UK in Space 2010

UK SPACE AGENCY

CONTENTS

Introduction

David Williams, Chief Executive (Acting)
of the UK Space Agency

David Williams

Welcome to the 2010 edition of our annual report, covering the achievements of the past year and looking forward to the next 12 months.

As most readers will know, the UK Space Agency was created on 1 April 2010. This will therefore be the last report for BNSC covering the activities in its final year of operations.

The Agency resulted in part from a public consultation launched in the summer of 2009, on the funding and management of UK civil space activities, and the industry-led Innovation Growth team Strategy (IGS), published in February 2010.

IGS report

Respondents to the public consultation agreed that BNSC was doing well but that its role could be strengthened by co-ordinating funding and programmes for UK civil space activities across Government. Among the IGS recommendations was the agreement that a UK space agency should lead all UK civil space activities.

In July 2009, the European Space Agency (ESA) opened a facility at Harwell in Oxfordshire. This is the first ESA facility in the UK and the first time that ESA has set up for business at an existing large science and technology facility. It will focus on robotics, novel power sources, climate change and economic services utilising satellite data streams.

On the mission front, the Herschel and Planck space telescopes are going strong a year after their launch. Images from Planck have revealed the forces driving the initial stages of star formation. Herschel made an unexpected discovery when it found a hole in space, which astronomers think is part of the end of the star formation process.

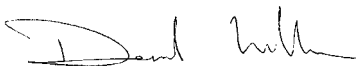
In late 2009, the Soil Moisture and Ocean Salinity (SMOS) satellite was launched. With UK designed software on board to control one of the

instruments, SMOS data will lead to better forecasting of weather and extreme-weather events. It will also help studies of regions of snow and ice.

In April 2010, CryoSat-2 was launched from the Baikonur Cosmodrome in Kazakhstan. CryoSat's role in Earth Observation will help to determine whether Arctic ice masses are thinning due to global warming. CryoSat-2 was built by ESA and the science team for the mission is being led by the UK.

Looking ahead to the next 12 months, we will continue the work to establish the Agency as a full executive agency, and this will take a significant effort over the coming months. We will also be reflecting on the potential impact of the economic issues facing Government and how these may affect the space programme. Space has continued to grow as an economic area throughout the recession. It is our role to ensure this momentum is maintained as one of the growth areas that will assist in the economic recovery. We also look forward to the launch of Hylas, a highly flexible broadband satellite, and to continued data flow from the science and environment satellite missions already in orbit.

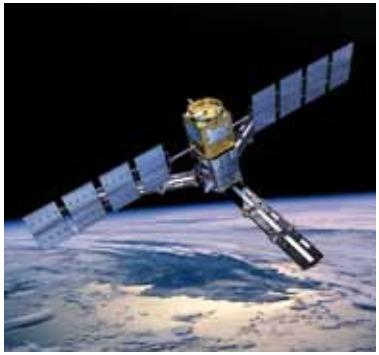
So, another busy year behind us and more to look forward to in the coming months. I hope you enjoy reading this edition of the annual report.



Dr David Williams

Credit: ESA

UK expertise can be found on ESA missions CryoSat-2 (above) and SMOS (below)



Credit: ESA

Space in the UK

Set up in 1985, the British National Space Centre, (BNSC), was responsible for co-ordinating UK civil space activities and was at the heart of Government efforts to explore and exploit space.

Astrium built Inmarsat's latest generation of telecommunications satellites with key payload technology invented and manufactured in the UK

Credit: Astrium

BNSC brought together representatives from Government, science, industry and education to promote advances in space technology and science to ensure the UK's investments in space produce maximum benefit. BNSC also supported the use of space to inspire young people and played a key role in the teaching of mathematics, technology, engineering and science.

Superseded from 1 April 2010 by the UK Space Agency, BNSC consisted of a partnership of six Government departments, two Research Councils, the Met Office and the Technology Strategy Board. It reported to the Minister for Science and Innovation in the Department for Business, Innovation and Skills and represented the UK in civil space matters at European and international level.

This report covers the last year of BNSC and gives an overview of current and future activities covered by the new UK Space Agency.

UK SPACE AGENCY

Credit: ESA

The full splendour of Saturn's stately rings captured by the Cassini spacecraft

International News

The full potential of space can only be realised if nations work together. Almost everything the UK does in space is in partnership with other countries, agencies or organisations. By working with international partners, the UK can participate in a wide range of space activities that it would never have the resources to carry out alone.

Over the past 25 years, BNSC has co-ordinated the UK's relations with the world's civil space community. This extended from projects with European partners and single nations, to global organisations such as the Committee on Earth Observation Satellites, the International Space Exploration Coordination Group and the United Nations.

Working with Europe

Around seventy per cent of UK civil space investment by BNSC's partners is channelled through the European Space Agency (ESA). UK funding for weather forecasting and climate research is also invested in the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).

With 18 member states, and one associate member, ESA is one of the world's leading space agencies. The ESA's programmes are featured throughout this publication and include missions to study the Earth, explore the Solar System and understand the Universe.

UK commitments to ESA programmes are agreed at Ministerial level. The last such meeting was held in November 2008, where it was agreed

Envisat image of a cloud-free France

Credit: ESA

CASE STUDY

SUPPORTING BUSINESS

A significant level of funding for collaborative research and development in Europe comes from the European Union's 7th Research and Development Framework Programme (FP7). In 2009 BNSC held two FP7 space information and networking events for the UK space community. The call for proposals was worth around £200 million.

The first event, held in July 2009, included presentations on the main areas of the work programme: the Global Monitoring for Environment and Security (GMES) initiative, which supports projects such as monitoring climate change; and Strengthening Space Foundations, which covers anything from space exploration to protecting vulnerable space assets. The second event, held in September 2009, included speakers from the European Commission and ESA to elaborate on the sort of research FP7 is aiming to fund.

The Diamond Light Source at the Harwell Centre

Credit: UKAEA

to set up a new ESA research facility in the UK. This centre, at the Harwell Science and Innovation Campus in Oxfordshire, was formally launched in July 2009. Work is progressing on establishing this facility to focus on key UK strengths in space. These include climate change modelling, innovative robotics systems and the design of new power sources.

The ESA facility sits alongside the new International Space Innovation Centre (ISIC) that is being established at Harwell. This is a partnership between industrial partners (Astrium, SSTL, Infoterra, Vega and Logica) and the UK Space Agency, the Science Technology Facilities Council (STFC), Technology Strategy Board (TSB), Natural Environment Research Council (NERC) and the South East England Development Agency (SEEDA). The ISIC will provide an end-to-end satellite control, data exploitation and visualization facility where businesses, universities, the Government and other space-related organisations can work together with wider UK science and engineering communities. This will become the centre of a major cluster of space activities in the UK.

European Inter-Parliamentary Space Conference (EISC)

Credit: : Paul Dawson

In October 2009, BNSC supported the European Inter-Parliamentary Space Conference (EISC) held in London. This annual event brings together parliamentarians from across Europe with industry representatives, ESA, the EU and other space nations. The aim is to create a permanent forum for co-operation between European national parliaments and develop a continuing dialogue on space policy issues. The event also looks to support the national governments and European institutions in their efforts to achieve a common European space policy. The conference provided an excellent opportunity to highlight UK achievements and look forward to future successes.

In the same month, Ministers from the 29 ESA and EU member states met for the first EU-ESA International Conference on Human Space Exploration. The conference provided an opportunity for Ministers to prepare a roadmap towards the development of policy on possible future missions to the Moon and Mars.

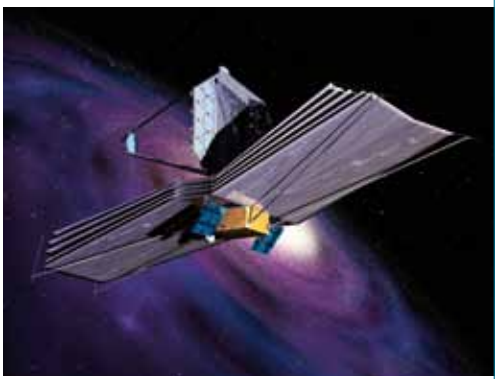
Global cooperation

The UK collaborates with most of the world's space agencies and continues to forge new international partnerships. BNSC has actively promoted UK space interests through international exhibitions, trade delegations, seminars and publicity campaigns. BNSC has also been one of the founding partners of the International Space Exploration Coordination Group (ISECG). Established in 2007, this group improves how agencies work together, strengthening exploration programmes and coordinating activities.

The UK's longest standing international partner is the United States. Space missions with US, UK and European involvement include Cassini-Huygens, STEREO and the James Webb Space Telescope. UK scientists and engineers also worked with India (on its first mission to the Moon) and the Japanese space agency (JAXA) on both Hinode and ESA's mission to Mercury, BepiColombo. Earth observation missions involving international partnerships include the Disaster Monitoring Constellation.

The UK works with the United Nations Office for Outer Space Affairs, responsible for promoting international cooperation in the peaceful uses of outer space. The UK is also taking a leading role in tackling the problem of space debris (see page 29).

Credit: NASA



Artist's concept of the James Webb Space Telescope

Surrey Satellite Technology Ltd plays an important role in Britain's space industry
Credit: SSTL

Space Industry and Growth

Future Growth

The space industry is a successful and important hi-tech sector of the UK economy. It covers a broad range of areas, ranging from satellite manufacturers and software designers, to satellite operators and service providers. Despite the economic downturn, evidence suggests that the UK space industry continues to grow.

In July 2009, the Government commissioned a report to develop a 20-year vision to grow the UK's share of the global space market. Chaired by the CEO of Logica, the Space Innovation and Growth Team involved Government, industry and academia. The findings were announced in February 2010 with a strategy aimed at positioning Britain as a leader in the world space landscape, as well as contributing revenue, jobs and value to the UK economy.

The Space Innovation and Growth Strategy (Space IGS) identifies future market opportunities and projects to enable the UK space industry to grow to a turnover of more than £40 billion a year. The IGS made 16 recommendations including increasing research and development spending within industry and a doubling of the civil space budget. The full report is available on the UK Space Agency website.

Developments in space technology are finding new applications and generating new business opportunities. BNSC, in partnership with the

Technology Strategy Board, has worked with industry to encourage, strengthen and seek funds for the future development of the space sector.

BNSC has carried out periodic surveys of the size and health of the UK space industry since 1991. The most recent study, in 2008, found that the industry employed around 19,000 staff, generating a turnover of £5.8 billion. This represented a rise of 8% on the previous survey two years previously. The UK Space Agency has commissioned a further study in 2010.

The UK's strong and competitive space industry can be divided into two main areas: upstream and downstream. Upstream industries include satellite manufacturers, technology development and software businesses. These companies are featured throughout this document and continue to win new contracts and develop innovative products.

The largest area of growth in recent years has been in the downstream sector: the applications and services that use space. With an annual turnover of £5,006 million, this sector represents the largest proportion of space industry business. It includes satellite broadcast service providers and communications companies, such as Inmarsat and Avanti Communications, as well as businesses that provide Earth Observation products or satellite navigation services, insurance, consultancy and finance services for the space industry.

SSTL is the world's leading manufacturer of small satellites

Credit: SSTL

Communications

Satellite communications have made possible the massive growth in digital broadcasting, telephone and web services. Broadband satellite technology has the potential to bring fast and affordable communications to even the most remote communities. BNSC and its partner the Technology Strategy Board have been committed to maximising the benefits of this technology.

The UK is home to the world's largest global mobile satellite communications provider. Inmarsat currently provides broadband coverage to some 85% of the world's landmass. The satellites have largely been built by Astrium in its Stevenage and Portsmouth factories.

The Government is committed to improving access to broadband services in even the most remote areas. A cost-effective way of doing this is through space technology and a new satellite has been built to provide affordable high speed broadband Internet to rural areas. The Highly Adaptable Satellite (Hylas) has been designed and built by Astrium for Avanti Communications. It is based around a low cost, low risk satellite that is nonetheless packed with new technology.

The satellite automatically allocates varying amounts of power and bandwidth to the different regions within its footprint, reacting to dips and peaks in demand. This means that between 150,000 and 300,000 users can be online via Hylas at the same time. Hylas has now successfully completed a series of tests designed to expose the satellite to the rigours of space and is due for launch in 2010 from the European spaceport in French Guiana.

Artist's rendering of HYLAS 1 in orbit

Credit: Courtesy of Orbital Sciences Corporation

To make of the most of the UK's reputation and expertise in satellite communications technology, the UK has committed €121 million to ESA's Advanced Research in Telecommunication Systems (ARTES) programme. During the past year, research and development work equivalent to £50 million was started in the UK as a result of this investment. The eventual benefits for the UK economy are expected to be considerable.

The UK is also taking a leading role in ESA's Integrated Applications Promotion (IAP). The aim of this programme is to develop applications from

space technology in a wide range of fields including health, energy and transport. The UK currently has six feasibility projects and two demonstration projects in progress or planned for 2010.

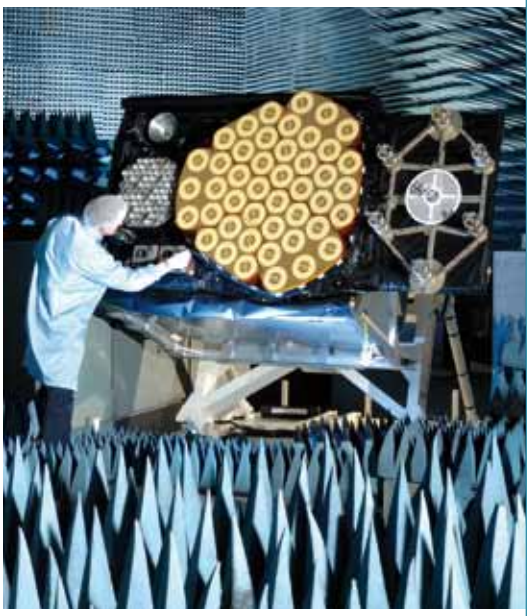
Artist's image of the Galileo constellation satellites
Credit: Astrium

Satellite navigation

Europe is developing a new satellite navigation system called Galileo. This will work in tandem with the existing US GPS system providing a much more accurate and reliable service than current technology. Galileo and its precursor EGNOS allow for use in so called 'safety of life' environments such as air traffic control.

EGNOS is to be officially certified for use later this year. The first two test satellites for the Galileo system, GIOVE-A and GIOVE-B have successfully completed their test and demonstration missions and continue to operate, providing additional and valuable data for the design and operation of the full system. GIOVE-A was built in the UK by Surrey Satellite Technology Limited (SSTL) and Astrium built the payload and ground control system for GIOVE-B.

The next stage of the project is 'In-Orbit Validation' (IOV) when four IOV satellites will be launched and tested in space. Astrium in Portsmouth is building the payloads for these satellites, which include clocks so precise they lose just one second in 300,000 years. The first two satellite payloads are complete and due for launch in 2011.



A Galileo satellite being tested in Astrium's anechoic chamber
Credit: Astrium

Galileo

The UK is a world leader in satellite and space technology. UK businesses manufacture sophisticated communications satellites, scientific instruments

GPS navigation systems are now available as standard in many new cars

and satellite navigation systems. Satellites built in the UK are being used to provide global broadband services, TV broadcasts and secure communications systems. UK technology is also at the heart of Europe's new global positioning system, Galileo.

A British company was awarded a key contract in Galileo, Europe's new satellite navigation system. In January 2010, the European Space Agency (ESA) selected Surrey Satellite Technology Ltd (SSTL) to supply 14 navigation payloads for the deployment phase of Galileo.

SSTL is teamed with OHB–System of Bremen, Germany for the provision of these full specification Galileo satellites. SSTL will design and build all the navigation payloads on board the satellites.

The contract is worth €236 million for SSTL and confirms the business' reputation as a world leader in sophisticated satellites and payloads. It also highlights how the UK is a worldwide destination for the space industry. The UK space industry is forecast to grow on average by about 5% a year until 2020, a position strengthened by this new contract.

Meanwhile UK companies have been quick to exploit satellite navigation technology, addressing immediate needs and preparing to exploit the new services Galileo will provide. National, ESA and European Commission programmes have supported these activities in areas as diverse as making national rail infrastructures more efficient and monitoring the threat of GPS jammers.

Launcher technology

A new facility for the development of a UK spaceplane has been officially opened near to Reaction Engines' main base at the Culham Science Centre

in Oxfordshire. The site will be used to construct components for the SABRE engine being built for Skylon.

Skylon is designed to take off and land using a traditional airport runway with the ability to carry over 12 tonnes into orbit. With its unpiloted design and air-breathing rocket engines, Skylon could provide inexpensive access to space compared with today's costly launches.

With the backing of BNSC, the company behind the project – Reaction Engines – was awarded one million Euros by ESA to develop new engine technologies for a spaceplane. The money is being invested in refining the engine's high performance heat exchangers and other critical engine technologies. The new production facility is a major step forward in proving that the manufacture of the SABRE engine is a practical proposition.

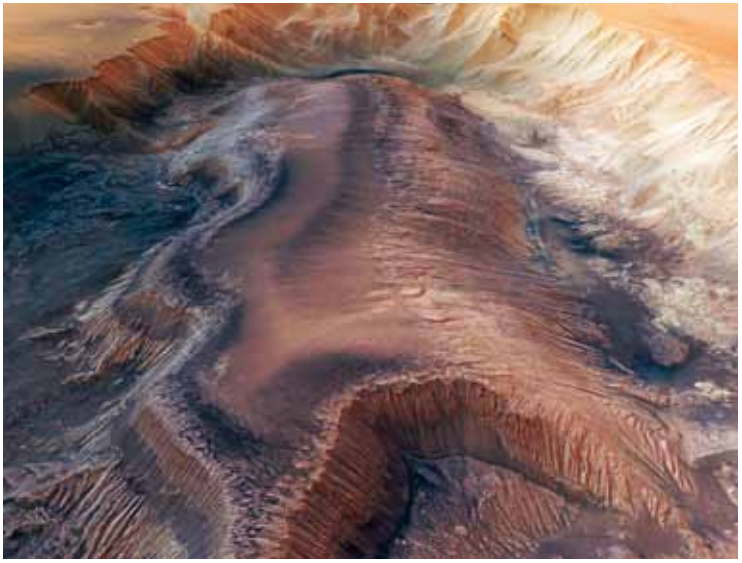
Artist's image of Skylon

Credit: Reaction Engines

Space Science

UK science and engineering teams are involved in more than twenty active missions to explore the Solar System, investigate the Galaxy and understand the Universe. Not only do these missions increase our knowledge of the cosmos, they help us better appreciate processes on Earth and lead to the development of new expertise and technologies.

Credit: ESA



The Hebes Chasma, a mountain region inside a giant canyon, captured by the Mars Express spacecraft

The UK is collaborating with its international partners on missions to the Sun, Mercury, Mars, Venus and Saturn. UK research teams are also working on space observatories including Herschel, Planck, XMM-Newton and Hubble; as well as future missions such as LISA Pathfinder and the James Webb Space Telescope.

The majority of missions are led by ESA and the UK is the second largest contributor to ESA's space science programme. The UK also collaborates with most other space agencies including NASA, the Indian Space Research Organisation and the Japanese Space Agency (JAXA). The International Space Exploration Co-ordination Group – of which the UK is a founder member – is working towards globally coordinated space exploration.

"Scientists working on the mission have been amazed at the high quality of the data at such an early stage"

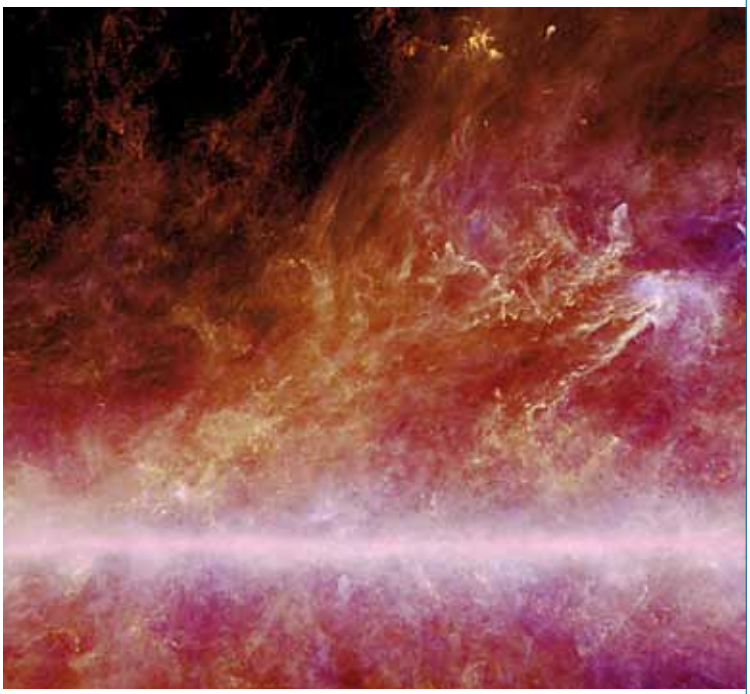
Matt Griffin, Cardiff University

Understanding the Universe

Launched together in May 2009, ESA's Herschel and Planck missions are delivering superb images and valuable scientific data. Early scientific results from Herschel were presented at a conference in Madrid in December 2009. They reveal previously hidden details of star formation and include the first images of stardust – the material that makes up everything in the Universe.

Herschel is the largest-ever infrared observatory and is designed to examine some of the coldest and most distant objects in space. Its major objectives are to discover how the first galaxies formed and evolved. One of the three instruments on board, SPIRE (Spectral and Photometric Imaging Receiver), was designed in the UK and is led by a scientist at Cardiff University.

Credit: ESA/HFI Consortium, IRAS



Planck sees a tapestry of cold dust

Planck is measuring Cosmic Microwave Background radiation – ancient light left over from the Big Bang. It is designed to help answer fundamental questions, such as how did the Universe and galaxies form. The spacecraft, which has detectors operating at just 0.1 degrees above absolute zero, completed its first complete survey in February 2010. The aim is to complete four full surveys before the end of the mission. Early results include an

Credit: ESA

Hubble celebrated its 20th year in space during 2010 and captured this image of the Carina Nebula 7500 light years away

insight into the complex forces driving star formation. Images from Planck reveal giant filaments of dust stretching through the Milky Way.

The UK is playing a major role in the Planck mission with several UK institutes – including the University of Manchester, STFC's Rutherford Appleton Laboratory (RAL) and Cardiff University – involved in developing instruments. UK research groups make up the London Planck Analysis Centre and Cambridge Planck Analysis Centre.

Other missions with UK involvement include Europe's X-ray telescope, XMM-Newton and Swift, which is investigating powerful cosmic explosions called gamma ray bursts.

Future missions

An extensive testing programme has been carried out prior to the launch of the UK-led Laser Interferometer Space Antenna (LISA) Pathfinder. Due for launch in 2012, LISA Pathfinder is a spacecraft and propulsion module that will prove the technologies for future missions to detect gravitational waves – ripples in time and space predicted by Einstein's Theory of General Relativity.

LISA Pathfinder is the first ESA science mission to be led from the UK since Giotto in 1985. It is designed to prove that a test mass can float freely in space so that any effects on its trajectory will only be the result of external gravitational forces. This complex engineering challenge is being tackled by Astrium, as the main contractor, and SciSys Limited as the software architect.

The Lisa Pathfinder Flight Science Module being prepared for tests

Credit: Astrium

"We've reached another important milestone in the construction of this new window on the ancient Universe"

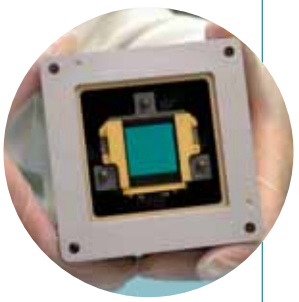
David Parker, UK Space Agency

Other missions under development with key UK involvement include BepiColombo, the international mission to Mercury; and Gaia, an ambitious mission to chart a three-dimensional map of our Galaxy. Astrium is responsible for Gaia's guidance and control systems as well as the powerful computers needed to process data. The 'eye' of the spacecraft's camera will use 106 detectors made by UK company e2v Limited.

The James Webb Space Telescope (JWST), a joint mission between ESA, NASA and the Canadian Space Agency, will investigate the origin and evolution of galaxies, stars and planetary systems. A team led by STFC's Astronomy Technology Centre in Edinburgh is developing MIRI [Mid InfraRed Instrument], one of the telescope's three cameras. In March 2010, a sophisticated working replica of MIRI was shipped to the United States for testing alongside other components for the telescope. Meanwhile, work continues on the flight instrument, due for delivery in 2011.

This model of the MIRI detector (in green) is similar to the charge-coupled devices in digital cameras

Credit: NASA

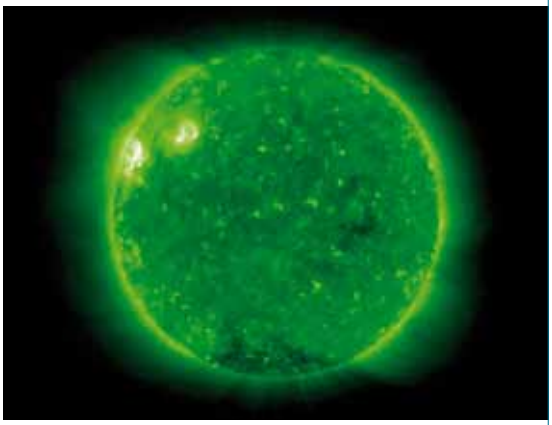


Exploring the Solar System

Missions exploring the Sun, Mars, Venus and Saturn continue to generate exciting results. A UK-built instrument has also flown on India's first mission to the Moon and Britain is working with its international partners on the future exploration of Mars.

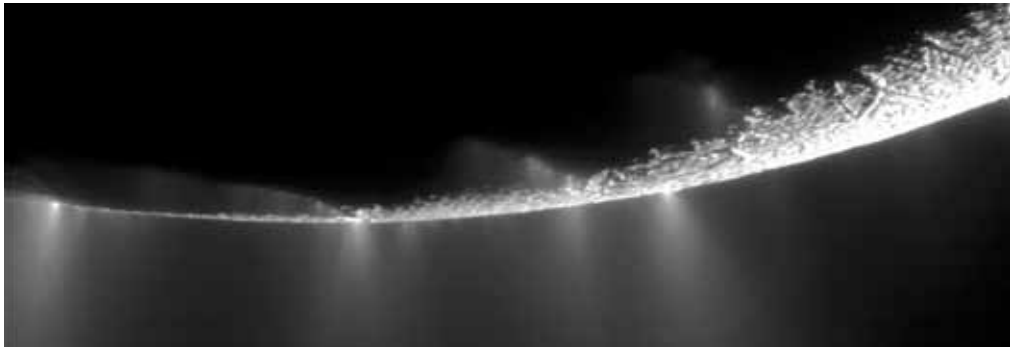
With their world-class expertise in solar physics, UK science teams are involved in three international missions to study the Sun: SOHO, Hinode and STEREO (Solar Terrestrial Relations Observatory). Results from these spacecraft will give us a better understanding of space weather – the effect the Sun's activity has on the Earth. Solar storms, eruptions and the stream

Credit: NASA/SOHO



STEREO (B) spacecraft observed a coronal mass ejection (CME) that erupted on the sun in May 2009

Credit: NASA/JPL/Space Science Institute



Dramatic plumes, both large and small, spray water ice out from Saturn's moon Enceladus

of charged particles – known as the solar wind – can disrupt satellites, communications systems and even electrical supplies.

A UK consortium, led by RAL and the University of Birmingham, developed one of the key instruments for NASA's twin STEREO spacecraft. Over the past 12 months, the two satellites have been moving further apart to allow them to see more of the Sun at the same time. University of Leicester scientists have used STEREO to develop more accurate predictions of when blasts of solar wind will reach Earth, Venus and Mars.

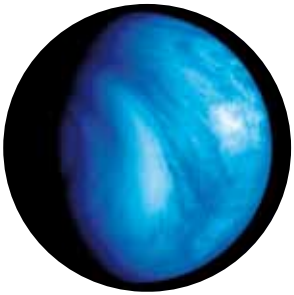
The largest interplanetary spacecraft ever built, Cassini-Huygens, continues its extended mission to explore Saturn and its many moons. Highlights this year include evidence for a large body of liquid water beneath the icy surface of the moon Enceladus. The UK has been at the forefront of the design, engineering and science of this important mission.

Mission operations for the ESA Mars Express and Venus Express missions have been extended until the end of 2012. This reflects the continuing success of these programmes with results that are transforming the understanding of our nearest planets.

A European spacecraft on a ten-year journey to rendezvous with a comet has made a final swing-by past the Earth. Rosetta passed close to our planet in November 2009, using the Earth's gravity to boost it on the final stage of its journey to comet 67P/Churyumov-Gerasimenko, where it is due to arrive in 2014.

Venus' southern hemisphere in the ultraviolet

Credit: ESA©2007 MPS/DLR-PF/IDA



Credit: ISRO

The UK-built instrument C1XS performed extremely well onboard Chandrayaan-1, which took this close-up of the Moon's surface

Credit: ESA

Rosetta captured this image of part of South America and Antarctica as it flew past the Earth

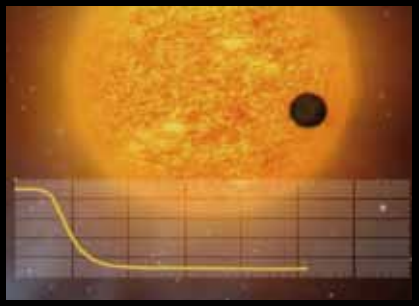
CASE STUDY

COSMIC VISION

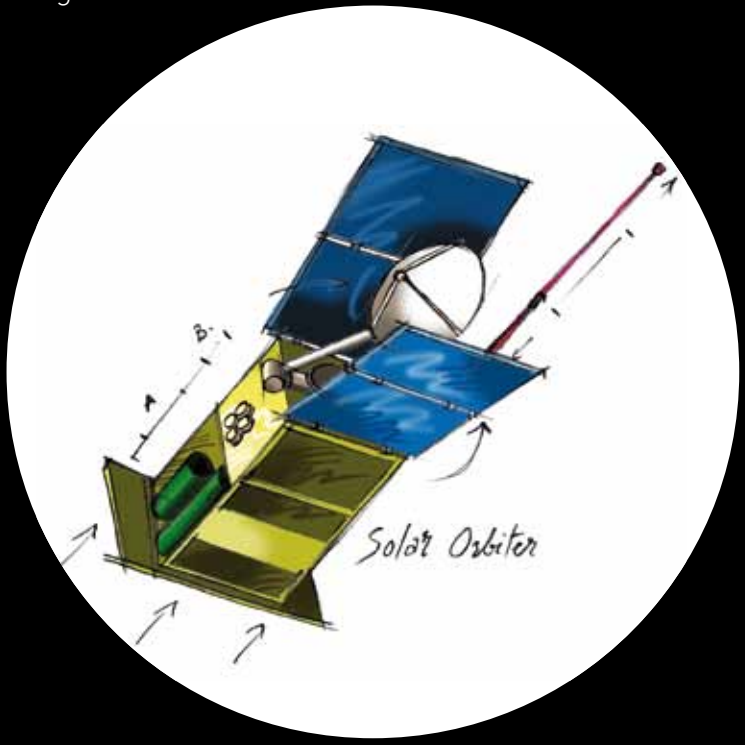
Missions to investigate dark energy, the mysteries of our Sun and habitable planets around other stars have been selected by ESA as candidates for two space science missions to be launched no earlier than 2017. The mission concepts were chosen in February 2010 from six ideas that had been carefully evaluated by technical and scientific experts from across Europe.

The three contenders are: Euclid, which would investigate mysterious dark energy and dark matter that is thought to make up most of the Universe; PLATO which would search for new planets orbiting distant stars; and Solar Orbiter, which would take the closest look yet at the Sun. Each of the missions already has involvement from UK science teams and the UK is well placed to contribute to the design and engineering involved.

Credit: CNES

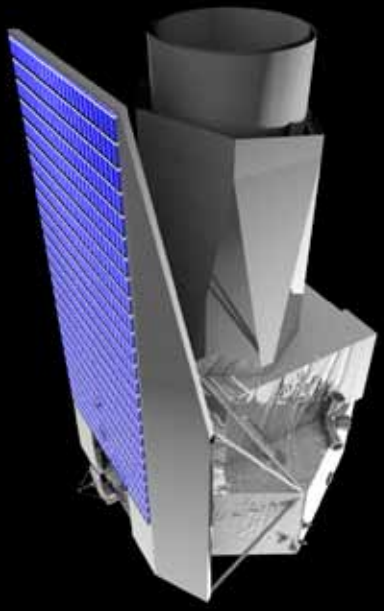


PLATO's search: one of the methods for detecting exoplanets is to look for a drop in brightness caused when they pass in front of their parent star



Artist's sketch of the Solar Orbiter

Credit: ESA



Artist's image of the Euclid satellite

Credit: ESA

Credit: Astrium

ExoMars rover

Aurora and the return to Mars

Aurora is the long-term European programme for the exploration of our Solar System. The UK is taking a leading role in the future exploration of Mars. In 2009 the ExoMars mission was redefined as a larger-scale collaboration between ESA and NASA and now consists of two key international missions: Mars 2016 and Mars 2018.

In 2016 an ESA-led orbiter will study the origin and distribution of methane and other trace gases in the atmosphere. It will also carry a lander to demonstrate European capability in undertaking a controlled landing on Mars.

The 2018 NASA mission will land the European ExoMars rover and a NASA rover. Astrium is leading the development of the ExoMars rover and a team led by the UK is developing its Panoramic Camera System. Other UK academic institutions and companies are working on instruments, components and software. Research from the Aurora programme has already resulted in patents, commercial applications and other spin-off benefits.

Aurora's long-term goal is for a Mars Sample Return mission. This would bring back samples of rock and soil to Earth for analysis. The International Mars Exploration Working Group – chaired by the UK during 2009/10, is co-ordinating plans for future Mars missions.

Earth Observation

Earth observation (EO) enables us to monitor changes to the environment and patterns of land use. It has revolutionised weather forecasting and the way we monitor the Earth's changing climate. EO has also transformed disaster prediction and response. Over the years, satellites have allowed us to accurately map the world and track pollution. They have also enabled us to witness the felling of rainforests, the advance of deserts and retreat of the ice sheets.

Great Britain and Ireland in 2009 as captured by Envisat, an ESA mission extended until 2013

Credit: ESA

The UK is a world leader in efforts to monitor the Earth from space. BNSC partner the Natural Environment Research Council has been responsible for the UK's funding of Earth Observation science missions and a number of UK EO facilities including the National Centre for Earth Observation. This centre brings together highly skilled scientists who use satellite data to investigate and understand some of our biggest environmental challenges.

By its very nature, EO is a global endeavour and the UK works closely with its international partners to co-ordinate space missions and share results. The UK supports EO through the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The UK is also an active member of groups such as the Committee on Earth Observation Satellites (CEOS), the Group on Earth Observation (GEO) and the International Charter Space and Major Disasters.

Credit: ESA

Artist's impression of GOCE

Earth Explorers

The UK is a major subscriber to the ESA Earth Observation Envelope Programme. Within this programme, the first three Earth explorer missions have now been launched: GOCE, SMOS and CryoSat-2.

GOCE (Gravity field and steady-state Ocean Circulation Explorer) has been in orbit for more than a year. Following a period of validation, the operations teams took over control of the satellite in November 2009. GOCE is measuring tiny variations in the Earth's gravitational field. The satellite employs a sophisticated electric propulsion system built in the UK by QinetiQ.

Following a successful launch in November 2009, ESA's Soil Moisture and Ocean Salinity (SMOS) satellite has begun its survey of moisture levels in the soil and the salinity of the oceans. These global measurements will improve our understanding of how water is transported around the Earth and how it circulates through the oceans. They will also lead to more accurate weather forecasts and climate simulations.

UK companies involved in SMOS include SciSys UK, ComDev and Chelton Antennas. Science teams include researchers from the National Oceanographic Centre and De Montfort University's Earth and Planetary Remote Sensing Laboratory.

Europe's 'ice mission', CryoSat-2, was launched in April 2010. Over the next five years, the satellite will measure the thickness of ice at the Earth's poles to the nearest centimetre. It will also monitor variations in Arctic sea ice to help assess long-term trends. The science team for the mission is being led from University College London (UCL).

Mapping changes at the poles are vital in our understanding of the Earth's changing climate. Polar ice is central to the Earth's climate

The night launch of SMOS and Proba-2

Credit: ESA

Cryosat measures the thickness of ice at the Earth's poles

Credit: ESA

"CryoSat-2 will help unravel the consequences of the dramatic changes in the poles that we've seen in the past two decades"

Duncan Wingham, CryoSat-2 Principal Investigator, UCL

system and a good indicator of what's happening across the world. Although previous satellites – such as Envisat – have been monitoring the polar regions, CryoSat-2's twin radar system and two onboard radar receivers will be able to produce a much more accurate 3D view of the ice.

Disaster management

Information from satellites is proving vital in aiding relief efforts and in assessing damage following disasters. The UK is a member of the International Charter Space and Major Disasters. This Charter can be triggered by national civil protection agencies and the United Nations to acquire and deliver data from satellites, for free, to those affected by natural or man-made disasters. The UK's involvement has been a collaboration between BNSC and UK company DMC International Imaging (DMCii). The Charter was activated 41 times in the financial year 2009/10, responding to disasters such as the earthquakes in Haiti and Chile, fires in Greece and flooding in the southern United States.

Surrey Satellite Technology Limited (SSTL) has built a unique network of satellites designed for disaster response. The Disaster Monitoring Constellation (DMC) provides detailed images of most parts of the world in times of need. The satellites are operated by the UK, Algeria, Nigeria, Spain and China and the DMC family of satellites continues to grow.

In July 2009, the UK-DMC2 and Spanish-owned Deimos-1 satellites were launched. These new generation satellites have improved cameras, enhanced memory capacity and faster communications. They can image much larger areas in a single pass than the previous satellites.

People queue for food in Haiti following the 7.0 magnitude earthquake that struck in January 2010

The effects of deforestation in the Amazon

A further DMC satellite, NigeriaSat-X, was built as part of a training programme for the West African country's future space scientists and engineers. It is scheduled for launch in 2010 alongside another SSTL satellite, NigeriaSat-2, the world's most advanced small satellite.

Although disaster management is an important role of the Constellation, its main purpose is to provide satellite images for commercial campaigns. DMCii is currently imaging sub-Saharan Africa for ESA's Global Monitoring for Environment and Security (GMES) programme, following a successful European campaign in 2007. The Constellation also mapped Indonesian forest clearing and has captured images of the Amazon Basin for the Brazilian government for 'six consecutive years' to measure changes in deforestation.

Global view

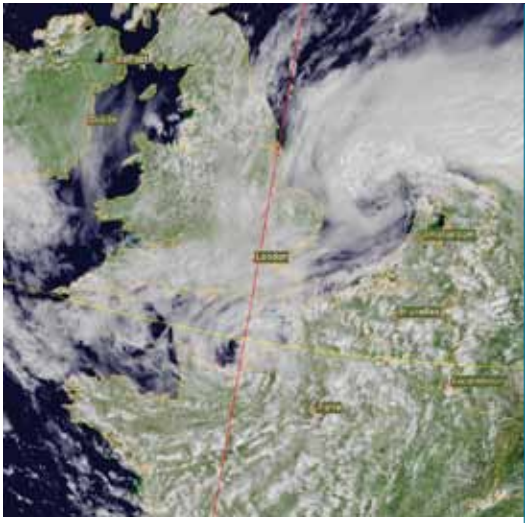
The UK supports international Earth Observation initiatives and is an active member of the Group on Earth Observation (GEO). Contributions are made both nationally and through the Committee on Earth Observation Satellites (CEOS). This committee contributes the space component to GEO, helping to respond to action areas identified in the ten year Global Earth Observation System of Systems (GEOSS) implementation plan.

Meanwhile in Europe, the Global Monitoring for Environment and Security (GMES) programme, a joint initiative between the European Commission and ESA, continues to develop. The UK is actively seeking to develop the GMES initiative to meet UK requirements and is working closely with ESA and the UK space community to achieve this.

Weather

Satellites are used to monitor the weather as it develops, as well as for long-term studies of weather and climate. The operation of Europe's weather satellites is co-ordinated by EUMETSAT, with the Met Office representing the UK.

The UK exploits the latest satellite technology to put itself at the forefront of modern weather forecasting. The combination of satellite observations and powerful computer models means that the accuracy of our two-day forecasts is now the same as one-day forecasts were ten years ago.



Double vortex over the North Sea and the Channel, June 2009
Credit: EUMETSAT

Meteosat Second Generation

Geostationary weather satellites provide a constant view of a large region of the Earth. Meteosat-9 provides images from across Europe and Africa every 15 minutes. Meteosat-8 serves as a backup and also provides a rapid scanning service, sending back images every five minutes. This improves our ability to monitor rapidly developing weather systems. Satellite information contributed to the accurate advance warnings of the Cumbrian floods in November 2009.

To ensure continuity of data, the Meteosat Third Generation (MTG) of satellites is already under development. MTG will provide continued geostationary imagery and satellite products beyond 2018.

MetOp

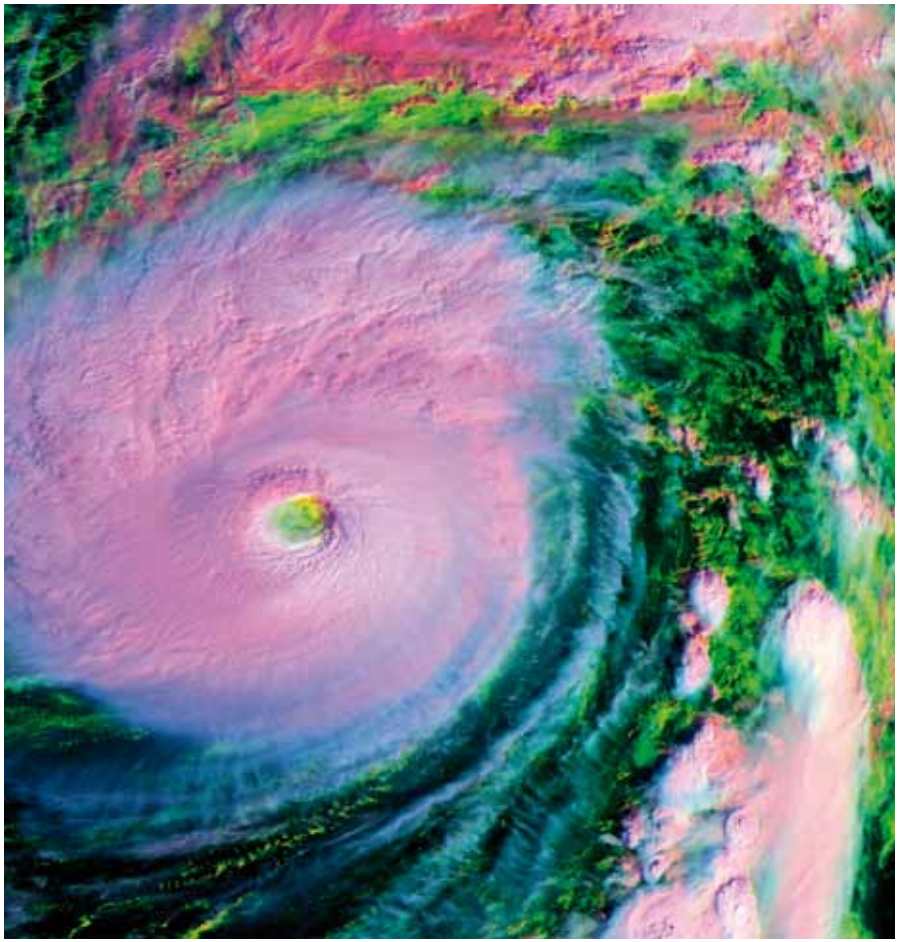
Europe's first operational polar-orbiting weather satellite, MetOp-A, was launched in 2006 and is the first of three MetOp satellites. The second, MetOp-B, is planned for launch in 2012. The final in the MetOp series, MetOp-C, will be launched after 2016.

Severe flooding in Cockermouth, Cumbria, followed torrential rain

MetOp satellites carry state-of-the art sounding and imaging instruments, providing precise details about atmospheric ozone and other trace gases, as well as wind speed and direction over the oceans. This improves weather forecasting and provides continuous, long-term, data records of the Earth's changing climate.

Jason-2

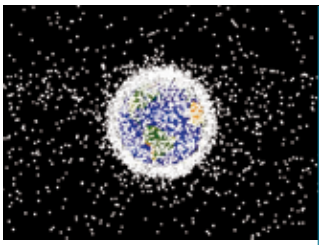
Jason-2 was launched in 2008. The third satellite in a series of high-accuracy ocean altimeters, the Jason series provides us with the capability to accurately measure sea level changes over the world's oceans. These satellites have improved our understanding of extreme weather events as well as the critical role the ocean plays in climate change. The follow-on programme, Jason-3, is currently in the development phase and is planned to provide high-accuracy altimetry data beyond 2013.



Typhoon Nida moving northward over the Pacific, east of the Philippines

Credit: Eumetsat

Credit: ESA



There are currently over 13,000 objects orbiting the Earth

Space Debris and Near Earth Objects

There are tens of thousands of objects orbiting the Earth but only around 800 of them are operational satellites. The rest are space debris, comprising everything from redundant satellites and launch stages, to fragments of metal and even flecks of paint. Currently more than 13,000 catalogued objects are being tracked in orbit. This debris poses a danger to orbiting satellites and can severely damage or even destroy them.

The UK has been at the forefront of international efforts to manage the threat posed by space debris and to prevent it from getting any worse. In February 2010, the United Nations established a Working Group to examine the long-term sustainability of space activities. Ultimately reporting to the General Assembly, BNSC has taken a leading role with other spacefaring nations in defining the scope of this important initiative. The group will engage with satellite operators and space agencies and make recommendations aimed at improving and formalising coordination between space users.

The UK funds the operation of the Starbrook space surveillance sensors. Developed by UK company Space Insight Limited, these sensors enable efficient surveys of debris in higher Earth orbits. Over the past year BNSC, in association with industry and academia, has also led the technical development of new international standards (ISO) for debris mitigation. Aimed at satellite manufacturers and operators, these standards will be refined following further consultation and reviews.

The International Space Station must change its orbit to avoid being hit by space debris

Credit: ESA

"This next level of guidelines will seek to encourage best practice and coordination amongst satellite operators in both government and industry"

Richard Crowther, UK Space Agency

Scientists at Surrey Satellite Technology Limited have developed a concept for de-orbiting redundant satellites. The Cubesail demonstration mission consists of a small (10 cm x 10 cm x 30 cm) satellite that deploys a 25 square metre plastic sheet. In low Earth orbit, residual air molecules will catch the sheet, dragging the satellite towards the Earth to burn up in the atmosphere. Cubesail is due for launch in 2011 and, if successful, the low-cost system could be fitted to future satellites and launch vehicles.

Near Earth Objects

Comets or asteroids whose orbits come close to our planet are called Near Earth Objects (NEOs). If a fragment of cosmic debris of even a few metres across were to hit the Earth, it would have a catastrophic effect. A January

CASE STUDY

OUTER SPACE ACT

BNSC (and now the UK Space Agency) regulates UK space activity to ensure it complies with Britain's international obligations, including space debris mitigation. The Outer Space Act (OSA) 1986 requires UK individuals or organisations to apply for a licence whenever they launch or procure the launch of a space object, operate a space object or carry out any other activity in outer space.

The UK considers it particularly important that satellite operators are able to dispose of their satellites once they have reached the end of their operational life to avoid contributing to the problem of space debris.

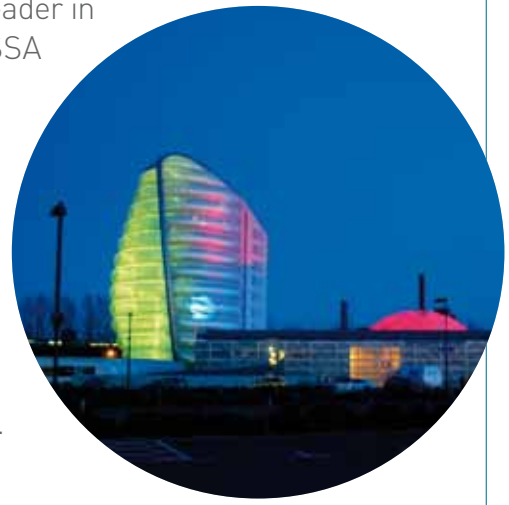
2010 meeting in Mexico City involving government scientists, legislators and astronauts concluded that governments have an important role to play in identifying and tackling any potential NEO hazard, as well as communicating this to the public.

The UK supports international efforts to track NEOs and in 2009/10 chaired the UN Working Group addressing the NEO threat. The Government also supports outreach programmes to provide accurate and timely information on NEOs to the public and media. In Europe, the ESA Space Situational Awareness (SSA) programme combines the issues of space debris, coordination of orbital data, NEOs and space weather (the impact of the space environment on spacecraft and the Earth). The UK is a leader in all of these fields and was one of the founding agencies of the SSA programme.

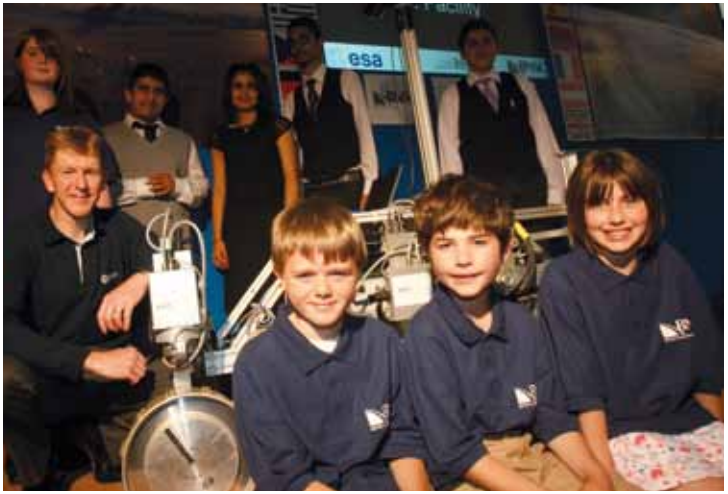
The UK has two outreach centres: The Spaceguard Centre, located at the former Powys Observatory, near Knighton in mid-Wales; and the Near Earth Object Information Centre (NEOIC), established in response to the Government's Task Force Report on NEOs. The NEOIC is operated by a consortium led by the National Space Centre in Leicester (under contract to BNSC) and includes a NEO exhibition. It provides a primary contact point for public and media enquiries.

Leicester's National Space Centre

Credit: National Space Centre



Credit: BIS



UK astronaut Tim Peake with students and Britain's prototype Mars rover

Education

Space offers one of the most varied and exciting ways to teach science, technology, engineering and mathematics (STEM) subjects. The space industry provides a range of exciting jobs and needs well-qualified workers to continue its expansion. These two strands are mutually-supportive: space can be used to inspire take-up of STEM subjects and this in turn will result in greater numbers of skilled workers available to both the space sector and the wider economy.

To help enable this, a European Space Education Resource Office (ESERO) has been set up in the UK to provide space-related resources to help teachers to deliver the STEM curriculum. Many of these resources already exist at a local level or elsewhere in Europe, but the ESERO will develop networks of educators to collate, evaluate and promote them. It is operated by the National STEM Centre, based at the University of York, and is due to be available for use from early autumn 2010. Funding is being provided by ESA and the Department for Education.

Also this year, a scholarship scheme was announced to support UK students to enable them to attend the International Space University in Strasbourg. The aim is to encourage more students to consider careers in the space sector and to increase the number of well-qualified staff available to UK companies.

The 'Space for All' community funding scheme has, in its first round, supported 13 groups carrying out education, outreach and promotion activities across the UK. These include a schools contest in which 160 pupils from 12 schools spent a weekend at Imperial College London designing space settlements. The winners are due to compete at the international finals in Houston, Texas in July 2010. Other grants support inspirational STEM teaching in Cornwall, space days in primary schools as well as cross-curricular space-based activities run by Queen Mary University of London focused on IT, design and STEM. Support has also been given to a group coordinating events surrounding the 50th anniversary of human space flight in 2011 and for the UK Space Conference held at Charterhouse School in April 2010.

A public consultation was undertaken by BNSC during the summer of 2009 on the need for a National Space Conference. There was widespread support throughout the space sector for BNSC to facilitate such a conference to bring together for the first time various existing events run by different organisations to involve industry, academia, policy-makers, students and the media.

Communications

2009-10 was the 'Year of the Launch'. In this transformational year the British National Space Centre (BNSC) worked closely with the European Space Agency (ESA), BNSC partners, the research community and industry contacts, to raise the profile of space in order to share the enormous benefits that space research and technology brings to us all.

The UK Space Agency website

Keeping you up-to-date

BNSC promoted an array of missions including the Herschel and Planck space observatories, the Gravity field and steady-state Ocean Circulation Explorer (GOCE), the Soil Moisture and Ocean Salinity (SMOS) satellite, CryoSat-2 and ExoMars. Other milestones included: coordinating the launch of ESA's first facility in the UK at Harwell, Oxfordshire; the completion and response to the Space Innovation and Growth Strategy; the announcement of the first Briton, Tim Peake, selected by ESA to be trained as an astronaut; and the successful launch of the UK Space Agency – which headlined news of a £40m investment in the International Space Innovation Centre (ISIC) at Harwell. All these events generated extensive coverage in major national news outlets.

Speaker platforms ranged from the annual conference of UK Students for the Exploration and Development of Space (UKSEDS) – targeted at students studying physics, engineering and space related degrees – to the XIth European Inter-parliamentary Space Conference, which showcased

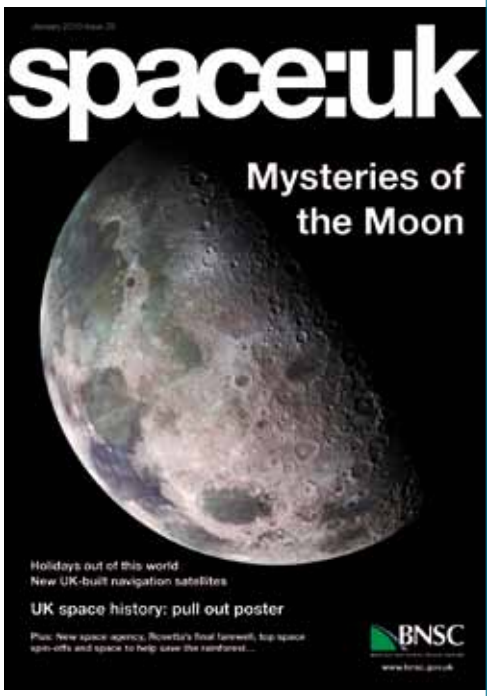
UK policy and industrial developments to an influential audience of parliamentarians from Europe's ten leading space nations.

At the start of 2009, the BNSC website, now relaunched as www.ukspaceagency.bis.gov.uk, was refreshed as part of a plan to develop the site into *the* first source of information about UK involvement in space. The website hosts a wide range of information including the latest developments in UK space science and industry, and details of forthcoming space events. Publications such as the annual report and *space:uk* magazine, the widely distributed BNSC forum for space news and educational articles, are also available for free download. In addition, people can now follow us on digital channels such as Twitter, YouTube and FaceBook.

Through its communications efforts, the UK Space Agency is highlighting how important the space and satellite industry is to the UK. Space is critical in providing high-speed broadband, high definition television, GPS and weather forecasting to the modern world. The UK Space Agency communications team will continue working to ensure people can keep up to date with the latest news and developments in this exciting and inspirational field.

"Space is a fascinating subject and through our wide ranging and varied communications work we are reaching an ever increasing and worldwide audience"

Emma Lord, UK Space Agency



Space:uk magazine

Finance

Breakdown of funds – by spend area (£ million)

Amount accrued during financial year 2009/10	UK Contributors								
	STFC	NERC	TSB	MOD	Met Office	Defra	DECC	BIS	Total
Earth observation									
National		6.84	0.50			0.10		0.50	7.94
ESA		52.17		Note 1		1.00			53.17
EUMETSAT					27.20	0.07	0.26		27.53
AATSR							0.82		0.82
Science/Exploration									
National	31.50							0.20	31.70
ESA	80.00								80.00
Telecomms and navigation									
National			0.50	Note 2				0.10	0.60
ESA			73.00						73.00
Technology									
National				0.10				0.20	0.30
ESA									0.00
Transportation									
National									0.00
ESA			7.00						7.00
Other national								0.80	0.80
ESA general budget	18.30	11.36							29.66
Total	129.80	70.37	81.00	0.10	27.20	1.17	1.08	1.80	312.52

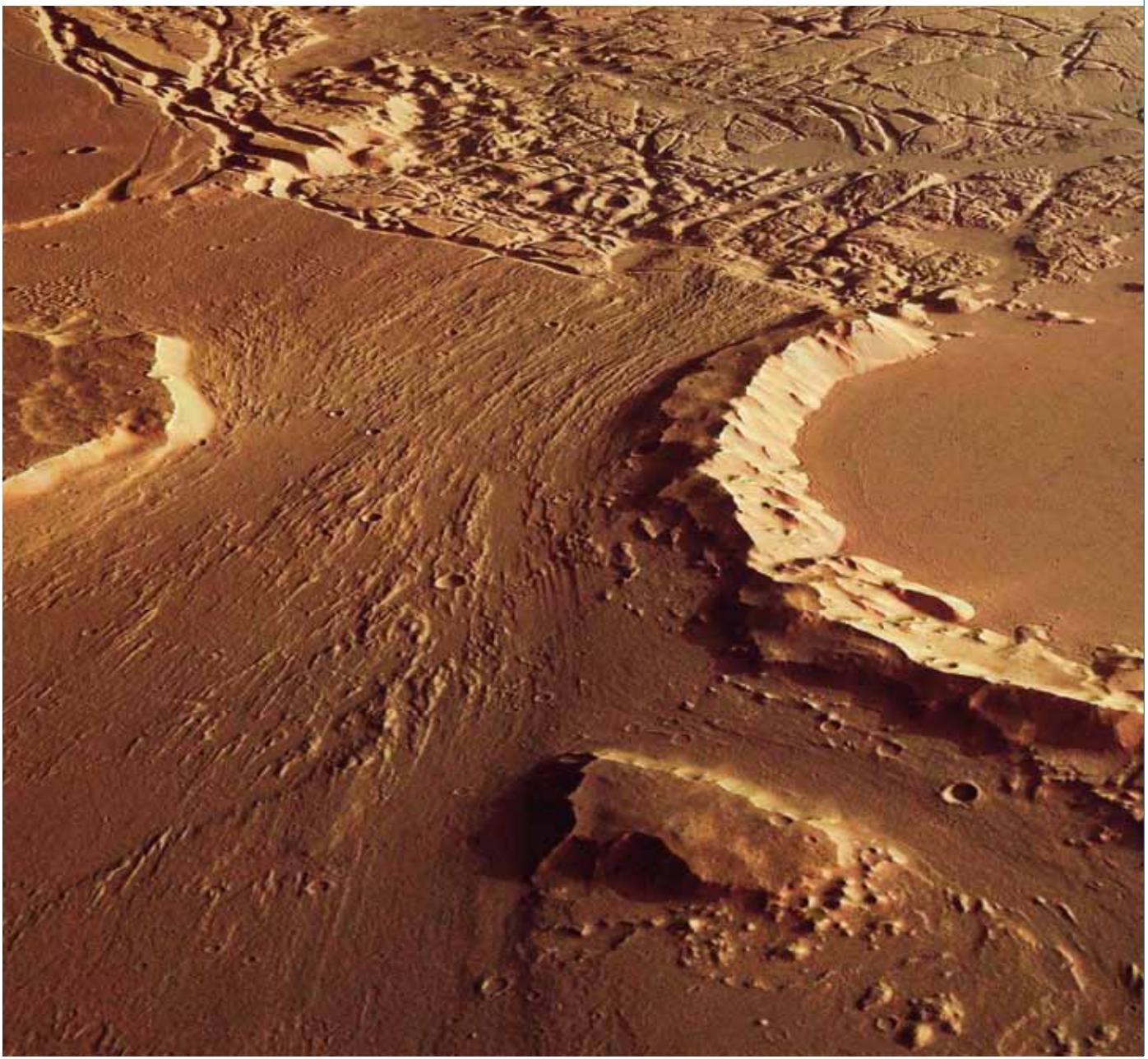
Note 1. MOD benefits from a number of ESA programmes but funding for these is covered under National contributions

Note 2. MOD expenditure on SATCOM for Defence purposes is not publicly releaseable

Note 3. Money contributed to ESA by DIUS (2008/09) is now paid by TSB

Note 4. TSB figures shown are estimated, based on interim accounts

Aurora is the largest space exploration programme that the UK has significant interest in. It involves detailed exploration of the surface of Mars and the return of samples



Credit: ESA

UK Space Agency
Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1SZ
Tel: +44 (0)20 215 5000 ukspaceagencyinfo@ukspaceagency.bis.gov.uk www.ukspaceagency.bis.gov.uk
Printed in the UK on paper with a recycled content of 75% July 2010. URN 10/88