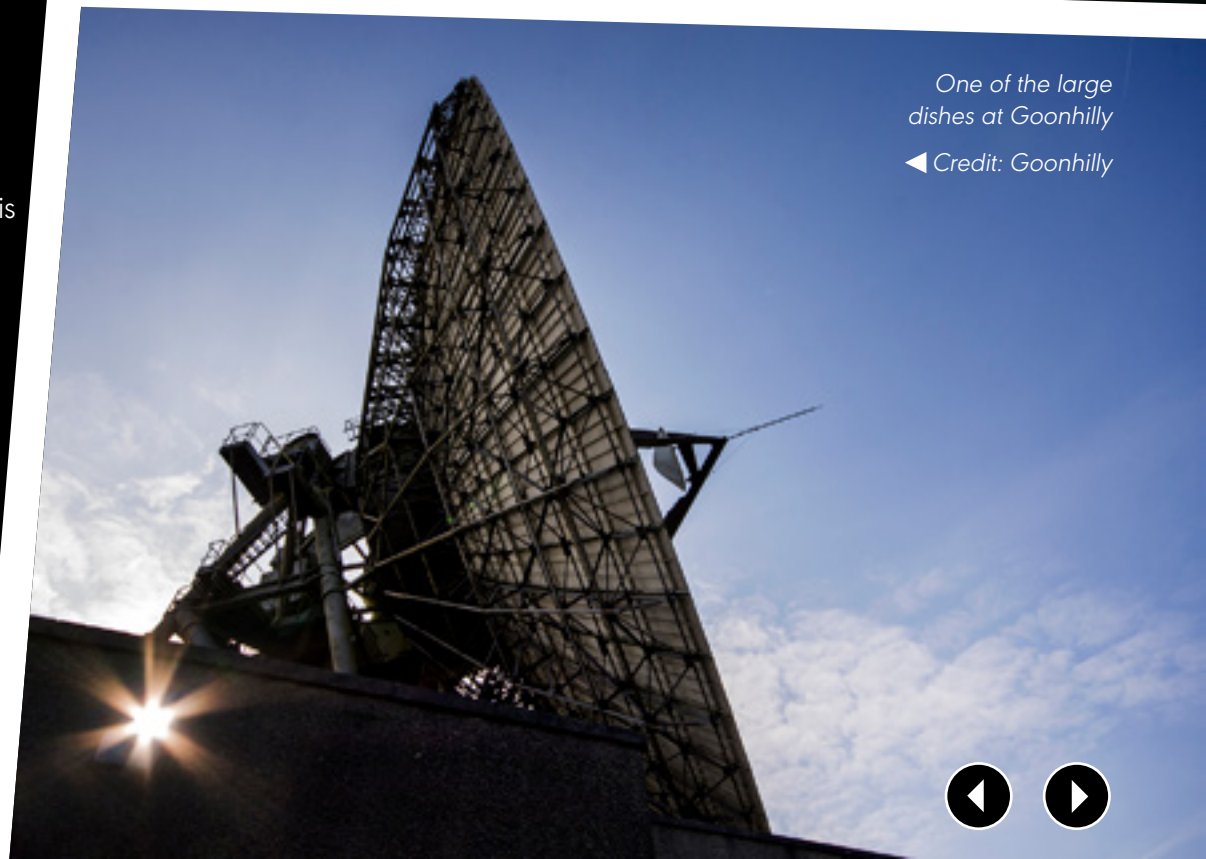
Antennas at Goonhilly beamed images of the 1969 Moon landing and, shortly after it was built in 1985, the 32-metre Goonhilly-6 antenna carried the historic Live Aid concert broadcast to TV viewers around the world.

A Space Industry Bill, announced as part of the Queen's speech in 2017, will introduce new powers to allow rocket and spaceplane launches from UK soil. Goonhilly is also offering spacecraft tracking and communications facilities as part of the Spaceport Cornwall funding bid.

"We see huge opportunities for the developing space sector in Cornwall," said the UK Space Agency's Head of Local Growth Strategy, Colin Baldwin. "We look forward to working with local partners, including Goonhilly Earth Station and the Local Enterprise Partnership, as their plans develop."

The first Moon landing

Credit: NASA ▶



One of the large dishes at Goonhilly

◀ *Credit: Goonhilly*

Space Weather Watcher

The European Space Agency (ESA) is planning a new space weather mission to monitor and better understand the effects of plasma and other material ejected from the Sun, and British space companies and researchers will play a leading role in its development.

Space weather is perhaps most familiar to people through the aurora borealis, or northern lights, a harmless display caused by charged particles from the Sun bombarding the atmosphere. But the Sun's more violent outbursts have the potential to cause real damage here on Earth.

A recent ESA study estimated that the potential cost to Europe from a single extreme space weather event could be as high as €15 billion. Much of this disruption could be avoided through accurate forecasting.

The new mission is being designed to put a satellite at the L5 Lagrange point to monitor the Sun's activity and provide an early warning system. L5 is a position in space where the gravitational attraction of the Sun and the Earth balance out, providing a stable parking spot relative to the two larger bodies.

Of the four teams developing the platforms and instruments for the mission, three are from the UK. Airbus UK will lead development of the mission, with a focus on operations and the spacecraft platform. RAL Space and UCL's Mullard Space Science Laboratory will lead the development of instruments.

"We have been advocates for such a space weather mission over many years," said Jackie Davies of RAL Space. "It is extremely satisfying to achieve this goal and we are now looking forward to the challenge of leading a multi-instrument, multi-national instrumentation development programme."

The fourth partner is OHB from Germany, heading up a consortium developing a different platform concept. All proposals will be assessed by ESA before the mission gets the final go-ahead.

The new spacecraft will monitor the Sun from the L5 position in space

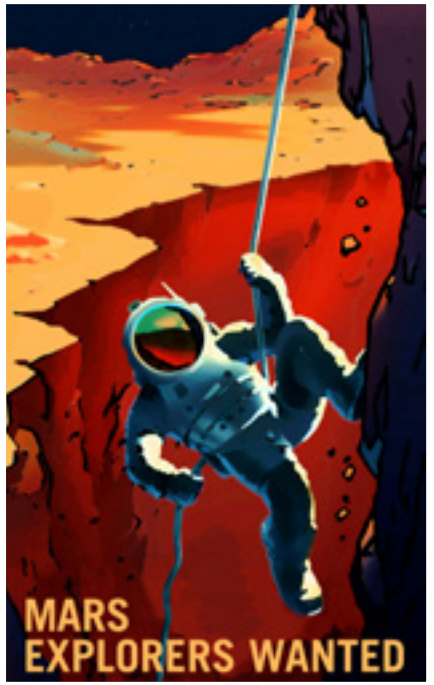
Credit: ESA ▶

An aurora above the Earth, seen from the ISS

Credit: ESA, NASA ▶

People – maybe a UK astronaut – could one day work on Mars

▼ *Credit: NASA*



Mapping the Route to Mars

If you want to know when and how humans are likely to land on Mars, you could do worse than read the Global Exploration Roadmap. The latest update has been published by a consortium of 14 international space agencies to showcase their thinking on the future of solar system exploration.

First published in 2011, the Roadmap represents the shared vision of the International Space Exploration Coordination Group, a voluntary, non-binding forum for participating agencies to share ideas. The predicted timeline foresees a crewed Mars orbital mission in the 2030s, with the possibility of humans on the planet's surface in the following decade.

The 2018 document is notable for the addition of China's and the United Arab Emirates' space agencies to the list of contributors, alongside NASA, ESA, Roscosmos, the UK Space Agency and others.

The role of private space companies is also considered, and it introduces the concept of an international Deep Space Gateway. This would be a small "human-tended" facility orbiting the Moon, to support human and robotic lunar exploration and provide a staging post for operations further out in the Solar System.

In the medium term, a role is envisaged for China's planned space station to support low-earth orbit operations beyond the planned life of the International Space Station (ISS). Along with the big picture of objectives and key technologies, the document sketches out how individual missions planned by space agencies will contribute to the collective effort.

"This update to the Global Exploration Roadmap presents an exciting vision for future exploration activities," said Head of Space Exploration at the UK Space Agency, Sue Horne. "The UK currently makes a strong contribution to the field, including building the ExoMars rover in Stevenage and upcoming experiments on the ISS. We look forward to joining in the international efforts to further exploration in the coming years."

The document is available here.

The Roadmap sets out the next stages in human exploration of space

Credit: ESA, NASA ▶

Honour for UK Astronaut

The Queen has appointed Britain's first astronaut, Helen Sharman, a Companion of the Order of St Michael and St George in a ceremony at Windsor Castle.

A research chemist, Sharman was selected from 13,000 applicants and trained for 18 months for her eight-day mission to Mir in 1991, becoming the first woman to visit the space station. During the mission, a joint Russian and private British venture called Project Juno, Sharman performed scientific experiments, connected to British schools via radio link and took seeds into space. On her return, these seeds were compared with control samples to see if being in space affected their growth.

Sharman is now Operations Manager for Imperial College London's chemistry department. The university celebrated several awardees in the honours list including Michele Dougherty. A professor of space physics, Dougherty received a CBE for services to UK Physical Science Research.

Dougherty was the Principal Investigator of the magnetometer on the Cassini-Huygens mission to Saturn. The spacecraft spent 13 years making scientific observations and discoveries before burning up in the planet's atmosphere in September 2017.

"I am extremely honoured to receive a CBE for essentially doing my job," Dougherty said. "It was enabled by all my great colleagues and collaborators over the years."

Dougherty chaired the UK Space Agency's Science Programme Advisory Committee between 2014 and 16, and Sharman supported the Agency's outreach activities during Tim Peake's Principia mission in 2015.

"They've made huge contributions to the space community," said Chief Executive of the UK Space Agency, Graham Turnock, "and provided inspiration for thousands of young people across the country."

Helen Sharman with her spacesuit at the Science Museum in London

▼ *Credit: UKSA*

New Satellite Tracks Pollution

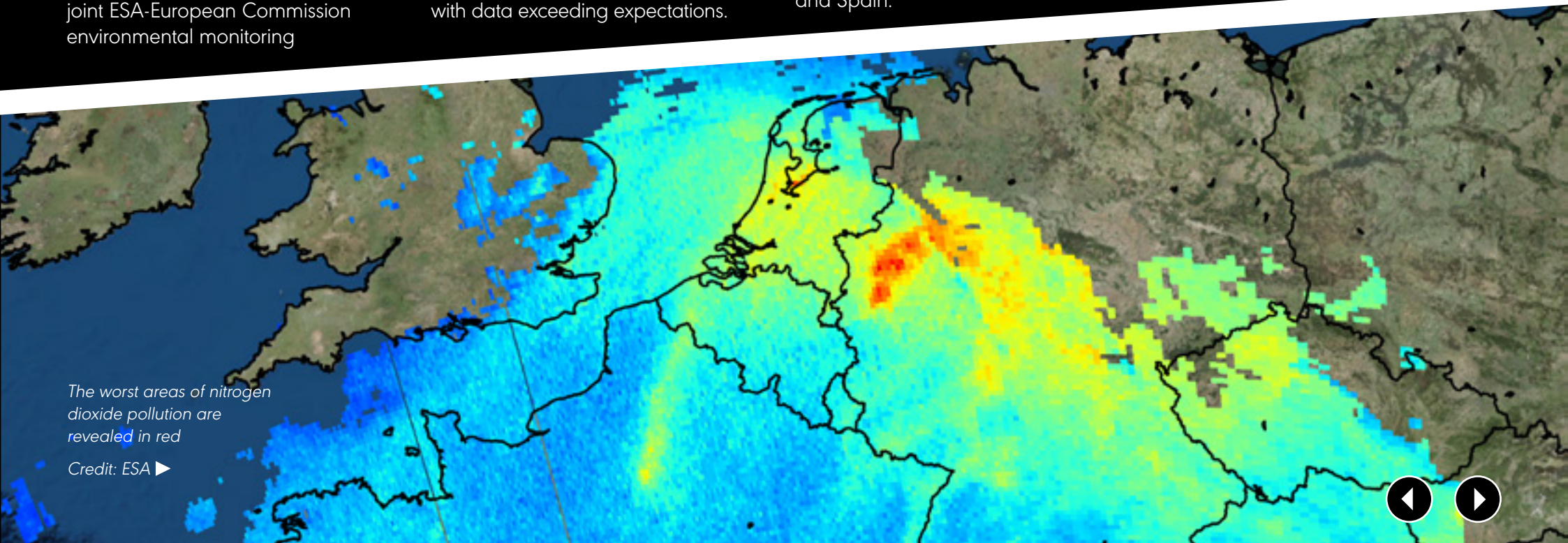
The first data from the British-built Sentinel-5P satellite has revealed nitrogen dioxide pollution across Europe, ash from an Indonesian volcano and the effects of forest fires in the US.

The new satellite was launched in October and forms part of the joint ESA-European Commission environmental monitoring programme, Copernicus. It's designed to study the atmosphere and track the spread of pollutants.

Full commissioning and calibration of the satellite, which carries a high-resolution atmospheric sensor, will take mission controllers until at least April. Early results, however, are promising, with data exceeding expectations.

One of the first images from the satellite shows nitrogen dioxide over Europe, caused largely by traffic and the combustion of fossil fuels from industry. High concentrations of the air pollutant can be seen over the Netherlands, the Ruhr area in Germany, as well as parts of Italy and Spain.

Construction of Sentinel-5P was led from Airbus Defence and Space in Stevenage. The satellite joins a fleet of five other Sentinels, delivering a wealth of images and environmental information about our planet.



The worst areas of nitrogen dioxide pollution are revealed in red

Credit: ESA ▶

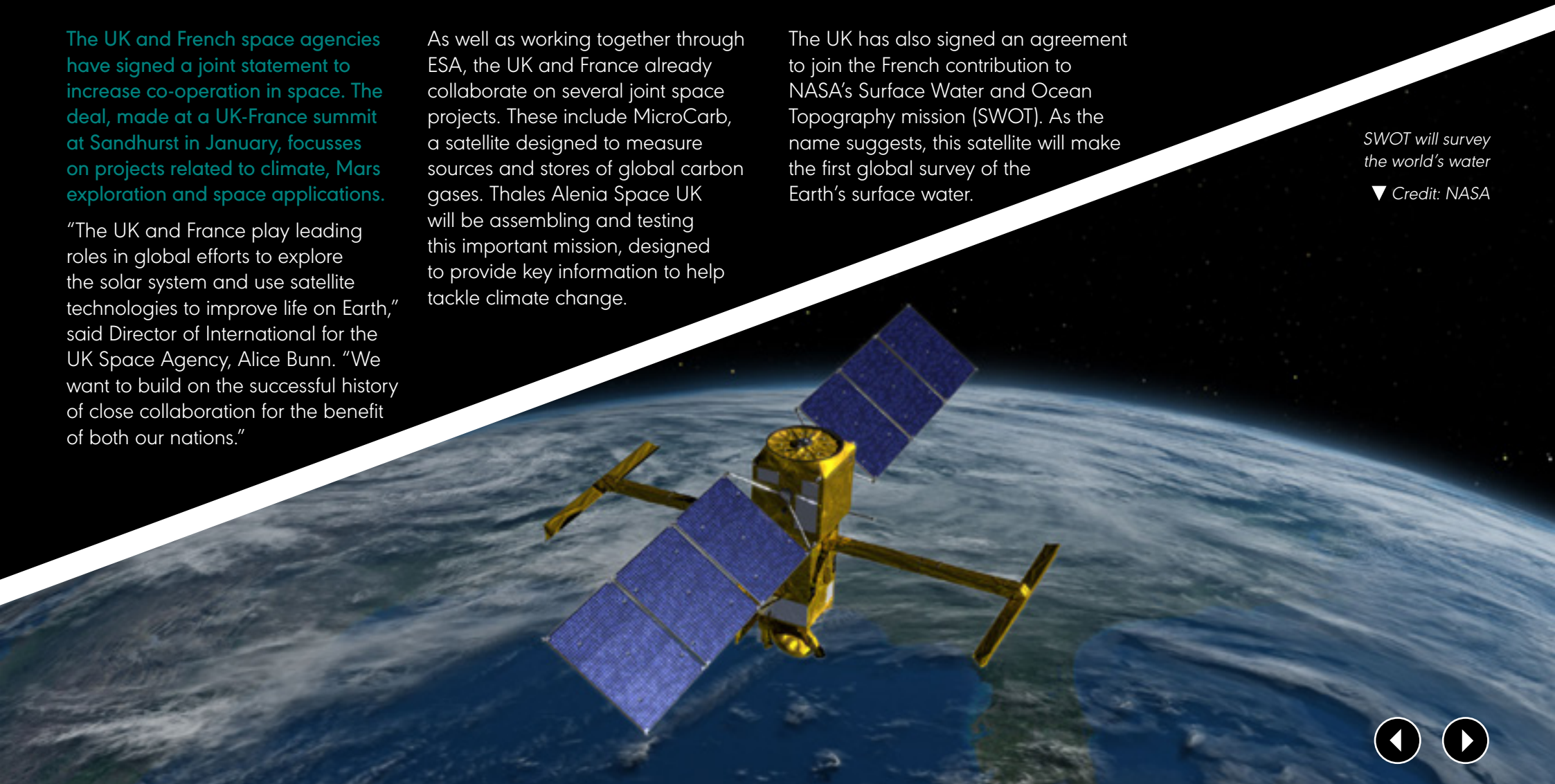
UK-France Space Deal

The UK and French space agencies have signed a joint statement to increase co-operation in space. The deal, made at a UK-France summit at Sandhurst in January, focusses on projects related to climate, Mars exploration and space applications.

"The UK and France play leading roles in global efforts to explore the solar system and use satellite technologies to improve life on Earth," said Director of International for the UK Space Agency, Alice Bunn. "We want to build on the successful history of close collaboration for the benefit of both our nations."

As well as working together through ESA, the UK and France already collaborate on several joint space projects. These include MicroCarb, a satellite designed to measure sources and stores of global carbon gases. Thales Alenia Space UK will be assembling and testing this important mission, designed to provide key information to help tackle climate change.

The UK has also signed an agreement to join the French contribution to NASA's Surface Water and Ocean Topography mission (SWOT). As the name suggests, this satellite will make the first global survey of the Earth's surface water.



SWOT will survey the world's water

▼ *Credit: NASA*

Staring at the Sun

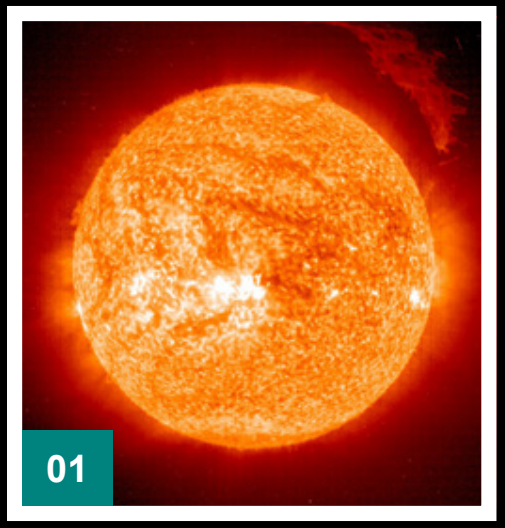
With a Core temperature of 15 million °C, the giant nuclear reactor at the centre of our solar system makes life on Earth possible. But material from the Sun also has the potential to damage modern infrastructure.

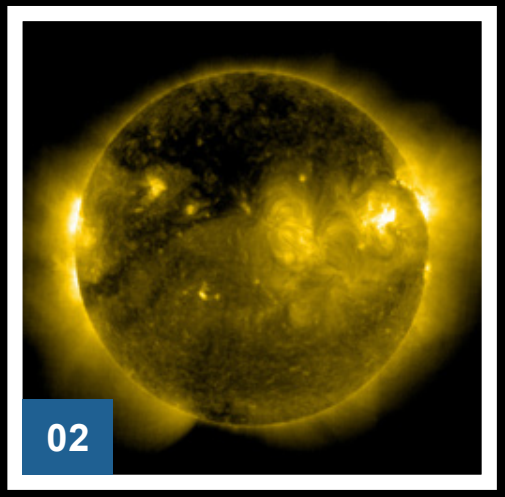
Every second a million tonnes of hot plasma and charged particles escape the Sun's gravity. The effect of this solar wind on the Earth is known as space weather. Events such as Coronal Mass Ejections, where billions of tonnes of material are belched-out at once, can trigger disturbances in the Earth's magnetic field and knock-out satellites or cause power cuts on the ground.

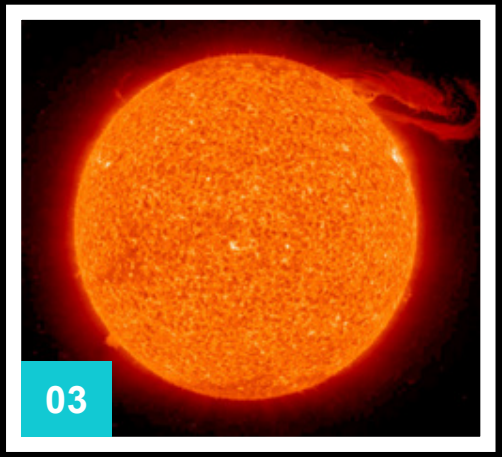
UK scientists are leading teams involved in several international missions to study the Sun and its influence on the Earth.

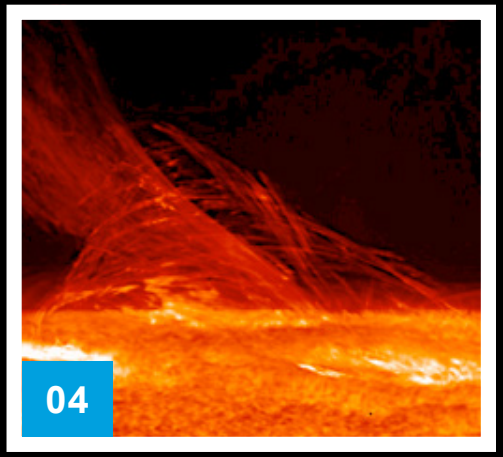
Click on the images to find out more.

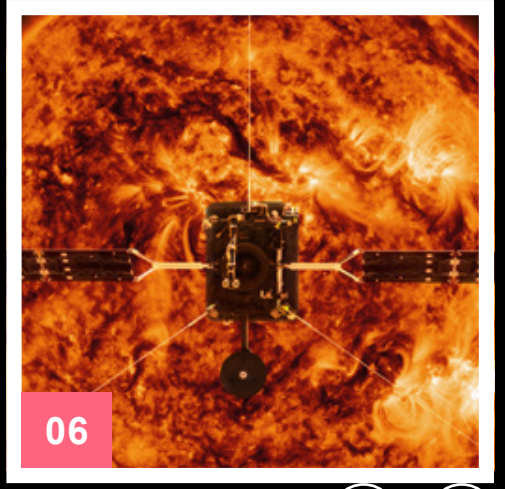
Credits: ESA, NASA and JAXA

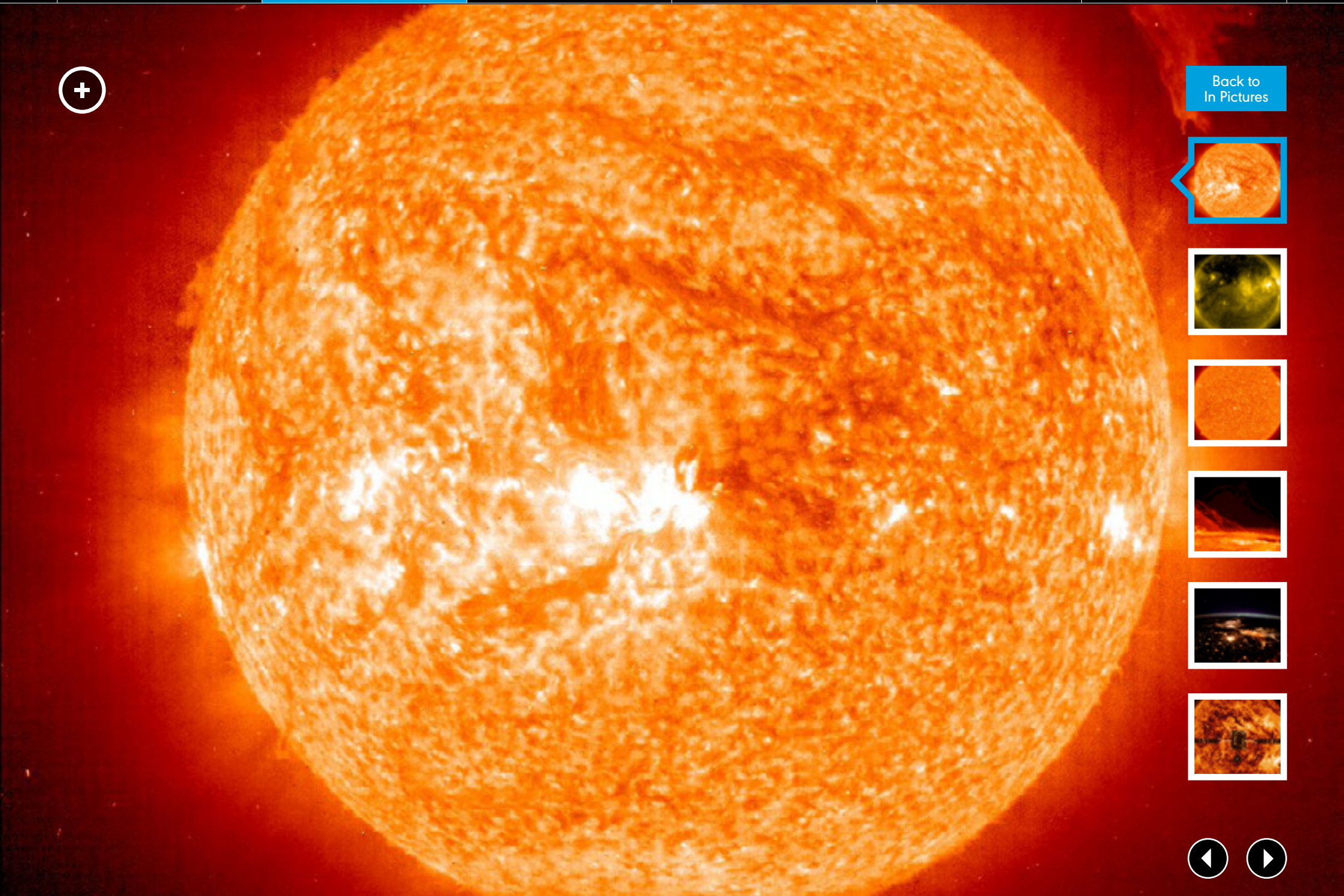




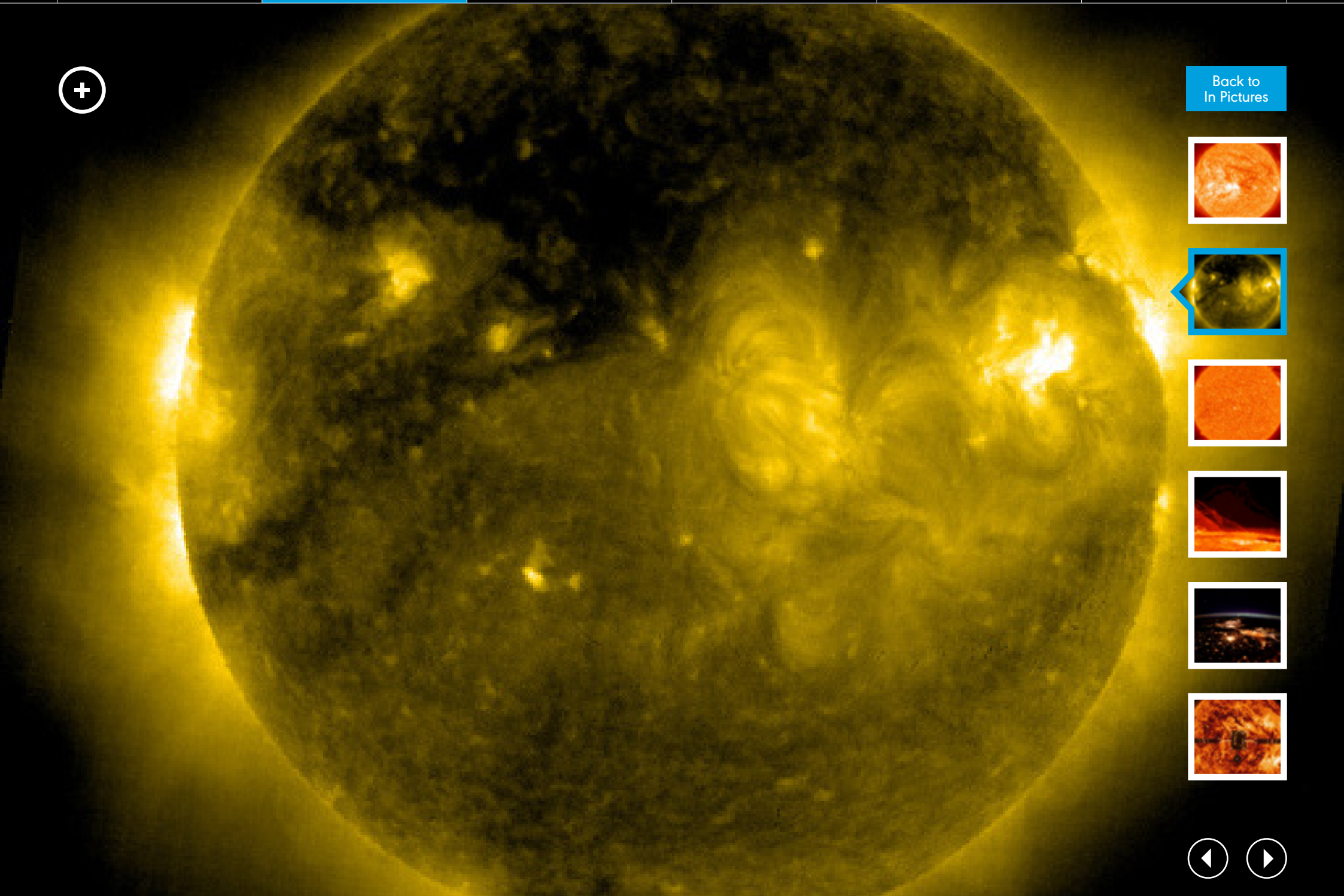








Back to In Pictures



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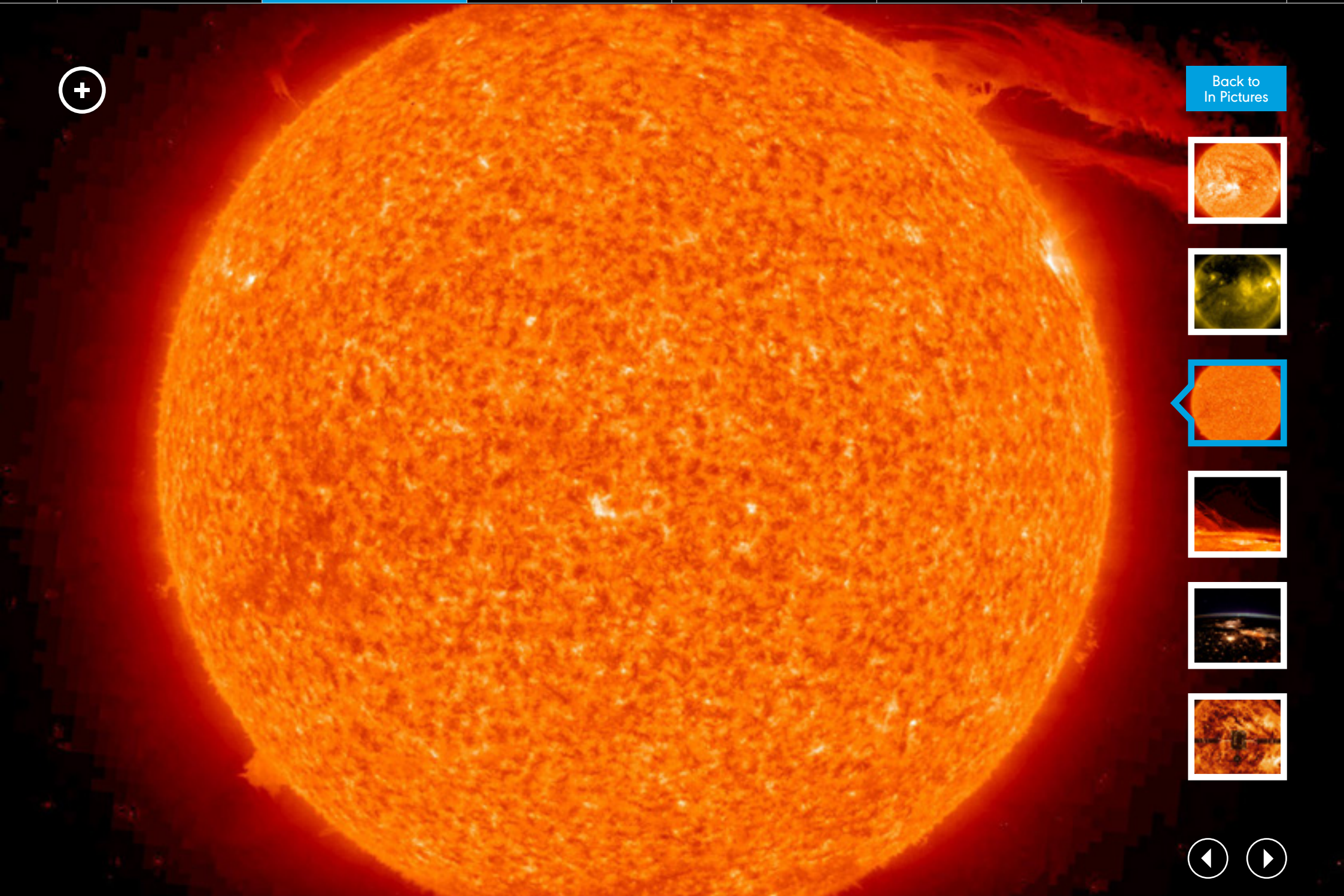

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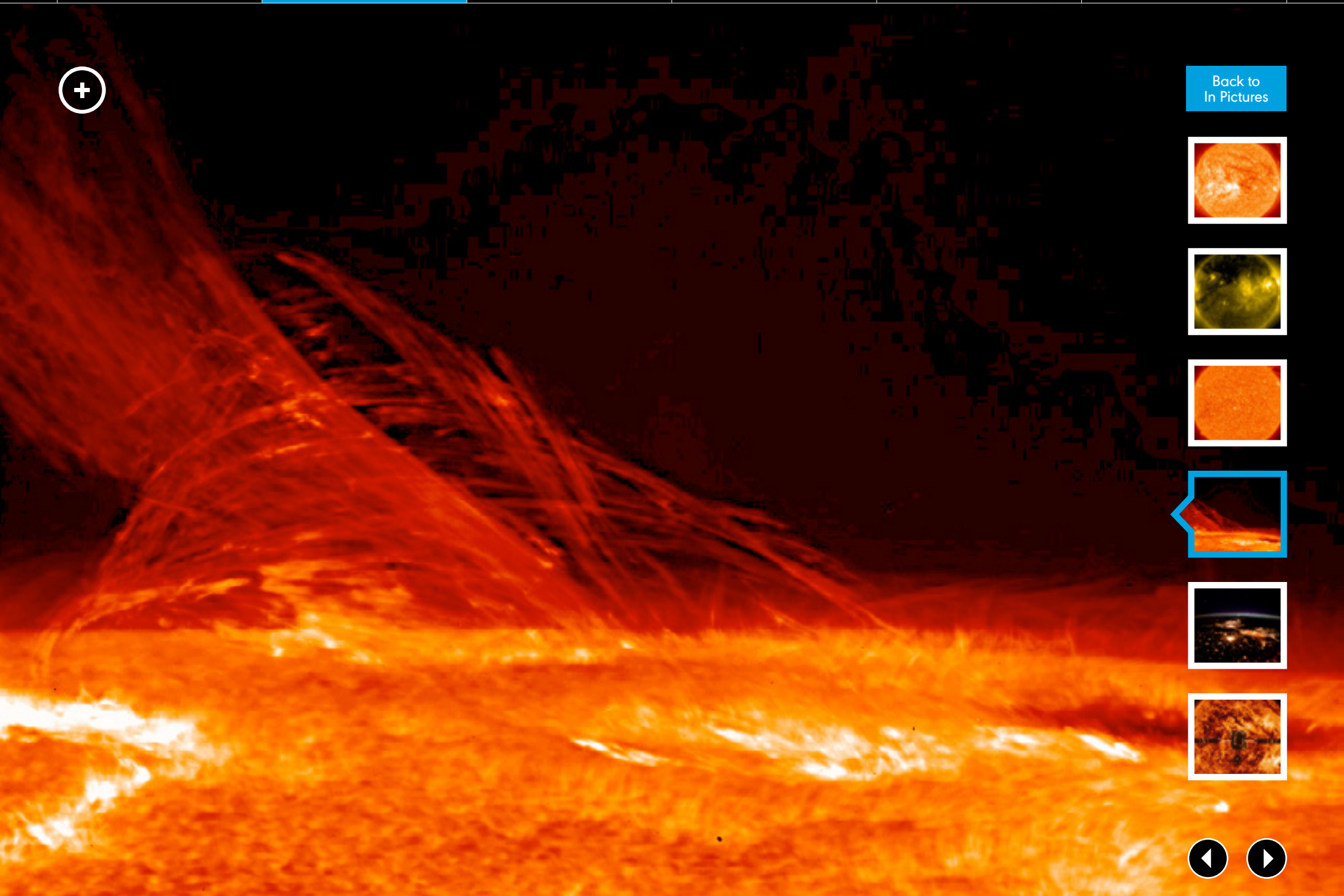

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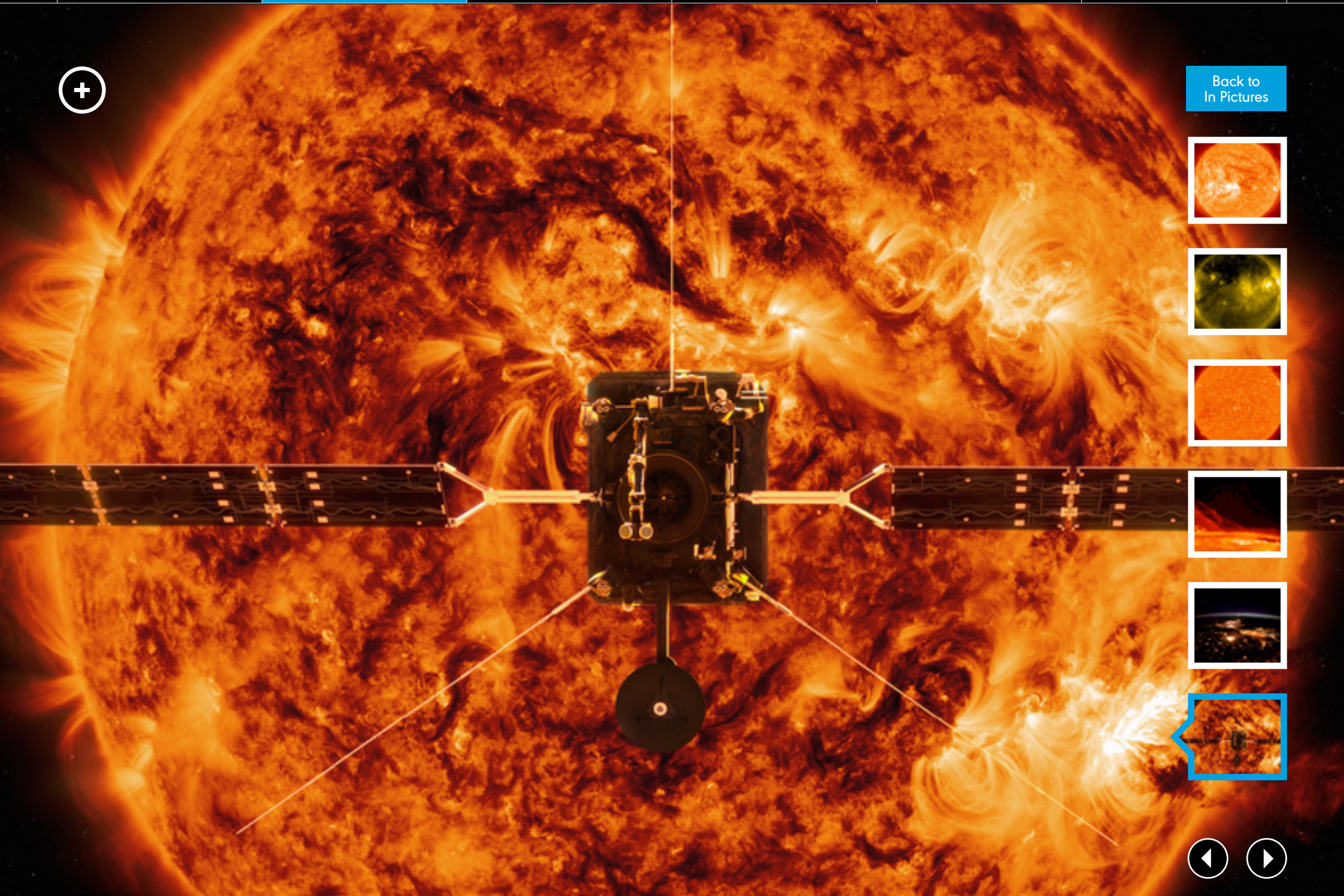


Back to In Pictures

Mysterious Mercury

By Richard Hollingham

The UK is taking a leading role in a major new mission to Mercury, being launched later this year.

"One of the most interesting things about Mercury is that it even exists in the first place," says Emma Bunce, Professor of Planetary Plasma Physics at the University of Leicester and leader of one of the instrument teams for BepiColombo, ESA's first mission to Mercury. "It's an extreme example of a planet."

Over the years, the closest planet to the Sun has continued to confound scientists. For a start, surface temperatures reach up to 425°C and yet ice water has been discovered in craters. Then, there is the fact that the iron core is apparently solid but Mercury has a magnetic field. That doesn't fit with the theory of how planets should be.

"The planet is a bit like a Malteser," says Manuel Grande, Professor of Physics at Aberystwyth University, also working on the mission. "It's got a thin crust of rock on top of an enormous iron core – but how did it get this way?"

"We really want to understand as much as we can about this small body, because it gives us context about our solar system," adds Bunce. "The more we understand about how planets form and evolve, the more we can also understand how other solar systems and planets might operate."

Due for launch on a European Ariane 5 rocket in October this year, BepiColombo is a joint mission between ESA and the Japanese space agency, JAXA, and will be only the third spacecraft to visit Mercury. The first mission to fly past the strange planet was the Mariner 10 probe in 1974. In 2015, NASA's Messenger mission came to an end after spending four years in orbit around Mercury – answering many of the scientific questions but raising plenty more.

Testing the spacecraft's antennae in intense simulated sunlight
▼ *Credit: ESA*

The complete BepiColombo spacecraft at ESA's test facility in 2017. The walls of the chamber are fitted with powerful speakers to reproduce the noise expected during launch

Credit: ESA ▲

"Messenger has done a fantastic job," says Bunce. "We've been able to adapt our science questions while we've been developing the new mission but there are some fundamental differences between the missions, which means we'll be able to get some very different information about Mercury."

BepiColombo is named after Giuseppe (Bepi) Colombo (1920-84) who studied Mercury's orbital motion. With its two orbiters, the spacecraft is designed to investigate the planet's interior and exterior. The mission consists of four modules joined together for launch: ESA's Mercury Planetary Orbiter (MPO), the Japanese Mercury Magnetospheric Orbiter (MMO), a sunshield to protect the MMO, and the Mercury Transfer Module (MTM) which will propel the spacecraft to the planet *(diagram here)*.

Bunce is the Principal Investigator for the Mercury Imaging X-ray Spectrometer (MIXS), one of 11 instruments on the MPO. MIXS is designed to map the composition of the planet's exterior by measuring X-rays emitted from the surface.

"High energy X-rays coming from the Sun interact with atoms on the surface and cause them to emit X-rays," Bunce explains. "Each element has its own X-ray signature, so MIXS will give us information about the individual elements that make up the surface – then we can start to piece together the jigsaw telling us about the formation of the planet."

MIXS will be able to map elements across the whole surface of Mercury to a few kilometres in resolution. But to produce meaningful results, it needs to work alongside another instrument: SIXS, or Solar Intensity X-ray and particle Spectrometer. This is used to measure material being emitted from the Sun.

"To get the exact composition of the surface of the planet from reflected X-rays, you need to know what the input of X-rays from the Sun is," explains Grande, who's Co-Principal Investigator for SIXS. "Our instrument points at the Sun and measures X-rays and solar particles."

Grande has been working on the mission since its conception, even before the current spacecraft design was adopted. "We put a proposal

forward to ESA back in the early '90s, which was quite a radical idea in those days," he says. "ESA liked it so much they made it a large mission and it's taken the next 25 years to get launched!"

The timescale reflects the challenges of developing such the ambitious mission and the learning process that goes into developing new instruments. A predecessor of MIXS for example, built by the UK's RAL-Space, was first flown on Europe's Smart-1 mission to the Moon in 2003.

"Smart-1 was a dress rehearsal in many ways for BepiColombo," says Grande, who led the mission's X-ray instrument. "As a result, there's a new generation of instruments on Bepi."

One of the biggest mysteries puzzling scientists is the nature of Mercury's magnetic field – it's the reason both BepiColombo's orbiters are fitted with magnetometers.

"For a magnetic field, theories suggest you need conducting liquid which is convecting and rotating to generate a magnetic field like a dynamo – the same process we have on Earth," says Chris Carr, Co-Investigator at London's Imperial College for the mission's Magnetic Field Investigation instrument. "But if Mercury has a solid centre, it shouldn't have a magnetic field."

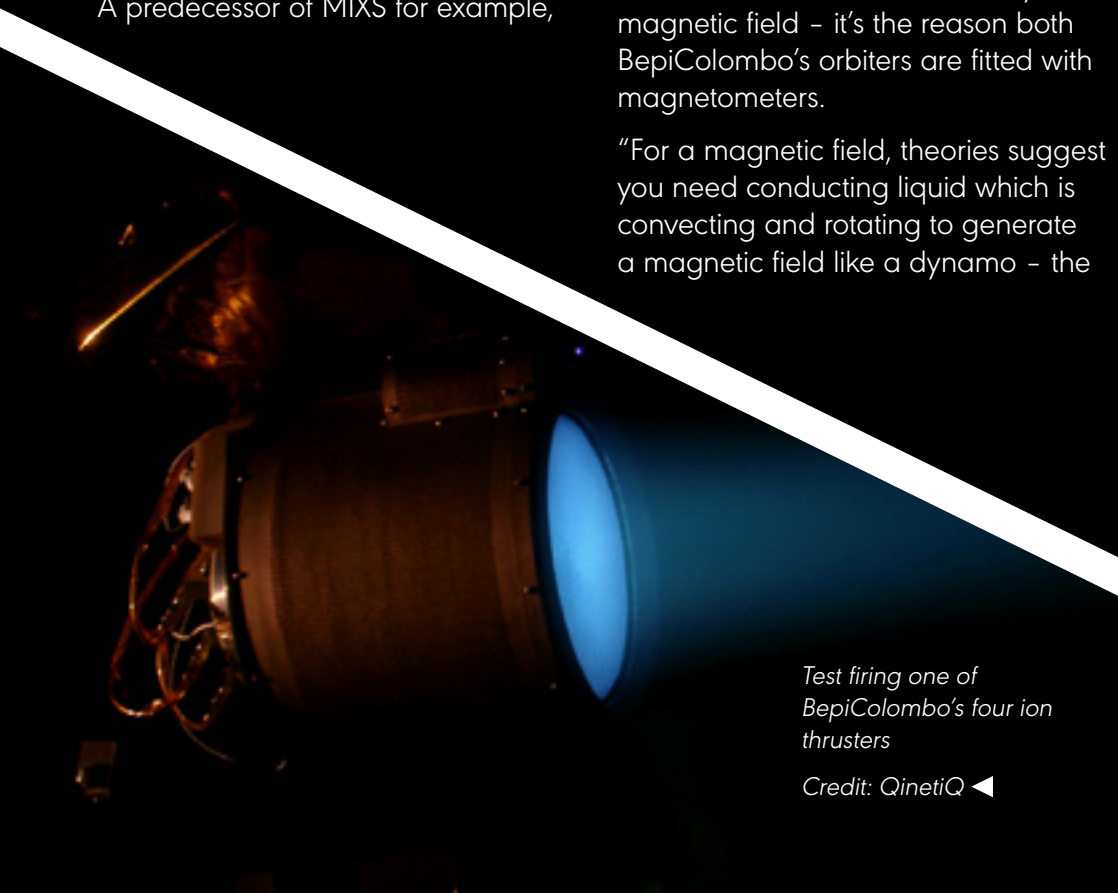
By studying the magnetic field, scientists will also be able to build up a picture of the planet's interior and that should have applications closer to home. "If we understand more about how the dynamo works at Mercury," says Carr, "it may help to further understand what's happening on Earth."

BepiColombo is equipped with an electric propulsion system. Built by QinetiQ in Farnborough and fitted to the MTM, it takes power from solar panels to create a plasma of xenon. Electric thrusters accelerate beams of these positively charged xenon atoms – known as ions – away from the spacecraft to propel it forward.

"It's very efficient," says Jerry Bolter, who's been overseeing the assembly and testing of BepiColombo modules at Airbus Defence and Space in Stevenage. "Although you get a very small thrust, you can operate for a long period of time."

And that time factor is crucial. Although Mercury is relatively close to Earth, it will take the spacecraft seven and a half years to reach the planet. "If you headed straight there, you'd be going too fast to stop because you're accelerating into the gravity well of the Sun" says Bolter. "We calculated that if you put a single engine on there with a conventional chemical propulsion system, you'd need to take 17 tonnes of fuel to get into orbit around Mercury – we only take 600 kilos of xenon."

To reach Mercury at the correct speed, BepiColombo will need to make several detours via Earth, Venus and Mercury itself. "It's mind-blowing, isn't it?" says Bunce. "It turns out that it takes the same amount of energy to slow BepiColombo down as it would to get to the outer solar system – it's not really what you'd expect."



Test firing one of BepiColombo's four ion thrusters

Credit: QinetiQ ◀

As well as the challenge of getting to Mercury, the other difficulty facing the engineering teams has been how to protect the spacecraft from the extreme temperatures it will need to operate under. "There are times where we'll be flying between the Sun and Mercury, with temperatures of up to 450 degrees on either side," says Bolter. "We have a design to allow components inside to operate at room temperature."

The secret to achieving this has been to develop a combination of thick multi-layer insulation on one side and an ammonia-filled radiator panel facing away from the Sun on the other, to radiate heat into deep space. Some components, such as the main communications antennae are designed to operate in full Sun.

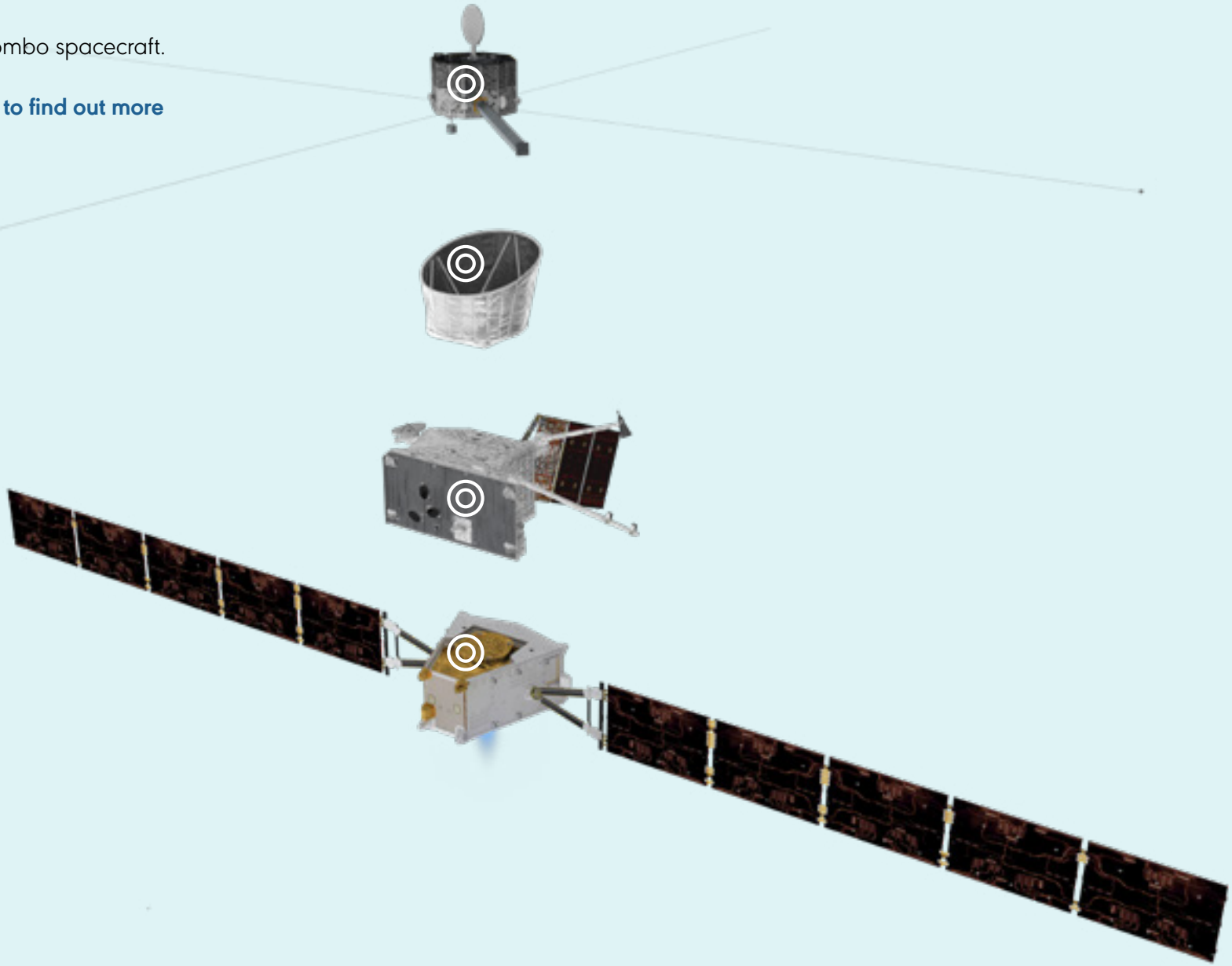
Bolter admits that it's been a learning process. "When we tried out the first thermal test model, we found we needed a serious upgrade," he says. "It's been a tough project but we're absolutely delighted to be so close to launch – I think the scientists will be very pleased with what they get from this spacecraft."

Lowering the MPO into ESA's space simulator to test the spacecraft under the conditions it will endure at Mercury

Credit: ESA ▶

An exploded view of the BepiColombo spacecraft.

Click or tap the highlighted areas to find out more



The Zero-G aircraft

◀ *Credit: Novespace, ESA*

Zero-G Science

By Sue Nelson

UK scientists are flying experiments in Europe's 'Zero-G' aircraft to simulate the conditions of space. But, as our reporter discovers, the flights are not for the faint-hearted.

After reaching its cruising altitude, the Novespace Airbus 310 Zero-G plane arcs across the sky. Scientists, most of whom are either standing or sitting on the padded aircraft floor, hold-on tightly to strategically placed straps.

First, the aircraft climbs steeply at a 50-degree angle. Everyone on board experiences 2G and feels twice as heavy as normal. At the top of the arc there are 20 seconds of weightlessness. Then the plane plummets towards the ground for another 20 seconds of 2G, before levelling out again. Imagine going over a huge peak on a roller coaster, with an uncomfortable pressure on your body during the up and down parts of the ride.

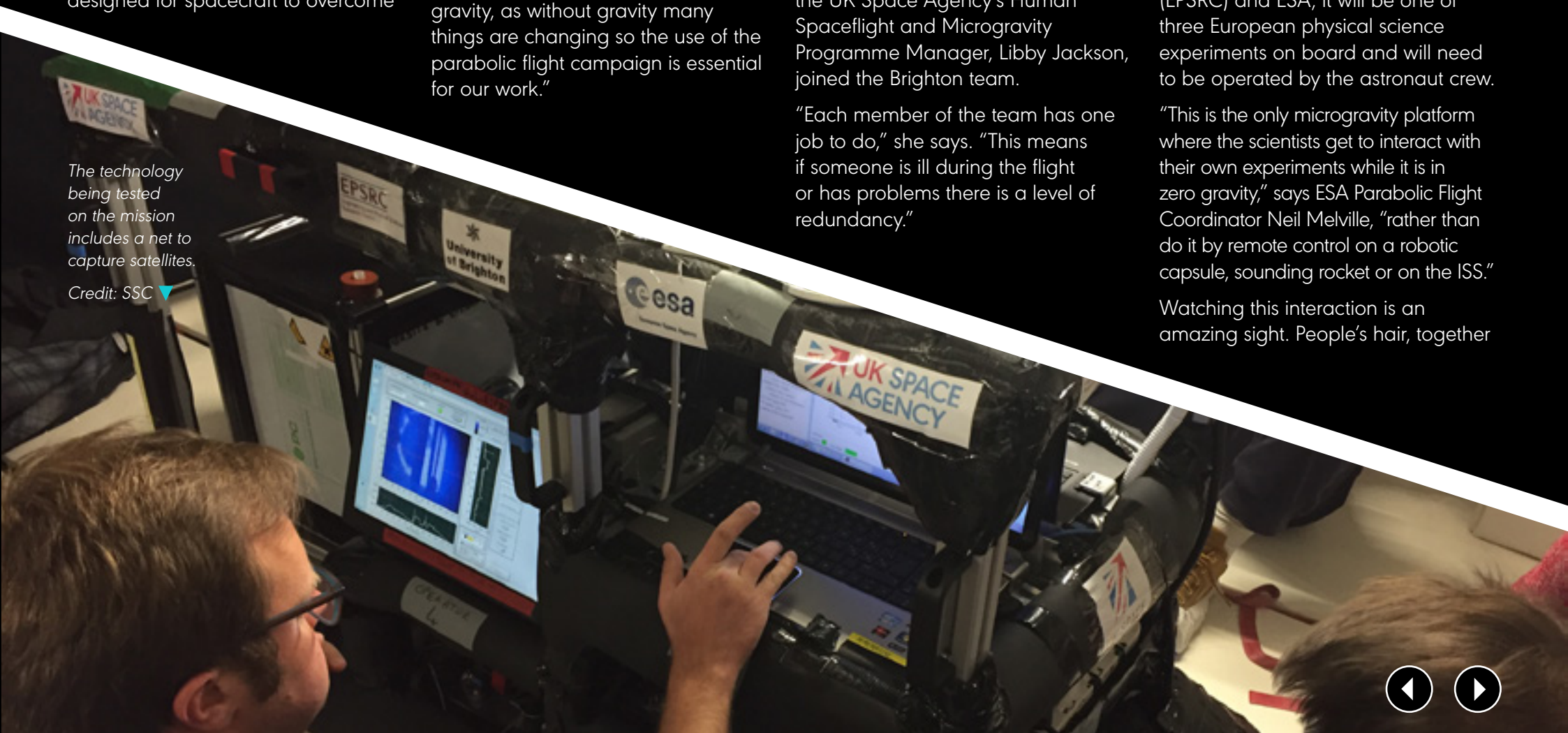
After a three-minute break, the Zero-G plane does it all over again. Another thirty times. All science has its ups and downs but, when you are performing experiments in microgravity, these are exactly the sorts of conditions you need.

For me, it was an opportunity to float in a safe cordoned-off area like an astronaut. It was also a chance to witness how science is done under extraordinary conditions. The experiments during my flight ranged from psychology and neuroscience to testing small satellites. There was even an inflatable balloon designed to make measurements in the atmosphere of Mars.

For Professor Marco Marengo and his team from the University of Brighton, those 31 parabolas – 93 over three days of flight – are an opportunity to examine how a pulsating heat pipe could help regulate heat in satellites and interplanetary space probes.

The pipe uses an evaporator, which boils a liquid to produce a vapour. A condenser converts this gas back into a liquid phase. This circulation can be used to transport heat, from a hot zone to a cold zone. It is being designed for spacecraft to overcome temperature extremes in space, which can range across hundreds of degrees.

"This is an experiment of basic physics," says Marengo. "It allows us to understand what happens without gravity, as without gravity many things are changing so the use of the parabolic flight campaign is essential for our work."



The technology being tested on the mission includes a net to capture satellites.

Credit: SSC

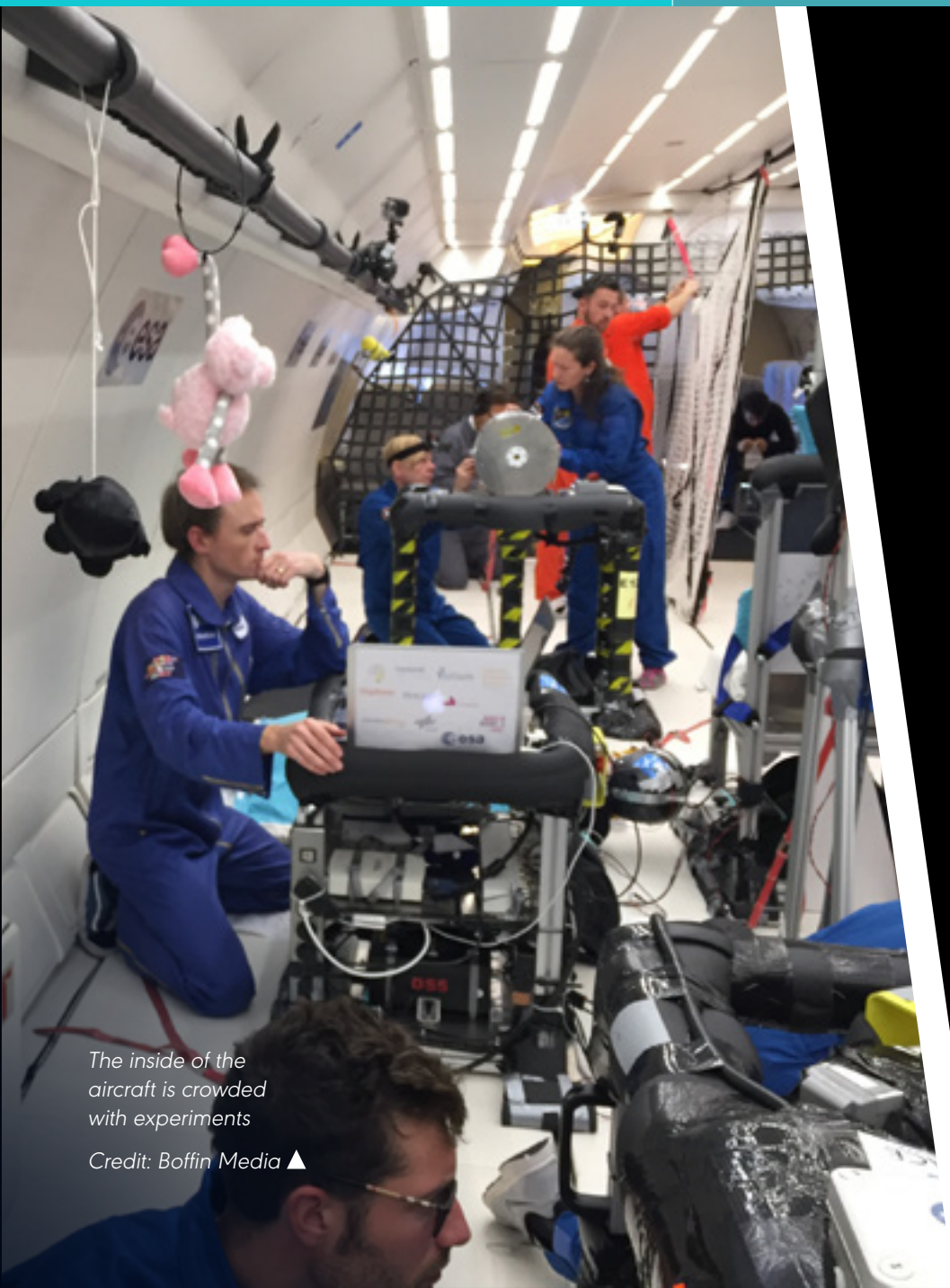
These science campaigns normally consist of a week's preparation at the Zero-G plane's base at Bordeaux airport. This is followed by a day's safety briefing, before three days of flights. On the second flight day, the UK Space Agency's Human Spaceflight and Microgravity Programme Manager, Libby Jackson, joined the Brighton team.

"Each member of the team has one job to do," she says. "This means if someone is ill during the flight or has problems there is a level of redundancy."

The next stage for Marengo's team is to place their heat pipe on board the International Space Station (ISS) for a longer period of microgravity. Funded by the The Engineering and Physical Sciences Research Council (EPSRC) and ESA, it will be one of three European physical science experiments on board and will need to be operated by the astronaut crew.

"This is the only microgravity platform where the scientists get to interact with their own experiments while it is in zero gravity," says ESA Parabolic Flight Coordinator Neil Melville, "rather than do it by remote control on a robotic capsule, sounding rocket or on the ISS."

Watching this interaction is an amazing sight. People's hair, together



The inside of the aircraft is crowded with experiments

Credit: Boffin Media ▲

with tethered mascots of cuddly toys, rise upwards into the air during weightlessness and scientists scramble between the 31 parabolas to fine tune their experiments, correct faults or prepare for different configurations.

"The next campaign coming up is a partial flight campaign and is really interesting," Jackson says. "It's the first one ESA will have run."

This partial flight campaign – where conditions do not quite reach zero-G – will take place in June and, again, one of the experiments on board will be from the UK. Northumbria University's Aerospace Medicine and Rehabilitation Laboratory will be doing spinal muscle research using equipment that has helped produce Hollywood blockbusters like the Avengers.

"We'll do this using a 3D motion capture system made by Vicon Motion Systems," says Professor of Aerospace Medicine and Rehabilitation, Nick Caplan.

"There will be 14 cameras around the participants that will track the 3D movements of small round markers covered in reflective tape that are placed at various points on the body," he explains. "The cameras can pick up the movement of those reflective markers and we can track the movements of the spine very accurately."

Many astronauts experience back problems in space despite completing two and a half hours of daily exercise. "We know that not only does six-12 months in zero-G lead to lower back pain in many astronauts," says Caplan. "But when astronauts come back down to Earth, in that first year they are at four times a greater risk of suffering a slipped disc."

It is known that the spine lengthens in space, usually by 3-5 cms. "That can stretch some of the ligaments between the vertebrae, which could be causing some of the problems," Caplan says. "The muscles that keep the spine upright in normal gravity also get smaller and weaker, but it's not entirely clear exactly what is causing the pain."

The research has applications for those of us never likely to leave the planet. If the group can develop an exercise device that works for astronauts, then it could also be adapted for the elderly or the injured.

"The great thing about using astronauts is that this spinal muscle deconditioning is very similar to what we see in people on Earth," says Caplan. "We will always try to derive terrestrial benefits."

The Northumbria University experiment also involves using a technique called fine wire electromyography to measure electrical signals that are sent to the spinal muscles. Using ultrasound, scientists will guide a needle containing a wire into the muscle. This wire remains in place when the needle is removed, allowing the team to measure the activity of those muscles. The aim is to see which muscles are and aren't affected by a reduction in microgravity.

During each flight of the June campaign there will be 10 parabolas at 0.25 G, 10 parabolas at 0.5 G and 10 parabolas at 0.75 G. With talk of a future Moon base and human trips to Mars, could these experiments be of use for these potentially much longer stays in space?

"While none of those levels are lunar or Martian gravity," says Caplan, "what we can do is look at how the spinal muscles work at those different gravity levels and make predictions about how they could be affected at lunar and Martian gravity levels."

There is a tremendous diversity of research that can be done in microgravity for the scientists that have the stomach for it. But if the flight doesn't agree with you after the first parabolic arc – and I saw several scientists sat at the back with a sick bag – then take pity on them as they have 30 more rollercoasters to go. Suffering in the name of science. Fortunately, for most of us, it was a scientific joy ride.

One of the team mascots on board

Credit: Boffin Media ▶

Before his spaceflight, Tim Peake trained in the aircraft

Credit: ESA ▶

Participants in one of the experiments

▲ *Credit: Boffin Media*

Helpline From Space

By Richard Hollingham

A UK Space Agency programme is helping to provide satellite communications to those most in need.

Right now, somewhere in the world, there is a good chance that a natural or man-made disaster is unfolding. In the Philippines, for example, the Mayon volcano has been erupting since the middle of January, with the volcano spewing out streams of lava and vast plumes of ash.

Over the past weeks, more than 80,000 people have been forced to leave their homes. The disaster has shut roads and schools, and disrupted agriculture and communications. People on the ground fear the situation could get worse.

"The eruption is a disaster that is still unfolding," says Oscar Lizardo, who works for UK-based satellite communications company Inmarsat in the region. "A more violent eruption could affect a larger area and mean evacuees needing to stay for months in temporary camps."

When it comes to dealing with disasters, the Philippines is already one of the best prepared countries on Earth. And it has to be. Every year, there are more than 20 cyclones and tropical storms, as well as frequent volcanic eruptions and Earthquakes.

These disasters often knock-out terrestrial communications – including mobile phone networks. As a result, satellite communications are increasingly important for bringing help to those most in need. "Previous disasters have shown that the quick delivery of information increases survival rates," says Lizardo, "and results in the faster alleviation of suffering of the people affected."

Unloading emergency supplies in the aftermath of December's tropical storm Tembin, which killed more than 180 people in the Philippines

◀ *Credit: Inmarsat*

A rescue worker uses a satellite phone to coordinate the response

Credit: Inmarsat

In the wake of the Mayon eruption, and in partnership with the Philippines government, Inmarsat has deployed its new Global Xpress (GX) satellite terminals. This system – operating at several megabits per second – provides disaster response teams on the ground with vastly improved voice and broadband services, enabling them to send and receive maps and images and re-establish communications networks.

"The GX system is the main means for all government agencies responding to the disaster to communicate," adds Lizardo. "We've set up the command post in a hospital near to the evacuation camps and it's essential in terms of sending and receiving information from national government."

The £6.8 million project to provide broadband satellite communications to areas in the Philippines affected by disasters has been funded through the UK Space Agency's International Partnership Programme (IPP). This five-year £152 million scheme – part of a wider Global Challenges Research Fund – is employing UK space expertise to help solve some of the world's most pressing challenges.

"Although the Philippines is already an experienced Inmarsat user for disaster response, this programme has enabled us to provide them with a step-change in capability," says James Cemmell, Inmarsat's Vice President for Government Engagement.

The project is also examining ways of restoring normal life – including business infrastructure such as shops and banking – as quickly as possible to avoid any breakdown in social order. "It's really important to get money back in people's pockets, get the grocery stores open and the critical services recovered," says Cemmell. "Working with our partners, including the private sector, we're looking at overcoming the challenges to support that."

This means the technology won't only have benefits for the Philippines but elsewhere in the world – even the UK – in the aftermath of disasters. Inmarsat is now working with charities Telecom Sans Frontieres and Team Rubicon, to improve disaster response.

An Inmarsat portable ground station

Credit: Inmarsat

"The lessons will be felt next time there's a catastrophe elsewhere," Cemmell says. "We have charity partners who deploy our technology globally and what the IPP does is allow us to go through that innovation path, which will have major benefits to humanitarian response."

"One of the exciting projects we are beginning to discuss with Southampton University, is the development of a shipping container that can be deployed after a disaster," says Paul Gudonis, President of Enterprise at Inmarsat. "It will have power generation, water purification and also communications systems so local people can get in touch with loved-ones and charities can co-ordinate aid efforts on the ground."

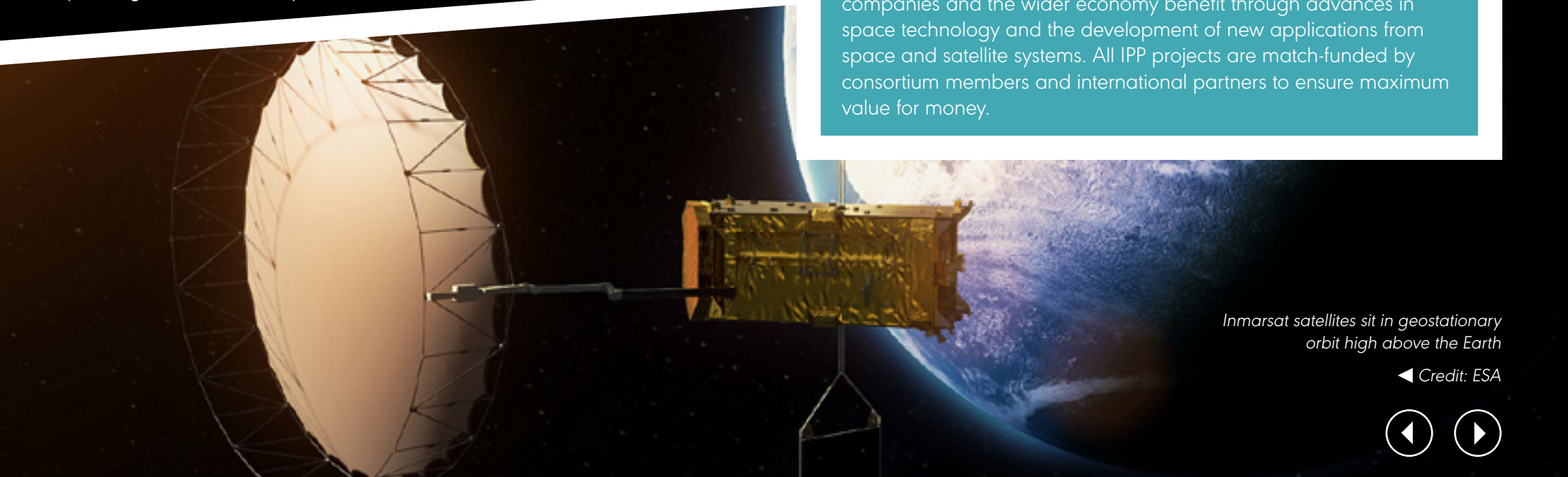
As for volcanoes like Mayon, satellite technology could in future be used to help forecast the likely extent of any disaster. "We're developing sensors and equipment to put into volcanoes to help predict an eruption that might cause loss of life," says Gudonis. "There're a number of areas where we think our services could make a fundamental difference to responding and preparing for disasters."

Tackling global challenges

The International Partnership Programme (IPP) is part of the Government's Global Challenges Research Fund. This £1.5 billion fund supports cutting-edge research and innovation on global issues affecting developing countries and is part of the Government's commitment to the UN's sustainability goals.

22 IPP projects are currently delivering benefits to people around the world. The UK Space Agency has just announced a further £38 million for ten new schemes. These include combating dengue fever in Asia, tackling illegal gold mining in Colombia, toxic mine waste in Peru and helping smallholder coffee farmers in Africa.

Each IPP project involves UK space companies working with local partners to produce long-term benefits. At the same time, UK companies and the wider economy benefit through advances in space technology and the development of new applications from space and satellite systems. All IPP projects are match-funded by consortium members and international partners to ensure maximum value for money.



Inmarsat satellites sit in geostationary orbit high above the Earth

◀ *Credit: ESA*

Destination Space...the sequel

Five science centres and museums across the UK have been selected to take part in a new national STEM programme, Destination Space 2.

The UK Space Agency has previously funded phase 1 of Destination Space which engaged more than 700,000 people in the science of Human Spaceflight. The programme closely followed Tim Peake's Principia mission, where educational shows and special events were held in 20 centres across the UK. The Destination Space programme has now returned, this time to celebrate the UK's outstanding science and engineering contributions to the space sector.

It's an exciting time for the UK in space and Destination Space 2, in partnership with the UK Association for Science and Discovery Centres, aims to inspire, excite and educate people of all ages. Topics will include the James Webb Space Telescope (due for launch in Spring 2019), the ExoMars mission and, in particular, the ExoMars rover (for launch in 2020). This carries several scientific instruments that have been developed and tested in the UK. The programme offered will also cover satellite applications and the UK's satellite launch programme, LaunchUK.

The five selected science centres and museums piloting phase 2 of this educational programme will begin delivery to schools and members of the public – through engaging stage shows, workshops and activities – between April 2018 and February 2019.

To find out more about the programme visit the *Destination Space website.*

Since his mission to the ISS, Tim Peake has been meeting groups of school children across the UK

Credit: The UK Association for Science and Discovery Centres ▲

All Aboard the Skylark

A pioneering British rocket that produced a legacy of world-class space scientists, is being celebrated in a new exhibition at London's Science Museum.

On 13 November 1957, in the middle of a remote Australian desert, Britain made space history with a resounding roar. Its Skylark rocket launched for the fourth time but, unlike the previous successful missions that year, this one contained science experiments and surpassed previous altitudes by reaching 124 kilometres. Before Sputnik beeped around the world, Britain had officially entered the space age.

Skylark was a research sounding rocket which contained experiments to 'sound out' and make measurements of the atmosphere. Commissioned by the Royal Aircraft Establishment in Farnborough, and developed with the Rocket Propulsion Establishment in Westcott, these rockets were 7.6 m long and just 44 cm in diameter. They could carry sensors, science payloads and cameras. The Royal Ordnance Factory in Bridgwater, Somerset, produced the rocket's solid-fuel motors.

Skylark didn't go into orbit but, at the top of its parabolic arc, experiments could be performed in microgravity during the several minutes of weightlessness. The payload was recovered relatively easily via parachute and, in total, 441 Skylark missions took place over almost 50 years, making it one of the most successful rocket programmes in the world.

The early launches were all from Woomera, about 450 km north of Adelaide. In 1960 a booster stage was added, called Cuckoo, which burned for 4 seconds and enhanced the rocket's performance. From 1964, there were launches in Europe, on behalf of the European Space Research Organisation (ESRO) in Salto di Quirra, Sardinia, and then from Kiruna in Sweden.

The Skylark programme contributed to Britain's Blue Streak nuclear missile programme, Britain's first satellite Ariel 1, as well as many scientists' careers, including Chris Rapley, the former director of the British Antarctic Survey and the Science Museum in London, where the Skylark exhibition is currently on display.

An early Skylark rocket blasts-off into space

▼ *Credit: Airbus*

Testing an early Skylark payload at Woomera

▼ *Credit: Ken Pounds*

The President of the Royal Astronomical Society, John Zarnecki, was a PhD student at University College London when he was given the opportunity to develop an instrument for a Skylark rocket. "Scientifically it was fantastic," he says. "For centuries astronomy had been done from the surface of the Earth using visible light. The coming of the space age gave us the ability to get above the atmosphere and build detectors to measure X-rays, ultraviolet and infrared radiation. It opened up a whole new astronomy."

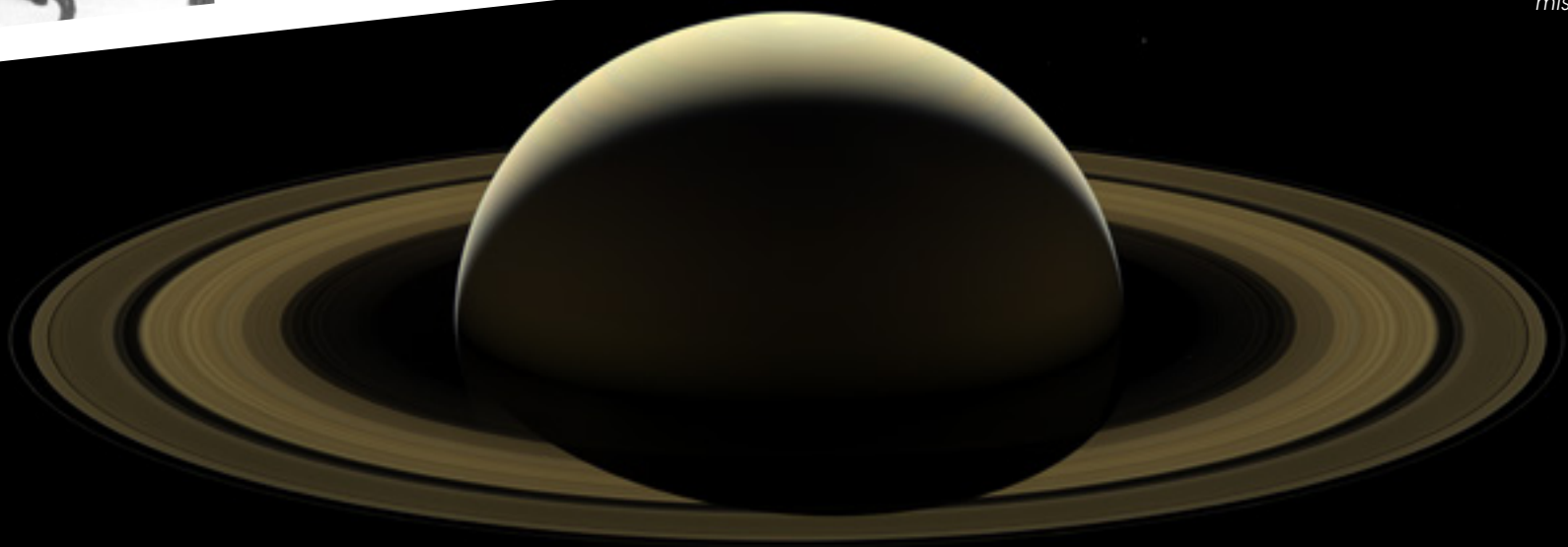
He remains grateful to the training that working on sounding rockets gave him. "I've used that experience working on the Hubble Space Telescope, the Giotto mission to Halley's comet and Cassini's mission to Saturn."

Zarnecki was the principal investigator for the Surface Science Package and co-investigator for the Atmospheric Structure Instrument on the Cassini-Huygens mission to Saturn. The Huygens atmospheric probe was the first spacecraft to land on the moon of an alien world when it descended to Titan on 14 January 2005. "I owe a lot to the Skylark project," he says.

Alan Smith from University College London is also proud of working on the project. His career has included working at the Mullard Space Science Laboratory and ESA. "It's a bit of history," says Smith. "We were in a different league in those days and, with Skylark, we were leading the Americans."

Skylark helped build British space expertise for missions such as Cassini-Huygens to Saturn

◀ *Credit: ESA*



NASA astronaut Jeff Hoffman, seen here in the foreground repairing Hubble, began his career on Skylark

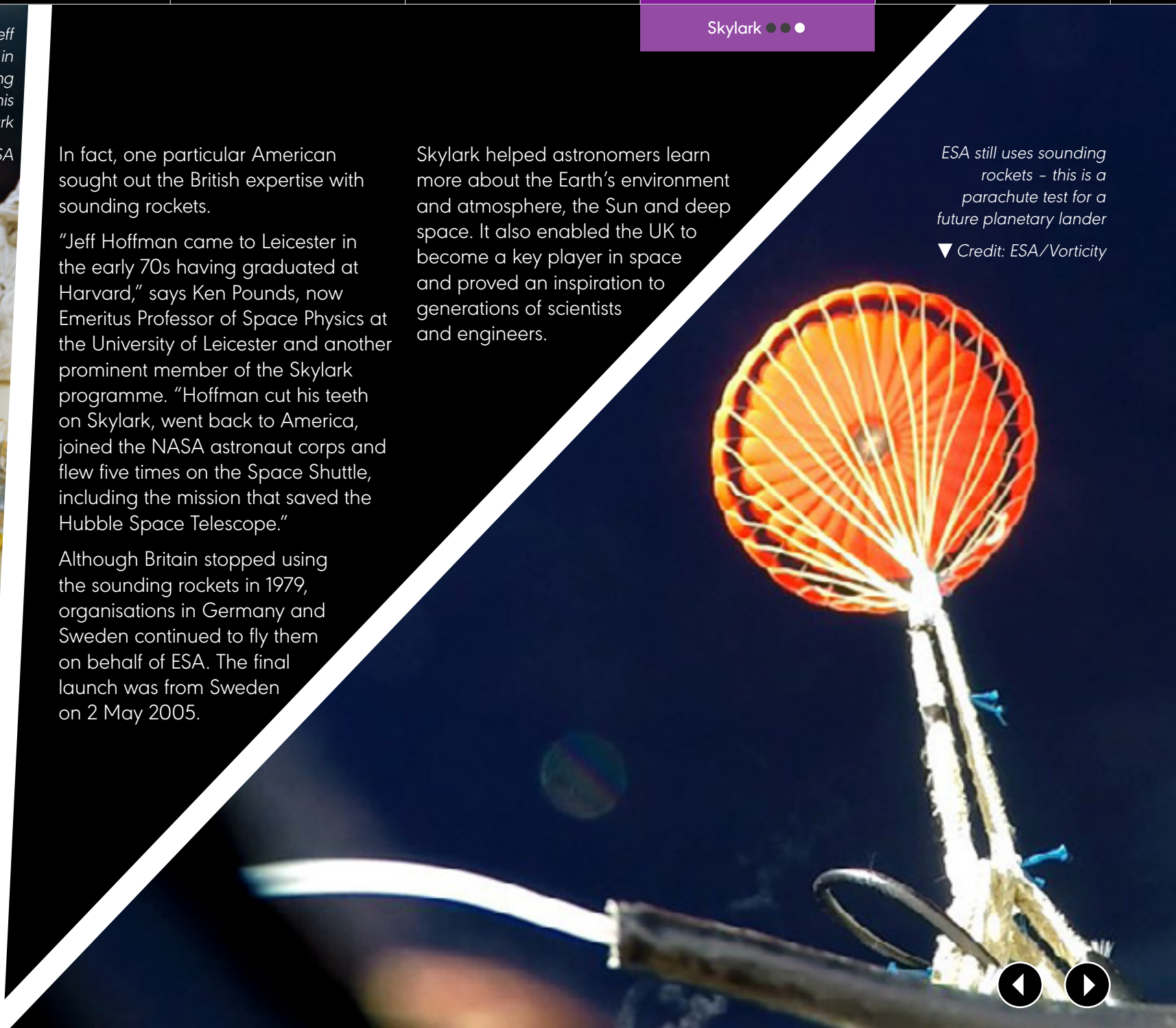
▼ *Credit: NASA*

In fact, one particular American sought out the British expertise with sounding rockets.

"Jeff Hoffman came to Leicester in the early 70s having graduated at Harvard," says Ken Pounds, now Emeritus Professor of Space Physics at the University of Leicester and another prominent member of the Skylark programme. "Hoffman cut his teeth on Skylark, went back to America, joined the NASA astronaut corps and flew five times on the Space Shuttle, including the mission that saved the Hubble Space Telescope."

Although Britain stopped using the sounding rockets in 1979, organisations in Germany and Sweden continued to fly them on behalf of ESA. The final launch was from Sweden on 2 May 2005.

Skylark helped astronomers learn more about the Earth's environment and atmosphere, the Sun and deep space. It also enabled the UK to become a key player in space and proved an inspiration to generations of scientists and engineers.



ESA still uses sounding rockets – this is a parachute test for a future planetary lander

▼ *Credit: ESA/Vorticity*

Earth-i

Guildford-based Earth-i recently launched an innovative test satellite to capture video from space. Space UK spoke to the company's Product Development Director, Owen Hawkins.

What does Earth-i do?

We are a prime example of a 'New Space' business. We get data from satellites, mix it with a variety of different information sources, then use advanced analytics to extract the maximum amount of useful information for our clients. We get data from a range of satellites and we'll be launching our own constellation of satellites, the Vivid-i Constellation. Vivid-i will be the first constellation to provide full-colour video from space.

Can you give us an example?

We can task satellites to record environmental, commercial or industrial activities taking place around the world. For example, we're mapping the state of Queensland, Australia to provide the Government with high-resolution, up-to-date maps for use across departments. In Kenya and Rwanda we are rolling out a project using satellite data to improve yield for smallholders' coffee farms.

You've just launched a test satellite, VividX2, which will capture video from space. What extra information does that give you?

Video adds an additional dimension to the data. For example, we can see how objects like ships or cars are moving. Another powerful feature is the ability to quickly create detailed 3D maps of buildings across an entire city, anywhere around the world.

Earth-i's test satellite, VividX2, was launched from India in January

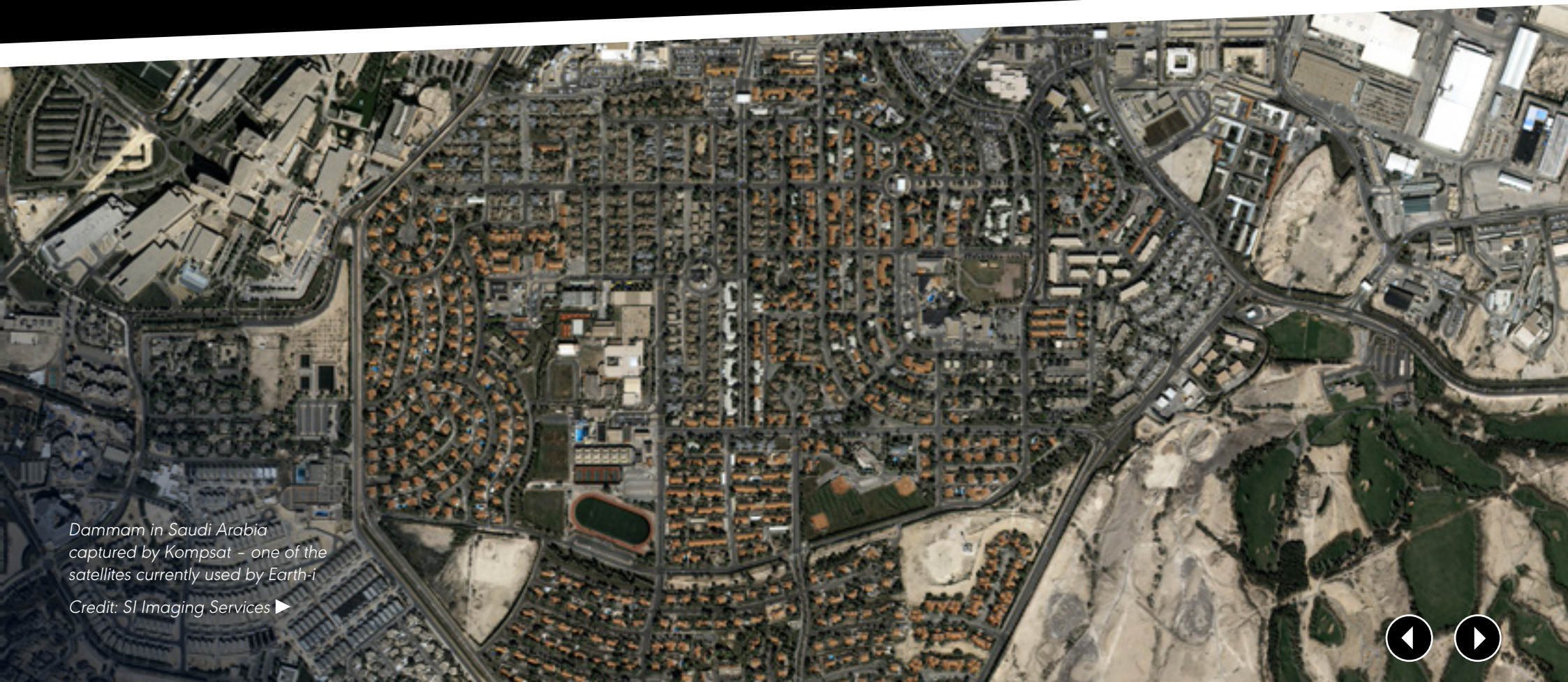
▼ *Credit: ISRO*

You are planning a fleet, or constellation, of satellites launched in batches of five over the coming years. What's the advantage of a constellation?

The word makes you think of a constellation of stars, but in this case, it means the satellites are flying in formation above the Earth. The more satellites we have, the more often we can revisit a particular location and the more opportunities to capture data we have. This means we can get images and videos at different times through the day, look at more places at the same time and avoid cloud cover.

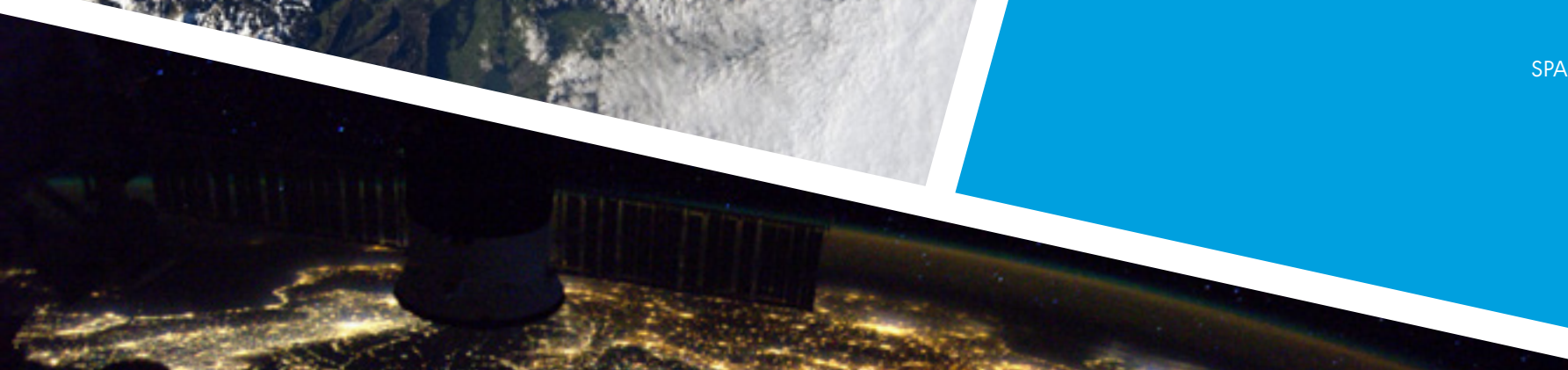
Your role is to look at what can be done with this data?

I take Earth observation data, mix it with open and crowd-sourced data to create products for our clients. I gather their needs and combine them with data sources and technical tools to create products. Then, all of the great minds at Earth-i work together to create products to answer pressing customer questions. There are a huge number of areas where Earth observation can help and there are big opportunities.



Dammam in Saudi Arabia captured by Kompsat – one of the satellites currently used by Earth-i

Credit: SI Imaging Services ▶



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