In Brief

3rd Space Station Element to be Launched

NASA and the Russian Aviation and Space Agency (Rosaviakosmos) plan that the next component of the International Space Station (ISS) – the Zvezda service module – will be launched on 12 July from the Baikonur Cosmodrome in Kazakhstan.

Following a Joint Programme Review and a General Designers' Review in Moscow, it was agreed that Zvezda (Russian for 'star') will be launched by a Proton rocket with the second and third stage engines modified to increase engine reliability.

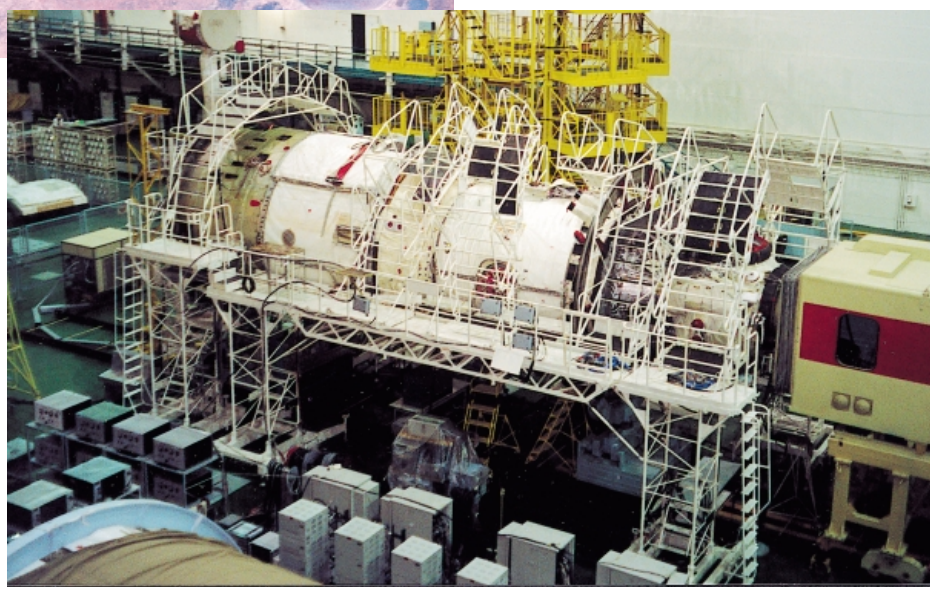
Zvezda will provide the early living quarters for ISS crew, together with the life support, electrical power distribution, data management, flight control, and propulsion systems for the ISS.

ESA, together with a European industrial consortium headed by DaimlerChrysler (D) and including Belgian, Dutch and French partners, was responsible for the design, development and delivery of the core data management system, which provides Zvezda's main computer.

ESA also has a contract with Rosaviakosmos and RSC-Energia for performing system and interface integration tasks required for docking with Zvezda by ESA's Automated Transfer Vehicle (ATV), which will be used for ISS re-boost and logistics support missions from 2003 onwards. Through its ATV industrial consortium led by Aerospatiale Matra Lanceurs (F), ESA is also procuring some Russian hardware and software for use with the ATV.

On the scientific side, ESA has concluded contracts with Rosaviakosmos and RSC-Energia for the conduct of scientific experiments on Zvezda, including the Global Timing System (GTS) and a radiobiology experiment (called Matroshka) to monitor and analyse radiation doses in ISS crew. Cooperation on further scientific experiments to be conducted on the Russian segment of the ISS is continuing with Rosaviakosmos and Russia's IBMP (Institute for Biomedical Research). esa

Zvezda (left-most module) is the third infrastructure element of the International Space Station (ESA/D. Ducros)

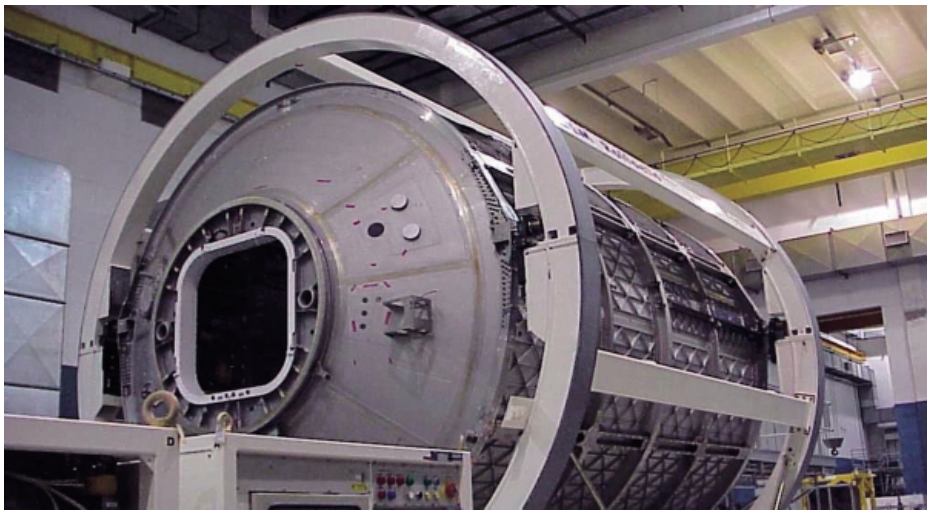


Zvezda integration at the Baikonur Cosmodrome

Synergies and Cooperation Save on European Contribution to the ISS

At a ceremony held on 14 April at Alenia Spazio in Turin, Italy, the Columbus flight structure was handed over to ESA by ASI (Italian Space Agency). On the same occasion, the Environmental Control and Life Support Subsystem (ECLSS) ownership transfer from ESA to ASI was formalised.

Columbus, the cornerstone of ESA's contribution to the International Space Station, is a scientific laboratory scheduled for launch in 2004. Astronauts from Europe and elsewhere will be able to use the laboratory to conduct material sciences, medicine, biology and technology experiments, many eventually leading to benefits in commercial processes or everyday life on Earth.



The ECLSS, composed of fans, heat exchangers, sensors and motorised and pneumatic valves, all operated and monitored via the onboard computer, provides comfortable working conditions inside the space laboratories. In particular, the system controls temperature, humidity and ventilation, regulates atmospheric pressure, detects fire and monitors contamination of the living environment.

Prior to the ESA Council meeting at ministerial level in Toulouse in November 1995, it had seemed that approval of European participation in the ISS would be impossible to obtain, owing to the excessive price of the proposed programme. In mid-1994, ESA had embarked on a serious 'design-to-cost' exercise to revive the programme. The main thrust of this effort was to make Columbus a four-rack module, similar in length to the ASI Multi-Purpose Logistics Module (MPLM), in order to radically reduce the programme's design and operational costs.

In the second half of 1994, and into 1995, ESA and ASI reached an agreement whereby they would cooperate both generally on the development of pressurised modules and specifically on two particular cases. The essence of this agreement was that:

– ESA would design and verify an Environmental Control and Life Support Subsystem which would satisfy the requirements of both the MPLM and the Columbus laboratory, and would deliver to ASI engineering models, three sets of flight hardware, some spares and the ground support equipment for the MPLM. ESA would then use this equipment for its Columbus module.

– ASI, which was already developing the MPLM, would supply ESA with a flight unit primary structure for Columbus based on that of the MPLM, and would provide the MPLM qualification data to enable ESA to qualify Columbus on the basis of commonality, thereby avoiding the need for a separate qualification test model.

Thanks to this agreement, both Agencies would avoid duplicating high development costs and would help save roughly € 70 million of taxpayers' money. Further reductions arising from the downsizing of the Columbus laboratory enabled the Columbus part of the ESA ISS development programme to be literally halved in price, down to approximately € 700 million. On that basis, the ministers responsible for space gathered in Toulouse in November 1995 were able to approve the overall ISS programme.

Alenia Spazio, as the MPLM prime contractor, manufactured the structure and performed ECLSS integration for the Multi-Purpose Logistics Module under ASI contract; DASA-Dornier, as the ECLSS subcontractor for Columbus, was entrusted with ECLSS development and verification under a contract with ESA. The industrial activities were jointly controlled by ESA and ASI.

In addition to these specific joint developments, further synergies were found. Alenia Spazio became the prime contractor for ISS Nodes-2 and -3, a contract managed by ASI on behalf of ESA, the price of which is being used to offset the launch costs of the Columbus laboratory by NASA's Space Shuttle. European industry is thus developing hardware for the Station using ESA funds, rather than ESA paying NASA in dollars for the launch of Columbus.

Alenia Spazio is also the contractor for the pressurised Carrier part of the Automated Transfer Vehicle (ATV) which, launched atop Ariane-5, will be used as a 'ferry' vehicle for payload, propellant, fresh food and general provisions.

This agreement has also fostered an increasing use of common subcontractors (and hence common design principles) for the Columbus and Node harnesses and Mechanical Ground Support Equipment (OHB, Germany) and Thermal Control Subsystems (Microtecnica, Italy), further improving the cost-efficiency of European human spaceflight projects. These synergies will continue into the operational phase, in terms of integration, payload operation and logistics activities.

The final ECLSS equipment and the Columbus primary structure were delivered in March/April. Much of the ECLSS hardware is already at NASA/Kennedy Space Center awaiting the first launch of the MPLM Leonardo, currently planned for February 2001, but several tonnes of ECLSS and structure equipment can still be viewed in Turin, together with other elements of ASI and Alenia Spazio's contribution to the development of the International Space Station.

Physics on Stage

Physics is everywhere. The laws of physics govern the Universe, the Sun, the Earth and even our own lives. In today's rapidly developing society, we are becoming increasingly dependent on high technology – computers, transport and communication are just some of the key areas that are the result of discoveries by scientists working in physics.

But how much does the average person really know about physics? There is now a unique opportunity to learn more about this elusive subject! Three major European research establishments have organised a unique Europe-wide programme to raise public awareness of physics and related sciences.

'Physics on Stage' was launched in February by ESA, CERN (European Laboratory for Particle Physics) and ESO (European Southern Observatory) with support from the European Union. Other partners include the European Physical Society (EPS) and the European Association for Astronomy Education (EAAE). This exciting programme is part of the European Week for Science and Technology and will culminate in a Science Festival, on 6-11 November, at CERN (Geneva).

The primary goal of 'Physics on Stage is to heighten interest in and knowledge of physics in Europe by means of a series of high-profile, physics-related activities. It will bring together leading scientists and educators, government bodies and the media, to confront the diminishing attraction and knowledge of physics in young people and to develop strategies to reverse this trend. The objective in the short term is to infuse excitement and to provide new educational materials. In the longer term, it will generate new developments by enabling experts throughout Europe to meet, exchange and innovate.

During the first phase of the programme (until October), the National Steering Committees (NSC) will survey their own country's* respective situation and collaborate with national media to identify new and exciting educational approaches to physics. These may involve demonstrations, interactive experiments, video and CD-Rom presentations, web applications, virtual reality, theatre performances, etc. Nationally-run competitions will select some of the best and most convincing new ideas for presentations and educational materials which will receive development support from the programme.

The project will culminate in November 2000, with approximately 400 delegates converging at CERN for the 'Physics on Stage' conference. The conference will enable the national competition winners, science teachers, science communicators, publishers, top scientists and high-level representatives of the ministries and European organisations to brainstorm solutions to bolster the popularity of physics. The conference will also include spectacular demonstrations of educational tools, the best of which will be disseminated over national TV networks and other media to the European public.

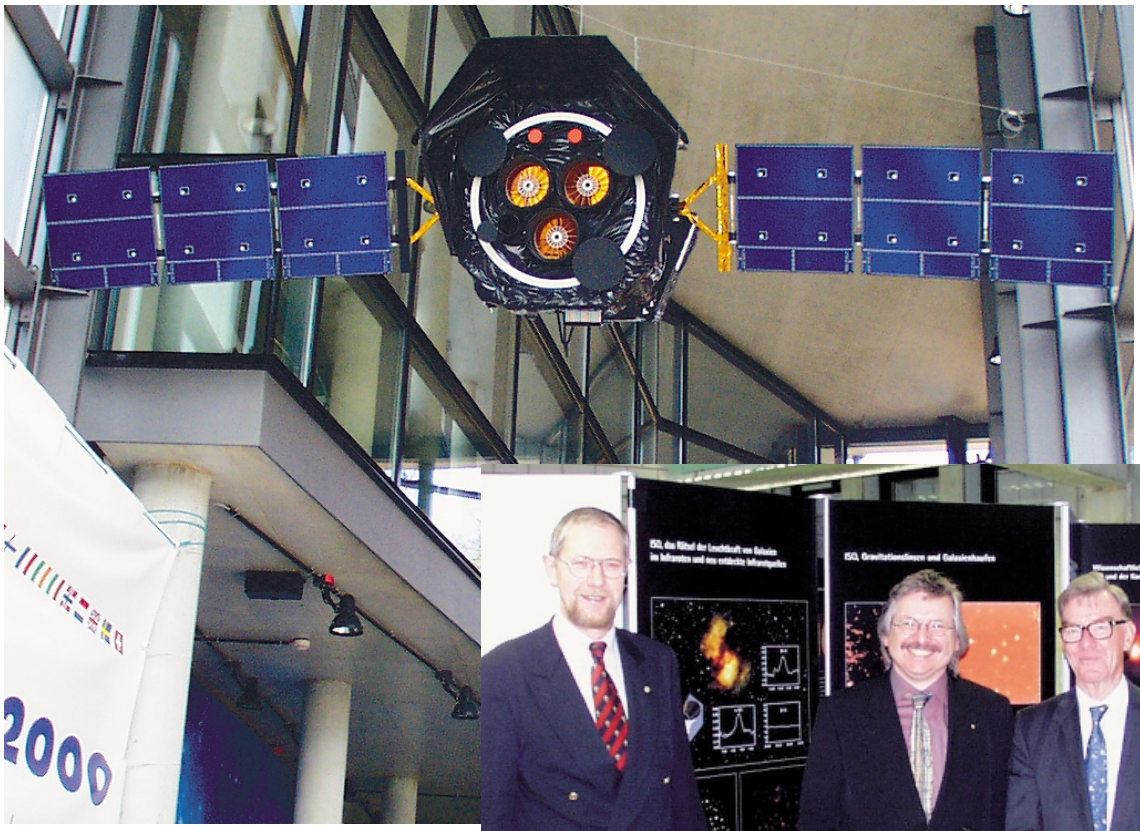
Statements by the Directors General of ESA, CERN, and ESO

Antonio Rodotà (ESA): *"Space has become an integral part of every day life. The immense technological development that has led to this achievement has taken place and might be taken for granted. But now is the time to follow up and form the future on this basis, a future that has to be made by the youth and has to give its benefits to the youth. The European Space Agency is dedicated to support the youth in its development to become a space generation. Many activities have been done and are taking place, and many more are planned for the future. Teachers and educational institutions and organisations form a key role in this development. ESA is enthusiastic about cooperating with ESO, CERN and the European Union to create an opportunity to receive ideas from the educational society and will perform a dedicated effort in finding ways to support the realisation of those ideas."*

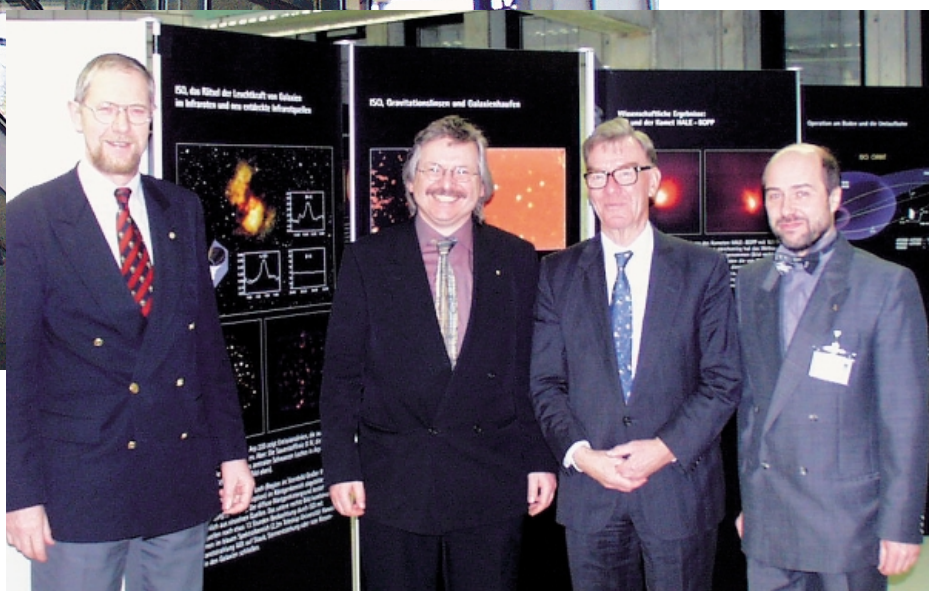
Luciano Maiani (CERN): *"Science is a critical resource for mankind and, among natural sciences, physics will continue to play a crucial role, well into the next century. The young people of Europe deserve the best possible physics teaching. An enormous resource of first class teachers, teaching materials and innovative thinking exists in our countries. The 'Physics on Stage' project will bring these together to generate a new interest in physics education which will be to the long-term benefit of children all over Europe. CERN is delighted to take part in this collaboration between the European Community and the continent's three leading physics research organisations."*

Catherine Cesarsky (ESO): *"Astronomy and astrophysics are at the very heart of modern physics. As vibrant research disciplines they use the most advanced technology available to humanity to explore the cosmos. It is also a science of extreme conditions – the largest distances, the longest periods of time, the highest temperatures, the strongest electrical and magnetic fields, the highest and lowest densities and the most extreme energies. The cosmos is indeed the greatest physics laboratory. For years, ESO - Europe's Astronomy Organisation - has been engaged in communicating the outcome of the exciting research programmes carried out at the ESO observatories to a wide audience and in particular to Europe's youth. I warmly welcome the broad international collaboration within 'Physics on Stage'. I am confident that working together with the European Union and our sister organisations ESA and CERN, as well as teachers' organisations and dedicated individuals in all member countries, this innovative education programme will make a most important contribution towards raising the interest in fundamental research in Europe."*

* 'Physics on Stage' is being initiated in 22 European countries which are members of at least one of the participating organisations or the EU: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, United Kingdom. More information can be found via the 'Physics on Stage' website: <http://www.estec.esa.nl/outreach/pos>. esa



The XMM-Newton model welcomes visitors in the exhibition entrance hall (photo courtesy E. Popow)



At the exhibition (left to right): Dr G. Hartmann (DLR, Bonn), Prof G. Hasinger (Director AIP), Prof R. Lüst (MPI for Meteorology) and Dr F. Jansen (author of ESA 2000). (photo courtesy E. Popow)

ESA 2000 Space Science Exhibition

The ESA 2000 Space Science Exhibition (13 March - 25 May) was opened by Prof. R. Lüst (ESA's Director General from 1984 to 1990) during the inauguration of the new Schwarzschild-building of the Astrophysical Institute Potsdam in Germany. A scientific talk was also given by Prof. R. Giacconi (Associated Universities Inc., Washington).

The exhibition consisted of 8 scale models and more than 70 information panels which informed the public about ESA in general and its science missions in particular. In addition, guided tours, videos, and the ESA brochures 'ESA 2000 The scientific programme of the European Space Agency' and 'Success Story: 30 discoveries from ESA's science missions in space' provided further insight. esa

ERS-1: Nine-year Success Story Comes to an End

Having given excellent service for nine years, over three times its planned lifetime, the ERS-1 mission was ended on Friday 10 March by a failure in the onboard attitude control system. Since its launch on 17 July 1991, ESA's first sun-synchronous polar-orbiting mission, has made 45 000 orbits, acquiring more than 1.5 million individual Synthetic Aperture Radar (SAR) scenes. ERS-1 SAR images, together with the data from other instruments on board, were delivered to a worldwide community of some 4000 users in science and applications. Surface winds derived from the scatterometer and altimeter have been supplied to meteorological services worldwide since 1991. The duration of the mission has also meant that scientists have already observed several El Niño phenomena through combined obser-vations of surface currents, topography, temperatures and winds. The measurements of sea surface temp-eratures, critical to the understanding of climate change, made by the ERS-1 Along-Track Scanning Radiometer, are the most accurate ever from space. All these critical measurements are being continued and enhanced by the current ERS-2 mission.

The most exciting results from the ERS-1 mission have been in the field of SAR interferometry, where for the first time precise topographic information could be routinely produced from space data. The ERS-1 and ERS-2 tandem operations demonstrated this technique for various applications and paved the way for the definition of new dedicated SAR interferometry missions. ERS-2 (launched in 1995) took over the operational services of ERS-1 in 1996. It too has now exceeded its nominal lifetime and remains in excellent condition. Next year Envisat will be launched to continue this series of Earth Observation missions. esa

Long-Term Ozone Measurements from Space Assured

The continued monitoring of ozone is assured well towards the end of the next decade through a € 38.3 million contract signed on 3 March in Florence, Italy for three new Global Ozone Monitoring Experiment (GOME-2) instruments.

GOME-2 is an enhancement of the ESA GOME-1 instrument flown on ERS-2, the Earth Observation satellite which, continues to provide a wealth of scientific data from orbit. Within the EUMETSAT Polar System, consisting of a space segment comprised of three METOP satellites and their payloads, and a ground segment for command, control and data processing, GOME-2 is the operational instrument specifically devoted to measuring the ozone content in the atmosphere. GOME-2 measurements will allow the daily global retrieval of total ozone and vertical ozone profile in the atmosphere and, in addition, the measurement of atmospheric trace gases.

The EUMETSAT Polar System and the ESA METOP-1 Programme together form a cooperative venture between the two organisations, and lead to the launch of the first METOP satellite in mid-2003. The system provides operational meteorological data from polar-orbiting satellites, to complement and complete an international system of polar satellites operated together with the US.

The contract on the procurement of three flight models of the GOME-2 instrument was signed by (left to right) Dr. Giancarlo Grasso, Deputy Head, Defence Sector of Finmeccanica for Alenia Difesa/Officine Galileo BU Spazio, Dr. Claudio Mastracci, ESA Director of Applications Programmes, and Dr. Tillmann Mohr, EUMETSAT Director

The variations of atmospheric ozone are of vital importance for many reasons, and its distribution in the atmosphere needs to be mapped continuously. The enhanced GOME-2 instrument on METOP will continue the series of ESA measurements started by GOME-1 on ERS-2 and to be provided by the SCIAMACHY instrument on ESA's environmental satellite Envisat due to be launched in 2001.

In addition, to innovative data for Numerical Weather Prediction, one of the most important contributions of GOME-2 will be the continuation and improvement of the climate record of ozone. Monthly and seasonal maps of ozone distribution throughout the atmosphere will provide a record of its variation with time and will help detect long-term trends of major importance for the health of the planet and its population. esa

ISU Summer Session

The International Space University is a non-profit organisation, founded in 1987, with the aim of educating professionals in the field of space and its peaceful applications. Its programs are designed to meet the needs of a rapidly expanding sector where international and cross-disciplinary understanding and cooperation are fundamental to the success of future development. Specialised educational opportunities and training are offered by international experts in all space-related disciplines from a global perspective. Programmes include: Master of Space Studies, Professional Development Programs, tailor-made Forum Activities and the ISU Summer Session.

ISU Summer Session Program (SSP)
This intensive summer program covers the principal space-related fields, both technical and non-technical. These include space and society, space business and management, space policy and law, space system architecture and mission design, space engineering, space resources, robotics and manufacturing, satellite applications, space physical sciences, space life sciences and an informatics lecture series.

The interdisciplinary curriculum with its emphasis on international cooperation gives students broad new perspectives on the world's space activities, perspectives otherwise reserved for those with years of professional experience.

The SSP has proved to be an excellent forum where students and faculty alike can network with leaders in space research and development from around the globe. The interactive, international environment provides participants with numerous opportunities to forge new professional relationships. SSP alumni, numbering over 1200 to date, faculty members, visiting lecturers and members of the host community have all contributed to creating a professional network facilitating access to information and exchanges.

Summer Session 2000
This year's summer session will take place from 1 July - 2 September and is hosted by the Universidad Tecnica Federico Santa Maria in Valparaiso, Chile.

For more information visit the ISU SSP site at:
<http://www.isunet.edu/Programs/SSP/SSP.html>. esa

SOHO Top Comet Finder

Calculations confirm that a comet spotted by a Lithuanian astronomer on 4 February is a previously unknown object, making it the 100th comet discovered with the SOHO spacecraft.

Launched four years ago as a project of international cooperation between ESA and NASA, the Solar and Heliospheric Observatory has revolutionised the science of the Sun.

Although this latest comet, SOHO-100, is an 'ordinary' comet, SOHO has also revealed an amazing number of kamikaze comets plunging into the solar atmosphere, which help to make SOHO the most prolific comet finder in the history of astronomy.

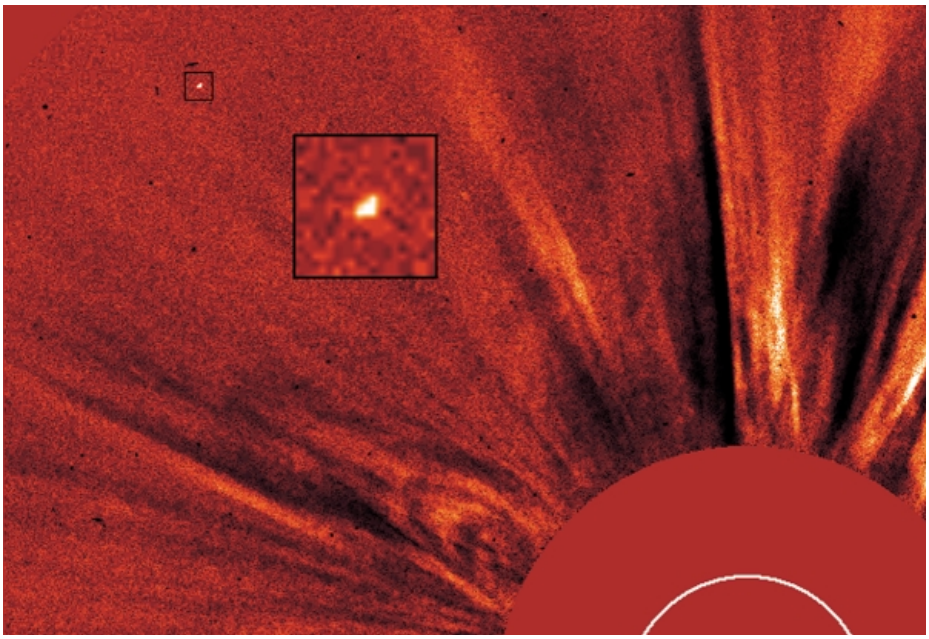
Like nearly all of SOHO's discoveries, the 100th comet showed up in images from the LASCO instrument. This is a set of coronagraphs that view the space around the Sun out to 20 million kilometres, while blotting out the bright solar disk with masks. Developed for SOHO by a multinational team led by the US Naval Research Laboratory, LASCO watches for mass ejections from the Sun that threaten to disturb the Earth's space environment. The comet discoveries are a big bonus.

SOHO's experts spot many of the comets as soon as the images come in. But still pictures and movies from LASCO are freely available on the Internet to astronomers around the world, who can discover less obvious comets without leaving their desks. This was the case when Kazimieras Cernis of the Institute of Theoretical Physics and Astronomy in Vilnius, Lithuania, found SOHO-100.

"On 4 February I saw the comet as a small speck of light in the previous day's LASCO images," Cernis explained. *"It had no visible tail, but it was too fuzzy to be an asteroid. By the time I had seen the object moving steadily across the sky in six successive images, I was convinced it was a comet and I sent the details to the SOHO scientists for verification."*

The competition to find SOHO's 100th comet was keen. An amateur astronomer, Maik Meyer of Frauenstein, Germany, discovered SOHO-98 and -99. On 5 February, less than 24 hours after Cernis reported the candidate SOHO-100, Meyer found the candidate SOHO-101. On the same day and in the same LASCO images, Douglas Biesecker, a member of the SOHO science team, spotted the candidate SOHO-102 travelling ahead of 101. Computations have now validated the orbits for all three candidates, and shown them to be bona fide comet discoveries.

Other amateur astronomers have used the LASCO images to find comets. In the summer of 1999, Terry Lovejoy in Australia found five and, since September 1999, an amateur in England, Jonathan Shanklin, has spotted three more.



In this coronagraph image, the shaded red disk is a mask in the LASCO instrument that bolts out direct sunlight. The white circle added within the disk shows the size and position of the visible Sun. the square black outline (upper left) shows the position of SOHO-100 and the larger black outline is a zoomed-in view

"SOHO is a special chance for comet hunters," said Shanklin, Director of the British Astronomical Association's comet section. *"It allows amateurs to discover some of the smallest comets ever seen. Yet they link us to sightings of great comets going back more than 2000 years."*

Nine of the comets found with LASCO, including SOHO-100, 101 and 102, passed the Sun at a safe distance. SOHO-49, which showed up in LASCO images in May 1998 and was designated as Comet 1998 J1, became visible to the naked eye in the Southern Hemisphere. But the great majority of SOHO's comets failed to survive very close encounters with the Sun.

Snowballs in hell

Of the first 100 SOHO comets, 92 vaporised in the solar atmosphere. Isaac Newton suggested 300 years ago that infalling comets might supply the Sun with fuel, but no one has ever tracked a comet that definitely hit the bright surface. Near misses are well known, and 100 years ago Heinrich Kreutz in Kiel, Germany, realised that several comets seen buzzing the Sun seemed to have a common origin, because they came from the same direction among the stars.

These comets are now called the Kreutz sungrazers, and the 92 vanishing SOHO comets belong to that class. They were not unexpected. Between 1979 and 1989 the P78-1 and SMM solar satellites spotted 16 comets closing with the Sun.

Life is perilous for a sungrazer. The mixture of ice and dust that makes up a comet's nucleus is heated like the proverbial snowball in hell, and can survive its visit to the Sun only if it is quite large. What's more, the very strong tidal effect of the Sun's gravity can tear the loosely glued nucleus apart. The disruption that created the many SOHO sungrazers was similar to the fate of Comet Shoemaker-Levy 9, which went too close to Jupiter and broke up into many pieces that eventually fell into the massive planet in 1994. esa

"SOHO is seeing fragments from the gradual breakup of a great comet, perhaps the one that the Greek astronomer Ephorus saw in 372 BC," commented Brian Marsden of the Center for Astrophysics in Cambridge, Massachusetts. *"Ephorus reported that the comet split in two. This fits with my calculation that two comets on similar orbits revisited the Sun around AD 1100. They split again and again, producing the sungrazer family, all still coming from the same direction."*

The sungrazing comets slant in from the south, at 35° to the plane where the Earth and the other planets orbit. As SOHO moves around the Sun, in step with the Earth, it sees the comets approaching the Sun from the east (left) in February and from the west (right) in August. In June and November the sungrazers seem to head straight up towards the Sun.

"The rate at which we've discovered comets with LASCO is beyond anything we ever expected," said Douglas Biesecker, the SOHO scientist personally responsible for the greatest number of discoveries, 45. *"We've increased the number of known sungrazing comets by a factor of four. This implies that there could be as many as 20 000 fragments."*

Their ancestor must have been enormous by cometary standards. Although SOHO's sungrazers are all too small to survive, other members of the family are still large enough to reappear, depleted but intact, after their close encounters with the Sun. Among them were the Great September Comet (1882) and Comet Ikeya-Seki (1965).

The history of splitting gives clues to the strength of comets, which will be of practical importance if ever a comet seems likely to hit the Earth. And the fragments seen as SOHO comets reveal the internal composition of comets, freshly exposed, in contrast to the much-altered surfaces of objects like Halley's Comet that have visited the Sun many times. LASCO reveals how much visible dust each comet releases. Gas produced by evaporating ice is detected by another instrument on SOHO, the Ultraviolet Coronagraph Spectrometer or UVCS, and enables scientists to measure the speed of the solar wind as it emerges from the Sun.

A comet spotted by its gas cloud

The count of SOHO's comet discoveries would be one fewer without a recent bonus from SWAN. This instrument's name unpacks into Solar Wind Anisotropies, and it was provided by the French Service d'Aéronomie and the Finnish Meteorological Institute. SWAN looks away from the Sun to survey atomic hydrogen in the Solar System, which glows with ultraviolet light and is altered by the solar wind. The instrument also sees large clouds of hydrogen surrounding comets, produced by the breakup of water molecules evaporating from the comets' ice.

In December 1999, the International Astronomical Union retrospectively credited SWAN and SOHO with finding Comet 1997 K2 in SWAN full-sky images from May to July 1997. It made number 93 on the SOHO scorecard. This comet remained outside the orbit of the Earth even at its closest approach to the Sun. Although it was presumably a small, faint comet, the gas cloud grew to a width of more than 4 million kilometres.

"The discovery was a surprise," said Teemu Mäkinen, a Finnish member of the SWAN group. *"Our normal procedure is to observe hydrogen clouds of comets detected by other people. In that respect, SWAN on SOHO is the most important instrument now available for routinely measuring the release of water vapour from comets."*

When Comet Wirtanen, the target for ESA's Rosetta mission (2003), made its most recent periodic visit to the Sun, it pumped out water vapour at a rate of 20 000 tons a day, according to the SWAN data. For the great Comet Hale-Bopp the rate reached 20 million tons a day and SWAN watched its hydrogen cloud grow to 70 million kilometres – by far the largest object ever seen in the Solar System.

For further information on SOHO, pictures and movies visit the ESA science web pages at <http://sci.esa.int/soho > and <http://sohowww.estec.esa.nl>. esa

Farewell to a Legendary Mission

ESA hands the IUE archive over to the global scientific community

The IUE (ESA/NASA/UK) spacecraft launched in January 1978 became the first space observatory facility available to the entire astronomical community. It marked the beginning of UV astronomy, a field for which space telescopes are essential since UV light does not reach the Earth's surface. By the time IUE was switched off, in September 1996 – 14 years later than originally planned – IUE had changed the view astronomers had of the Universe. Among many other findings, IUE discovered the auroras in Jupiter; detected for the first time the halo in our galaxy and measured the size of a black hole in the core of an active galaxy.

The IUE archive, storing two decades of ultraviolet astronomy, has become a historical reference. It contains more than 110 000 spectra from observations that in most cases cannot be repeated, and is an excellent source for studying variable phenomena. The long time-lapse covered and the stability of the instrument have enabled astronomers to witness events they never thought they would. The archive was the first of its kind accessible online – already in 1985, when the World Wide Web did not yet exist – and has been a key catalyst for science. To date, it has triggered the publication of some 3600 articles in refereed journals and a whole generation of astrophysicists has used IUE data at some stage.

Now, the IUE archive will belong to the global scientific community. ESA has just released the new IUE archive, INES (IUE Newly Extracted Spectra) as the first astronomical database distributed to national data centres all over the world for faster and easier access. *"This is the best farewell from ESA to a historic mission. Thanks to the new distributed system the IUE archive will become both a mine of discoveries and a powerful educational aid for future astronomers. It is a legacy worthy of the IUE project",* says Willem Wamsteker, ESA astronomer and ESA IUE Project Scientist.

"The INES system and its data guarantee that future generations of astronomers will be able to use IUE data as much as they want, regardless of whether they know

about the technicalities of the mission or whether there is an improvement in archive technology. And the distributed structure is better adapted to changes in user needs than a single archive centre", says Antonio Talavera from the Laboratory for Space Astrophysics and Theoretical Physics (LAEFF), based at Villafranca. *"ESA has created INES using a minimalist engineering approach for the world scientific community, and has made it to last. INES is easy to use and easy to upgrade, and LAEFF in Spain is proud to serve as the hub for the whole world".*

The INES Principal Centre is at the LAEFF, owned by INTA, the Spanish National Institute for Aerospace Technology. This centre, with a data mirror at the CADC in Victoria (Canada), holds the complete database and provides information not available from national hosts. So far 17 national hosts have come online. Together they form with the Principal Centre an efficient and highly reliable distribution system for the community. The whole process of data retrieval is fully automated and totally transparent to the end user. This distributed structure avoids localised connectivity problems and guarantees availability of data.

The INES Newsletter and Brochure are available from ESA Publications <http://esapub.esa.int>

Envisat, the Largest Environmental Satellite Takes Shape at ESA's Test Centre

ESA's Envisat satellite is currently undergoing integration and tests at the European Space research and Technology Centre (ESTEC) in the Netherlands.

Last August, the Envisat Payload and Service Modules were submitted to thermal and space environment tests in ESTEC's Large Space Simulator (LSS).

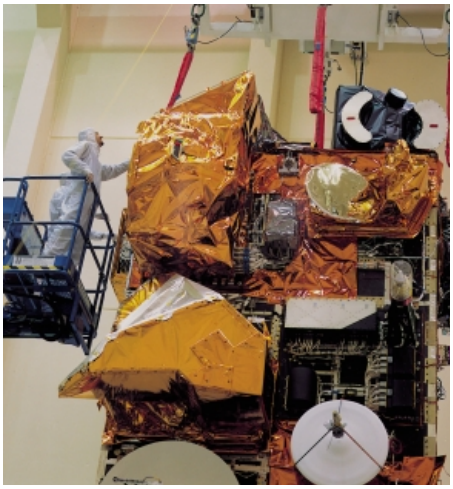
While the flight model instruments were progressively integrated on board the Payload Module, the Service Module verification was proceeding in parallel, including the recent demonstration of compatibility to the Ariane-5 in-flight shocks and separation tests.

Mating of these two modules of Europe's largest-ever environmental satellite took place at ESTEC's test facilities in mid April. Envisat stands over 10 metres tall and the two elements combined weigh over 8 tons. Even the engineers who have worked on it for years are still impressed by the size of the satellite.

Designed for at least 5 years of in orbit operation, Envisat with its ten highly advanced instruments on board will help European scientists advance our understanding of global warming, climate change, ozone depletion, and changes in the oceans, ice sheets, vegetation and atmospheric composition. Thanks in particular to its advanced imaging radar, Envisat will produce – all weather day and night – high-quality images of the oceans, coastal zones, polar ice and land regions.

The solar array will be integrated early summer. After a solar array deployment test, Envisat will be submitted to acoustic tests in the Large European Acoustic Facility (LEAF). The HYDRA hydraulic shaker will then be used to check the satellite's ability to cope with the vibrations it will experience during the launch phase. With its eight actuators delivering a force of 60 000 newtons each, the HYDRA is one of the largest test facilities of its kind.

With the Envisat flight model test programme, ESTEC demonstrates its capabilities as one of the most complete test centres in the world. Over 100 highly skilled specialists from ESA and European companies, led by the prime contractors Matra-Marconi Space (UK) for the satellite platform and DaimlerChrysler-Dornier Satellitensysteme (D) for the payload, are currently involved in the testing of Envisat. In March next year the spacecraft will



finally be prepared for shipment to Kourou.

Scheduled for launch on an Ariane-5 in June 2001, Envisat will fly on a Sun-synchronous orbit at about 800 km altitude with an orbit repeat cycle of 35 days, identical to the ERS-2 ground track. ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany, will handle the command and control of Envisat. The Agency's Earth Oservation application team, located at ESRIN, Frascati, Italy, will coordinate the payload data exploitation from instrument data recovery to delivery of products to the scientific and application user communities.

Once in orbit, Envisat will provide remote sensing data of unprecedented quality, helping Europe to meet the environmental challenges of the 21st Century.

ESA's First Biomedical Application Research Contract for the ISS

ESA and researchers from academia and industry signed the contract on 3 May for a health research project that will develop a space bioreactor for research aboard the International Space Station into biomedical applications. At the ceremony, held in the Erasmus User Centre at ESTEC, Mr Jörg Feustel-Büechl, ESA's Director of Manned Spaceflight and Microgravity, pointed out that *"This is the first in a series of almost 50 contracts for application-oriented research projects that involve the International Space Station."*

Mr Jörg Feustel-Büechl (left) and Prof Augusto Cogoli sign the contract for the first in a series of almost 50 new projects in ESA's Microgravity Applications Promotion Programme

A bioreactor is used for growing bacteria, yeast or animal cells and, more recently, for tissue. The new bioreactor will be designed specifically for cultivating medically-relevant mammalian cells, tissues and organ-like structures, with particular emphasis on vessels and cartilage.

Millions of people every year suffer organ and tissue loss from diseases and accidents. Transplantimg tissues and organs from other human bodies is severely limited by the availability of donors. Taking tissue samples from healthy areas of the patient's own body, growing them in vitro, outside the patient's body, to a size and structure which then allow their reimplantation into the damaged parts is a promising alternative. Reimplantation also avoids the fundamental problem of rejection of foreign tissues and organs. Growing tissue samples in vitro – in a bioreactor – is currently one of the major goals of medical research. It is expected that such techniques will revolutionise biomedical and surgical procedures in the near future. Space research may be instrumental for the breakthrough in tissue engineering – the microgravity environment may provide much better conditions for obtaining proper 3D cell structures.

A potential application is the mass cultivation on Earth of biological implants to regenerate the meniscus and articular cartilage of the knee, using techniques resulting from the space experiments. Cartilage regeneration is urgently needed for 20 to 50 year-old patients, many of them suffering from sports accidents. The demand for such implants in Europe alone is estimated to be 100 000 per year.

The modular space bioreactor for medically-relevant organ-like structures was proposed by a European scientific and industrial research team under the coordination of Prof. Augusto Cogoli from the Swiss Federal Polytechnical University (ETH) Zurich. It will be essential in clarifying the cellular and molecular mechanisms responsible for cell aggregation and differentiation control mechanisms, and in obtaining better pseudo-organs for possible clinical uses.

Prof. Cogoli's team comprises participants from Switzerland, Italy and Germany: Dr. Isabelle Walther from ETH, Dr. Werner Müller from the Sulzer Medica company in Winterthur (CH), Prof. Saverio Ambesi-Impiombato from the University of Udine (I), Dr. Augustinus Bader from the Medical University of Hannover (D), Prof. Peter Bruckner from the University of Münster (D) and Dr. Ralf Pörtner from the Technical University of Hamburg-Harburg (D).

The modular space bioreactor project is one of more than 50 microgravity application projects for the Space Station that ESA expects to initiate in the near future. They will use the Station to obtain application-oriented data that provide deeper insights into Earth-based industrial processes or be used in numerical simulations. The availability of the Space Station means that examining specific applied-research questions in that unique environment may be, in the long term, rewarding for industry.

The modular space bioreactor project is sponsored by ESA's Microgravity Applications Promotion Programme and is funded jointly with the participating scientific research institutes and industry. A major aspect of this MAP Programme is the setting up of Europe-wide teams and networks involving partners from academia and industry to work together on industrially-relevant research. The aim is to initiate concrete industrial projects in which terrestrial research with industrial objectives and commercial funding, together with the participation of researchers from scientific institutes, are supported by ESA, including the sponsoring of space flight opportunities and associated ground-based activities.

Prof. Cogoli and his scientific-industrial team proposed the space bioreactor project in response to ESA's first Announcement of Opportunity (AO) for Physical Sciences and Biotechnology. This 1998 AO for Space Station research proposals produced 145 responses, substantially exceeding expectations. After a review by independent peers, 6 proposals were rated as 'outstanding', 26 as 'highly recommended' and 30 as 'recommended'. Of these, 31 dealt with application-oriented research, including thermophysical properties of liquid metals, advanced foams, biological tissue culturing, osteoporosis and combustion processes.

The peer review panel summarised its evaluation of the proposal made by Prof. Cogoli and his team as *"The proposal for producing cartilage … is an outstanding and innovative approach. … this may be the only way for in vitro production of a functional cartilage analogue. This approach cannot be done except under microgravity conditions."*

Historic WA Town to Host Deep Space Ground Station

The start of construction of a Deep Space Ground Station, just outside the historic monastic town of New Norcia, Western Australia, has been marked with a Foundation Stone Laying Ceremony by ESA on Thursday, 2 March 2000.

Mr David Dale, ESA Director of Technical and Operational Support, and the Western Australian Minister for Planning, Graham Kierath, officially buried a time capsule and laid the first foundation stone.

Part of ESA's global network, the Ground Station features a 35-metre high antenna which will be built 8 km south of New Norcia.

The $40 million antenna will transfer data to and from ESA's deep space missions. The first large mission, the Rosetta satellite, will leave in 2003 on a 10-year mission to study the Wirtanen Comet. Rosetta will send a Lander to the surface of the comet to analyse its structure and composition.

The antenna will also communicate with ESA's first mission to Mars. The Mars Express will also be launched in 2003 as part of an international flotilla of spacecraft sent to study the planet.

Construction of the antenna tower commenced in April. Components for the antenna will be shipped from Europe and assembled on site. The expected completion date is Spring 2001.

Mr Dale said New Norcia was chosen over a number of sites in the Southern Hemisphere. *"This site has excellent weather conditions, sits on the perfect latitude for the launch operations and is sufficiently distant from urban areas so that no other transmission devices disturb the satellite's operations." "Western Australia also has high quality telecommunications infrastructure and we are working closely with Telstra because of its experience in the maintenance and operation of tracking stations."*

Bovis Lend Lease will oversee the construction under the leadership of the Canadian company, SED, which will head the International Antenna Consortium formed to manage the project. Telstra has been contracted to maintain the Ground Station on ESA's behalf.

Further information is available from ESOC Public Relations (Robert-Bosch-Str. 5, 64293 Darmstadt, Germany).

Site of the new Deep Space Ground Station outside New Norcia, Western Australia

Mr David Dale (right), ESA Director of Technical and Operational Support, and Mr Graham Kierath, Western Australian Minister for Planning, during the stone laying ceremony

ESA Astronaut Brings Back New Views of Earth

German astronaut Gerhard Thiele landed back on Earth on 22 February with his five international colleagues after a ground-breaking Space Shuttle mission that will change the way we look at the Earth.

The Space Shuttle Endeavour glided to an early evening landing at the Kennedy Space Center, touching down on the runway after a mission of over 11 days.

Elated scientists from all over the world gave the international SRTM team a standing ovation and heralded the mission as a huge success.

ESA astronaut Gerhard Thiele, completing his first space flight, described the mission as a 'fantastic experience'. *"We have mapped regions that are home to 95% of the world's population and this data will be used to produce unrivalled three-dimensional images of the world,"* he said.

Orbiting at 233 km above the Earth, with two radar antennas mounted in the Shuttle payload bay and two extended on a 60-metre mast, the imaging system has measured the undulations of landscapes that have been sculpted through the millennia.

NASA extended mapping operations for nine hours, allowing Endeavour's astronauts to continue collecting data until a day before returning to Earth and, therefore, achieving almost 100 percent of the planned coverage. The mission's target mapping area included about 123 million square kilometres and more than 65% of this – nearly 80 million square kilometres – was mapped with two or more passes.

The Shuttle Radar Topography Mission (SRTM), consisting of a specially modified radar system, was designed to demonstrate the technology for obtaining high-resolution digital topographic maps of the Earth. The radar has imaged mountains and deep valleys carved by glaciers and rivers – like those in the Andes, the Rocky Mountains and the Himalayas of Asia – vast expanses of deserts and coastal plains around the world, as well as cold regions and forests of the northern latitudes.

In the future, any project that requires accurate knowledge of the shape and height of the land – such as flood control, soil conservation, reforestation or volcano monitoring – will benefit.

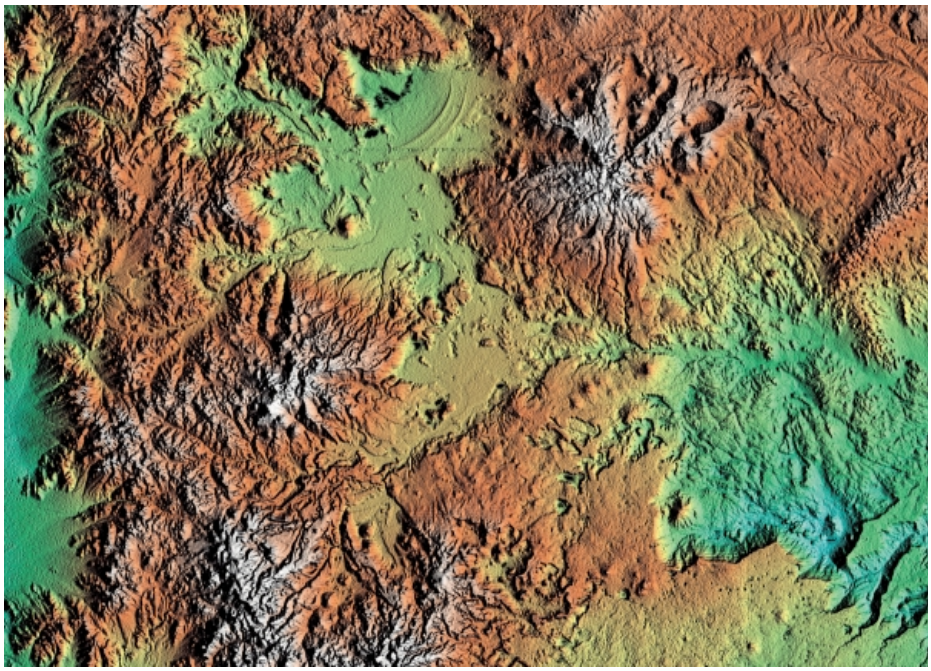
After a series of delayed launch attempts, the mission got off to a perfect start on 11 February with Thiele reporting successful deployment of the 60 metre radar mast – the longest structure to be flown in space from the Shuttle – and activation of the complex radar instruments going more smoothly than expected. *"We'd expected that there would be more teething problems but the intensive training and preparations paid off,"* he said.

STRM is a joint project between NASA, the United States National Imagery and Mapping Agency (NIMA), the German Aerospace Centre (DLR) and the Italian Space Agency (ASI). NASA's Jet Propulsion Laboratory (JPL) developed the C-band Spaceborne Imaging Radar and DLR developed the X-band Synthetic Aperture radar (X-SAR). Dornier Satellitensysteme GmbH, a corporate unit of Daimler-Chrysler Aerospace (Dasa), is the prime contractor for the X-SAR system.

Although the first images have already been released, the gathering of the radar data from orbit marks only the end of the first phase. Scientists will spend another 18 months processing the huge volume of SRTM data.

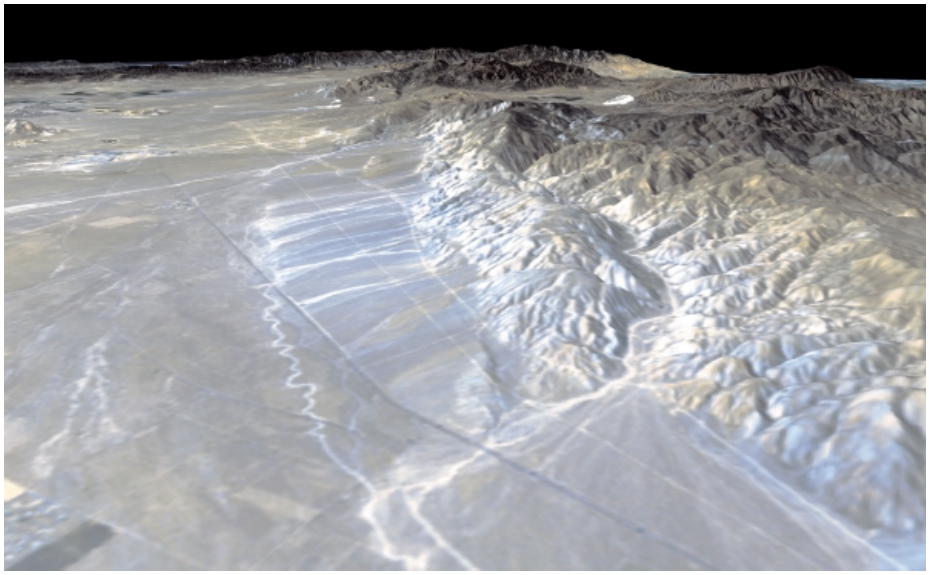
For further information, see the following web pages:
ESA:
<http:/www.estec.esa.int/spaceflight/operations/sts99.htm>
DLR:
<http://www.dlr.de/srtm>
NASA:
<http://spaceflight.nasa.gov/shuttle>

The STS-99 crew poses at the entrance to the orbiter Endeavour. From left are Mission Specialists Janet Lynn Kavandi (NASA), Gerhard Thiele (ESA), Janice Voss (NASA) and Mamoru Mohri (NASDA), Commander Kevin Kregel (standing) and Pilot Dominic Gorie (kneeling)



This topographic image of Patagonia, Argentina, shows a spectacular landscape formed by volcanoes, rivers, and wind. The area is located just east of the narrow range of the Andes Mountains, about 100 km east of the border with Chile. Interesting features include basalt-capped mesas with sink holes (lower centre), arcuate ridges of windblown beach sands downwind from a salty desert lake (upper centre), young volcanic cones (right). A computer-generated artificial light source illuminates the elevation data to produce a pattern of light and shadows. Colours show the elevation as measured by SRTM, ranging from blue at the lowest, to white at the highest elevations. White speckles on the face of some of the mountains are holes in the data caused by steep terrain and will be filled using coverage from an intersecting pass. Geologists will use SRTM topographic data to study the interaction of volcanic, climatic and erosion processes

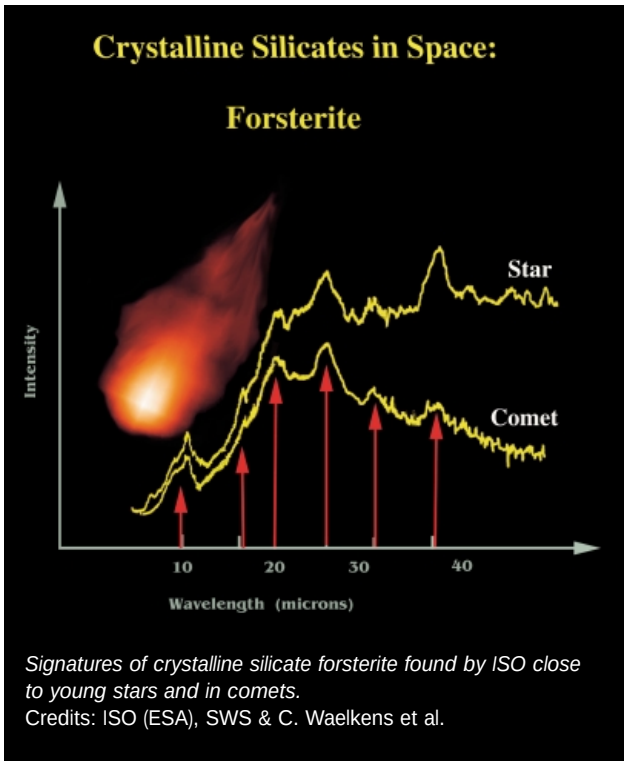
Honolulu, on the island of Oahu, is a large and growing urban area with limited space and water resources. This perspective view, combining a Landsat image with STRM topography, shows how the topography controls the urban growth pattern, causes cloud formation, and directs the rainfall runoff pattern. Features of interest in this scene include downtown Honolulu (right), Honolulu harbour (right), Pearl Harbor (centre), and offshore reef patterns (foreground). The Koolau mountain range runs through the centre of the image. Clouds commonly hang above ridges and peaks of the Hawaiian Islands, and in this rendition appear draped directly on the mountains. The clouds are actually about 1000 metres above sea level. This type of display adds the important dimension of elevation to the study of land use and environmental processes as observed in satellite images, allowing ecologists and planners to assess the effects of urban development on the sensitive ecosystems in tropical regions



California's Garlock Fault, marking the northwestern boundary of the Mojave Desert, lies at the foot of the mountains, running from the lower right to the top centre of this image. These mountains are the southern end of the Sierra Nevada and the prominent canyon emerging at the lower right is Lone Tree Canyon. In the distance, the San Gabriel Mountains cut across from the left side of the image. At their base lies the San Andreas Fault, which meets the Garlock Fault near the left edge at Tejon Pass. The dark linear feature running from lower right to upper left is State Highway 14 leading from the town of Mojave in the distance to Inyokern and the Owens Valley in the north. The lighter parallel lines are dirt roads related to power lines and the Los Angeles Aqueduct which run along the base of the mountains. The data will be used by geologists studying fault dynamics and landforms resulting from active tectonics

'Beyond the Peaks'

On 2-4 February 2000, the 'ISO beyond the Peaks' workshop was held in Villafranca del Castillo, Madrid, Spain. This workshop was the second in a series initiated with the successful 'First ISO Workshop on Analytical Spectroscopy', held in October 1997, in which 100 astronomers gathered in Villafranca to discuss ESA's Infrared Space Telescope ISO observations and associated scientific interpretation, 2 years into the ongoing mission. This second workshop took place with all ISO data having entered the public domain. 140 astronomers, more than expected, attended the workshop, discussing in 38 talks and 50 posters, aspects of the detailed ISO spectroscopic heritage including, among other topics, the cosmic cycle of water and the derivation of an inventory of cosmic ices. Many results lead to the development of more sophisticated models, such as dynamical models for AGB stars, or upper layers of warm molecular gas in the atmospheres of Mira stars. Representatives of upcoming IR missions such as SIRTF, SOFIA and ASTRO-F were also present.



Signatures of crystalline silicate forsterite found by ISO close to young stars and in comets.
Credits: ISO (ESA), SWS & C. Waelkens et al.

The Crystalline Revolution
ISO's Finding Opens a New Research Field, 'Astro-Mineralogy'

Silicate crystals, the most abundant minerals on Earth, are also found in great quantities around old stars and in protoplanetary discs – the discs where planets form. This finding, presented at a press conference on the last day of the 'Beyond the Peaks' workshop, is considered by experts in space chemistry as one of the main results of ESA's infrared space telescope, ISO. Silicate minerals were known to be a main component of dust in space, but detecting them in a crystallised state has been a surprise. It allows the identification of precise silicates in astronomical objects, which will open a totally new field in astronomy: 'astro-mineralogy'. *"This is the crystalline revolution",* said the author, Dutch astronomer Rens Waters of Amsterdam University.

"It's really fantastic, this possibility of identifying the silicates. Before ISO everybody thought that all silicates in space were amorphous, without a well-ordered internal structure; that means you cannot differentiate among the many different silicates existing. Now we can try to identify them and track their presence in different regions. A whole new research field is starting", said Waters, who brought to the press conference samples of several terrestrial crystalline silicates: olivine and pyroxene, the most common silicates on Earth.

Crystals give key clues about the physical conditions and evolutionary history of crystal-bearing objects. The precise mechanisms for crystal-making are now being actively researched in laboratories, although some working-hypotheses are already being used. For instance, crystals can be made by heating the material to temperatures above 1300°C and then slowly cooling it down. Those found so far by ISO are at -170°C, both in stellar envelopes and in protoplanetary discs.

In the case of the old stars – red giant stars, where crystals are found to account for as much as 20% of all the surrounding dust – astronomers think that that the high temperatures near the star triggered the crystallisation of the silicates. In the protoplanetary discs some experts postulate that electric shocks – like lightning flashes – heated the dust, which cooled afterwards.

"The crystals detected by ISO in these discs have a size of about a thousandth of a millimetre. They collide with each other, forming bigger and bigger bodies. Models predict that in about ten to one hundred million years they will make planets", Waters says. "In fact, crystalline silicates are very common in our own Solar System. You also have them in the comet Hale Bopp!".

The reason why crystalline silicates had not previously been detected in stars has to do with their low temperatures. Cold material emits mostly infrared light, which means an infrared space telescope like ESA's ISO was needed. The two high-resolution spectrometers onboard the satellite, able to detect the 'chemical fingerprint' of the crystals, did the rest.

Astronomers are sure about the discovery because those chemical fingerprints, the spectra, can be compared in laboratories with spectra from crystalline silicates found on Earth. This method has demonstrated the crystalline structure and has even already allowed the identification of some of the crystals, such as forsterite and enstatite. However, crystalline silicates are a large family and their chemical signatures can be very similar; to enlarge the list of precise crystals more work will be needed, say experts in space chemistry.

"Crystalline silicates are synthesised around the stars; then that dust goes into the interstellar space, and enriches the raw material out of which more stars and planets will form. So you would expect crystals also to be in the interstellar medium! Crystals will certainly make us learn a lot...", according to Waters.

"This finding shows that ISO is really unveiling the chemistry of the Universe", says ESA astronomer Alberto Salama, chairman of the workshop about ISO results in spectroscopy held this week at ESA's Villafranca station in Madrid where the results were presented to the scientific community. *"This is becoming more and more a 'hot field' of research. Initially we intended to organise a modest workshop, but we have had 140 astronomers coming from all over the world!".*

AP2000 Millennium Conference Summary

The AP2000 Millennium Conference on Antennas and Propagation was held from 9-14 April in Davos, Switzerland. Some 1100 delegates, one third from overseas, attended the conference, presenting over 900 papers in 65 specialised oral and poster sessions. Several short courses were also offered to delegates by eminent scientists. Equipment, software and books were displayed by industry in some 20 exhibitions. AP2000 is the largest conference ever organised in this field in Europe.

Current work in Antennas and Radio-wave Propagation is driven by new requirements for expanding wireless communication and remote sensing applications.

For mobile communications, multibeam reflector and planar or conformal arrays with active or semi-active feeding and smart beam forming, are being developed for satellites and for cellular base stations. Channel modelling in complex communication environments, building penetration and avoidance of interference are key topics in mobile propagation. Interactions of microwave with biological tissues is also an area of extensive research activity. Concurrent engineering involving antenna, propagation and signal processing disciplines is becoming the key to mobile communication system design.

For wideband multimedia communications, the trend is to use higher frequencies up into the millimetre-wave range. This requires new propagation models, new impairment restoration techniques to overcome fading and scintillation at higher frequencies. Here also, closer cooperation between propagation modelling and antenna design is required to develop active fade compensation techniques for satellite and terrestrial systems, where antenna gain and power are continuously adapted to propagation conditions. At millimetre wave frequencies, integrating active components and radiating elements on the same substrates, some of them with frequency sensitive (Photonic Band Gap), or for multifrequency capability (fractal antennas) is the object of sustained research activities.

The new concept of stratospheric communication relay, and perhaps observation platforms, also introduces new challenges to propagation and antenna engineers, which are currently being investigated.

In the field of remote sensing, challenging perspectives have been discussed both for passive and active instruments. In particular, the SMOS sensor, accepted by ESA in the framework of the Earth Explorer Opportunity Missions, will monitor from space soil moisture, salinity, vegetation biomass and surface temperature using microwave interferometry at L-band. Such a new instrument, with its large two-dimensional array poses challenging antenna engineering and retrieval problems. Atmospheric remote sensing for communication and radar applications is also an expanding field.

Multifrequency synthetic aperture radar requires new low-cost printed antenna technologies, much discussed at the conference. Spaceborne repeat and single-pass SAR interferometry opens new perspectives and challenges for digital elevation mapping, cartography and seismology

Finally, ground penetration radars, involving both antennas and complex propagation issues, have been extensively discussed at AP2000, mostly for the detection of buried objects. They are also being considered for planetary observation missions.

This successful conference has provided ESA with precious inputs for its future R&D in the key areas of antennas, wave propagation and microwave remote sensing. It has also enhanced the image of ESA's technical excellence in the antenna and propagation communities world-wide, as well as in the associated engineering societies.

For technical information on the AP2000 conference, please consult the AP2000 website:
<http://www.estec.esa.nl/AP2000/>
or contact:
Dr Antoine G. Roederer
AP2000 Chairman
ESTEC,
2200 AG Noordwijk
The Netherlands
E-mail: aroedere@estec.esa.nl

The Proceedings of the conference are available on CD-ROM from the ESA Publications website <http://esapub.esa.int> (ESA Publications Bookshop) or fax +31-71-565-5433.

Photos of the AP2000 Opening Session

ESA and Hubble: Changing our Vision

In light of the Hubble Space Telescope's 10th anniversary on 27 April, ESA held a press conference at the Space Telescope-European Coordinating Facility (ST-ECF) in Munich in which the new and fully European outreach initiative, the 'European Space Agency Hubble Information Centre' was presented and launched.

With the astronauts who took part in the most recent Servicing Mission (SM3A) in attendance, ESA presented a complete overview of Europe's major contribution to the HST mission, and reviewed the first ten years of operations and the outstanding results that have 'changed our vision' of the cosmos.

With this initiative, ESA shows its commitment to public outreach and to the communication of science.

With an expected life time of 20 years, Hubble is now at the midpoint of its life. It has so far been one of the most successful scientific space missions, and the continuous maintenance and upgrading of the observatory through the Servicing Missions makes Hubble's next ten years appear even more promising.

Visit the new 'European Space Agency Hubble Information Centre' at <http://hubble.esa.int>

ESA Brochure-157 '10 Years that Changed our Vision' covers the background and science information of the Hubble Telescope Project. It is available from the ESA Publications Bookshop at <http://esapub.esa.int>

ERS – ENVISAT SYMPOSIUM

'Looking Down to Earth in the New Millenium'

Organised by: ESA and the Chalmers University of Technology

16-20 October 2000 – Gothenburg, Sweden

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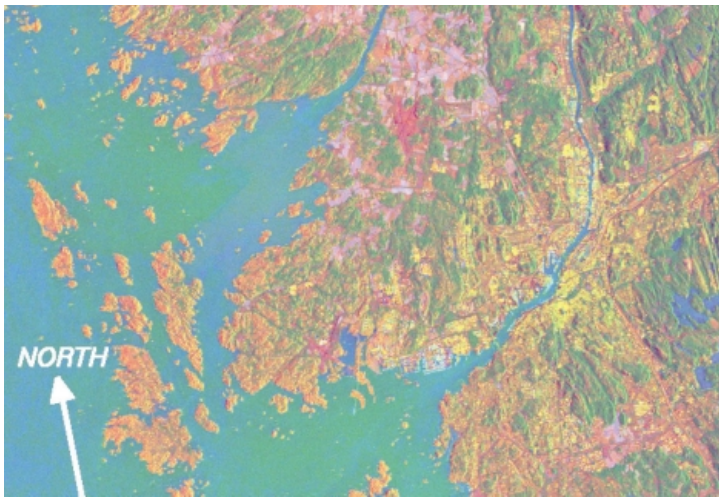

Contacts:

– for Website aspects, registration, information:
Barbara Scarda, ESRIN
tel. +39-06-94180941
fax +39-06-94180942
E-mail: bscarda@esrin.esa.it

– for Symposium contents:
Gianna Calabresi, ESRIN
tel. +39-06-94180625
fax +39-06-94180552
E-mail: gianna.calabresi@esrin.esa.it

– for Local Support:
Britt-Marie Boisen
Chalmers University of Technology,
Gothenburg, Sweden
tel. +46-31-7721840
fax +46-31-164513
E-mail: boisen@rss.chalmers.se