UK | Space Activities 2008

BNSC
BRITISH NATIONAL SPACE CENTRE

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INTRODUCTION BY DAVID WILLIAMS DIRECTOR GENERAL OF BNSC

Welcome to the 2008 edition of UK Space Activities, the British National Space Centre's (BNSC's) annual publication that covers the achievements of the past year and looks forward to the next 12 months.

This year has been busy from a policy perspective. It has seen the publication of the former House of Commons Science and Technology Select Committee's report into UK space policy in July 2007 and the Government's response. In February 2008, the UK Civil Space Strategy 2008-2012 and beyond was published, which set out a new high-level vision for BNSC.

During the last year, Government restructuring of the former Department of Trade and Industry (DTI) and Department for Education and Skills (DfES) led to the creation of three new Departments: the Department for Business, Enterprise & Regulatory Reform (BERR), the Department for Innovation, Universities & Skills (DIUS) and the Department for Children, Schools and Families (DCSF). DIUS has taken over the hosting of BNSC from DTI, and BERR and DCSF have become new members of the BNSC partnership.

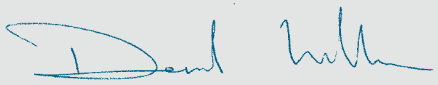
This year has seen a high level of interest in the UK's space activities. The UK has been involved in several excellent space science missions, including Venus Express, Hinode and STEREO. These missions, organised by the European Space Agency (ESA), have led to a new understanding of the Sun and our nearest planetary neighbour, Venus.

There have also been important developments in the use of space applications and information, such as the UK's leadership of the International Charter for 'Space and Major Disasters' and the successful launch of the second Galileo test satellite, GIOVE-B. In addition, the new National Centre for Earth Observation, involving 26 UK universities, was inaugurated.

The next few months are marked by two major international events. The first, in September 2008, is the 59th International Astronautical Congress in Glasgow. This is the first time the UK has hosted this prestigious occasion since 1987. It is followed in November by the ESA Ministerial Council in The Hague.

On the domestic front, the major event in the coming year for BNSC will be the relocation of our offices from London to Swindon. Whilst DIUS will remain the host Department for BNSC, we will be co-located in Swindon with the Natural Environment Research Council, the Science and Technology Facilities Council, and the Technology Strategy Board.

I hope you enjoy reading UK Space Activities.



Dr David Williams
Director General

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1 Artist's image of the Venusian surface; *Credit: ESA*

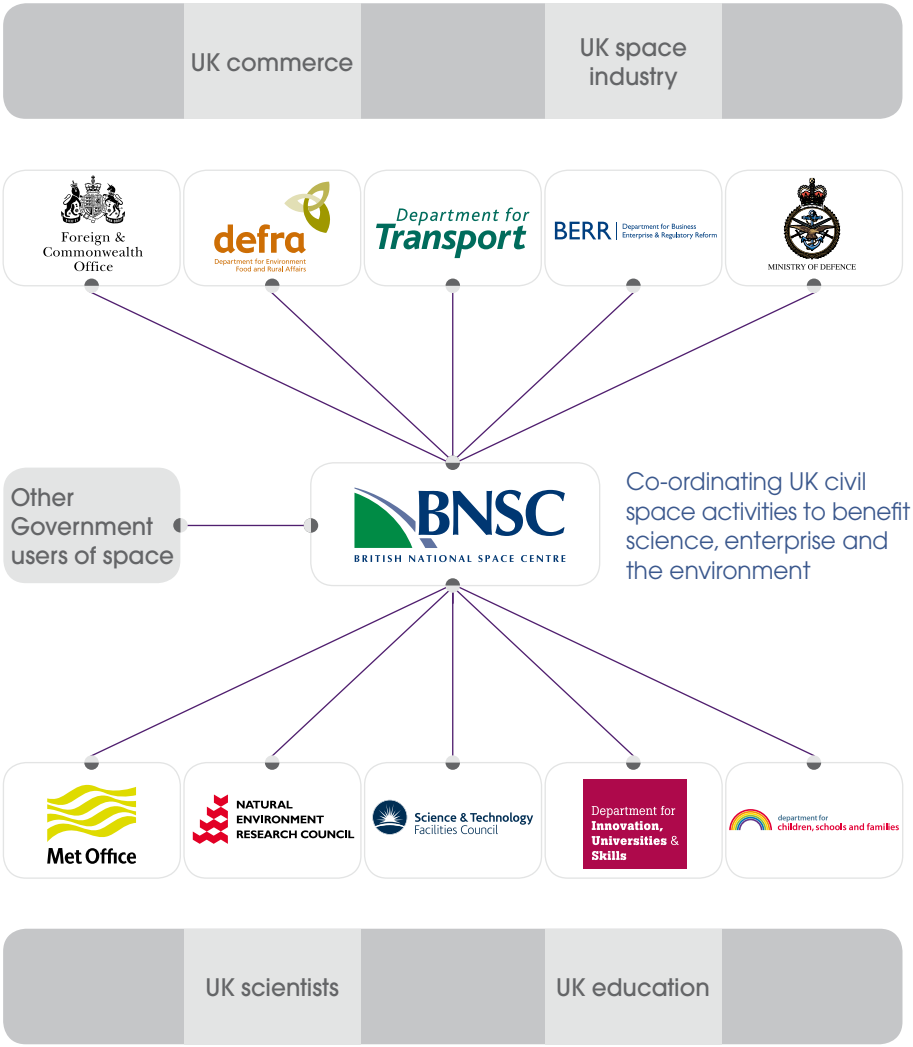
2 Envisat captures an ice-free Foxe Basin; *Credit: ESA*

BNSC PARTNERSHIP

The British National Space Centre (BNSC) is a partnership of seven Government departments, two research councils and the Met Office. Reporting to the Minister for Science and Innovation in the Department for Innovation, Universities & Skills (DIUS), BNSC is at the heart of Government efforts to explore and exploit space.

BNSC co-ordinates UK civil space activities and brings together representatives from Government, science, industry and education to promote advances in space technology and science to ensure the UK's investments in space are made to maximum benefit. BNSC also supports the use of space to inspire young people and play a key role in the teaching of maths, engineering and science.

The BNSC ethos of collaboration applies across Government as well as to external organisations, including European and global partners such as the European Space Agency (ESA), the European Union, national space agencies and the United Nations (UN).



UK CIVIL SPACE STRATEGY

This year saw the publication of the 'UK Civil Space Strategy 2008-2012 and beyond'. The strategy document was developed following a wide-ranging public consultation, with opinions received from members of the public, industry and academia. It also followed the publication of a detailed and thorough inquiry into UK space policy undertaken by the former House of Commons Science and Technology Committee.

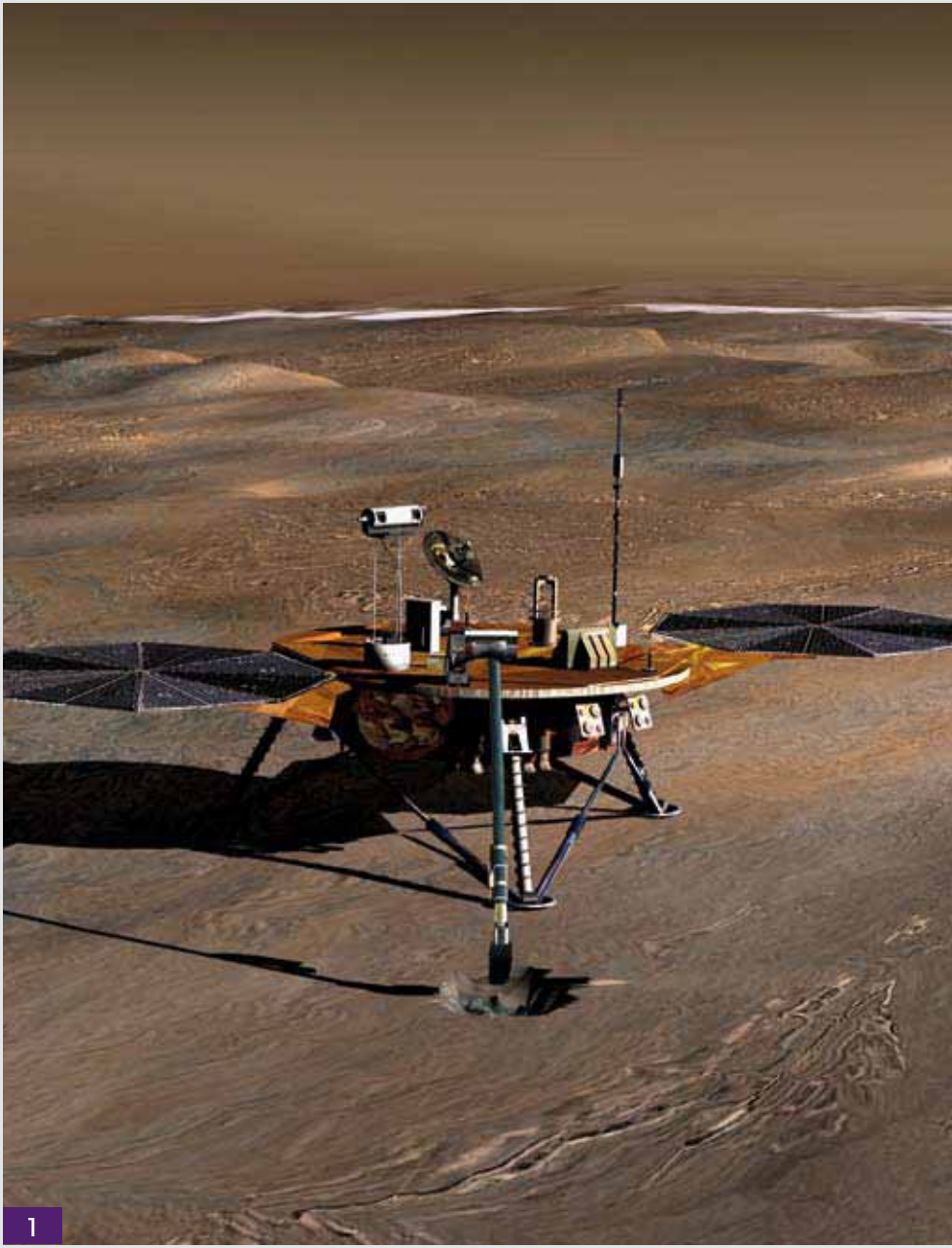
This strategy will shape the future direction of UK space policy and is based on five key objectives:

- win an increasing share of the global market in space systems, services and applications in the race to develop tomorrow's economy
- deliver world-leading exploitation of space systems for managing our changing planet
- be a partner of choice in global scientific missions to explore the Universe
- benefit our society by strengthening innovation from space, and stimulate the creation of new products and services for everyday use
- develop a major channel for skills development and outreach for a high-technology future, and improve public and political recognition of the value of space systems as part of the critical national infrastructure

1 Land's End seen by the UK's TopSat satellite; *Credit: QinetiQ*

It is the role of BNSC to provide the strategic leadership and co-ordination between Government, academia and business in order to deliver this vision.

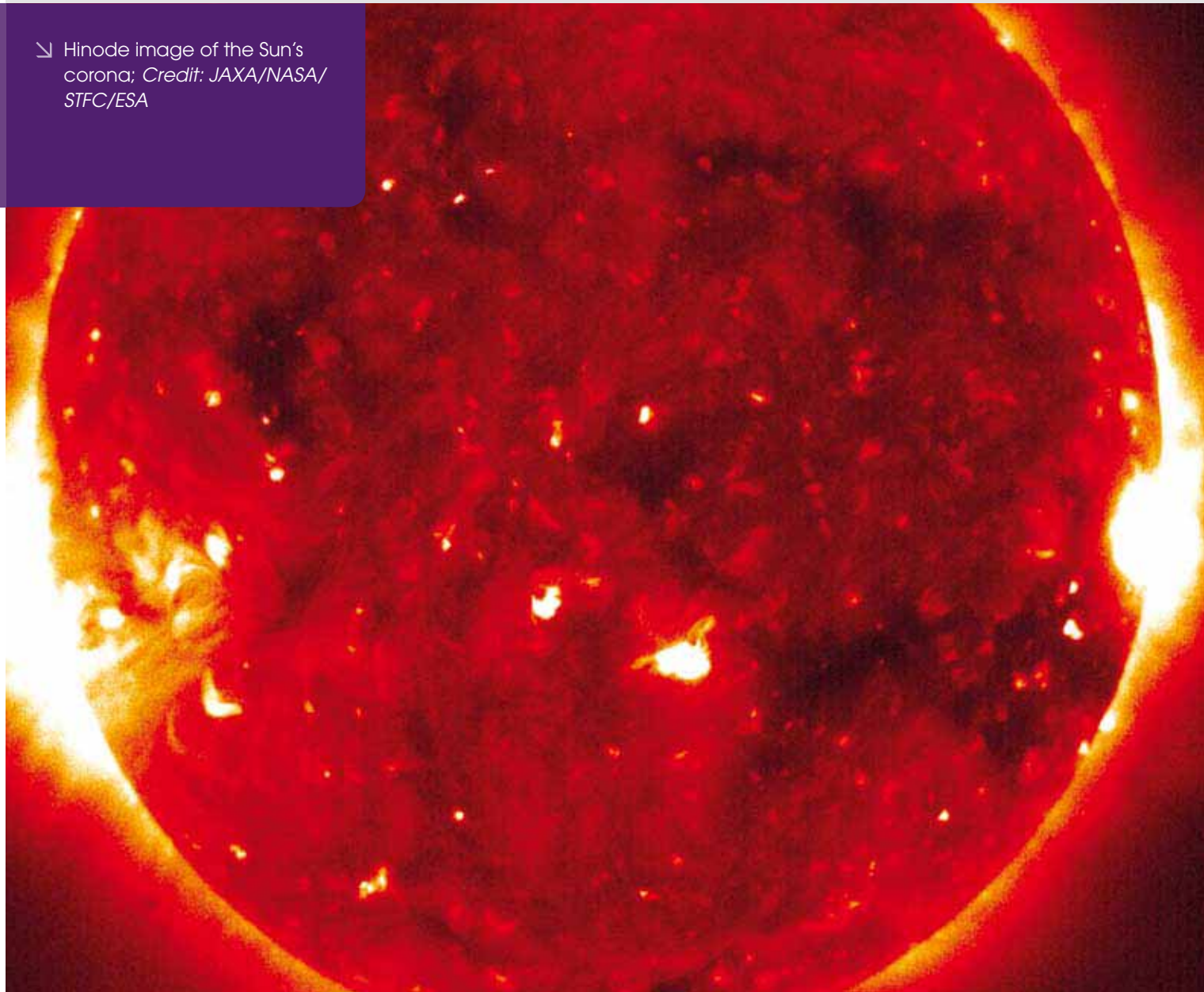
The UK Civil Space Strategy recognises the enormous contribution space makes to our economy and the direct benefits it brings to all our lives. It also emphasises the importance of using space to understand the environmental challenges we face, manage resources and respond to disasters. The UK is a world leader in many areas of space science, innovation and Earth observation and BNSC aims to ensure that space will play a key role in the UK's future economic prosperity.



1 UK scientists are involved in the latest mission to Mars – Phoenix; *Credit: NASA/JPL*

HIGHLIGHTS 2007-2008

↘ Hinode image of the Sun's corona; *Credit: JAXA/NASA/ STFC/ESA*



With an ambitious satellite navigation programme, more than 20 ongoing space science missions, innovative new satellites, international partnerships and improved disaster response, the UK is involved in a wide range of space activities. More details of the activities and events outlined here are detailed in later sections.

INTERNATIONAL LEADERSHIP

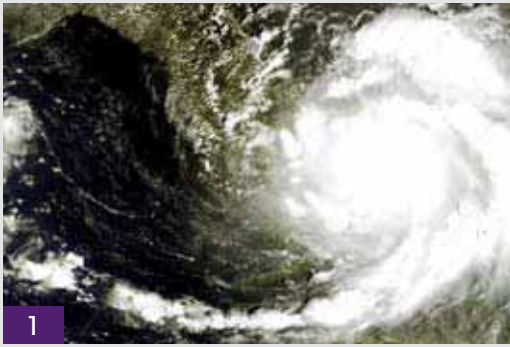
Satellite information can help save lives and is proving vital in the aftermath of natural or man-made disasters. From October 2007, the UK led the International Charter 'Space and Major Disasters'. The Charter can be triggered by national civil protection agencies and the UN to acquire and deliver space data to those who need it most. There were 18 activations during the period the UK led the Charter, with satellites being used to track the progress of disasters and monitor and map the extent of damage. **See pages 12 to 15.**

SATELLITE SUCCESS

Europe's Galileo satellite navigation programme took a major step forward this year with the launch of the second test satellite, GIOVE-B. The payload for GIOVE-B was developed by Astrium in the UK with the satellite carrying the most accurate clock ever flown in space. Eventually, Galileo will feature 30 satellites to provide the whole planet with a highly accurate, guaranteed global positioning system under civilian control. **See pages 44 to 47.**

CLOSE TO THE SUN

UK scientists are involved in major international missions to study the Sun and its influence on the Earth. Hinode has sent back dramatic images of giant fountains of hot gas erupting in the star's atmosphere and has provided new insights into the origins of solar flares. After more than a year in their operational orbits, the twin STEREO (Solar Terrestrial Relations Observatory) spacecraft are helping scientists investigate the complex structure of the Sun and its extended atmosphere. **See pages 17 to 19.**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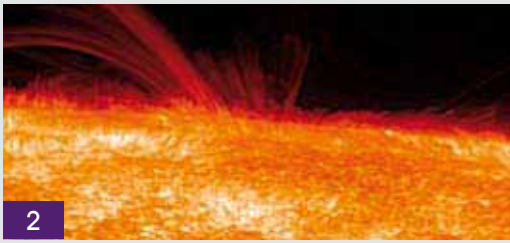
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1 Hurricane Katrina off the coast of southern Florida. Satellites are proving vital in weather forecasting and disaster response; *Credit: ESA*

2 The surface of the Sun seen by Hinode; *Credit: ESA/JAXA/NASA/STFC*

3 GIOVE-B, Europe's latest navigation satellite; *Credit: ESA/P Müller*

VENUS REVEALED

Venus Express is continuing to unravel the mysteries of Venus. The spacecraft has enabled scientists to investigate Venus from the top of its thick cloudy atmosphere down to the volcanic surface. With the mission now extended, new results could help us better understand climate change on Earth. **See page 21.**

SATURN

Cassini-Huygens is undoubtedly one of the most successful space missions ever launched. After four years in orbit around Saturn, the international endeavour continues to produce new and exciting results. The UK has been at the forefront of the design, engineering and science of Cassini-Huygens, whose mission has now been extended until 2010. Achievements this year included flying through spectacular jets of ice particles erupting from the south pole of the moon Enceladus. **See page 25.**

1 Artist's image of Venus Express entering its operational orbit; *Credit: ESA/AOES Medialab*

SWIFT PROGRESS

A mission designed to detect, locate and observe gamma ray bursts – powerful cosmic explosions – has witnessed the brightest yet seen. The Swift Gamma-Ray Burst Explorer has key UK involvement and is one of a number of missions examining the very depths of space. Other missions include the Herschel Space Observatory – the largest ever infrared space observatory – which is designed to collect radiation from some of the coldest and most distant objects in the Universe.
See page 26 and 27.

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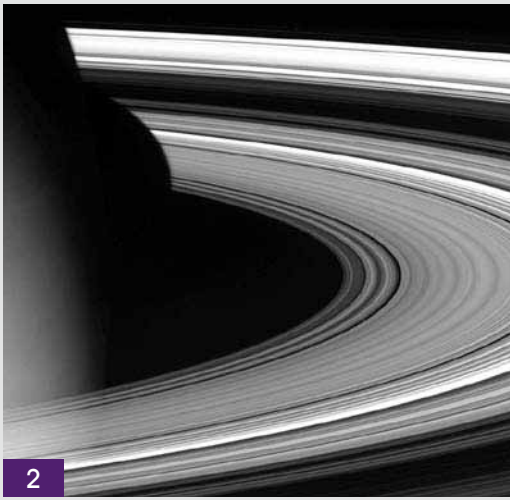
1 Inspecting the mirror on the new Herschel space observatory; *Credit: ESA*

2 Cassini image of Saturn's rings; *Credit: NASA/JPL/Space Science Institute*



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OUR CHANGING PLANET

UK science teams have leading roles in key missions to assess the global impact of human activity and the future extent of climate change. A new national centre has been set up, involving 26 UK universities and more than 100 staff. The National Centre for Earth Observation aims to provide reliable information to enable government, business and citizens to manage the environment wisely and predict how it will change. This year has also seen a major scientific effort focused on the Earth's polar regions and the extension of the Envisat mission – Europe's largest and most sophisticated Earth observation satellite.
See pages 30 to 43.

GLOBAL PARTNERSHIPS

Ties between the UK and US in space continue to be strengthened with the establishment of a Joint Working Group which has been examining the possibilities of working together on future missions to the Moon and Mars. In February 2008, the group identified potential areas of collaboration, including the development of a UK-led robotic lunar mission.
See page 22.

NEW CONTRACTS

The UK space industry employs more than 16,000 skilled individuals and generates a turnover of almost five billion pounds. This year has seen UK companies continue to win new contracts and develop new products. Highlights include an agreement between the UK's largest satellite manufacturers as well as success for a small Cumbrian software company which has won a major contract with NASA.
See pages 52 to 55.


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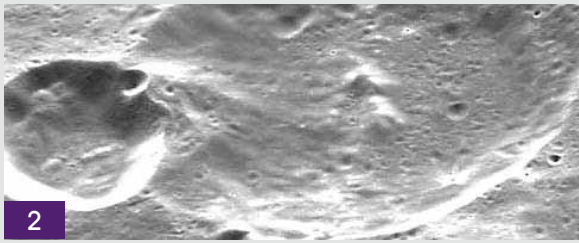
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1 This Envisat image shows the Italian island of Sardinia; *Credit: ESA*

2 SMART-1 image taken during its final few orbits; *Credit: ESA/SPACE-X (Space Exploration Institute)*

3 Orion arrives at NASA's Dryden Flight Research Center in California; *Credit: NASA*

SEEING SATELLITES

The Earth has become surrounded by tens of thousands of objects. These range from working satellites to parts of rockets and tiny bits of 'space junk' such as fragments of dead satellites. A ground-based sensor to track orbiting satellites has been developed by a UK company with support from BNSC. **See pages 58 to 59.**

HALF A CENTURY IN SPACE

October 2007 marked the 50th anniversary of the launch of the Earth's first artificial satellite, Sputnik-1. The dawn of the space age was celebrated with events across the UK. 2007 also marked the 50th anniversary of the Lovell Telescope at Jodrell Bank in Cheshire. Working with its partners, BNSC has been proud to celebrate 50 years of the UK's considerable achievements in space and looks ahead to the next half century. **See page 64 to 65.**

1 The destruction of satellites and rocket bodies creates thousands of pieces of space debris; *Credit: ESA*

INTERNATIONAL COLLABORATION

↘ Phytoplankton bloom off the coast of Scotland; Credit: *ESA*

As a global resource, space can bring benefits to everyone on the planet. To maximise the potential of space exploration and exploitation, nations need to work together in scientific research and development.

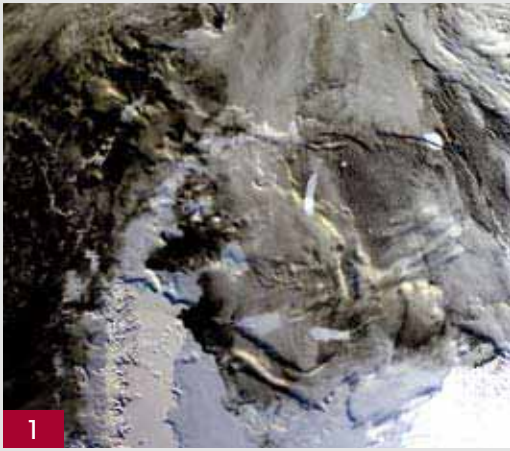
International partnerships are crucial to the UK for all aspects of space science and technology. By working with international partners, the UK can take part in a wide range of space activities that it would be unable to carry out alone.

BNSC co-ordinates the UK's relations with the world civil space community. This co-operation includes projects with European partners and bilateral agreements with an increasing number of other nations. The UK works to co-ordinate space activities at global level through bodies such as the Committee on Earth Observation Satellites (CEOS), the International Space Exploration Co-ordination Group, the International Charter 'Space and Major Disasters' and the United Nations.

EUROPEAN PARTNERSHIPS

Some 70 per cent of the total civil space investment by BNSC's partners is channelled through the European Space Agency (ESA). ESA is among the front rank of space organisations and, since its inception in 1975, has generated enormous benefits for its Member States and their citizens. UK funding for space activities is also invested in the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).
See page 41.

ESA has developed a range of programmes intended to provide Europe and its citizens with a competitive space sector, lead the search for new discoveries and consolidate Europe's share of the worldwide market. The UK is working closely with its European partners to shape the future direction of space exploration.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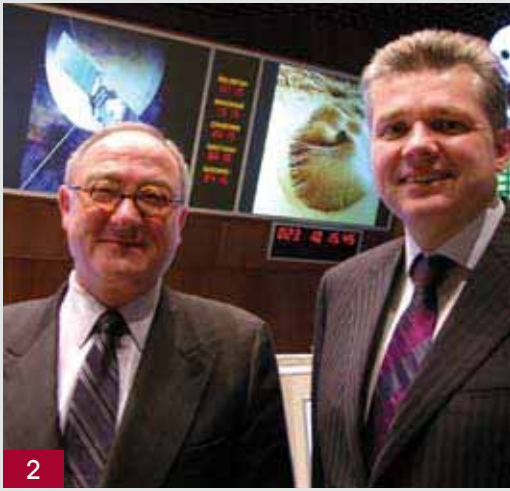
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1 Peninsula in the Antarctic observed from space; *Credit: ESA*

2 Ian Pearson MP, UK Minister of State for Science and Innovation (right) with ESA Director General Jean-Jacques Dordain (left) in the main control room at ESA's Operations Centre at Darmstadt in Germany during his visit in January 2008; *Credit: ESA*

Approximately every three years the ESA Council meets at Ministerial level to discuss future objectives and priorities. The next meeting will be in The Hague, Netherlands in November 2008. At the last ESA Ministerial (Berlin 2005) Member States committed some €8.8 billion to ESA programmes and activities. The UK is represented at these Councils by the Minister for Science and Innovation.

European Space Ministers also meet at EU 'Space Councils' to discuss and agree a coherent approach to space-related issues. A European Space Policy (ESP), setting the priorities for future European space activities, has been developed by the European Commission and ESA, and was presented to the May 2007 Space Council. The UK took a full role in the development of this ESP and is now working to agree an implementation plan. The policy aims to foster better co-ordination of civil space programmes between the European Union, ESA and their Member States.

At its forthcoming meeting in September 2008, the Space Council will focus on the European Space Policy in relation to four key areas: climate change, competitiveness, security and exploration. The UK will be represented at the Space Council by the Minister for Science and Innovation.

The UK is the second largest financial contributor (17 per cent) to the ESA Aurora programme to explore the Moon and Mars. Final decisions on future strategy for long-term exploration will be taken at the ESA Ministerial meeting in November.

ESA is in the process of drawing up its scientific programme for 2015-2025 and the Science and Technology Facilities Council (STFC) is currently assessing the missions being considered for future development. European funding for collaborative research and development projects in science, technology and engineering also comes to the UK via the EU's Framework Programme. **See page 55.**

1 This year BNSC signed a further agreement with the Algerian Space Agency; *Credit: T Perriment*

2 The UK was well represented at the IAC held in Hyderabad, India

INTERNATIONAL PARTNERSHIPS

The UK space community collaborates with most of the world's space agencies and, through BNSC, continues to forge new international partnerships. BNSC actively promotes UK space interests through international exhibitions, trade delegations, seminars and publicity campaigns.

BNSC works closely with UK Trade and Investment, the Government organisation that supports UK companies doing international business. It also liaises with the Science and Innovation Network, set up by the Foreign & Commonwealth Office to encourage interchange between international science communities and foster closer global links between science and business.

The United States is one of the UK's longest standing international partners in space exploration. These ties have continued to be strengthened this year following further visits from NASA Administrator Michael Griffin and with the establishment of a Joint Working Group which has been examining the possibilities of working together on future missions to the Moon and Mars.

BNSC is also active with other countries. For example, in April 2008, the Director Generals of the Algerian Space Agency and BNSC signed an agreement to further strengthen space collaboration.

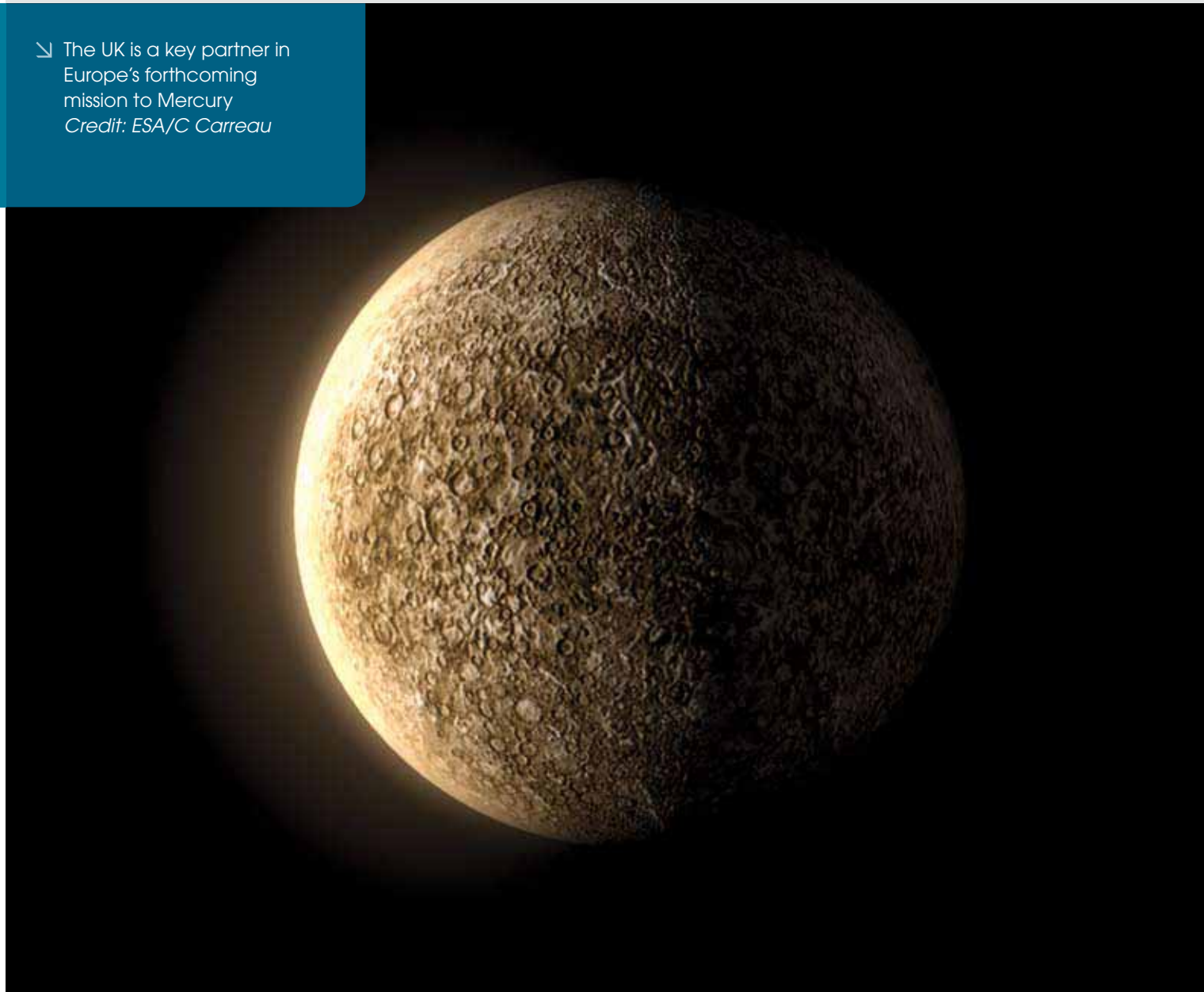
The UK works with the United Nations Office for Outer Space Affairs, responsible for promoting international co-operation in the peaceful uses of outer space. BNSC also takes a leading role in organisations such as the Inter-Agency Space Debris Co-ordination Committee and international groups concerned with Near Earth Objects. **See pages 60 to 61.** Through its membership of the Committee on Earth Observation Satellites (CEOS), BNSC works to foster closer co-operation in missions that observe and study the Earth.

The UK took over the lead of the International Charter 'Space and Major Disasters' in October 2007. The Charter provides for the free provision of satellite imagery following major disasters. More details of the UK's activities during its leadership of the Charter are given on **pages 33 to 35.**

BNSC is an active supporter of the International Astronautical Congress (IAC), the world's premier annual space congress and exhibition. The 2007 event was held at Hyderabad in India with British experts presenting a wide range of technical papers. The UK space industry was well represented at the event.

2008 will be the first time the UK has hosted the IAC in more than 20 years. IAC Glasgow will be held from 28 September to 3 October 2008 at the Scottish Exhibition and Conference Centre in Glasgow. Further details are available at **www.iac2008.co.uk**

SPACE SCIENCE



↘ The UK is a key partner in Europe's forthcoming mission to Mercury
Credit: ESA/C Carreau

From satellites investigating the Earth's magnetic environment to spacecraft exploring the depths of the Universe, the UK is involved in more than 20 on-going space science missions and many other missions being prepared for launch over the next decade. These include missions to the Sun, Moon, Venus, Mars and Saturn as well as space telescopes and ambitious projects to answer fundamental questions about the nature of the Universe.

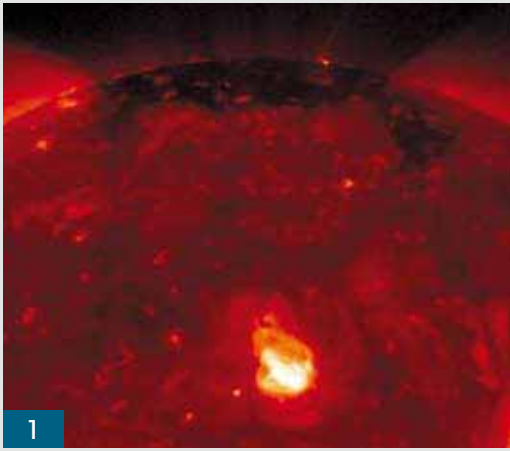
The UK's space science effort is funded through BNSC partner, the Science and Technology Facilities Council (STFC). The majority of missions with UK involvement are led by the European Space Agency (ESA). The UK is the second largest contributor to the ESA science programme. UK scientists also work with other international partners including NASA, the Japanese space agency (JAXA) and the Indian Space Research Organisation.

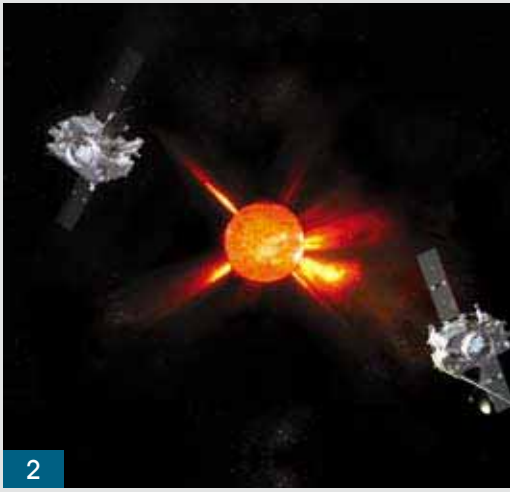
Activities to report this year include new results from ongoing missions and significant developments on future plans to explore the Solar System and beyond.

THE EARTH AND THE SUN

The past year (2007-2008) has seen one of the largest and most ambitious international scientific efforts for 50 years: International Polar Year (**see page 36**) and International Heliophysical Year (IHY). The main focus of IHY has been the study of how the Sun affects the Earth and the rest of the Solar System. The UK has particular expertise in solar physics, space plasmas and the atmospheres of planets, and UK scientists are involved in three major international missions to study the Sun: Hinode, STEREO and SOHO. The UK is also a leader in the ongoing effort to study the magnetic 'bubble' surrounding the Earth: the magnetosphere.

Launched in September 2006, the Japanese (JAXA) Hinode mission is studying the processes involved in solar flares and Coronal Mass Ejections – when billions of tonnes of particles are ejected into space. Designed and built by teams in the US, Japan and the UK, Hinode has key involvement from University College London's Mullard Space Science Laboratory (MSSL) and the STFC Rutherford Appleton Laboratory (RAL).





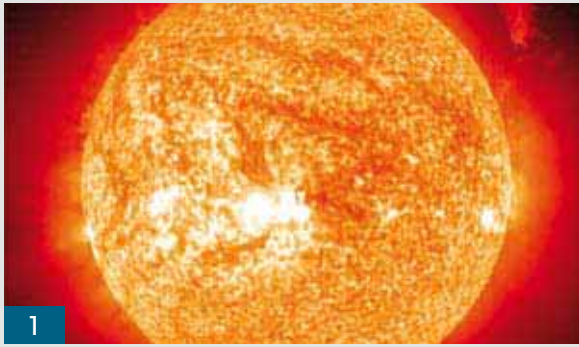
1 Hinode has sent back detailed images of the Sun; *Credit: JAXA/ NASA/STFC/ESA*

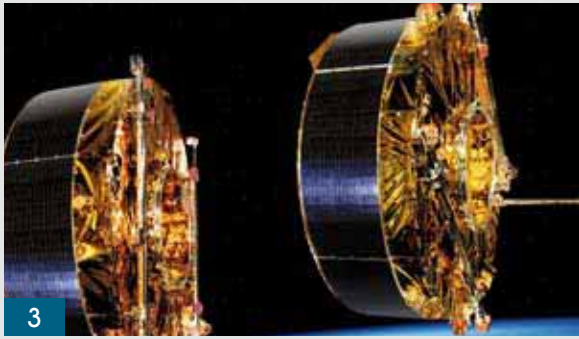
2 STEREO is studying the Sun from two different viewpoints in space; *Credit: NASA*

Hinode has been studying the Sun's dynamic atmosphere, including the giant fountains of hot gas erupting in the star's atmosphere, and has provided new insights into the origins of solar flares. One of the most significant results obtained from Hinode this year has been the discovery of the source of the solar wind – the continuous stream of charged particles emitted from the Sun. Every second a million tonnes of hot plasma and charged particles (electrons and ions) escape the Sun's gravity. By using data from the UK-built Extreme Ultraviolet Imaging Spectrometer (EIS) on board Hinode, an international team of scientists has found that when magnetic fields from two bright regions of activity on the Sun's surface collide they allow hot gas to escape. This material flows out as the solar wind.

A UK consortium developed the Heliospheric Imager, one of the key instruments on board the twin spacecraft of NASA's Solar Terrestrial Relations Observatory (STEREO). The development of the imager was led by RAL and the University of Birmingham. STEREO is now sending back remarkable 3D images of the Sun. After more than a year in their operational orbits, the spacecraft are helping scientists investigate the complex structure of the Sun and its extended atmosphere.

The two spacecraft are also tracking the powerful solar storms that can knock out vital communications and navigation satellites.





1 SOHO image of the Sun; *Credit: ESA/NASA*

2 One of the Cluster satellites being tested prior to launch; *Credit: ESA/ Starsem/S Corvaja*

3 The Cluster satellites orbit in formation; *Credit: ESA/J L Atteleyn*

Originally designed to last two years, the Solar and Heliospheric Observatory has been observing the Sun for more than twelve. SOHO is a joint project between ESA and NASA and has been studying the Sun from its deep core to outer corona. Mission highlights include revealing the first ever images of a star's turbulent outer shell – known as its convection zone – and the structure of sunspots below the surface. The UK remains a major player in the SOHO project, from design and construction, to operation and science. The UK-led Coronal Diagnostic Spectrometer instrument, used to investigate the physics of the Sun's atmosphere, is run from an operations facility at RAL.

The four Cluster satellites continue to examine the interaction between the solar wind and the magnetosphere. Each spacecraft carries 11 identical instruments, three of which are led by UK scientists. Cluster is being operated at RAL in conjunction with China's Double Star mission. TC-1, one of the two satellites of Double Star, has now been decommissioned and literally turned to dust as it re-entered Earth's atmosphere.

Europe is now planning Solar Orbiter. Teams are currently being selected for this ESA-led mission with NASA involvement. Due for launch in 2015, this mission will involve numerous Venus encounters, as well as Earth fly-bys, to give the spacecraft a highly eccentric 150-day orbit passing close to the Sun. This unusual orbit will allow scientists to study the Sun at all latitudes. A number of UK groups are bidding to provide instruments for this exciting mission.

Space pioneer bows out

The joint NASA and ESA Ulysses mission to study the Sun is finally drawing to a close. The spacecraft, which has lasted more than 17 years – or almost four times its expected mission lifetime – is now succumbing to the harsh conditions of space.

Ulysses was the first mission to survey the space environment above and below the poles of the sun. The massive amount of data Ulysses returned has forever changed the way scientists view our star and its effects. The UK was involved in Ulysses from the start. Imperial College London and the University of Kent helped to build four of the instruments on board. The team at Imperial has also been leading the studies of the Sun's magnetic field.

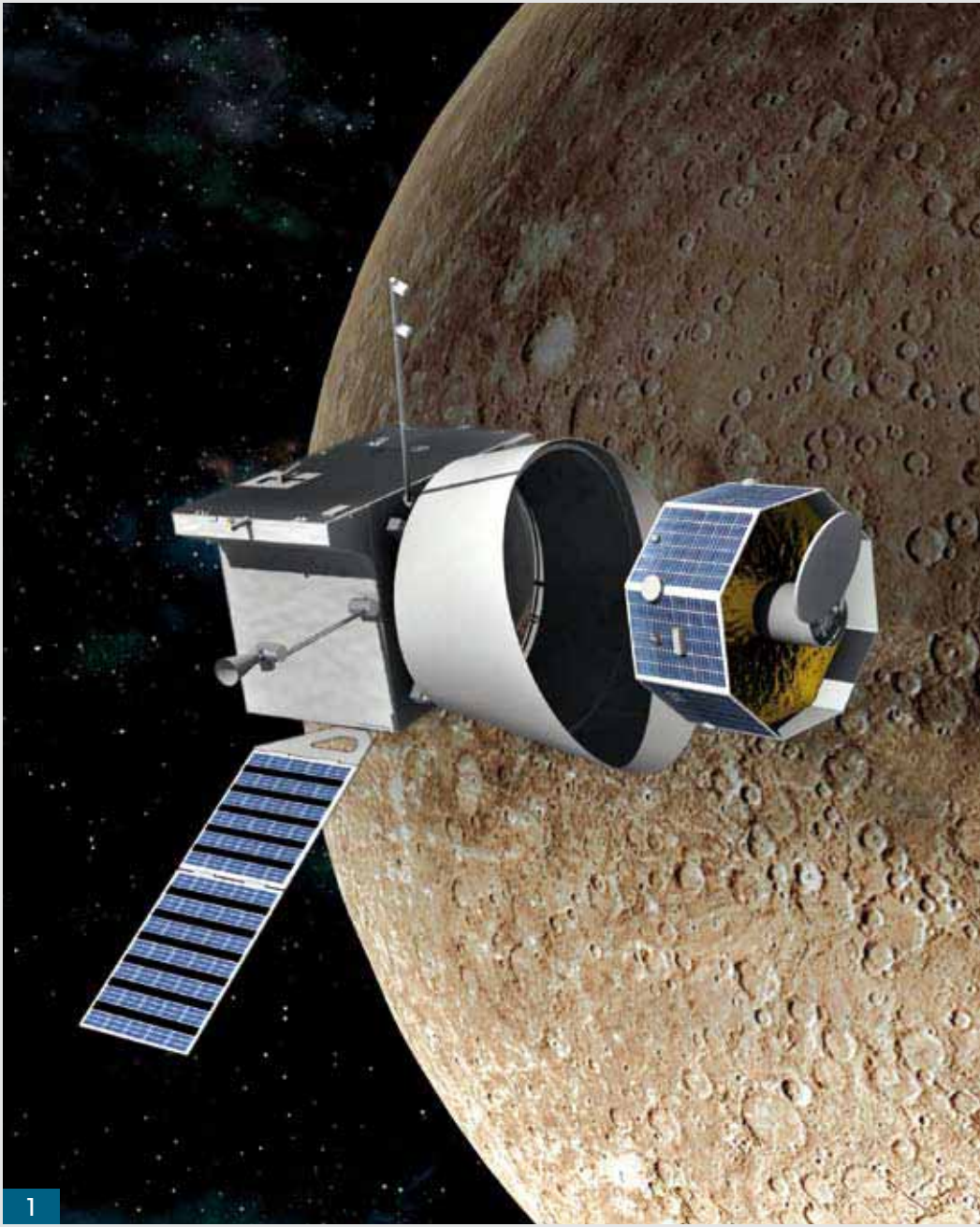
Artist's image of Ulysses;
Credit: ESA/D Hardy

MERCURY

On 18 January 2008, the industrial development of BepiColombo – the joint European and Japanese mission to Mercury – was started. UK scientists and industry have key roles in the mission which is due for launch in 2013.

BepiColombo will be only the third spacecraft to visit Mercury in the history of space exploration. Mercury's harsh environment makes it a particularly challenging mission. The spacecraft will have to endure intense sunlight and temperatures up to 350°C while gathering data.

BepiColombo will consist of three sections: a Mercury Transfer Module (MTM) – designed to get the spacecraft to the planet – and two orbiters: the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). ESA is responsible for the larger MPO. Its 11 scientific instruments will study Mercury from a low polar orbit.



1 Artist's image of BepiColombo; *Credit: Astrium*

Astrium has been appointed as the prime contractor to build the European components. In the UK, the company will provide all the spacecraft structures as well as the electrical and chemical propulsion systems for the MTM, the chemical propulsion system for the MPO (which will be the first dual mode propulsion system designed and built in Europe) and the systems which will separate the spacecraft modules on arrival at Mercury.

Scientists from the University of Leicester are leading work on the Mercury Imaging X-ray Spectrometer (MIXS) instrument which is being developed with UK company, Magna Parva. MIXS will be used to help determine the chemical composition of the planet's surface. Researchers from RAL, Open University and MSSL are also involved in many aspects of the mission.

VENUS

ESA's Venus Express has now been in orbit for more than two years. The spacecraft is continuing to unravel the mysteries of Venus, its atmosphere and its interaction with the solar wind and interplanetary environment. Venus Express, which is now in its extended mission phase, has enabled scientists to investigate Venus from the top of its thick cloudy atmosphere down to the volcanic surface.

Venus has been described as 'Earth's fiery twin' and results from Venus Express, published in the journal Nature in November 2007, reveal more detail about the processes at work that have made Venus evolve so differently to Earth.

The planet's proximity to the Sun does not explain why the environment is now so extreme, particularly since the clouds on Venus reflect the extra solar energy. It appears that Venus started out with large amounts of water on the surface and in the atmosphere but this was stripped away by the solar wind. The Earth, on the other hand, has a magnetic shield protecting us from the worst of this onslaught. It is hoped that the study of Venus will help us better understand climate change on our own planet.

On 5 June 2007, Venus Express was joined by NASA's Messenger spacecraft on its way to Mercury for a joint observation campaign. The two spacecraft carry sets of instruments that complement each other. Messenger made its closest approach to Venus at a distance of approximately 330 km, while on the other side of the planet – almost above the planet's south pole – Venus Express was orbiting at some 35,000 km.

Other results from Venus Express this year include the confirmation that the Venusian atmosphere generates its own lightning. The mission was conceived by UK scientists and were developed with UK participation. It has now been extended until at least 2009.

THE MOON

Following the success of ESA's SMART-1 mission, UK scientists and engineers have developed an instrument to fly on India's first mission to the Moon, Chandrayaan-1, due for launch later this year.

The C1XS (Chandrayaan-1 X-ray spectrometer) has been built by a team at RAL in conjunction with the Indian Space Research Organisation. It is an advance on the D-CIXS instrument that flew on SMART-1.

C1XS will be used to examine the composition of the Moon and the distribution of chemical elements. By flying at a lower altitude than SMART-1, Chandrayaan-1 should be able to spot elements at finer resolution. As well as studying X-rays, it will also detect infrared wavelengths and produce detailed images of the Moon's surface. C1XS is one of three instruments funded by ESA for the Chandrayaan-1 mission.

The UK is involved in a number of development projects for future exploration of the Moon. While much of the effort is focused through ESA, following the agreement signed between BNSC and NASA in 2007, a Joint Working Group has been examining the possibilities of developing a joint robotic lander programme.

In February 2008, two potential areas of collaboration were identified:

- The implementation of a UK-led robotic lunar mission such as MoonLITE (Moon Lightweight Interior and Telecoms Experiment). MoonLITE would comprise a small orbiter and four 'penetrators' which would impact the Moon at high speed. A feasibility study into the mission has already been completed by Surrey Satellite Technology Limited (SSTL). If approved, launch might be as soon as 2012.
- The development of science instruments and technology needed for mid-term robotic and human exploration activities.

Areas for longer-term co-operation include searching for terrestrial material on the Moon, rover design and examining the Earth's magnetosphere from the Moon.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1 Alan Pearce assembling the C1XS instrument in a clean room at RAL; *Credit: STFC*

2 SMART-1 gets a close-up view of crater Pentland on the Moon; *Credit: ESA/SPACE-X (Space Exploration Institute)*

3 Artist's impression of ESA's SMART-1 mission at the Moon; *Credit: ESA /AOES Medialab*

MARS

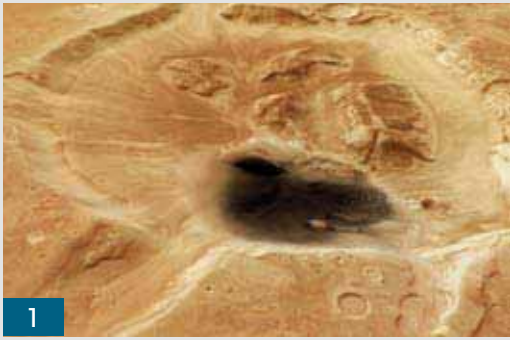
After five years in space, Mars Express continues to make an outstanding contribution to our understanding of the Red Planet. Highlights include evidence for volcanic and glacial activity on Mars from early in the planet's history until relatively recently.

The UK has been involved in the design, operation and science of Mars Express. The mission has been extended until mid-2009, which will allow the completion of a complete global survey.

The UK is also involved, to a lesser extent, in Phoenix – NASA's latest mission to Mars. The Phoenix probe landed successfully on the planet's previously unexplored northern plains on 25 May 2008. Scientists from the University of Bristol and Imperial College London are participating in this mission.

Supported by grant funding from STFC, the Phoenix team at Imperial College London has provided silicon substrates. These provide a surface on which to hold the microscopic dust and soil samples so images can be obtained. The soil grains are being delivered by a jointed robotic arm which can break the frozen surface and dig a trench up to 50 cm deep into the Martian soil. Phoenix can then analyse the soil sample's chemistry and water ice content by heating it in a miniature oven to check for hydrogen and carbon-based chemicals, the building blocks of life.

Considerable UK scientific and engineering effort is going into Europe's latest mission to Mars. ExoMars is part of ESA's Aurora programme and lays the foundation for future human exploration of the Solar System. Its aim is to examine the biological environment on Mars in preparation for other robotic missions and possible human exploration. Data from the mission will also provide invaluable input for broader studies of geochemistry, environmental science and exobiology – the search for life on other planets.



1 Mars Express image of a crater at the end of the Mamers Valles; *Credit: ESA/DLR/FU Berlin/ G Neukum*

2 Artist's image of Mars Express in orbit around Mars; *Credit: ESA/D Ducros*

3 Mars Express image of the Martian moon Phobos. *Credit: ESA/DLR/FU Berlin/G Neukum*

Due for launch in 2013, ExoMars will consist of a Rover and a Lander, both of which will carry an extensive suite of instruments designed to carry out a range of experiments. At around 250 kg, the ExoMars Rover will be the largest and most sophisticated vehicle ever to visit Mars.

A maximum of 23 instruments will be carried on the ExoMars Rover and Lander. The UK is leading on two instruments on the Rover and two on the Lander (named 'Humboldt') as principal investigator and is acting as co-investigator with other European countries on a further seven Rover and seven Lander instruments. Astrium is building the Rover and there is considerable involvement from academic institutions with the on-board instruments. Development of the wide-angle stereo camera on board the rover is led by the UK, with scientists from MSSL working with the University of Aberystwyth, Birkbeck College and Leicester University.

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1 The ExoMars rover is designed to be ESA's robotic field biologist; *Credit: ESA/AOES Medialab*

SATURN

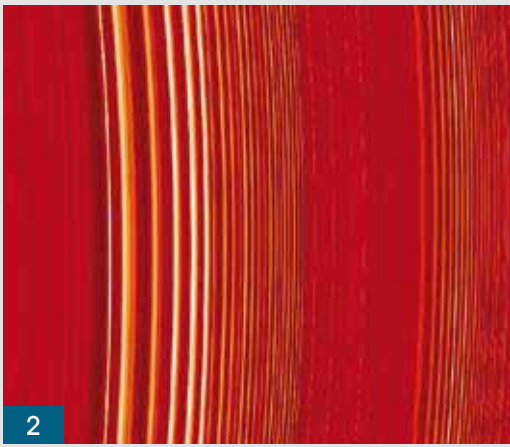
The international Cassini-Huygens mission has been one of the most successful of all time. By July 2008, Cassini will have been in orbit around Saturn for four years and in space for more than ten. Every day the spacecraft sends back spectacular images which have transformed our understanding of the ringed planet and its moons. The mission has proved so successful that it has now been extended until 2010.

The UK has been at the forefront of the design, engineering and science of Cassini-Huygens. The mission's achievements include the discovery of new rings and several new moons. Cassini has also witnessed ice plumes on Enceladus, a massive hurricane-like storm in Saturn's atmosphere and found evidence that the planet's rotation appears to be slowing.

Saturn's largest moon, Titan, is a major focus of the mission. Results based on data from the Huygens probe, which landed on the planet in January 2005, suggest there is liquid methane rain on the planet. Instruments on board Cassini have also found evidence of seas in the northern parts of Titan that might be filled with liquid methane or ethane.

Cassini has discovered that the tiny moon, Enceladus, has spectacular jets of ice particles erupting from its south pole. In March 2008, the spacecraft flew through these plumes to analyse samples of material. Some scientists believe the geysers are evidence for reservoirs of water trapped beneath the surface.

Another moon, Phoebe, has turned out to be older than Saturn itself. The 'black and white' moon, Iapetus, was found to have a ridge along its equator higher than any mountain on Earth. The latest moon – the 60th – has been now officially named Anthe. It was spotted by Carl Murray from Queen Mary, University of London, in collaboration with the Cassini imaging team.



1 Close up view of Saturn's moon Enceladus; *Credit: NASA/JPL/ Space Science Institute*

2 A false colour image of Saturn's A-ring obtained by Cassini; *Credit: NASA/JPL/Space Science Institute*

BEYOND THE SOLAR SYSTEM

UK science teams are working with international partners on current and future missions that are examining the very depths of space. These include space observatories such as Hubble; Europe's largest scientific satellite, XMM-Newton; and new satellites including the James Webb Space Telescope and ESA's Herschel and Planck missions.

The successor to Hubble, the JWST (James Webb Space Telescope), is under construction. Due for launch in 2013, the JWST is a joint mission between NASA, ESA and the Canadian Space Agency (CSA). UK scientists are taking a leading role in the mission which is designed to investigate the origin and evolution of galaxies, stars and planetary systems.

At the heart of the new observatory is a large telescope with a primary mirror 6.5m in diameter, making it almost three times the size of the one on Hubble. The JWST will also carry a suite of three cameras that are sensitive to infrared wavelengths.

The most sophisticated of these, the MIRI (Mid InfraRed Instrument), is being developed by an international consortium led in Europe by STFC's UK Astronomy Technology Centre in Edinburgh.

Since passing a major Critical Design Review last year, a verification model for MIRI has been successfully tested in the Assembly, Integration and Verification Facility at RAL. The RAL team has now begun work on the final flight model.

Preparations are being made for the launch, scheduled for late 2008, of the Herschel and Planck missions. Herschel will be the largest ever infrared space observatory and will collect radiation from some of the coldest and most distant objects in the Universe. Herschel will observe previously unexplored wavelengths of light in the far infrared region of the electromagnetic spectrum to examine the formation of galaxies and stars.

1 Development work on the JWST sunshield; *Credit: NASA*

2 Artist's image of JWST, the successor to the Hubble Space Telescope; *Credit: NASA/ESA*

3 A star is born: image obtained from Swift data showing starbirth; *Credit: NASA/Swift/S Immler*

A key component of the satellite is being led by the UK. The SPIRE (Spectral and Photometric Imaging Receiver) instrument has been developed by an international consortium. It is led by a Principal Investigator from Cardiff University.

The Planck satellite is being launched on the same launch vehicle as Hershel. Planck will help scientists answer some of the most fundamental questions about the birth and evolution of the Universe. By using Planck to examine the ancient radiation released shortly after the Universe was formed, known as the cosmic microwave background, scientists will be able to study most of the way back to the time of the Big Bang itself 15 billion years ago. The mission will provide information about how our galaxy and others first formed and will give us clues about when they may end.

University and industrial groups in the UK are helping to design and build the instruments on Planck. UK science teams will play a major role in the analysis of results from the mission. Groups involved include Cardiff University, RAL, Cambridge University and Imperial College London. The main industrial partner in the UK is System Engineering and Assessment Limited.

The Swift Gamma-Ray Burst Explorer continues to deliver impressive results. Swift is a NASA mission in partnership with STFC and the Italian Space Agency. It has key UK involvement from the University of Leicester and MSSL. Swift is designed to detect, locate and observe gamma-ray bursts (GRBs). These are powerful cosmic explosions which astronomers think are the birth cries of black holes.

On 19 March 2008, Swift witnessed the brightest GRB ever seen. It was so bright that it could have been seen with the naked eye, even though it originated more than 7.5 billion light years from Earth. The enormous energy released in the explosion was caused by the death of a massive star which collapsed to form a black hole. The location of the burst was rapidly pinpointed using the UK-built X-ray and optical cameras on the spacecraft.

Staring into space

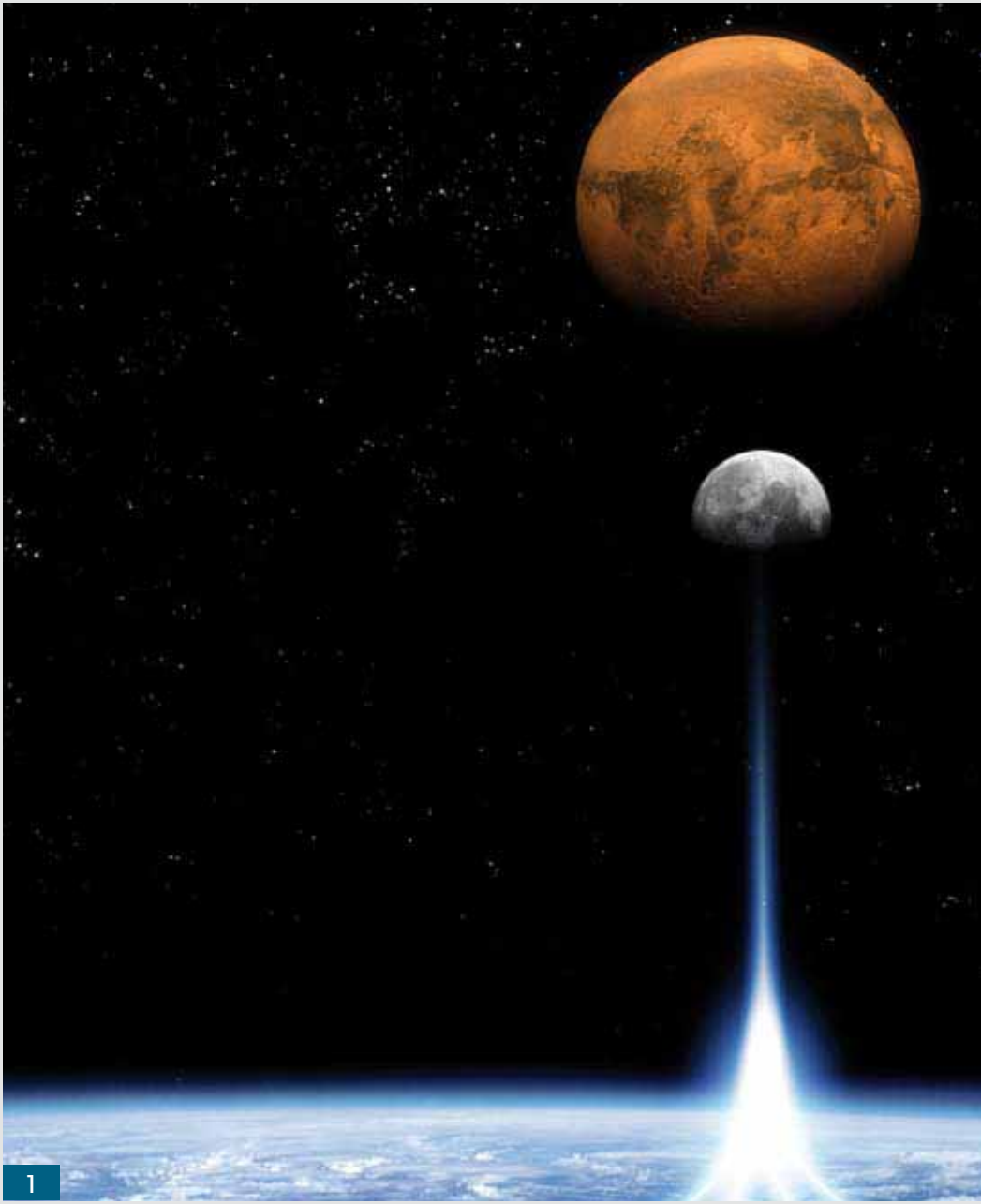
The Hubble Space Telescope, orbiting the Earth at 8 km per second, is our window onto the Universe. Launched in 1990, it has been one of the most important astronomical projects of all time. Later this year the telescope is due for its final upgrade during Space Shuttle mission STS-125. In a series of complex spacewalks, astronauts hope to install two new cutting-edge science instruments to enhance Hubble's capabilities. They will also refurbish a number of Hubble's subsystems and will attempt the first ever in-orbit repair of two existing instruments – the Space Telescope Imaging Spectrograph and the Advanced Cameras for Surveys. If all goes to plan, the mission should extend the telescope's operating life to at least 2013.

Hubble Space Telescope; *Credit: NASA*

FUTURE DEVELOPMENTS

A remarkable mission to test technology for detecting gravitational waves is being designed and built in the UK. LISA (Laser Interferometer Space Antenna) Pathfinder, due for launch in 2010, is a spacecraft and propulsion module that will test technologies for the future LISA mission.

Gravitational waves are ripples in space and time. They were predicted by Einstein's 1916 Theory of General Relativity and are thought to be generated by some of the most violent astrophysical events – such as exploding stars and collisions of black holes at the centres of galaxies. However, LISA Pathfinder must first prove that a test mass can float freely in space so that any effects on its trajectory can only be the result of external gravitational forces. These test masses are two identical metal cubes which will be placed into gravitational freefall.



1 Aurora will take Europe to the Moon, Mars and beyond; *Credit: ESA/AOES Medialab*

UK scientists from the University of Birmingham, the University of Glasgow and Imperial College London are collaborating on LISA Pathfinder. Astrium is the spacecraft's main contractor and is testing the prototype Science Module before integration of flight equipment. SciSys Limited is the software architect.

Future missions are currently under consideration as part of ESA's 'Cosmic Vision 2015-2025' strategy. The UK will be a major force in this programme which will ultimately result in six major missions to fly by 2025. STFC is working through the peer review process for a number of ambitious missions in order to decide which ones to support. The vigorous assessment programme for Cosmic Vision helps ensure that a finite scientific budget is spent in the most productive ways.

Missions under consideration include Marco Polo – a mission to return a sample of a Near Earth Object to Earth; XEUS – a potential successor to XMM-Newton; and Laplace – designed to carry out an in-depth study of Jupiter's moon Europa and the Jupiter system.

The UK is a founder member of the International Space Exploration Co-ordination Group which came into being in November 2007. This group represents 14 of the world's leading space agencies working together for globally co-ordinated space exploration of the Moon, Mars and beyond. This exploration will use robotic and human means to investigate destinations where humans could one day live and work. At present, the feasible destinations are the Moon, Mars and certain asteroids. Part of ESA's contribution to the strategy is the Aurora programme.

In September 2007, a report assessing the UK's involvement in future space exploration was published by the UK Space Exploration Working Group. This reviewed global plans for space exploration, assessed opportunities and benefits for UK participation, and recommended suitable focus for UK space activities. The full report is available on the BNSC website.

XMM excellence

In November 2007, ESA's Science Programme Committee unanimously approved an extension for the XMM-Newton mission, pushing back the mission end date to December 2012.

Launched in 1999, XMM-Newton is an orbiting X-ray telescope observing all kinds of astronomical objects – from planets in our Solar System to the most distant quasars. The telescope studies thousands of different X-ray emitting objects and can detect more sources of X-rays than any previous satellite.

The observatory has given us a deeper understanding of the physical processes taking place in stars and binary star systems in our own galaxy and distant galaxies. It has also significantly increased our understanding of the early Universe. More than 1,000 scientific papers have, so far, been published using data from the spacecraft.

Teams from Leicester University and MSSL have key involvement in the mission. The spacecraft remains in excellent health and should, in theory, last for at least another ten years.

EARTH OBSERVATION

↘ Storms lash the Scottish coast. Earth observation satellites have a vital role in monitoring the weather and the Earth's changing climate

Our ability to monitor the Earth from space has profoundly altered the way we view our planet. Earth observation (EO) enables us to monitor changes to the environment and patterns of land use. It has revolutionised weather forecasting and mapping and has considerably improved disaster prediction and response.

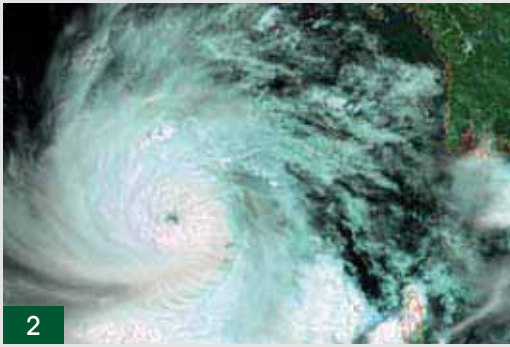
By its very nature, EO is a global endeavour and the UK, through BNSC, works very closely with its international partners to co-ordinate space missions and share results. The UK provides support through the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites, EUMETSAT. The UK is also an active member of groups including the Committee on Earth Observation Satellites (CEOS), the Group on Earth Observation (GEO) and the International Charter 'Space and Major Disasters'. The UK took over the lead of the Charter in October 2007.

UK PRIORITY

Climate change is high on the political agenda and EO technologies have a vital role to play in understanding and monitoring how the Earth's climate is changing. This year the UK Natural Environment Research Council (NERC) established a major new National Centre for Earth Observation (NCEO), involving 26 UK universities and more than 100 staff.

The NCEO aims to provide reliable information to enable UK Government, business and citizens to manage the environment wisely and predict how it will change. The Centre will broaden the use of EO by the scientific and industrial communities and build a solid science and technology capability to place the UK at the forefront of EO exploitation.

One of the key science activities of the new NCEO will be to use EO to improve predictions of how our environment and climate will change in the future – vital topics that directly affect society both in the UK and worldwide.

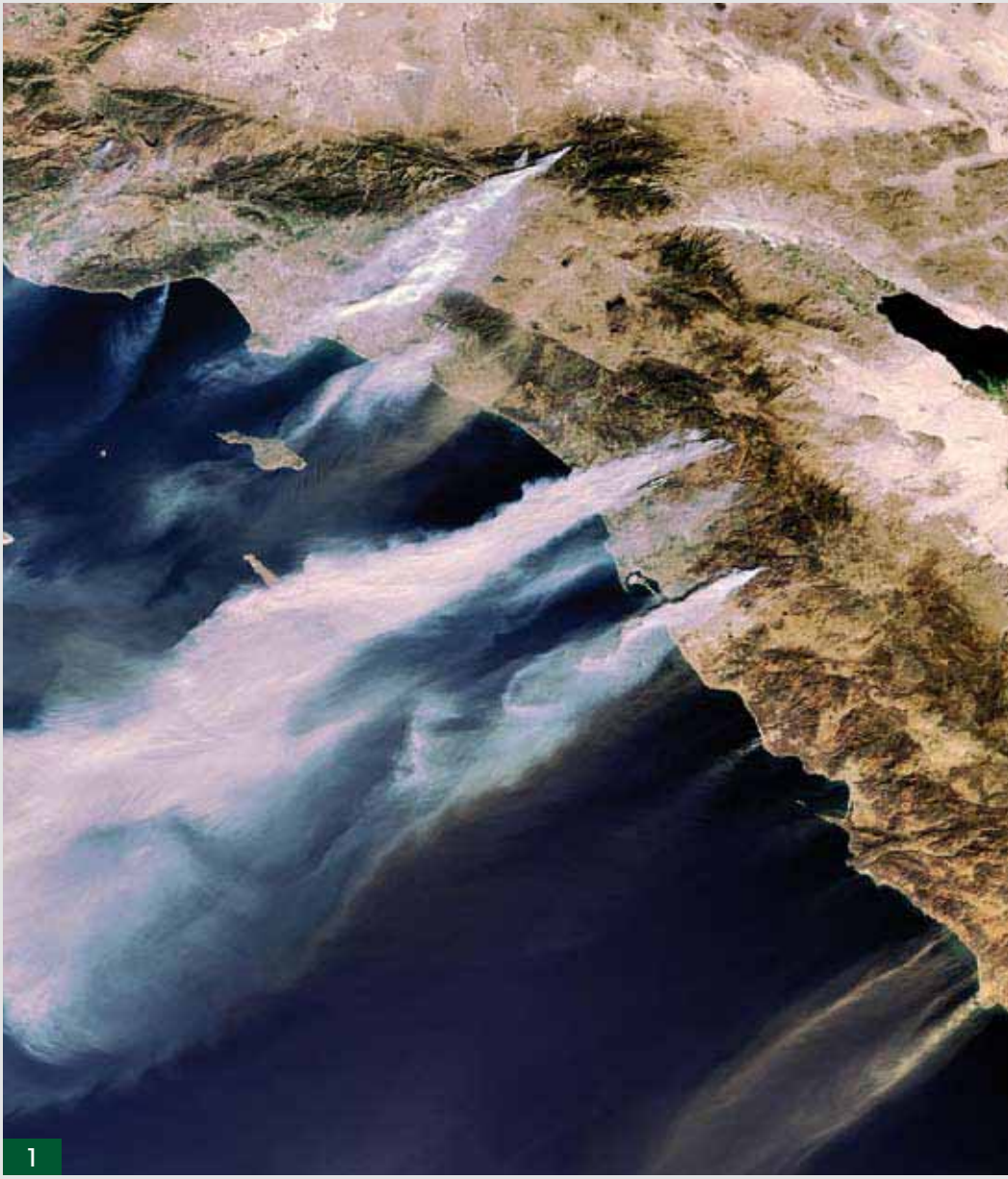


1 Heat maps produced from data measured by Envisat; *Credit: ESA/University of Leicester*

2 Envisat captures Cyclone Nargis making its way across the Bay of Bengal south of Burma; *Credit: ESA*

In order to strengthen the UK's position in instrument development, a centre has been set up to bring together and enhance the partnership of the science community with industry. The Centre for Earth Observation Instrumentation (CEOI) aims to put the UK in a much stronger position to win international contracts for the development of new, technologically advanced space instruments. Jointly funded by DIUS and NERC, it is focusing on the UK's scientific strengths and is managed by a consortium led by Astrium, operating in partnership with the University of Leicester, QinetiQ and Rutherford Appleton Laboratory (RAL).

The Centre's initial programmes are aimed at developing new remote-sensing technologies to understand how atmospheric chemistry affects climate; detectors that measure pollutants in the atmosphere; novel space-based instruments to analyse the quantity and flow of carbon dioxide; and sensors to monitor trace gases in the lowest part of the atmosphere.



1 This Envisat image, acquired on 22 October 2007, captures fierce easterly desert winds blowing smoke from wildfires in Southern California; *Credit: ESA*

DISASTER MANAGEMENT

Satellites have become increasingly important for disaster prediction, prevention and response. Satellites are being used to provide maps and detailed images to assist relief efforts and UK research teams are using satellite data to monitor areas at risk of earthquakes, floods and landslides.

For six months from October 2007, the UK led the International Charter 'Space and Major Disasters'. The Charter can be triggered by national civil protection agencies and the UN to acquire and deliver space data to those affected by natural or man-made disasters. This is the first time the UK has led the Charter since joining in 2005.

UK floods

Many homes and businesses are still suffering from the aftermath of the floods which hit northern England in June 2007 and the south west of England, in July. In Hull alone, two months of rainfall fell in a matter of hours. It is estimated that the total bill for damage will eventually run into hundreds of millions of pounds.

The floods were on such a large scale that the Environment Agency decided that the best way to assess their full extent was to view them from space. The Agency first requested the activation of the International Charter 'Space and Major Disasters' in June and again in July in response to the flooding of the Avon and Severn rivers.

Because of widespread cloud cover, some of the most useful information came from radar instruments on satellites. Radar is able to 'see' through clouds and can clearly show the difference between water and dry ground.

Spacecraft used included the Disaster Monitoring Constellation which provided images of the York and Doncaster areas. Detailed radar data came from Radarsat and the recently launched TerraSAR-X satellite. The information from satellites was used to produce maps of the flooded areas.

Flooding in the south west of England, July 2007

The Charter has proved its worth many times during the past year. There were 18 activations during the period the UK led the Charter and satellites have been used to track the progress of disasters and monitor and map the extent of damage. Over the past 12 months, the Charter was activated for disasters such as:

- UK floods in the summer of 2007
- fires that ravaged large areas of Greece in August 2007
- widespread floods in the Mexican state of Tabasco during November 2007
- eruption of the Tungurahua volcano in Ecuador in January 2007
- the cyclone that killed tens of thousands of people in Burma in May 2008
- the magnitude 7.8 earthquake which struck eastern Sichuan in China in May 2008.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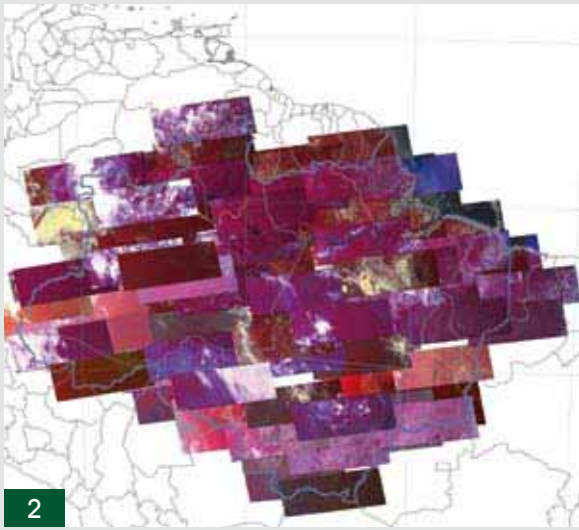
1 One of the DMC satellites under construction; *Credit: SSTL*

2 A DMCii map of the Amazon basin; *Credit: DMCii*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The UK's involvement in the Charter is a collaboration between BNSC and UK company DMC International Imaging (DMCii). DMCii works with the members of the Disaster Monitoring Constellation (DMC) – a network of four satellites designed to provide detailed images of any part of the world in times of need. The satellites have been built in the UK by Surrey Satellite Technology Limited (SSTL). They are owned by the UK (UK-DMC), Algeria (AlSAT-1), Nigeria (NigeriaSat-1) and China (Beijing-1). The UK satellite is supported by BNSC.

During the period the UK led the Charter it also secured access to the UK's TopSat satellite. TopSat was built by a consortium led by QinetiQ and contains a single powerful camera capable of delivering high-quality images from around the globe.

In October 2007 a workshop was held with the Cabinet Office Civil Contingencies Secretariat to raise awareness of the Charter among the UK emergency response and civil contingencies community.

The leadership of the Charter has now passed to the Canadian Space Agency, but the UK continues to take an active role with a continuing effort to improve access to the Charter for a wider range of countries, particularly in Africa.

BNSC and DMCii supported a Charter workshop in May 2008 in Nigeria to raise awareness of, and involvement in, the Charter in West Africa. The event was sponsored by BNSC and the UN and hosted by Nigerian National Space R&D Agency (NASRDA) and Nigerian National Emergency Management Agency (NEMA).

The DMC constellation continues to develop new markets for reliable satellite imagery for many international customers in forestry and agriculture. In 2007, projects included the third annual mapping of the Amazon basin to monitor rainforest loss for the Brazilian government and a complete coverage of Europe, on behalf of ESA, for use in Global Monitoring for Environment and Security (GMES) projects (**see page 41**).

SSTL is currently working on the next generation of DMC spacecraft. The Spanish Deimos-1 satellite is nearing completion and is due for launch in 2008. Work is also underway on UK-DMC2, also for launch in 2008, and NigeriaSat-2 with a further Nigerian satellite to be built as part of a training programme for the West African country's future space scientists and engineers. The Nigerian satellites are scheduled for launch in 2009.

Each of the new DMC satellites will have improved cameras, enhanced memory capacity and faster communications. Rather than simply taking 'snapshots' of the ground, they will also be able to take continuous images over thousands of kilometres. The new technology should enable images and maps to be delivered more rapidly to rescue workers on the ground.

MONITORING A CHANGING PLANET

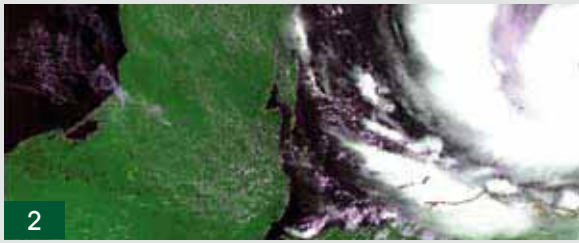
Satellites allow us to monitor pollution, land use and climate on a national, regional and global scale. In the long term they enable a reliable assessment to be made of the impact of human activity and the likely future extent of climate change.

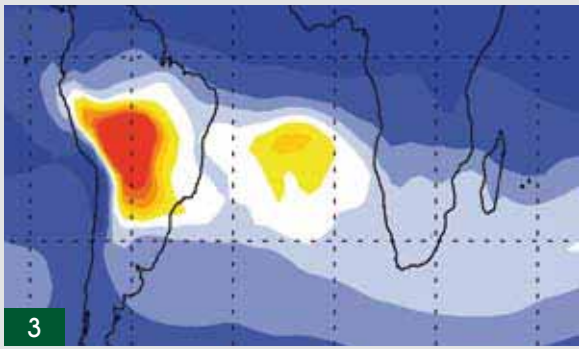
This year has seen a major scientific effort focused on the Earth's polar regions. International Polar Year (IPY) addresses the urgent need for clearer understanding of how our climate is changing. Space research during IPY focuses on space itself, particularly solar processes that impact the Earth's outer atmosphere, measurements of distant space from polar regions and the use of satellite sensors in space to monitor polar conditions and processes.

Some 65 UK institutions have been taking part in IPY – from universities and museums to research councils and science centres. UK efforts are co-ordinated through the NERC-funded British Antarctic Survey (BAS). The UK is involved in around half of the IPY's 200+ scientific projects – ranging from the Census of Antarctic Marine Life to Polar View, which brings together multiple satellite observations, imagery and data for polar monitoring for the first time.

ESA satellites and UK instruments are playing a crucial role, providing scientists with images and scientific data. There are many benefits to using satellites for polar research. Apart from being cost effective ways of monitoring large, inaccessible areas, they can study regions in all weathers and over long periods of time.

Europe's largest and most sophisticated EO satellite, Envisat, continues to perform well. ESA has now agreed to extend the mission until 2010. Many UK teams are involved in collecting and analysing results from Envisat with more than 1,200 scientific projects across Europe currently using data from this mission.





1 Ash being blasted from the Chaiten volcano in Chile; *Credit: ESA*

2 Hurricane Dean off the Mexican coast in August 2007; *Credit: ESA*

3 A computer simulation, based on satellite images, of the movement of carbon monoxide from South American wildfires; *Credit: SRON*

FUTURE MISSIONS

The UK is involved in new European missions which will add to the understanding of our planet. Between them CryoSat-2, GOCE and SMOS will measure ice coverage, gravity, soil moisture and ocean salinity.

CryoSat-2, which is currently under construction, will measure precise changes in the thickness of the polar ice sheets and floating sea ice. The CryoSat-2 science team will be led from University College London in the UK. The first CryoSat mission was launched in 2005 but the satellite was lost because of a technical failure. However, due to the importance of the mission, a replacement satellite was approved.

CryoSat-2 has the same objectives as the original spacecraft. It will make measurements of the ice sheets of Antarctica and Greenland. It will also monitor variations in Arctic sea ice. Data from the mission will be compared with information gathered from other ESA satellites (such as Envisat) and the NASA satellite IceSat to build up a picture of long-term trends in the Earth's ice cover. In preparation for the launch of CryoSat-2, due in late 2009, an international science team (which includes UK participants) has been conducting an extensive field campaign in the far north of Greenland and Canada. This is a continuation of a number of earlier campaigns that focus on collecting data on the properties of snow and ice over land and sea. The data collected during these studies will enable scientists to interpret measurements from CryoSat-2 accurately.

GOCE (Gravity Field and steady-state Ocean Circulation Explorer) is a two-year mission that will measure the Earth's gravitational field and help advance our understanding of ocean circulation and climate. This mission is due for launch in late 2008.

The warming Earth

Scientists are using a UK-designed instrument on board Europe's latest weather satellites to provide observational evidence for the greenhouse effect. The Geostationary Earth Radiation Budget experiment (GERB) has been flying on Meteosat-8 since 2002 and Meteosat-9 since December 2005. The instrument, largely developed by Imperial College, RAL and the University of Leicester (with contributions from teams in Belgium and Italy), measures the amount of sunlight that is reflected or scattered from the Earth and the amount of heat emitted by the Earth. As well as providing evidence for climate change, it has also helped improve climate forecasts by monitoring the greenhouse effect of small dust particles over the Western Sahara and by reassessing the brightness of clouds. EUMETSAT has funded the building of the next two GERB instruments which will fly on Meteosat-10 and 11.

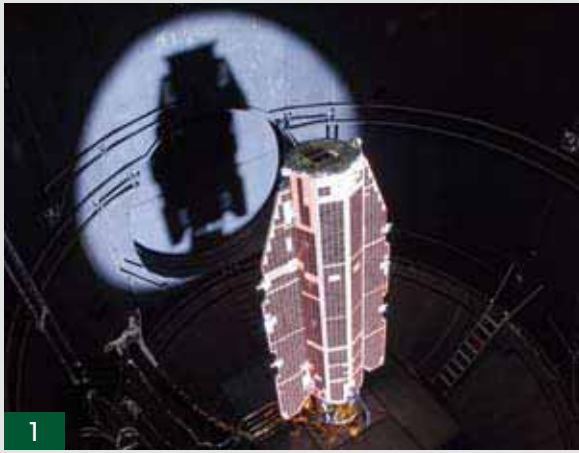
By measuring tiny variations in the Earth's gravitational field, GOCE will provide scientists with a greater insight into how the Earth works – the physics of its interior and changes in sea levels. The data will be combined with information about sea surface height from other satellites which will track the direction and speed of ocean currents.

UK company QinetiQ has supplied the two ion thruster engines for the spacecraft, and SciSys Limited has developed a satellite simulator for the mission in support of satellite missions.

SMOS (Soil Moisture and Ocean Salinity) due for launch in early 2009, will make global observations of the Earth's surface soil water content and the salt level in the oceans. Both are linked to the Earth's climate and water cycle. A greater understanding of soil moisture and ocean salinity will lead to better forecasting of weather and extreme-weather events.

UK science and industrial teams have contributed significantly to the SMOS mission. SciSys UK Limited is a member of the SMOS Payload Module Team and has developed the on-board software that controls one of the instruments. ComDev developed the X-band filter, while Chelton Antennas was involved in the manufacture of the antennae. Two Principal Investigators involved in SMOS are from the National Oceanographic Centre, Southampton and De Montfort University's Earth and Planetary Remote Sensing Laboratory, Leicester.

CryoSat-2, GOCE and SMOS are all Earth Explorer missions and are part of ESA's Living Planet programme. These data will contribute to seasonal climate forecasting and will also help studies of regions of snow and ice.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1 GOCE under test at ESA's Test Centre at the European Space Research and Technology Centre in the Netherlands; *Credit: ESA*

2 The two main parts of the SMOS satellite are attached together at Thales Alenia Space in Cannes, France; *Credit: ESA*

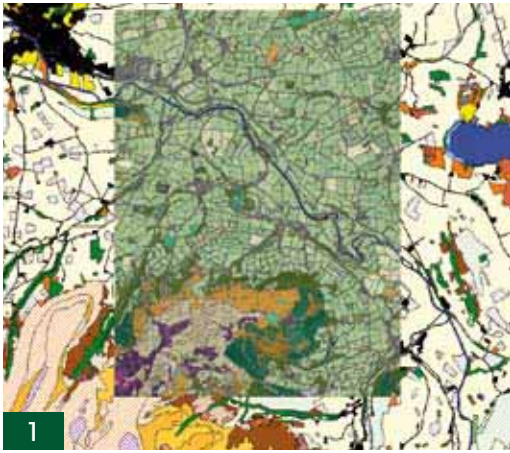
THE EARTH FROM SPACE

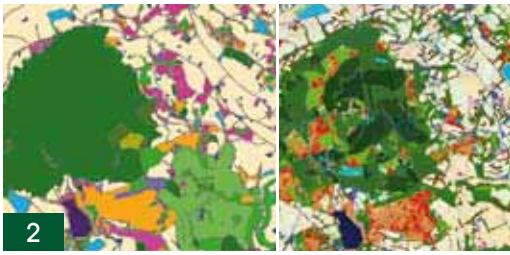
UK-built satellites and instruments are sending back unprecedented views of our planet. Information acquired from space has tremendous potential to improve our lives on Earth and BNSC is working to increase the number of users of data acquired by space technology.

The Government Information from the Space Sector (GIFTSS) programme is majority-funded by BNSC to encourage the take-up of space applications in other government departments and agencies. BNSC works with interested end-users to assess and develop new uses of space. Three new projects have been started this year: monitoring of moorland burning with Natural England; exploration of forest mapping with the Forestry Commission; and assessment of measuring CO_2 emissions over Scotland with the Scottish Government. Additional projects are currently in the planning stage.

The GIFTSS of space

Conservation agencies carry out surveys to map habitats but these maps take years to complete and are very costly. GIFTSS sponsored a test project with the Countryside Council for Wales (CCW) to explore whether satellite imagery could be used instead. In further collaboration with the University of Wales, CCW has produced a draft habitat map of the whole of Wales, covering 20,000 square kilometres. The new map is much more detailed than before and the system will allow rapid updating as new satellite imagery becomes available. This use of EO will allow Wales to carry out evidence-based policy and spatial planning. It will also help with monitoring and mitigating the impact of climate change on landscapes and biodiversity.





1 The new habitat map superimposed on the old map, showing smaller and more varied objects; *Credit: Countryside Council for Wales*

2 Old map before 1996 (left) and new map 2007 (right); *Credit: Countryside Council for Wales*

THE GLOBAL VIEW

The UK continues actively to support international Earth observation initiatives, particularly those that contribute to the monitoring of our planet and help us to better understand climate change.

The UK, led by Defra, supports the Group on Earth Observation (GEO) which is a high-level international group headed by Ministers from a growing number of countries (in January 2008 the number stood at 72). GEO sets out to help co-ordinate EO around the globe. The UK contributes to GEO and its Global Earth Observation System of Systems (GEOSS) implementation plan. The UK attended the Ministerial conference in Cape Town in December 2007, where Ministers expressed their support for the progress made so far.

The UK also participates in the Committee of Earth Observation Satellites (CEOS), a group that has positioned itself as a co-ordinator of space-acquired data responding to GEO and the GEOSS implementation plan.

1 A composite image of the Earth and Moon from space; *Credit: NASA*

In Europe the Global Monitoring for Environment and Security (GMES), a joint initiative between the European Commission and ESA, continues to develop. The next phase of financial commitments to the ESA-managed GMES space component is due to be made at the November 2008 ESA Ministerial meeting (see also **page 14**). 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. GMES will be a major European contribution to GEO.

WEATHER ON EARTH

Observations of the Earth from space have transformed the way we forecast the weather. By incorporating satellite data into computer models, weather can be predicted with increasing accuracy several days ahead. Satellites are used to monitor weather as it develops, as well as for long-term statistical studies of weather and climate.

The UK is at the forefront of modern weather forecasting by exploiting the latest satellite technology. The operation of Europe's weather satellites is co-ordinated by EUMETSAT where the Met Office, a BNSC partner, represents the UK. EUMETSAT has a close working relationship with ESA, the space agency with responsibility for initial satellite development.

EUMETSAT also works closely with other international meteorological agencies to share satellite meteorological information. International efforts are co-ordinated by the World Meteorological Organisation (WMO). The WMO facilitates the free and unrestricted exchange of data and information on matters relating to safety and security of society, economic welfare and the protection of the environment.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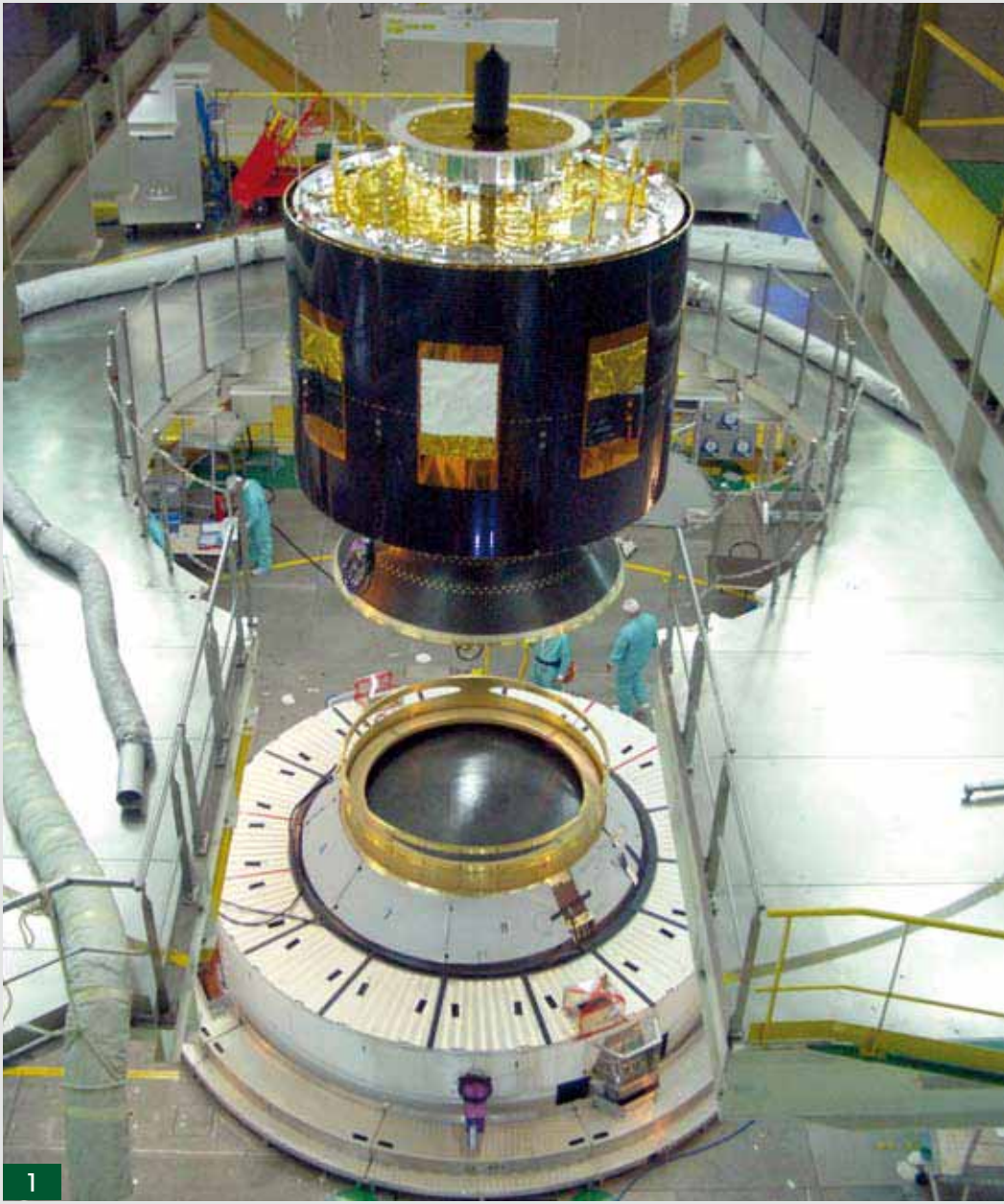
1 EUMETSAT controls the MSG and MetOp satellites from its centre in Darmstadt, Germany; *Credit: EUMETSAT*

2 A virtually cloud-free Europe captured by Meteosat-8 (MSG-1); *Credit: EUMETSAT*

METEOSAT SECOND GENERATION (MSG)

Europe's latest geostationary weather satellite, Meteosat-9 (launched as MSG-2 in December 2005), is now the prime satellite for European weather services. Meteosat-9 provides updated images every 15 minutes, allowing the monitoring of rapidly developing weather systems, such as the deep area of low pressure that brought severe gales to many parts of the UK on 10 March 2008. This event was accurately forecast several days in advance. Meteosat-8 has been redeployed as the back-up satellite, and will operate in 'Rapid Scan' mode from May 2008, giving image updates every five minutes, and further improving our ability to monitor this type of weather system.



1 MSG-2 being prepared for launch at Europe's spaceport in French Guiana; *Credit: ESA/MSG Team*

METOP

Europe's first operational polar-orbiting weather satellite, MetOp-A, carries several new instruments for monitoring the atmosphere and the ocean surface, including the Infrared Atmospheric Satellite Interferometer (IASI), a sophisticated instrument that measures atmospheric temperature and humidity with a greater accuracy than has been possible from space before. Future missions are already being developed to ensure continuity of satellite coverage.

Launched in late 2006, MetOp-A shares a common set of core instruments with polar-orbiting meteorological satellites operated by US partner National Oceanic and Atmospheric Administration (NOAA) in the United States. In addition, MetOp carries a set of European instruments, which measure atmospheric temperature and humidity with unprecedented accuracy along with profiles of atmospheric ozone and other trace gases. Wind speed and direction over the oceans are also measured.

As well as improving forecasting accuracy, in the longer term these instruments will contribute to monitoring our changing climate more accurately.

FUTURE MISSIONS

Launched in June 2008, Jason-2 is a high-accuracy ocean altimetry mission. Jason-2 will continue its predecessor's role in detecting sea level and wave height in support of climate monitoring, operational oceanography and weather forecasting.

To ensure continuity of coverage and collection of data, there is an ongoing satellite replacement programme. The replacement for the MSG satellite series, Meteosat Third Generation (MTG) will be needed by 2015 and is already under development. The follow-on programme for MetOp is in the early stages, in preparation for launch from 2019. A Jason-2 follow-on will also be required from 2012, and proposals for its continuation are currently under consideration.

1 An Ariane 5 successfully launched Europe's first MSG satellite; *Credit: ESA/CNES/ARIANESPACE-Service Optique CSG*

SATELLITE NAVIGATION

↘ Highly accurate, guaranteed global positioning will mean increased safety for the world's airlines

Satellite navigation enables users to find out exactly where they are anywhere on Earth using signals from orbiting satellites. The UK is involved at every level in developing the next generation of satellite navigation technologies. UK companies are designing and building the satellites, payloads and the ground infrastructure to support them. Others are involved in developing new and innovative applications for the technology.

GALILEO

This year, the new Galileo satellite navigation system took a major step forward with the successful launch of GIOVE-B (Galileo In-Orbit Validation Element-B). GIOVE-B is the second Galileo satellite and is designed to test new technologies for the European Galileo network. The satellite carries the most accurate clock ever flown in space, a key component for the final system which is due to become fully operational in 2013.

Galileo is designed to provide the whole planet with a highly accurate, guaranteed global positioning system under civilian control. Featuring 30 satellites and a ground support network, Galileo is being developed to offer users satellite navigation with an accuracy of less than one metre. Unlike current navigation systems, such as GPS, Galileo will provide a guaranteed service under all but the most extreme circumstances.

GIOVE-B was launched on board a Soyuz-Fregat rocket from the Baikonur Cosmodrome in Kazakhstan on 27 April. The satellite started its operations on 7 May when it began transmitting the Galileo signal.

The payload for GIOVE-B was developed by Astrium in the UK. A Portsmouth-based team tested and integrated the equipment on board the satellite. The network of ground stations involved in monitoring the signals from GIOVE-B includes the Chilbolton antenna in Hampshire, operated by the Science and Technology Facilities Council.

Galileo is being developed by the European Space Agency (ESA) and the European Commission. The UK Government has been one of four big contributors to the development of Galileo, along with Germany, France and Italy. To date, BNSC and the Department for Transport have supported development of the system by ESA. The European Commission will take responsibility for operational deployment and operations.

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1 GIOVE-B in the ESTEC Test Centre; *Credit: ESA/A Le Floc'h*

Over the coming months, a series of tests will be carried out on the Galileo technology being carried by GIOVE-B. Research teams will be assessing the accuracy of the atomic clocks and quality of the navigation signal on board. If the tests prove successful then the go-ahead will be given for the launch of the first fully operational Galileo satellites.

GIOVE-A, the first satellite in the Europe-led Galileo satellite navigation system, continues to perform well after more than two and a half years in orbit. ESA has confirmed that the UK-built satellite is a 'full mission success' and has extended operations for an additional year.

GIOVE-A was developed by Surrey Satellite Technology Limited and was designed, built and tested in a rapid (30-month) programme. The satellite was launched on 28 December 2005 with a primary mission of securing the Galileo frequency filings at the International Telecommunications Union (ITU). The satellite also played a crucial role as a test bed for the Galileo payload and the primary atomic clock, fundamental to all future Galileo satellites.

EGNOS

EGNOS is the European Geostationary Navigation Overlay System. It is being developed to operate alongside existing satellite navigation systems to improve the accuracy of navigation signals. This will make EGNOS suitable for safety-critical applications such as landing aircraft or navigating a ship through a narrow channel.

The EGNOS service, which covers the whole of Europe, is broadcast via two Inmarsat communications satellites and a third spacecraft, Artemis. EGNOS transmits a signal containing information on the reliability and accuracy of the positioning signals sent out by GPS and allows users to determine their position to within two metres. UK companies including BT, Astrium, Logica and Airsys (UK) are involved in developing the EGNOS system.

During the past year, further trials have been carried out with EGNOS. These have involved using test planes and helicopters for air traffic control applications. It is planned that the system will be certified in 2009 for safety critical use in air traffic management.


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1 A screen in the GIOVE-B control room in Fucino, Italy displays the spectra of signals received from the satellite shortly after it began transmitting navigation signals; *Credit: ESA*

2 The inauguration of EGNOS in Toulouse; *Credit: Cnes/T D'Ortoli*

3 EGNOS will be suitable for safety-critical applications such as landing aircraft

APPLICATIONS

The UK, through BNSC, is actively encouraging the development of new technologies to exploit the potential of satellite navigation. A recent study suggested that, by 2013, end-user satellite technology will generate yearly global revenues of $240 billion (source: ABI Research). Industry estimates suggest that by 2015, Galileo will be generating €10 billion worth of benefits every year (source: Astrium). The UK is already seeing the benefits of applications which make the most of existing satellite technology.

The Location and Timing Knowledge Transfer Network managed by the Technology Strategy Board is fostering efforts to develop new applications and services. A collaboration between academics, industry and Government, the network is helping to create new markets and provide support to business.

BNSC continues to support (as a principal sponsor) the UK SatNav Challenge. This competition is co-ordinated by the Hertfordshire Business Incubation Centre and is aimed at encouraging innovation in the applications of satellite technology. This year's UK SatNav Challenge attracted more than 100 entries, and the winner, Eric Goodyer from De Montfort University in Leicester, was also a runner-up in the wider European competition.

Mobile medicine

Eric Goodyer came first in the 2007 UK Satellite Navigation Challenge for 'MobiAssist', a device designed to help people who might otherwise have to live in care, lead more active and independent lives.

Worn by the user like a watch or pendant, MobiAssist would take regular medical readings – such as temperature and heart rate – and send them to medical professionals using mobile phone technology. If the person were to suffer a medical crisis, an inbuilt satellite navigation receiver could also alert emergency services to their location.

MobiAssist has already gained support from politicians, business and industry and, in conjunction with Leicestershire Social Services, funding is being sought for a pilot project.

SATELLITE COMMUNICATIONS

↘ The UK is a world leader in satellite communications

The UK is one of the world's leading manufacturers of communications satellites, a major developer of new satellite communications applications, and is home to both the world's most successful satellite TV broadcaster and the world's largest global satellite communications provider.

Satellite communications have made the massive growth in digital TV broadcasting, global mobile telephony, internet traffic and other broadband services possible. In the long term, the technology should bring fast and affordable telecoms to urban and rural communities worldwide. As the demand for services continues to grow, BNSC is committed to helping the UK industry capitalise on major market opportunities.

GLOBAL BROADBAND

The UK is at the forefront of the emerging field of satellite broadband supplying users with broadband data connections and 3G phone services anywhere on Earth.

UK company Inmarsat provides broadband data connections and 3G-type phone services to mobile users worldwide via compact terminals that can be used on land, at sea and in the air. Its newest generation satellite system – the Inmarsat-4 series – currently covers 85 per cent of the world's landmass. The satellites have largely been built in the Astrium factories in Stevenage and Portsmouth.

This year saw the signing of a €260 million contract between Inmarsat and Astrium to design and build an advanced communications satellite. Alphasat will be the first of a new generation of satellites and will be more powerful and versatile than previous designs.

Alphasat is set to bring affordable communications for the developing world. It will be more powerful, versatile and cheaper for users than previous telecoms satellites. Alphasat will support broadband services that can be received by smaller, more efficient terminals, and will pioneer new broadcast and multicast services. Telephone services, particularly in Africa, will help address the current lack of affordable communications.

Astrium is prime contractor for the project and the key technology for the satellite payload will be designed and manufactured in Britain. Inmarsat will operate the satellite as part of its global broadband service.

The Alphasat contract is supported by ESA and BNSC and is expected to bring significant economic benefits to the UK. Development work on key components, as well as early stage conceptual studies, was funded through €8.67 million of UK investment in ESA's Advanced Research in Telecommunications Systems (ARTES) programme. Industry estimates suggest that the development and operation of the satellite will support around 500 highly-skilled jobs.

Avanti Communications, the UK's only fixed satellite services operator, is developing the Highly Adaptable Satellite (HYLAS). This small satellite, planned for launch in 2009, is designed to help solve the problem of unequal access to broadband internet services in Europe. It is based around a low-cost, low-risk satellite targeted at areas of Western Europe that are unlikely to receive any terrestrial service within the next ten years.

HYLAS is named after its 'highly adaptable' payload, developed by Astrium. It automatically allocates varying amounts of power and bandwidth to the different regions within its footprint, reacting to the highs and lows of traffic demand. This means that between 150,000 and 300,000 users can access HYLAS at any one time.

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1 Participants in the Alphasat contract signature ceremony held at ESA Headquarters on 23 November 2007. From left to right: Jean-Jacques Dordain Director General of ESA, Pascale Sourisse CEO Thales Alenia Space, Giuseppe Viriglio Director of Telecommunications and Navigation ESA, Eugene Jilg CTO Inmarsat, Christian Pietrowski Vice-president Telecom Satellites Astrium, Bernard Mathieu Head of Radio Communications Programmes CNES; *Credit: ESA/S Corvaja*

2 Artist's image of Alphasat; *Credit: Inmarsat*

As well as providing broadband Internet, HYLAS will facilitate the distribution and broadcast of a range of HDTV (high-definition television) programmes over much of Europe. By 2015, three million households are set to benefit from HYLAS.

BNSC has contributed development funds through the ARTES programme and Avanti has raised significant venture capital in the City of London. HYLAS is being designed and built by a core team from Avanti Communications and Astrium, with support from specialist organisations around Europe.

SECURE COMMUNICATIONS

Satellite communications (satcoms) are essential to support all aspects of modern military operations. They provide secure and flexible communications for maritime, air and land forces deployed around the world.

Since the 1970s, the UK has operated its own independent system of military communications satellites called Skynet. In addition to providing secure multimedia communications for British and NATO forces, these satellites also allow military personnel to speak to their families at home and provide TV services for those deployed abroad or at sea.

The Skynet 5 satellites are being built in the UK by Astrium to provide advanced and flexible satcoms for UK armed forces for the next decade. The Skynet constellation is operated by Paradigm, a subsidiary of Astrium, under a 17-year Public Finance Initiative agreement with the Ministry of Defence.

The satellite's capacity will be about two and a half times greater than the existing Skynet 4 system, enabling users to send and receive information much more quickly. The second of this new generation of satellites, Skynet 5B, was launched successfully in November 2007. Skynet 5C, launched in June 2008, will be an 'in orbit spare' and it is expected that a fourth satellite will be built and held in reserve.

1 The launch of Skynet 5B; *Credit: Arianespace*

INDUSTRIAL ACTIVITIES

↘ Satellites under construction at SSTL; *Credit: SSTL*

The UK space industry is one of the UK's most hi-tech sectors. It can be broken down into two main sectors: upstream and downstream. Upstream companies are considered to be those that build the technology and downstream companies are the technology users.

The latest survey of the size and health of the UK space industry, to be published shortly, indicated that the total turnover increased to £5.8 billion in 2006-07, up from £4.8 billion in 2004-05. In addition, the number of employees increased to 18,800 from 16,200.

MANUFACTURING

The UK's satellite manufacturing industry continues to win new contracts and develop new products. In April 2008, Europe's largest space company, EADS Astrium, signed an agreement to acquire Surrey Satellite Technology Limited (SSTL), a world leader in small and 'micro' satellites. Under the deal, which is subject to approval by regulators, SSTL will remain an independently-managed company with its own individual brand.

In the UK, Astrium is currently working on contracts including: Alphasat, a powerful new communications satellite; BepiColombo, Europe's mission to Mercury; and the robotic ExoMars rover which will explore the surface of Mars. On the commercial front, Astrium is also in the process of developing the HOTBIRD communication satellites for Eutelsat. HOTBIRD 9 is due for launch later in 2008.

1 The ExoMars rover is being developed by Astrium to drill into the surface of Mars depicted above; *Credit: ESA/ DLR/FU Berlin/ G Neukum*

2 Proba image of the Gobi Desert in China; *Credit: ESA*

Astrium and Thales Alenia Space have been awarded a $1.66 billion contract by United Arab Emirates-based 'Yahsat' to provide two communications satellites for customers in the Middle East, Africa, Europe and South East Asia. The main structure and subsystems for each satellite will be built at Astrium's factory in Stevenage. It is estimated that some 250 people in the UK will work on the programme.

This year, SSTL's achievements have been recognised with three prestigious awards from the Royal Aeronautical Society. The team responsible for the building and delivery of the highly successful Galileo test satellite, GIOVE-A, received two of the awards. The third was the Society's Bronze Award for the work of Dr Mike Cutter on the CHRIS camera which flies on Europe's Proba satellite.

SSTL is currently manufacturing new satellites for the Disaster Monitoring and RapidEye Constellations and is also involved in studies for missions to the Moon. It has been awarded a contract from Canadian company MacDonald, Dettwiler and Associates Limited (MDA) to deliver a satellite platform as part of the Sapphire space object surveillance programme.

Astrium, SSTL and another UK company, SEA group Limited, have secured contracts to develop and build the ESA EarthCARE Earth observation satellite. EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) will focus on clouds and tiny particles in the atmosphere – aerosols – to assess their influence on atmospheric radiation.

The EarthCARE platform will be built in the UK by Astrium, the Multi-Spectral Imager by SSTL and the Broadband Radiometer (BBR) by SEA. The company is predominantly UK-based and the winning consortium includes the Rutherford Appleton Laboratory and Sula. SEA also has a smaller role in another of EarthCARE's instruments, the Cloud Profiling Radar, which is being supplied by the Japanese Space Agency (JAXA).


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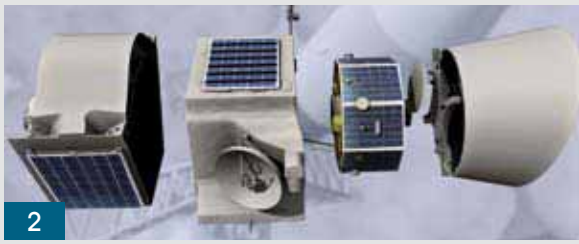
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1 Astrium engineer working on a satellite payload in Portsmouth; *Credit: Astrium*

2 The component parts of BepiColombo; *Credit: Astrium*

Other UK manufacturing companies that have achieved notable successes this year include e2v which has won a contract to supply sensors for the Indian Space Application Centre. These CCD (Charge Coupled Devices) sensors will provide Indian Earth observation programmes with resolution that will enable the monitoring of environment, land use and also aid in disaster support.

SUPPORTING BUSINESS

BNSC works with industry to seek funds and, through its expertise, encourage the future success and growth of the space sector.

BNSC subscribes to ESA programmes that lead to the development of new technologies. These include the Advanced Research in Telecommunications Systems (ARTES) programme, which supports the development of applied technology in the communications sector, and the Global Monitoring for Environment and Security (GMES) programme, aimed at delivering information and services required to enhance environmental and security policy in Europe.

A significant level of funding for GMES activities is coming from the 7th Framework Programme (FP7). This is the European Union's funding mechanism for collaborative research and development projects in science, technology and engineering. It is particularly valuable for UK researchers looking to get access to wider expertise. Future calls under the programme are expected to focus on the development of GMES downstream services with one emphasis on how GMES may supply data and services relevant to the climate change agenda.

Moon contract

A software company based in the Cumbrian town of Barrow-in-Furness has won a major contract with NASA. 3SL was selected against stiff competition from the world's computer giants to supply the space agency with 3SL's 'Cradle' software tool. Cradle is now mandated by NASA as the means to define the requirements for, and the high-level design of, all elements of the ambitious Constellation programme – NASA's plan for manned missions to the Moon, the creation of a Lunar Base and, ultimately, the first manned mission to Mars.

1 The Crew Mobility Chassis Prototype is NASA's new concept for a lunar truck; *Credit: NASA*

LICENSING SPACECRAFT

↘ Ariane 5 ECA lift-off;
Credit: ESA/CNES/ ARIANESPACE-Service Optique CSG

BNSC is charged with regulating UK space activity to ensure compliance with the UK's international obligations. The Outer Space Act (OSA) 1986 requires UK individuals or organisations to apply for a licence from BNSC whenever they launch or procure the launch of a space object, operate a space object or carry out any other activity in outer space.

Before granting a licence, the Secretary of State for Innovation, Universities and Skills has to be satisfied the activity will not jeopardise public health or the safety of people or property. The OSA also requires the Government to maintain an up-to-date public register of space objects launched by UK organisations or individuals.

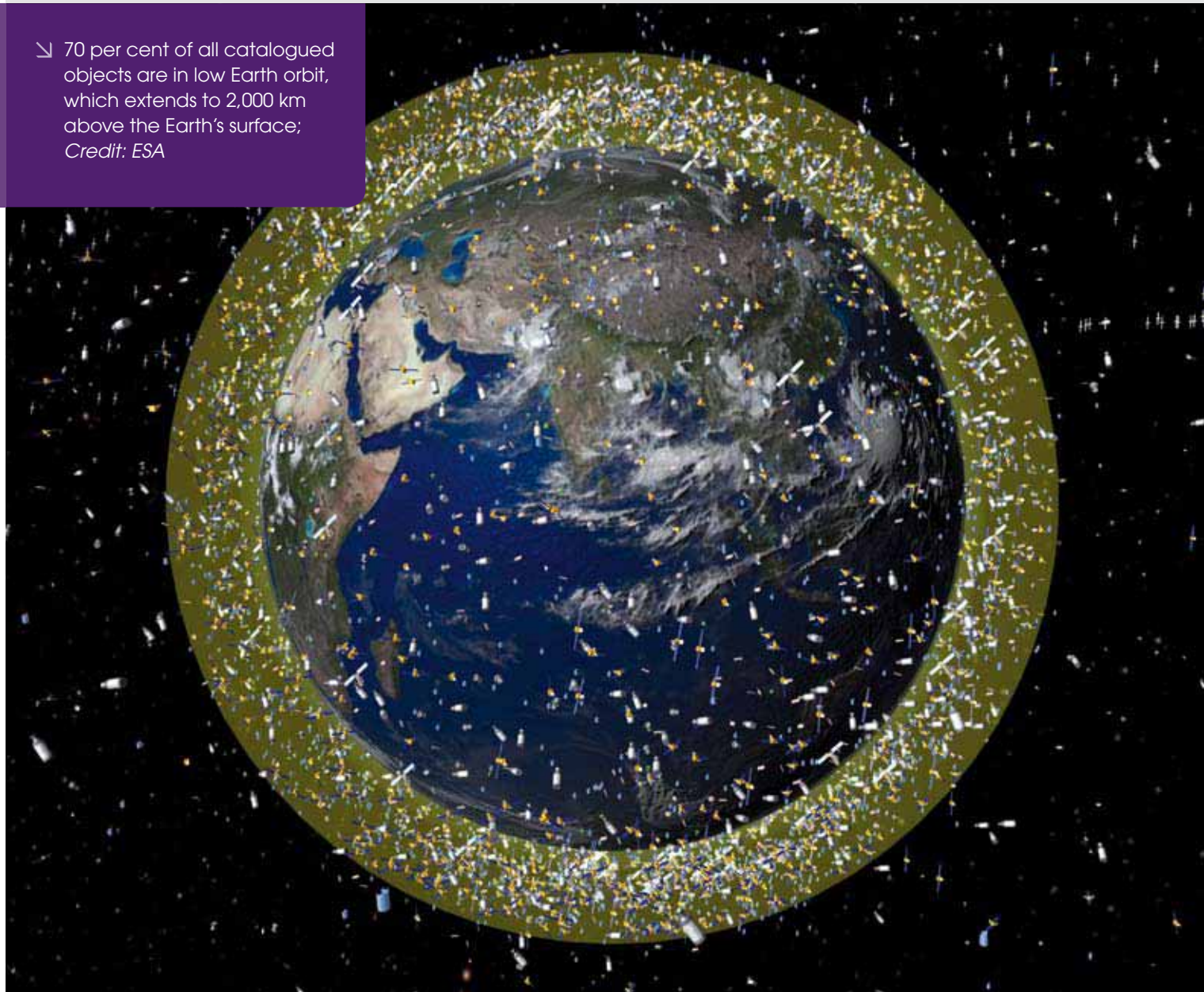
The UK considers it particularly important that satellite operators are able to dispose of their satellite once it has reached the end of its operational life to avoid contributing to the problem of space debris. In support of BNSC's commitment to the OSA, BNSC funds the operation of the Starbrook space surveillance sensors. In the past year, BNSC has also introduced improved safety assessments and developed enhanced collision risk analyses. This effort is to help prevent incidents that might lead to accidental release of debris.

BNSC is working on proposals to amend the existing regulations, including consideration of how space tourism might be addressed under the Act. These will be put out for public consultation in due course.

1 The Soyuz-Fregat launch vehicle carrying GIOVE-B; *Credit: ESA/S Corvaja*

SPACE DEBRIS

↘ 70 per cent of all catalogued objects are in low Earth orbit, which extends to 2,000 km above the Earth's surface; *Credit: ESA*



There are thousands of pieces of space debris orbiting the Earth. This 'space junk' includes fragments from redundant spacecraft and other space systems. They can severely damage and even destroy orbiting satellites. There are currently more than 12,000 catalogued objects, and the UK has taken a leading role in efforts to reduce and mitigate space debris.

BNSC is an active member of the Inter Agency Space Debris Co-ordination Committee (IADC). This organisation meets annually to co-ordinate research between its member agencies. Within Europe, BNSC is part of the Space Debris Network of Centres and has backed a European Code of Conduct on space debris. The UK is also taking the lead on debris activities at the International Standards Organisation which is developing standards for the implementation of measures to combat space debris.

In support of its commitment to the UK Outer Space Act, BNSC funds the operation of space surveillance sensors developed by UK company Space Insight Limited. The wide field of view of these sensors enables surveys of space debris in the higher Earth orbits to be carried out efficiently. Starbrook's role in debris surveys is being expanded to include surveys of the orbits used by navigation satellites, such as Galileo. Analysis of debris surveys is reported by the UK delegation to the IADC.

Scientists at the Natural History Museum in London, in collaboration with a team at the University of Kent, have been examining the impact of micrometeoroids on the aluminium foils of the Stardust spacecraft. The team has been able to assess the composition and density of projectiles based on the depth of crater. Another science team at the University of Southampton has developed computer models to enable future predictions of space debris to be made. The information will be used to advise policy makers on how best to manage the orbital environment in a sustainable manner for generations to come.

1 Space debris can put spacecraft and astronauts at risk; *Credit: NASA*

NEAR EARTH OBJECTS

↘ The UK has been at the forefront of efforts to examine the threat posed by future Near Earth Objects; *Credit: Dan Durda/FIAAA*

Our planet is surrounded by cosmic debris – comets, asteroids, ice and rock. Hundreds of tiny fragments bombard the Earth every day but are rarely more than a few millimetres across. Occasionally, a larger piece of material will reach the surface. But if a fragment of even a few dozen metres in diameter were to hit the Earth, it would have a significant effect. Comets or asteroids whose orbits come close to our planet are called Near Earth Objects or NEOs.

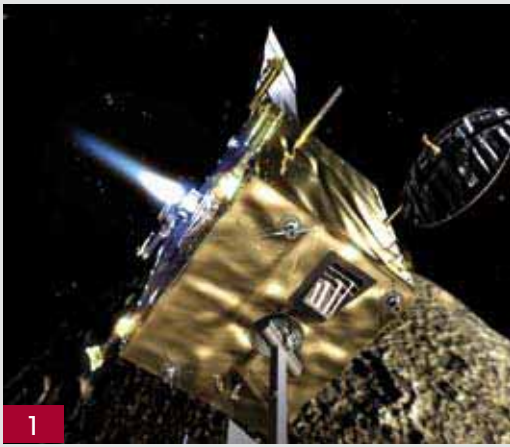
BNSC has been at the forefront of international scientific efforts to examine the potential threat that future NEOs could pose. The Government set up and supports the NEO Information Centre, based at the National Space Centre in Leicester. The UK is also home to the Spaceguard Centre, located near Knighton in mid-Wales. Both have a well-established outreach programme to provide accurate and factual information on NEOs to the public and media. The UK currently chairs the United Nations Working Group addressing the NEO threat.

UK research teams are also involved in several projects to examine methods to deflect NEOs were one to threaten the Earth. Glasgow University is pursuing a three-year programme, funded by the Engineering and Physical Sciences Research Council to study the options for changing the trajectory of an NEO.

QinetiQ and the Open University (OU) have been undertaking studies to develop ESA's Don Quijote mission. Don Quijote is a 'precursor' mission, designed to assess the technology that could one day be used to deflect an asteroid threatening our planet.

A team from Astrium developed the APEX mission concept which could rendezvous with the asteroid Apophis in January 2014. The spacecraft would then spend three years sending data back to scientists and engineers, enabling an accurate prediction to be made of its orbit. Astrium's APEX concept won a bronze medal in a global competition organised by The Planetary Society.

Preparatory studies for the proposed NEO sample return mission, Marco Polo, are being made by Astrium, together with the OU and Aberystwyth University. The OU, Leicester University, Oxford University, MSSL and RAL are also developing potential instruments. This mission has recently been selected as a candidate within ESA's Cosmic Vision programme and would be designed (most likely in co-operation with Japan's space agency JAXA) to return a sample of unaltered asteroid material to Earth.



1 Artist's image of Don Quijote; *Credit: ESA/AOES Medialab*

EDUCATION AND SKILLS

↘ Pupils from Newchurch Primary School launching air-powered rockets towards a Moon target;
Credit: Lucy Rogers

The role of space activities in promoting science, technology, engineering and mathematics (STEM) is an important aspect of the work of BNSC. The positioning of BNSC within the new Department for Innovation, Universities & Skills (DIUS), coupled with the report of the House of Commons Science and Technology Committee's recent inquiry into UK space policy, has focused BNSC education activities around an equally vital strand: high-value skills for a high-technology future.

BNSC's priority in education is to co-ordinate across the wide range of space education activities undertaken in the UK and to link these to the curriculum and teachers' needs. To this end, BNSC has been working with ESA and Yorkshire Forward to establish a pilot European Space Education Resource Office (ESERO) for the UK. Negotiations are now nearing their conclusion and the pilot phase is expected to be completed at the end of 2008. A decision on the longer-term implementation will then be taken.

Thanks to a major grant by the East Midlands Development Agency (EMDA), a Space Academy is being set up at the National Space Centre in Leicester, with partners at the University of Leicester, the University of Nottingham, the Regional Science Learning Centre for the East Midlands and STEMNET. This Academy will provide education programmes, summer space schools, roadshows and conferences. These will be built around the school curriculum using space as the inspiration. Initially, the Academy is aimed at students between 14-19 years of age, and their teachers, in the East Midlands and beyond. It will draw on the skills and reputations of Universities in the region and employers who need scientists and engineers.

A space education and skills working group – co-chaired by BNSC and the Department for Children, Schools and Families – has been established to provide policy-level oversight and to maximise impact on the Government's wider aims on STEM education.

SKILLS FOR A HIGH TECHNOLOGY FUTURE

With continuing strong growth, high productivity and investment in research and development, the space sector is an important part of the UK's portfolio of high-value sectors. The future health of the sector is reliant on the continuing availability of scientists, engineers and technicians with the necessary skills. BNSC plans a study to assess the critical issues in the future supply of skills for the UK space sector. This will be carried out in conjunction with employers and relevant skills bodies.


1

1 Space has a vital role in the teaching of science, technology, engineering and mathematics

COMMUNICATIONS

↘ Minister Ian Pearson (second from the right) joined representatives from science and industry at Jodrell Bank to highlight the UK's achievements in space; *Credit: A Holloway/Jodrell Bank*

BNSC wants to raise awareness of the benefits of UK space activities to a wide range of audiences including the media, teachers, young people and the wider public.

Key media events this year included the launch of the new UK Civil Space Strategy 2008-2012 which received widespread coverage in the national media, significantly raising the profile of UK space activities.

2007 also marked the 50th anniversary of spaceflight, and BNSC commissioned a series of podcasts for the BNSC website including unique archive material and interviews with UK space pioneers. BNSC also published a leaflet on the history of the UK in space, a special poster highlighting the past five decades, and was involved in organising a special event, attended by the Minister and other dignitaries, to celebrate 50 years of space at Jodrell Bank in Cheshire.

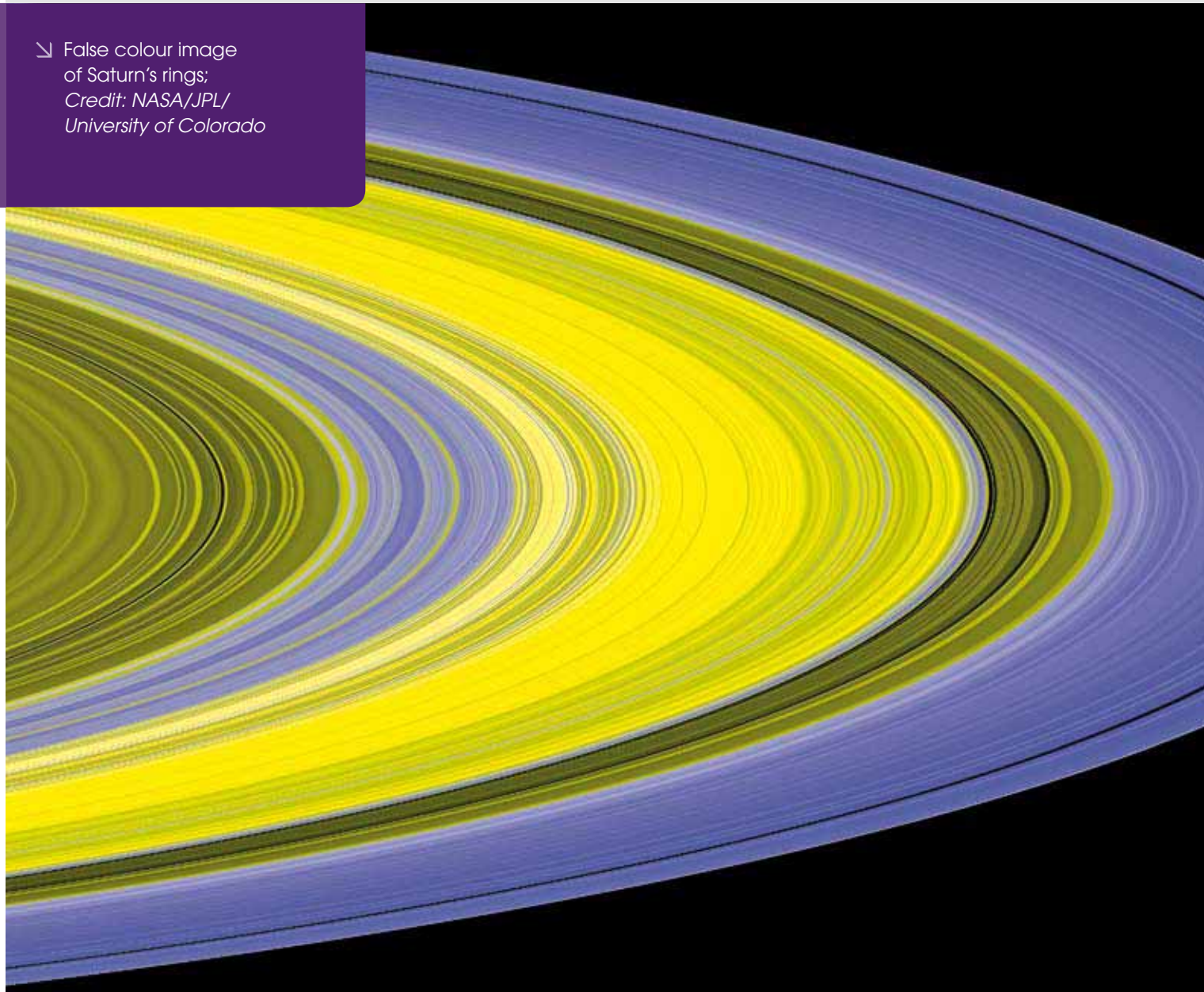
Events attended this year include the Cheltenham Science Festival, the International Astronautical Congress (IAC) in India and the Education Show. At the Cheltenham Science Festival, in addition to hosting a stand with posters, leaflets and other 'give-aways' designed to appeal to young people, BNSC sponsored three talks. BNSC's eye-catching stand at the Education Show also featured a range of displays and demonstrations to attract teachers. At the IAC, BNSC took the opportunity to showcase UK activities to a wider international audience including other space agencies and leading academics.

BNSC's *space:uk* magazine continues to prove popular. The publication has been re-designed and re-focused to target younger people and a general readership who are interested in space. The magazine is produced to coincide with the three school terms, and this year saw special issues to commemorate 50 years in space and an issue featuring a 3-D poster with accompanying glasses!

During the past 12 months, content on the BNSC website (**www.bnsc.gov.uk**) has undergone a series of major updates and rewrites to maintain the website as the place to find news, information and features on UK space activities.

1 *space:uk* magazine

FINANCE



↘ False colour image of Saturn's rings; *Credit: NASA/JPL/ University of Colorado*

BREAKDOWNS OF FUNDS – BY SPEND AREA (£ MILLION)

Amount accrued during financial year 2007/08	BNSC PARTNERS							
	MOD	DfT	STFC	NERC	Met Office	Defra	DTI/DIUS*	Total
EARTH OBSERVATION								
National				6.75		0.25	1.16	8.16
ESA	0.50			36.76		1.00	2.02	40.28
EUMETSAT					20.80			20.80
SCIENCE/MICROGRAVITY								
National			28.50					28.50
ESA			56.43					56.43
TELECOMMS AND NAVIGATION								
National							0.53	0.53
ESA		4.00					48.00	52.00
TECHNOLOGY								
National	0.50						0.58	1.08
ESA								0.00
TRANSPORTATION								
National								0.00
ESA							6.02	6.02
Other national							0.54	0.54
ESA general budget			10.66	8.28			5.83	24.77
TOTAL	**1.00**	**4.00**	**95.59**	**51.79**	**20.80**	**1.25**	**64.68**	**239.11**

*DIUS, BERR and DCSF were created from DTI and DfES on 28 June 2007

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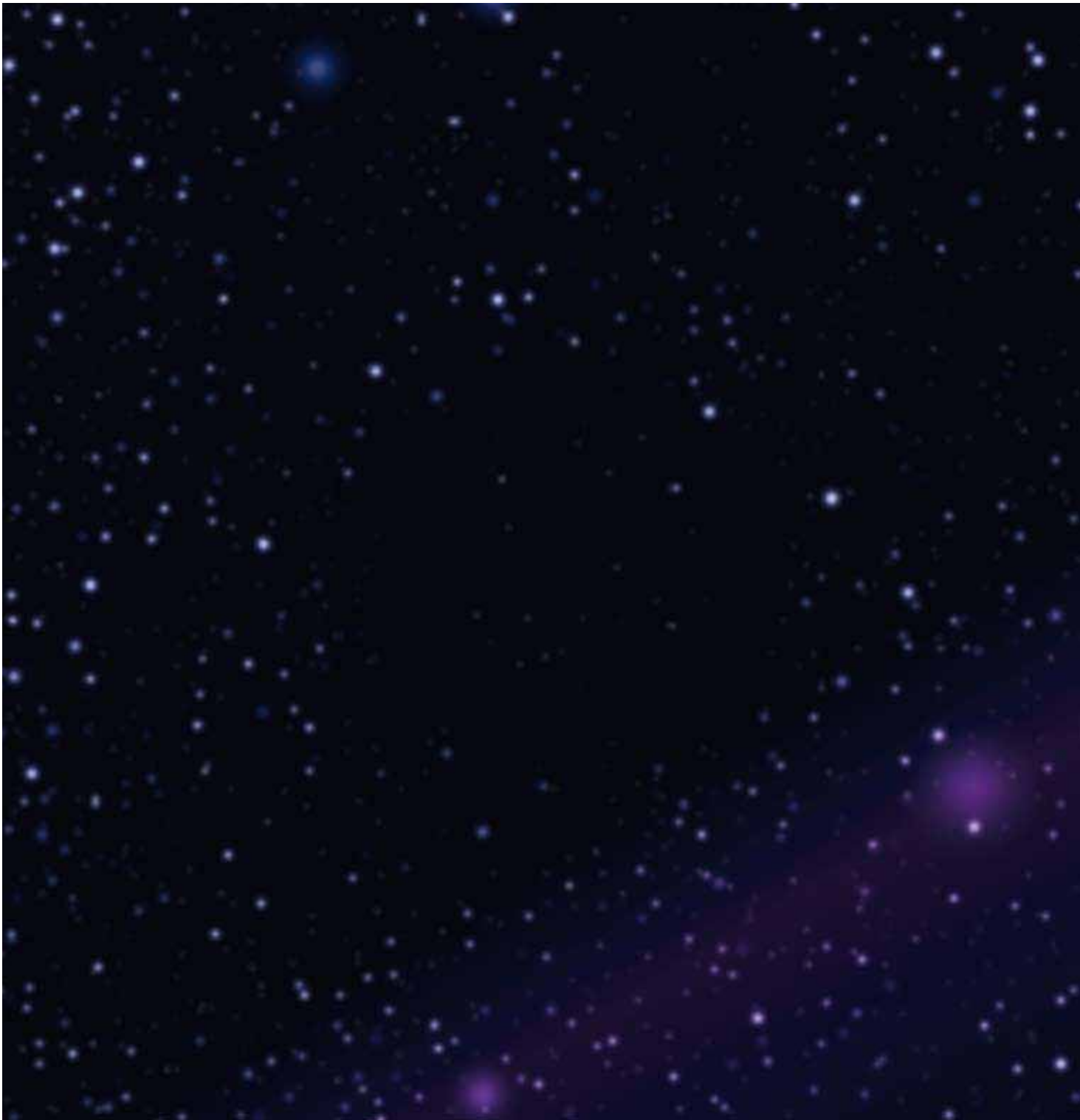

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