In Brief

SMART-1: Crash Scene Investigation

Early on 3 September, observers around the world saw a small flash illuminate the surface of the Moon. They had witnessed the final moments of ESA's tiny SMART-1 spacecraft as it impacted the lunar soil.

SMART-1 scientists and engineers at the European Space Operations Centre (ESOC), in Darmstadt (D), confirmed the impact at 05:42:22 UT, when the New Norcia ground station in Australia suddenly lost radio contact. SMART-1 ended its remarkable journey in the Lake of Excellence, at 34.4°S/46.2°W.

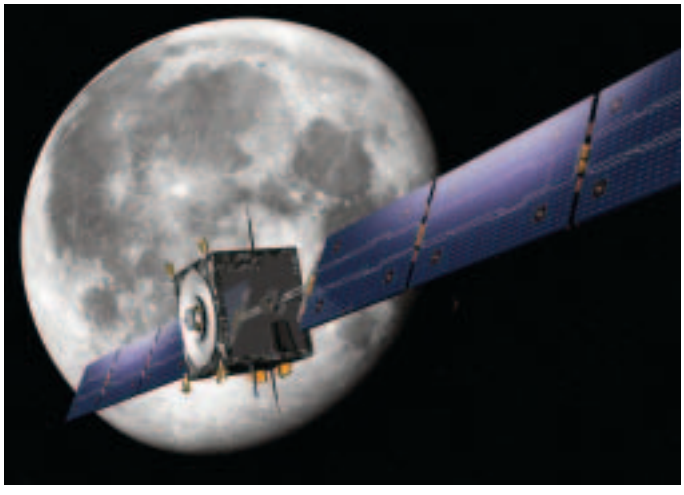
The 2 km/s impact occurred in a dark area near the terminator (the day-night line) at a grazing angle of 5–10°. The time and location were planned via a series of corrections during the summer – the last on 1 September – to favour observations by telescopes on Earth.

The impact concluded a spectacularly successful mission that, in addition to testing innovative space technology, had been exploring the Moon for 16 months, gathering data on the structure and mineral composition of the surface in visible, infrared and X-ray.

Professional and amateur observers from South Africa, the Canary Islands, South America, the continental USA, Hawaii and many other locations were watching, hoping to spot the faint flash for information about the impact dynamics and the lunar surface excavated by the spacecraft.

The final days of SMART-1 saw intense activity as controllers shepherded it towards its destiny. Based on estimates that included local topography, impact was due during orbit 2890, at 05:41 UT somewhere at mid-southern latitudes on the near-side. Then, with only a few days to go, the data suggested that, in the absence of any further manoeuvres, impact would very likely occur one orbit earlier, at 00:38 UT during orbit 2889, if SMART-1 clipped the 1600 m-high rim of Clausius crater.

During the night of 1–2 September, ESOC controllers planned to use the thrusters to

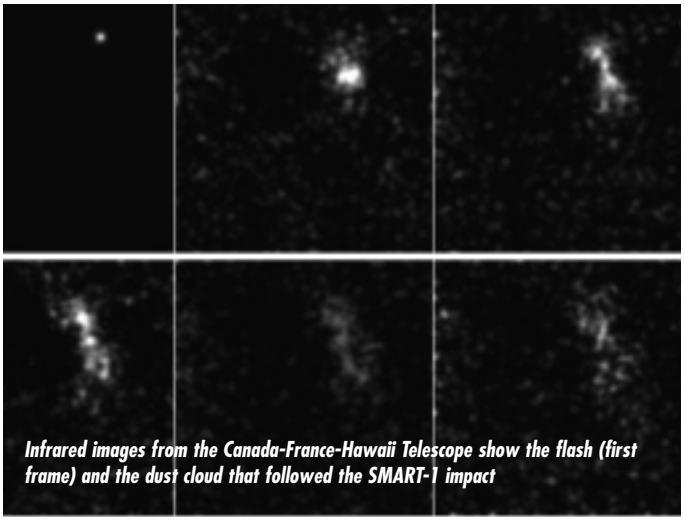


boost the perilune of the penultimate orbit, while maintaining the intended impact time and location. Suddenly, to add to the tension, SMART-1 unexpectedly placed itself into 'safe mode', at 13:09 UT on 1 September with the manoeuvres pending. Most spacecraft functions and payload operations were suspended.

After a tense 6 hours, Spacecraft Operations Manager Octavio Camino happily reported full recovery at 17:15 UT. The manoeuvres were successful, boosting perilune by 592 m and shifting impact to 05:42 UT.

The impact took place on orbit 2890. SMART-1 sent its last signals at 05:42:21:759 UT, and the Mount Pleasant Observatory radio telescope of the University of Tasmania in Hobart, lost the signal at 05:42:22.394 UT. These times are remarkable agreement with the final predictions and the coordinates derived from the position of the infrared impact flash observed by the Canada-France-Hawaii Telescope (CFHT) on Hawaii.

"*From the various observations and models, we are trying to*



Infrared images from the Canada-France-Hawaii Telescope show the flash (first frame) and the dust cloud that followed the SMART-1 impact

reconstruct the 'movie' of what happened to the spacecraft and the Moon's surface. For this lunar 'Crash Scene Investigation', we need all possible Earth witnesses and observational facts," said Bernard Foing, SMART-1 Project Scientist.

Extensive data processing is now under way to define the site's topography. From a preliminary analysis of the stereo data and earlier maps built with SMART-1 data, it should have hit the Moon on the ascending slope of a mountain about 1.5 km high, above the Lake of Excellence plain.

In the CFHT infrared movie, a cloud of ejected material and debris was seen moving about 80 km in 130 sec by Christian Veillet, Principal Investigator for the observations at CFHT. To determine which part of the flash came from heated lunar rock or from the probe's remaining propellant, it was important to obtain measurements in several optical and infrared wavelengths, in addition to the CFHT observations at 2.12 micron.

"*Our decision to extend the scientific mission by a further year (it was initially planned to last only 6 months) allowed scientists to use a number of innovative observing methods at the Moon. This was tough work for the mission planners, but the lunar data archive we are now building is truly impressive*," said Gerhard Schwehm, SMART-1 Mission Manager.

"*For ESA's Science Programme, SMART-1 represents a great success and a very good return on investment, both from the technological and the scientific point of view. Future scientific missions will greatly benefit from the technological and operational experience gained thanks to this small spacecraft, while the scientific data gathered by SMART-1 are already helping to update our current picture of the Moon*," said David Southwood, Director of Scientific Programmes.

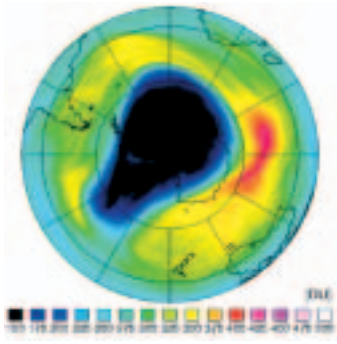
"*The legacy left by the huge wealth of SMART-1 data, to be analysed in the months and years to come, is a precious contribution to lunar science at a time when the exploration of the Moon is once again catching the world's interest*," said Bernard Foing. esa

Envisat Finds Record Ozone Hole

Measurements from ESA's Envisat satellite have revealed a record loss of ozone over Antarctica: the 40 million tonnes by 2 October 2006 exceeded the previous record of about 39 Mt in 2000. The size of this year's ozone hole is 28 million km^2, nearly as large as the record hole of 2000; its depth rivals 1998's record low.

"*Such significant ozone loss requires very low temperatures in the stratosphere combined with sunlight. This year's extreme loss can be explained by the temperatures above Antarctica reaching the lowest recorded since 1979*," said ESA atmospheric engineer Claus Zehner. The ozone layer, found about 25 km above us, shields life on Earth from the Sun's harmful ultraviolet rays. Over the last decade, the ozone has thinned by about 0.3% per year globally, increasing the risk of skin cancer, cataracts and harm to marine life. The reduction is caused by pollutants such as man-made chlorofluorocarbons, which have still not vanished despite being banned under the Montreal Protocol of 1987. A single molecule of chlorine can break down thousands of molecules of ozone.

The ozone hole of 27 September as measured by Envisat's SCIAMACHY instrument (KNMI/TEMIS)



The ozone hole, first recognised in 1985, typically persists until November or December, when the weakening polar vortex winds allow in ozone-rich air.
ESA is backing the Tropospheric Emission Monitoring Internet Service (TEMIS) to provide operational ozone and UV radiation monitoring based on Envisat SCIAMACHY and ERS-2 GOME-1 data. The ozone data from these instruments, spanning 11 years, will be extended by the MetOp satellite series and its next-generation GOME-2 for years to come.

"*Long-term measurements of ozone levels are of key importance for being able to monitor the ozone's predicted recovery, which is currently estimated to take place by around 2060*," Zehner said. esa

Space Colloquium

During 19–22 September, the Western European Union (WEU) Assembly and the European Interparliamentary Space Conference joined forces to hold a colloquium on 'Space, Defence and European Security' in Kourou, French Guiana, in association with ESA, CNES and Arianespace.

The event brought together more than 100 Members of Parliament from European nations along with Members of the European Parliament and senior executives from ESA, CNES, Arianespace and the space industry. The main aim of the discussions was to examine the space sector in its application to security and defence and assess industrial

Greece photographed by ESA astronaut Thomas Reiter from the International Space Station during his radio contact with 'Space Camp' students on 29 July. This year's ESA Space Camp was held in Patras, Greece

capabilities in the light of the challenges facing Europe. The participants noted the gulf between the strategic ambitions that Europe has for its space dimension and the level of funds it was prepared to commit to it.

The President of the Interparliamentary European Security and Defence Assembly (WEU Assembly), Jean-Pierre Masseret, emphasised the importance of Europe being able to draw on the full gamut of space-based facilities: Earth observation, telecommunications, intelligence, navigation and ballistic missile early warning systems, noting further that this comprehensive range of capabilities played a crucial part in preventing, managing and exiting crises, and would guarantee genuinely autonomous powers of decision and action in security and defence matters for Europe.

The President of the European Interparliamentary Space Conference, François Roelants du Vivier, welcomed the colloquium being held in Kourou, in his view "*not a moment too soon*". If Europe wanted to catch up with its main competitors in space, it needed to take the financial decisions that were necessary, and quickly. The vital necessity of the security and defence dimension being discussed at the colloquium was something that parliamentarians must seriously take on board in order to convince governments to invest massively in space – an area that has been far too long neglected.

The Director General of ESA, Jean-Jacques Dordain, felt that messages were being received from the conference that would constitute important inputs into the preparation, by the European Commission and ESA, of the European Space Policy, to be unveiled at the Fourth Meeting of the Space Council, in May 2007. Members of national parliaments and the European Parliament had affirmed the strategic importance of space for Europe. In defining and implementing a European Space Policy, Europeans should build on present successes. There was a need to take feedback from users, consolidate technological and industrial capacities, maintain flexibility, strengthen coordination between the parties involved and manage the evolution of space governance by stages. This was a challenge for everyone and one to which, with the commitment of all concerned, and in particular of the member states, Europe was quite equal.

For the President of CNES, Yannick D'Escatha, space had become thoroughly interdisciplinary, and was thus a key element of major European policies. He emphasised the special 'dual' contribution of space in virtually every field – military and civil – connected with people's security and was adamant that Europe must take advantage of this dual-use aspect, in view of the difference in levels of investment in Europe and the USA (1:6).

On the subject of access to space, the Chief Executive Officer of Arianespace, Jean-Yves Le Gall, pointed to the ever-stronger position of European launchers. Ariane-5's reliability and regular launches had enabled Europe to orbit the greatest number of commercial satellites in 2005 and 2006. This had given Europe a ready, reliable, guaranteed competitive access to space for sovereign missions by European governments.

In this respect, the European launcher programme was a model of the success of European integration in the service of security and defence, as the launches of 26 military satellites already illustrates. Finally, the full range of launchers in use at Europe's Spaceport in Kourou from 2008 – Vega, Soyuz and Ariane-5 – would mean that Europe could independently put a payload of any given weight into any chosen orbit. esa

Vega Nozzle

A ceremony at Snecma Propulsion Solide in Bordeaux (F) on 14 September marked the formal delivery of the first nozzle for the P80 first stage motor of ESA's Vega small launcher.

The delivery is a milestone for the Vega programme. Several years

of intensive development have achieved a major step forward in reducing costs. Not only a major event for Vega, it also bodes well for future updates to the Ariane-5 boosters.

Now in Kourou, the nozzle is being integrated with the P80 motor for the first firing test, planned for end-November. Vega's maiden flight is planned for late 2007. esa

New Goals for Earth Science

ESA announced in September a new science strategy for the future direction of its Living Planet Programme, addressing the continuing need to further our understanding of the Earth System and the impact that human activity is having.

The Changing Earth: New Scientific Challenges for ESA's Living Planet Programme focuses on the most fundamental challenge facing humanity at the beginning of the 21st century: global change. A better knowledge of the Earth System and the impact of increasing human activity is of crucial importance in providing the basis for managing a sustainable environment.

The Changing Earth *(SP-1304; €20, 83pp) can be ordered using the form at the back of this issue*

The new strategy aims to assess the most important Earth-science questions to be addressed in the years to come. It outlines the observational challenges that these raise, and the contribution that the Agency can make. Underpinning the strategy is a set of ambitious objectives, including:

– launch a steady flow of missions addressing key issues in Earth science;
– provide an infrastructure to allow satellite data to be quickly and efficiently exploited for research and applications;
– provide a unique contribution to global Earth observation capabilities, complementing satellites operated by other agencies and *in situ* observing systems;
– provide an efficient and cost-effective process for science priorities to be rapidly translated into space missions, adequately resourced with associated ground support;
– support the development of innovative approaches to instrumentation. esa

MetOp-A in Orbit!

MetOp-A, the first of three meteorological satellites developed jointly by ESA and Eumetsat, was successfully launched from Baikonur Cosmodrome, Kazakhstan at 16:28:13 UT on 19 October aboard a Russian Soyuz-2/Fregat rocket. Some 69 minutes later, the Fregat upper stage released the 4093 kg MetOp over the Kerguelen archipelago in the South Indian Ocean into a circular orbit at an altitude of 837 km.

With a slightly retrograde 98.7° inclination, this orbit enables MetOp-A to circle the globe from pole to pole while always crossing the equator at the same local time – 9:30 am. This Sun-synchronous orbit allows revisits to almost each point of the Earth's surface under similar illumination conditions almost on a daily basis. MetOp will provide a closer view of the atmosphere from low orbit, delivering data that will improve global weather prediction and enhance our understanding of climate change.

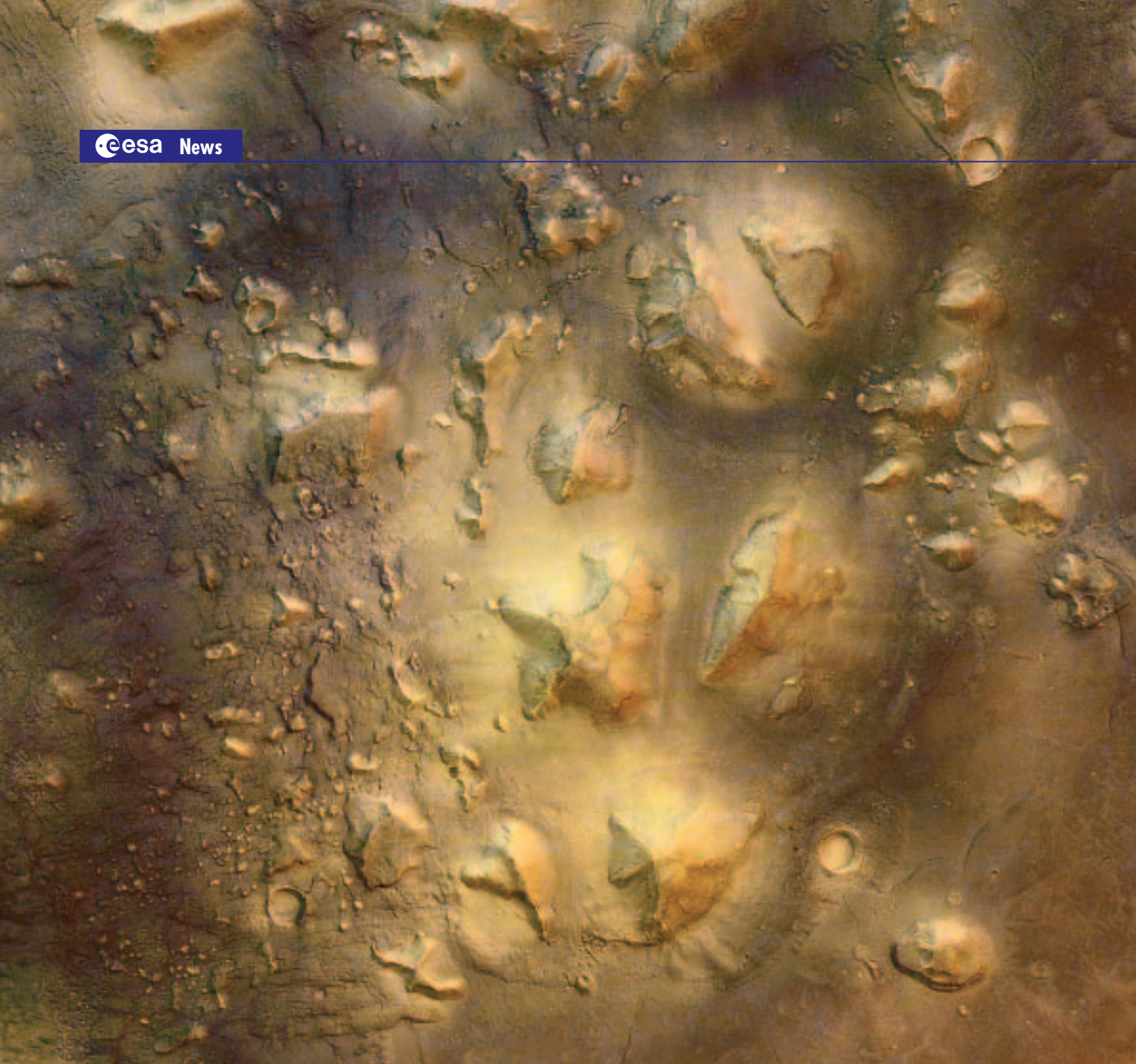
Following release, the satellite came under the control of ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany, and automatically deployed its solar array. It then underwent the first checkouts of its systems and deployed its antennas. Handover to Eumetsat was on 22 October for full satellite commissioning and routine operations. *Bulletin* 127 (August 2006) includes detailed articles on MetOp. esa

Leader Passes

It is with regret that ESA notes the death of Michel Bignier, on 12 October. A leading figure in the space world and Director General of CNES 1972–1976, he was Director of ESA's Spacelab programme 1976–1980, and then Director of Space Transport Systems until 1986. "*He has been one of the main players in the long struggle to adopt a balanced European Space Programme,*" said ESA Director General Jean-Jacques Dordain, echoing the deep regret of all those at ESA who had the opportunity to know Bignier and appreciate his work and commitment to a true European space policy. esa

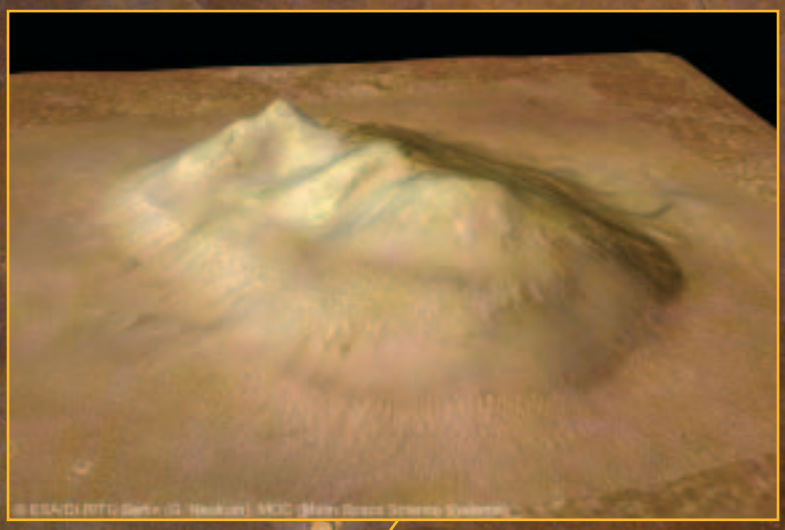
Asteroid Honour

The Minor Planet Center at the Smithsonian Astrophysical Observatory (Harvard, USA), under the auspices of the International Astronomical Union, has designated minor planet number 10969 as 'Perryman', named for Michael Perryman of ESA's Science directorate. Previously project scientist of the Hipparcos and Gaia missions, and professor at Leiden University, Michael Perryman was cited for his leadership in the development of space astronomy. The minor planet was discovered in May 1971 by C.J. van Houten and I. van Houten-Groeneveld on Palomar Schmidt telescope plates taken by T. Gehrels. esa



These spectacular images of the Cydonia region of the Red Planet were captured by the High Resolution Stereo Camera of Mars Express. Obtained on 22 July and released in September, they include the famous 'face' on Mars in unprecedented detail (inset and arrowed).

Cydonia sits in the transition zone between the planet's southern highlands and the northern plains, a region characterised by wide, debris-filled valleys and isolated remnant mounds of various shapes and sizes. One of these massifs became famous as the 'Face on Mars' in an image taken in 1976 by NASA's Viking-1 orbiter. It was an illusion caused by the angle of the Sun and the shadows giving the impression of eyes, nose and mouth. Other formations seen here in the top left quadrant resembled 'pyramids'. While the features are not artificial, they are nevertheless of great interest to planetary geologists. Image resolution is about 13.7 m per pixel. *(ESA/DLR/FU Berlin; G. Neukum)*



10 km N

New Zealand's dramatic landscape is captured by Envisat's MERIS imaging spectrometer on 10 September at a resolution of 300 m. Two of the volcanoes on the North Island are visible as snow-capped circular features. Mount Ruapehu, the North Island's tallest peak at 2797 m, is at top centre, while Mount Taranaki is at top left.
Mt. Ruapehu last erupted in 1995 and 1996; Mt. Taranaki is classed as dormant but it is still considered a risk. Their impressive landscapes have attracted attention from film directors: Mt. Ruapehu was transformed into the fiery Mount Doom in 'Lord of the Rings', while Mt. Taranaki served as the setting for 'The Last Samurai'. As almost all volcanoes occur near tectonic plate boundaries, it is no surprise that volcanism has greatly affected New Zealand's landscape. Volcanoes have claimed more lives in the country than any other form of natural disaster. South Island is at bottom left.

The current configuration of the International Space Station, after a second pair of 73 m-long solar wings (in shadow) was attached in September by Shuttle mission STS-115. The new wings will double the Station's power when they are brought online during the next Shuttle flight, STS-116, planned for launch in December. Part of the job will be done by ESA astronaut Christer Fuglesang during his two spacewalks on that mission. STS-116 will also return ESA astronaut Thomas Reiter, who has been working aboard the Station since 6 July, to Earth. Next year will be a busy time for ESA and its astronauts at the Station: Paolo Nespoli will accompany Node-2 aboard STS-120 in August, Hans Schlegel is scheduled to fly with the Columbus module on STS-122 in October, and the Agency's Automated Transfer Vehicle (ATV) will begin its delivery service some time during May–July following launch by Ariane-5 from Kourou.

A new Hubble image of the 'Antennae' galaxies is the sharpest yet of this merging pair of spiral galaxies. As they smash together, thousand of millions of stars are born, mostly in groups and clusters. The galaxies started to fuse about 500 million years ago, making them the nearest and youngest example of a pair of colliding galaxies. Nearly half of the faint objects are young clusters containing tens of thousands of stars. The orange blobs to the left and right of centre are the two cores of the original galaxies, and consist mainly of old stars criss-crossed by filaments of dust. The two galaxies are dotted with brilliant blue star-forming regions surrounded by pink hydrogen gas. Only about 10% of the new super star clusters will live to see their ten millionth birthday – most will disperse into individual stars but about 100 of the largest will survive to become globular clusters as we see in our Galaxy today. (*NASA/ESA/B. Whitmore, STScI*)

The fourth Ariane-5 success of the year. On 13 October, flight V173 from Kourou, French Guiana, delivered two commercial telecommunications satellites safely into geostationary transfer orbit. DirectTV-9S will broadcast TV services to the USA, while Optus-D1 will provide communications and TV services over Australia and New Zealand. The mission also carried Japan's LDREX-2 to demonstrate the deployment of a lightweight antenna planned for the ETS-8 engineering test satellite. The fifth and final Ariane-5 launch of the year is planned for December. As with the others in 2006, it will use the 'ECA' version to carry two main passengers: the AMC-18 TV-distribution satellite for SES Americom, and WildBlue-1 to handle Ka-band Internet traffic. Ariane-5 ECA, with its large cryogenic upper stage, is the most powerful of the world's commercial launchers. (*ESA-CNES-Arianespace/Photo Optique Video CSG*)